Macroeconomic and Financial Stability: Challenges for Monetary Policy

Sofía Bauducco
Lawrence Christiano
Claudio Raddatz
editors

Central Bank of Chile / Banco Central de Chile

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Series on Central Banking, Analysis, and Economic Policies

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Production Team

Editors:
Sofía Bauducco
Lawrence Christiano
Claudio Raddatz

Supervisors:
Camila Figueroa
Mario Giarda

Copy Editors:
Alan Higgins

Designer:
Mónica Widoycovich

Proof Reader:
Dionisio Vio

Technical Staff:
Carlos Arriagada

Printer:
Andros Impresores

Contributors

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Contributing Authors

Sofía Bauducco
Central Bank of Chile
Santiago, Chile

Denis Beau
Banque de France
Paris, France

Michael D. Bordo
Rutgers University
New Brunswick, NJ, USA
National Bureau
of Economic Research
Cambridge, MA, USA

Christophe Cahn
Banque de France
Paris, France

Guillermo Calvo
Columbia University
New York, NY, USA

Luis F. Céspedes
Universidad Adolfo Ibáñez
Santiago, Chile

Lawrence Christiano
Northwestern University
Evanston, IL, USA
National Bureau
of Economic Research
Cambridge, MA, USA

Laurent Clerc
Banque de France
Paris, France

Fabrizio Coricelli
Paris School of Economics
Paris, France

Michael B. Devereux
University of British Columbia
Vancouver, BC, Canada
Centre for Economic
Policy Research
London, United Kindom
National Bureau
of Economic Research
Cambridge, MA, USA

Javier García-Cicco
Central Bank of Chile
Santiago, Chile
Universidad Católica Argentina
Buenos Aires, Argentina

John Geanakoplos
Yale University
New Haven, CT, USA
National Bureau
of Economic Research
Cambridge, MA, USA

Robert E. Hall
Stanford University
Stanford, CA, USA
National Bureau
of Economic Research
Cambridge, MA, USA

Daisuke Ikeda
Bank of Japan
Tokyo, Japan

Luis Felipe Lagos
Instituto Libertad y Desarrollo
Santiago, Chile

John Landon-Lane
Rutgers University
New Brunswick, NJ, USA

Atif Mian
Princeton University
Princeton, NJ, USA

Frederic S. Mishkin
Columbia University
New York, NY, USA
National Bureau
of Economic Research
Cambridge, MA, USA

Benoît Mojon
Banque de France
Paris, France

Pablo Ottonello
Columbia University
New York, NY, USA

Claudio Raddatz
Central Bank of Chile
Santiago, Chile

Diego Saravia
Central Bank of Chile
Santiago, Chile

Robert Shimer
University of Chicago
Chicago, IL, USA

Matías Tapia
Pontificia Universidad
Católica de Chile
Santiago, Chile

Conference Discussants

Stijn Claessens
International Monetary Fund
Washington, DC, USA

Claudio Raddatz
Central Bank of Chile
Santiago, Chile

Rodrigo Cifuentes
Central Bank of Chile
Santiago, Chile

Luca Dedola
European Central Bank
Frankfurt, Germany

Saki Bigio
Columbia University
New York, NY, USA

Tobias Adrian
Federal Reserve Bank
of New York
New York, NY, USA

Virgiliu Midrigan
New York University
New York, NY, USA

Robert Hall
Stanford University
Stanford, CA, USA
National Bureau
of Economic Research
Cambridge, MA, USA

Pablo García
International Monetary Fund
Washington, DC, USA

Alejandro Micco
Universidad de Chile
Santiago, Chile

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Macroeconomic and Financial Stability: An Overview

Sofía Bauducco
Central Bank of Chile

Lawrence Christiano
Northwestern University and National Bureau of Economic Research

Claudio Raddatz
Central Bank of Chile

On September 2008, Lehman Brothers filed for bankruptcy and the world became aware that the financial crisis that had been unfolding for months was far more serious than expected. Months later, it became clear that the financial crisis of 2008-2009 was the worst economic downturn since the Great Depression of the 1930s: real GDP in the United States declined at an annual rate of 1.3% in the fourth quarter of 2008, 5.4% in the first quarter of 2009 and 6.4% in the second quarter of 2009. The crisis originated in the U.S. but it spread rapidly to the rest of the world, as real world GDP fell by 6.4% in the fourth quarter of 2008 and by 7.3% in the first quarter of 2009.[1]

The crisis not only brought the global financial system to the brink of disaster, but also shook the existing consensus regarding the appropriate conduct of monetary policy and macroeconomic stabilization.

Before the crisis, macroeconomists, in general, and central bankers in particular, believed that monetary policy was well understood. As Mishkin points out in his contribution to this volume,

1. See the paper by Mishkin included in this volume.

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there was general consensus that a central bank's monetary policy strategy should be oriented towards *flexible inflation targeting*, which implied an explicit commitment from the central bank to stabilize CPI inflation without disregarding a complementary objective of output stabilization. While most central banks arguably cared about financial stability, it was believed that this goal could be successfully pursued through careful regulation and monitoring of individual financial institutions, in many cases conducted by separate regulatory authorities. This belief did not come from neglecting the potential spillovers between the conduction of financial and macro stability, but from a sort of consensus that these spillovers could be successfully tamed through regulation, that preserving price stability contributed—or at least did not weaken—financial stability, and that the cost of using monetary policy to address financial stability concerns was too large and its efficiency too uncertain.

Mishkin convincingly argues that the crisis led policymakers and academic economists around the globe to question several aspects of this implicit consensus. In his view, this episode taught us that financial disruptions have highly non-linear effects over the economy. The impact of a financial crisis is larger and more persistent than that of a series of small shocks of the same overall size. Models based in local dynamics may do a very poor job predicting the impact of such an event. Indeed, the depth of these crises is such that the monetary policy rate is likely to reach the zero lower bound. He also explains that the recent experience suggests that price and output stability do not ensure financial stability because the buildup of risks in the U.S. financial system occurred during a period of stability that had even been dubbed as "The Great Moderation." Furthermore, he thinks that it may have even been the case that low nominal interest rates, through what has been recently labeled the *risk-taking channel* of monetary policy, may have fostered excessive risk-taking and contributed to create the conditions for a financial crisis to take place. Finally, the implicit commitment of governments to clean up after an episode of financial distress and protect financial stability means that financial crises often lead to fiscal crises.

In a way, the first and primary lesson to learn from the crisis was humility. The crisis challenged the conventional wisdom about monetary policy and rekindled the debate on the role of monetary policy in the presence of financial frictions.

The present volume collects twelve papers that were presented at the XVI Annual Conference of the Central Bank of Chile, that took place in Santiago on November 15 and 16, 2012. The event brought together leading economists from academia and central banks that discussed the main challenges that the rise of financial stability as a policy goal poses to the conduction of monetary policy.

The volume is organized as follows: The first section discusses the lessons left by the financial crisis for the conduct of monetary policy. The contribution of Mishkin outlines these key lessons and discusses where central banking should be headed in the coming years.

The second section is devoted to the analysis of the role of monetary policy in the buildup of a financial crisis. Bordo and Landon-Lane present evidence suggesting that loose monetary policy might aid in this process by contributing to a rise in asset prices. The articles by Shimer and Hall study markets with asymmetric private information and identify conditions under which a crisis in those markets may unfold. The article by Geanakoplos studies the leverage cycle and explains why high leverage in stable periods makes the economy more vulnerable to the drop in leverage associated to an increase in uncertainty.

The third section discusses the role of monetary and macro-prudential policies in preventing a financial crisis. Christiano and Ikeda show that macro-prudential policy, in the form of leverage restrictions, may increase welfare in an environment in which the effort exerted by financial intermediaries to obtain high returns for their creditors is not observable. Beau, Cahn, Clerc and Mojon analyze the interaction between monetary and macro-prudential policies and find that macro-prudential policies are not likely to interfere with the objective of price stabilization of monetary policy that, as Mishkin points out, should undoubtedly be the main goal of monetary policy. Mian argues that neither ex-ante macro-prudential policies, nor ex-post monetary policy, are effective in dampening the effects of the financial crisis because the households that have to engage in a deleveraging process are unlikely to be those benefited by these measures. He proposes instead the implementation of ex-ante flexible financial contracts that would satisfy the dual objective of making crises less likely and reducing its severity if a one indeed takes place.

Finally, the fourth section discusses policies that can aid the economy in the path to recovery from a financial crisis. Calvo, Coricelli and Ottonello document the fact that financial crises are usually followed by jobless recoveries. They show that, when inflation spikes accompany the recovery phase, the recovery is not jobless but instead wageless. Thus, a contained level of inflation immediately after the crisis may lead to a persistent level of unemployment. Currency depreciation can help reduce unemployment insofar as it is associated with inflation. Measures to reactivate credit flows could be beneficial to wage earners as a whole. Devereux studies the international transmission of shocks and argues that, with trade and financial market integration, if one country hits the zero lower bound in response to a negative shock, the liquidity trap becomes a global phenomenon. Fiscal policy is an effective policy tool when a country faces a liquidity trap, but at the cost of making the commercial partners worse off. To optimally respond to the shock, countries should coordinate their actions by jointly implementing fiscal expansions.

The last two papers of this section study the adoption of unconventional policies in Chile in the aftermath of the 2009 crisis. Céspedes, García-Cicco and Saravia look into the effects of the implementation of a long-term liquidity facility in Chile, the FLAP. They find that the FLAP caused a flattening of the nominal yield curve, with medium-term yields decreasing by around 30 to 50 basis points. Moreover, it stimulated commercial and consumption lending by banks. Lagos and Tapia explore the effects of the capitalization of BancoEstado, a publicly owned commercial bank. They report that this measure led to an expansion of commercial credit by BancoEstado. It is unclear, however, whether this additional provision of credit reached credit-constrained firms, which were the ones that needed it the most.

In what follows, we discuss in more detail each contribution in this volume and its relation to the existing literature.

1. The Buildup of a Financial Crisis

As **Mishkin** points out in the work reproduced in this volume, common wisdom among economists before the crisis was that price and output stability would promote financial stability. An important body of research stemming from the work of Bernanke, Gertler and Gilchrist (1999) and Bernanke and Gertler (2001) rationalized this idea.[2]

2. See Mishkin (in this volume) and Christiano et al. (2010) for a discussion on the conventional wisdom pre-crisis about financial stability and monetary policy.

The bankruptcy of Lehman Brothers in September 2008 and the financial crisis that unfolded right after however, led many economists to revise previous events in a quest to identify the macroeconomic conditions that led to it and the early warnings that could have foretold the events that were to come.

In this context, special interest was assigned to the role that monetary policy had (if any) in laying the foundations of the crisis through excessive liquidity provision.

Taylor (2007) was one of the first economists that suggested that the housing boom of the 2000s was fueled by the prevailing monetary conditions during that period. To justify this claim, he computes the U.S. Federal Funds rates that should have been implemented according to the Taylor rule estimated for the Fed, and compares them to the rates effectively in place during that period. He finds that the latter were around 3 percentage points below the former. At the opposite corner, Bernanke (2010), Bean, Paustian, Penalver and Taylor (2010), Turner (2010) and Posen (2009) have argued that the Fed's policy prior to the crisis did not fuel the housing bubble. Several recent studies finding mixed evidence on the relation between loose monetary policy and housing prices have failed to settle this debate.[3]

Beyond the focus on housing prices, several authors have studied the impact of prolonged periods of low interest rates on risk-taking and asset prices. As Borio and Zhu (2008) assert, monetary policy can influence the perception and pricing of risk with economic agents, resulting in a separate transmission mechanism that they label *the risk-taking channel* of monetary policy. The theoretical underpinnings of this mechanism have also been discussed in a number of studies (Rajan, 2005; Adrian and Shin, 2010; among others); recent empirical analyses using micro data seem to confirm its importance (Jimenez et al. (2013), Delis and Kouretas (2011)).

On a related note, Borio and Lowe (2002) argue that financial imbalances can build up in a low inflation environment and that, in some circumstances, it is appropriate for policy to respond in order to contain these imbalances. For instance, Christiano et al. (2010) show through historical data and model simulations that inflation tends to be low during stock market booms caused by signals of

3. Hott and Jakipii (2012), Gerlach, Assenmacher-Wesche (2008) and McDonald and Stokes (2013) find evidence that expansionary monetary policy had a key role in fostering housing booms in the last decade, but Del Negro and Otrok (2007) and Dokko et al. (2011), among others, claim that the increase in housing prices cannot be explained by low interest rates alone given the historical relationship between these two variables.

future technology. In such a situation, the prospect of higher future productivity creates downward pressures on inflation. A monetary authority that reduces the interest rate in response to these signals will suboptimally fuel the boom. Consequently, monetary policy that focuses on inflation can only be destabilizing and lead to suboptimal volatility of output and asset prices.

The work of **Bordo and Landon-Lane** contained in this volume revisits this issue and explores whether an expansionary monetary policy may cause the type of asset booms that end in costly asset busts. To answer this important question, the authors conduct a historical analysis of house price booms, stock market booms and commodity booms for 18 OECD countries from 1920 to 2010. They discern boom and bust periods using a dating algorithm of Bry and Boschan (1971) that identifies turning points of asset price series. Because the algorithm may spuriously identify some turning points, the authors further require these to satisfy some previously defined criteria.

Once the house price, stock price, and commodity price booms and busts have been identified, the authors conduct an empirical analysis of the effect of monetary policy on the deviations of asset prices from their long-run trend by pooling the data from the 18 countries analyzed. To this end, they include two different measures of the monetary policy stance. The first measure is the deviation of a short-term interest rate from that implied by a Taylor rule that assigns equal weight to deviations of inflation and output from their targets. The second measure is the deviation of the rate of money growth from 3%. Additional controls include the deviation of inflation from its long-run trend and a measure of credit conditions, which is the deviation of the share of bank loans to GDP from its long-run mean. Finally, they interact a dummy variable that takes the value of 1 if the given period corresponds to a boom, and with the other regressors to see if their effects over deviations of asset prices are different in booms with respect to normal times.

The results of this exercise show a clear relation between loose monetary policy and house price increases during booms that is absent during normal times. House prices also increase during booms while at the same time inflation falls below its long–run level, and when credit conditions are loose. Once again, during normal times these two factors are largely unrelated to housing prices. Monetary policy is also related to the evolution of stock and commodity prices during booms, although the relation between these variables, low inflation and easy credit is not established well in the empirical analysis.[4]

These new results add to the existing evidence cited above that an excessively loose monetary policy may help fuel asset price booms. While sorting causality in this literature is difficult and the issue is not completely settled, it would be wise for central banks to consider the potential consequences of their actions on risk taking and asset prices when analyzing different policy options. More specifically, the results presented by Bordo and Landon-Lane suggest that the deviation from well understood rules are the ones that tend to be associated with asset price increases. Thus, a monetary policy guided by stable monetary rules should be less subject to these types of undesired consequences.

While an overly expansive monetary policy may have contributed to create the conditions leading to the crisis, it is clear that other factors must have been at play. This has driven researchers to try to understand the market conditions that may foster a financial crisis. Understanding this issue may help policymakers identify the markets that are more prone to instability to develop early warnings and management programs that may prevent or limit the propagation of the crisis. **Shimer's** article in this volume contributes to this literature and studies trade with private information in markets for mortgage-backed securities (MBSs). The author first summarizes existing evidence of the presence of private information about the quality of loans on MBSs, and proceeds to show the implications of private information for the decline of trade when a crisis takes place.

Private information seems to be a relevant factor in explaining financial crises. A first effort, therefore, is devoted to assess whether private information is present on MBS markets. Shimer focuses on the market for MBSs issued by private financial institutions, so-called private-label MBSs, which experienced a rapid growth and subsequent fall in the period 2000-2009 (from a peak of $883 billion in

4. The results show that inflation and easy credit have a negligible effect on stock prices, even during booms. The analysis of commodity prices shows a stronger relation with loose monetary policy during booms than in normal times. Low inflation has a positive impact on these prices but easy credit does not. These last results should however be taken with caution, because the empirical exercise for commodity prices uses only U.S. data, rendering the number of observations small. The reason for this is that commodity prices are the same for all countries in the sample, so it is not possible to use a panel for the estimation.

2005 to a trough of $18 billion in 2009). A first reason for the presence of private information in these markets is that the underlying loans usually have low or no documentation. Instead, originators base their decision to lend on "soft" information, such as the mortgage originator's expectation about the buyer's income stability. (Keys et al., 2010; Demiroglu and James, 2012 provide evidence that supports this idea). Other reasons are misrepresentations of information provided by borrowers and identified by originators—such as income misreporting—(Jiang et al., 2011; Piskorski et al., 2013) and the use of superior valuation models by mortgage originators that are unavailable to MBS buyers. The U.S. mortgage industry has developed a number of techniques to moderate the amount of private information and mitigate its consequences, such as warranties,[5] independent evaluations by credit-rating agencies, reputation mechanisms and tranching. These devices, however, were insufficient to deal with private information in the MBS market when prices began to decline in 2005. Shimer presents a model in which sellers with favorable information separate from those with unfavorable information thanks to a shortage of buyers at high prices. The model can generate two mechanisms through which a crisis in MBS markets takes place. In the first, a change in fundamentals leads to an initial decline in house prices. Homeowners start to default at higher rates, and previously safe assets become risky. This fosters the emergence of private information relevant to the buyer, as information-insensitive debt becomes information-sensitive and, eventually, may imply that all trade breaks down in a crisis. The second mechanism arises when there is no change in fundamentals, but rather a reduction in the number of investors who use their cash to purchase securities.

In an insightful contribution, **Hall** uses the canonical model of trade with asymmetric information by Akerlof (1970) to reinterpret the mechanics of Shimer's model. He explains MBS market freeze-ups during the crisis by acknowledging that before the crisis over-collateralized claims on mortgage portfolios had zero perceived default probabilities and adverse selection was not a

5. As Shimer explains, MBS include warranties that insure the buyer against defects. A MBS is administered by an independent third party, the trustee, which has a specified amount of time after the execution of the MBS, to uncover any material defects in the underlying loans. If the trustee uncovers such defects, the securitizer must either purchase the loan by paying off the principal and interest, or it must replace the loan with a similar asset.

factor in transactions. With the advent of the crisis and the decline of house prices, investors learned that over-collateralization was inadequate, and adverse selection became an important issue to them. The consequence was a decline in transaction prices, and in the likelihood that a seller could make a deal with a buyer, and an increase in fire sales as financial institutions came under pressure from funding sources.

Overall, these two contributions to the volume that highlight the role of asymmetric private information also suggest that markets with these characteristics are especially prone to collapse during situations of macroeconomic turbulence. If the markets affected by this type of phenomenon are large, closely linked to the real economy, and with highly leveraged participants, their collapse may result in a financial crisis. Limiting the presence of private information in markets of crucial assets, and a careful monitoring of these markets, are measures that should be seriously considered by policymakers.

The role of leverage in the buildup of a financial crisis is studied in **Geanakoplos'** contribution to this volume. Contrary to Shimer and Hall, Geanakoplos considers that private and asymmetric information, though important, is not a crucial determinant of leverage. Instead, the author presents a theory in which agents are individually rational and there is no asymmetric information. Both the equilibrium leverage and the interest rate of a loan are determined from the equilibrium of supply and demand. The degree of impatience of borrowers with respect to lenders has an effect over the interest rate charged; similarly, the risk embedded in an asset has an effect over the collateral demanded by lenders. Next, he describes what he calls the *leverage cycle:* long periods of low uncertainty result in lenders increasing loan to value ratios, which in turn increases borrowing and asset prices through an increase in demand. The arrival of bad news in this setup creates downward pressures on asset prices, which translate into substantial losses for highly leveraged agents. This latter effect reinforces the fall in asset prices and leads lenders to tighten margins, thus reducing leverage. All these elements feedback on each other fueling a crash.

The policy implications of Geanakoplos' contribution are clear and powerful: in order to prevent a crash from occurring, it is necessary that the Fed constantly manage system-wide leverage, curtailing it in normal times and propping it up in downturns.

2. Preventing and Fighting a Financial Crisis

Since financial fragilities may build up in environments of price and output stability and bypass existing prudential regulation, what can then be done to prevent the occurrence of financial crises? This question has been repeatedly asked in academic and policy circles in the last 5 years, and has led to the development of a large body of literature that studies the roles of micro- and macro-prudential regulation and monetary policy in preventing crises.

The contribution of **Christiano and Ikeda** to this volume is part of this literature. It studies the effects of leverage restrictions on financial intermediaries that exert costly hidden effort to identify good risky investment projects and earn high returns for their creditors in a standard medium-size DSGE model. The basic premise of the model is that households cannot monitor the costly effort that financial intermediaries (banks) exert. This situation gives rise to a standard agency problem, and the competitive market solution does not necessarily deliver efficiency.

Christiano and Ikeda show that, in a steady state, leverage restrictions that imply a 15% decrease in leverage (in a steady state) increase welfare because they bring employment and consumption closer to the level they reach in the efficient equilibrium where effort is observable. This increase in welfare is potentially large, reaching up to 1.2% permanent increase in consumption. The intuition behind this result is that banks with low leverage can insulate their creditors from risk because their net worth can cover the losses that may arise from the asset side of its balance sheet. Creditors internalize this and demand lower interest rate spreads to banks with high net worth. For the bank, this lower spread implies that it can reap the full reward of its high effort, so it will be more willing to exert this high effort in the first place. Since the competitive equilibrium is not efficient, regulation acts as a commitment device that allows the equilibrium to come closer to the efficient one.

When studying the dynamic properties of the model economy, the authors find that contractionary shocks cause consumption, investment, output, employment, inflation and bank net worth to go down—consistently with the patterns observed in a recession—while the dispersion of equity returns across banks goes up. This is true regardless of the nature of the shock, as monetary policy shocks and financial shocks deliver similar qualitative implications.

Christiano and Ikeda's paper delivers a powerful message in terms of policy implications: even in steady state, leverage restrictions on banks are welfare enhancing because they promote high screening effort by banks and alleviate the agency problem between them and their creditors.

In light of these results, the next natural step is to analyze how macro-prudential and monetary policy should be conducted along the business cycle. Their model is well suited to study these crucial aspects of preemptive macroeconomic policy, as the analysis of the dynamic properties of the model suggests.

The paper by **Beau, Cahn, Clerc and Mojon** included in this volume complements the previous study by analyzing the interaction between monetary and macro-prudential policies in a DSGE model with financial frictions, a housing sector and heterogeneous agents based on Antipa et al. (2011). The model is estimated for the Euro area over the period 1985-2010 and is used to identify the conditions under which monetary and macro-prudential policies may have compounding, neutral or conflicting impacts on price stability.

The article describes the institutional arrangements for macro-prudential policies in the U.S. and Europe and explains the possible interdependency between monetary and macro-prudential policy that stems from the limits that the latter impose on the activity of financial institutions. Since these institutions provide liquidity to the economy, they constitute a crucial link in the transmission of monetary policy, and limiting their activity may impinge on this transmission. They also acknowledge the possible conflicting impact these policies may have on financial, price, and output stability. On one hand, there is the risk-taking channel of monetary policy, by which loose monetary policy may lead to more risk taking. On the other hand, a stringent macro-prudential policy that restricts credit and liquidity growth may have a negative impact on aggregate activity and price stability.

The paper considers four configurations of monetary and macro-prudential policies: a simple Taylor rule, an augmented Taylor rule that reacts to credit growth, a Taylor rule and an independent macro-prudential rule that limits the amplitude of the deviation of aggregate credit from its steady-state value, and an augmented Taylor rule that coexists with an independent macro-prudential rule. When analyzing the performance of each policy regime, it is important to acknowledge that the four possible configurations of monetary and macro-prudential policies may have different implications for inflation, depending on which shock the economy is subject to. The authors find that, if the economy is hit by a productivity, cost-push or monetary policy shock, then the four policy regimes studied yield very similar results in terms of the dynamics of inflation, as these shocks do not generate a conflict between price, output and financial stability.[6] When analyzing housing and credit shocks, however, macro-prudential policies can be destabilizing for inflation. Unlike productivity, cost-push and monetary shocks, these shocks do generate a trade-off for the policy maker between price and financial stability.

The stochastic structure of the model economy is estimated over the period 1985-2010.[7] Housing and credit shocks, which are the most relevant for macro-prudential policies, are not quantitatively relevant to explain the variance of inflation over this period. In contrast, productivity and cost-push shocks have an important role in accounting for inflation dynamics. Therefore, jointly implementing macro-prudential and monetary policies would have not had a conflicting impact on price stability in the period under study. More generally, there is no evidence that implementing macro-prudential policies would have been harmful for the conduct of monetary policy; on the contrary, if macro-prudential policies deter the emergence of asset bubbles and credit shocks by leaning against credit, their implementation would have contributed to the goal of price stability.[8]

Mian's contribution to this volume departs from the view of the previous two articles and challenges the traditional view that macroeconomic policies, either preemptive ones such as macro-prudential policies, or ex-post ones such as monetary policy, can reduce the incidence of financial crises, or their depth once they take place.

According to Mian, the main flaw of the existing paradigm in macroeconomics lies in the assumption of a representative agent in the household sector (or in broad groups of households), which

6. A positive and transitory productivity shock generates a decline in inflation and a negative output gap. At the same time, households acquire assets in order to smooth consumption. Consequently, a decrease in the policy rate that stabilizes output and inflation does not destabilize credit; on the contrary, it fosters consumption and lowers savings. As it is clear from this example, in this model productivity shocks do not entail conflicting interests between price, output and financial instability. Similar arguments can be applied to cost-push and monetary policy shocks.

7. The model is estimated assuming that monetary policy is conducted through a standard Taylor rule.

8. These results can be extrapolated to other economies and/or time periods, only insofar as productivity and cost-push shocks are the most relevant sources of fluctuations. The conclusions presented here do not apply in economies and/or periods in which credit and housing shocks are fundamental drivers of the business cycle.

implies that households can perfectly share idiosyncratic financial risks. If this assumption is wrong, then the bursting of a financial bubble may create a large cross-sectional redistribution of wealth. In other words, when the bubble bursts, the burden of the decline in asset prices is distributed unevenly in the population. Mian et al. (2012) show that this has indeed been the case in the U.S. after the financial crisis of 2008-2009: the ten percent of U.S. ZIP codes that lost most wealth during the crisis lost close to 60% of their total wealth in 2006. The ten percent of ZIP codes that lost the least, on the other hand, only suffered a wealth loss of around 10%.

A second consequence of departing from the representative agent assumption is that the hardest hit households cut their consumption sharply, causing an amplification of the shock that translated into job layoffs. The paper by Mian provides evidence that households that were hit by a stronger net wealth shock were those that reduced consumption more aggressively.[9] Moreover, there is also a strong correlation between job losses in the non-tradable sector and the net wealth shock experienced by a county, while the drop in employment in the tradable sector—whose production is evenly spread throughout the U.S.—is uniform across counties.

All this evidence supports the idea that households are unable to adequately share financial risk, and policy prescriptions obtained from models that implicitly assume full risk sharing among households may be deeply flawed. Following this line of argument, Mian discusses three reasons to doubt the ability of macro-prudential policies for preventing a financial crisis. First, regulation gives banks incentives to operate in the unregulated, or shadow, area of the financial system. Second, regulators have limited ability to properly measure capital and risk, so they may be unable to impose adequate capital requirements. Finally, Mian argues that the main bottleneck during the last financial crisis was the high leverage of households' balance sheets, which cannot be addressed by raising capital requirements in the banking sector.

Even if macro-prudential policy cannot do much to prevent a crisis from taking place, it might still be possible to use monetary policy to alleviate its effects. But Mian argues that, for monetary policy to be effective in the aftermath of a crisis, it must reach those

9. The paper in the current volume uses the number of new automobiles sold as a proxy for consumption. Mian et al. (2012) show that that result holds when considering broader measures of consumption.

households that have been hit hardest by the shock. According to evidence reported in Mian et al. (2012) this has not been the case, since these households were close to defaulting and hence were not eligible candidates to refinance their mortgage debts. Consequently, monetary policy in the U.S. has been unable to aid highly indebted households during the last financial crisis.

While Mian's views on the likely effectiveness of monetary and macro-prudential policies to deal with financial crises are a matter of debate, he proposes an unconventional, yet interesting, policy that would deal with the heterogeneous impact of a financial shock across households and its potential amplification mechanism: the establishment of *ex-ante flexible financial contracts*. These contracts would have contingent clauses that automatically write down the value of a household's outstanding debt if the overall economic environment is bad enough.[10] These characteristics would reduce the probability of a deep crisis following an economic downturn because they would break the amplification related with the deleveraging process, and for the same reason they would make the crisis less severe once it has effectively happened. Arguably there are many potential difficulties with the implementation of such contracts that need to be carefully looked into, but their benefits might well outweigh these difficulties.

3. Dealing with the Consequences of a Financial Crisis

Once it has occurred, a financial crisis has vast consequences for various aspects of macroeconomic performance. The article of Calvo, Coricelli, and Ottonello, and the one by Devereux, both in this volume, address the impact of crises on employment and their international spillovers, and suggest some avenues to deal with these consequences.

Calvo, Coricelli and Ottonello study the consequences of financial crises on unemployment, distinguishing between their impact during the crisis, and in its aftermath. Following Calvo et al. (2012), they claim that a salient feature of financial crises is that, once the recovery phase ends, there is an increase in unemployment with respect to its pre-crisis level that is higher than in other recession episodes. This phenomenon has been labeled as *jobless recovery* and

10. As an example, Mian suggests that the mortgage principal could be automatically written down if the local house price index fell beyond a certain threshold.

has received ample attention from the profession in the recent past (Knotek and Terry, 2009; Bernal-Verdugo et al., 2012). Calvo et al. document this finding by analyzing two different crises episodes in two countries: Sweden and Argentina.

Given the incidence of jobless recoveries after a financial crisis, the authors study three policy tools that may speed up employment recovery: an increase in inflation, a real currency depreciation, and a credit-recovery policy. They use data on 55 financial crises in emerging economies to document the effects of such policies in the aftermath of a financial crisis.

Their analysis shows that when high inflation spikes follow the crisis, the recovery does not seem to be jobless but is instead *wageless* (Calvo et al., 2012). Financial crises where the annual rate of inflation exceeds 30 percent have unemployment returning to trend at the same speed as output but real wages that lag significantly below their pre-crisis level. Further results lead them to argue that currency depreciations are ineffective in dealing with the rise in unemployment after a crisis unless they result in inflation. The reason is that they find that many crises associated with large depreciations do not result in quick employment recovery; only those do where there is a simultaneous increase in inflation that reduces real wages. All in all, this evidence brings support to the idea that nominal wages are partially rigid (Schmitt-Grohe and Uribe, 2013).

Since both jobless and wageless recoveries place the burden of a financial crisis on the labor market, as both affect wage earners, the authors argue that policy should be aimed at relaxing credit constraints for firms so that they can increase their labor demand. This assertion is based on the view that firms facing collateral constraints will avoid expanding employment in favor of investment in physical capital because the latter, but not the former, can be easily pledged as collateral. This hinders the creation of jobs and leads to a jobless recovery.

The authors provide some evidence that supports the view that credit policies can be an effective instrument in mitigating the effects of financial crises on real economic activity and, in particular, in improving employment and wages simultaneously during the recovery phase.

Most countries affected by the global financial crisis of 2008 engaged in aggressively expansive monetary policy as a first line of action to stimulate the economy. Still, the crisis was so deep that many countries saw their policy interest rates go down to nearly zero, hitting the so called *zero lower bound*, which until that moment had been regarded either as a theoretical curiosity or a Japanese phenomenon. Many authors, such as Christiano et al. (2011), Werning (2012), Cook and Devereux (2011), Cook and Devereux (2013) and Correia et al. (2013) among others, became interested in understanding the economic implications of reaching the zero lower bound and the effectiveness of fiscal policy in such situation.

In the present volume, the paper by **Devereux** contributes to this literature and studies how shocks are transmitted across countries when the zero lower bound is active in one or more of them. To this end, he sets up a two-country New Keynesian model that allows for parametric variation in the degree in which they are integrated in trade and financial markets, both of which can range from full openness to autarky. This rich configuration yields results for a wide range of possibilities in terms of international integration.

Countries are subject to country-specific demand shocks. A negative shock can drive a country into a liquidity trap that, depending on the degree of international trade and financial integration, may propagate to the other country. When trade and financial integration are complete, all liquidity traps are global, but less integrated markets reduce the transmission of shocks and the likelihood of a global liquidity trap. In this case, the country originally hit by the demand shock is the one more prone to hit the zero lower bound on its nominal interest rate and experience a terms of trade appreciation that amplifies the effect of the shock.[11]

In line with previous studies (Christiano et al., 2011; Cook and Devereux, 2011; Cook and Devereux, 2013), the author finds that fiscal policy is very effective when the economy is at the zero lower bound: at the zero lower bound, a home country fiscal expansion raises expected inflation in the home country relative to the foreign country. This reduces the home country's real interest rate, and generates a terms of trade depreciation. The terms of trade depreciation increases demand for the home good, but reduces demand for the foreign good. Therefore, the increase in activity comes at the cost of reducing the terms of trade, hampering international trade and reducing the output of the trading partner. The *beggar thy neighbor* nature of

11. As Devereux points out, the terms of trade appreciation is tied to the fact that while nominal interest rates are constrained by the zero bound, there is still arbitrage in bond markets, so a fall in demand in the home country, by reducing inflation in the home country, will raise the home real interest rate. This produces a terms of trade appreciation.

unilateral fiscal policy calls for international coordination in response to a shock that creates a liquidity trap. The optimal coordination policy consists of fiscal policy expansions in both countries and a policy rate increase in the least hit country, designed to revert the response of terms of trade to the shock. This coordination policy is welfare improving for both economies.

The limit reached by monetary policy at the zero lower bound has increased interest among policy makers and scholars to study alternative, or unconventional, monetary policy tools that may provide the stimulus needed by the economy after a crisis. As Mishkin points out in this volume, unconventional policy tools typically involve one or more of the following aspects: the management of expectations about the future path of the policy rate in order to affect long-term interest rates, a decrease in risk and term premiums by the purchase of securities, or exchange rate interventions that depreciate the domestic currency and foster exports.

The present volume contains two contributions to this literature that study the effects of unconventional policies implemented in Chile in response to the financial crisis of 2008-2009.

The work by **Céspedes, García–Cicco and Saravia** focuses on the Term Liquidity Program (FLAP) implemented by the Central Bank of Chile from July 2009 to May 2010. The FLAP was a facility that offered liquidity to banks at the monetary policy rate at the time for terms of 90 and 180 days against eligible collateral (Central Bank bonds, time deposits and bank mortgage bills).

In addition to providing liquidity at longer terms than usual, the FLAP also aimed at credibly communicating the commitment of the Central Bank of Chile to maintain the policy rate at the lower bound (50 basis points) for several months. The analysis in the paper of Céspedes et al. suggests that the FLAP indeed was able to achieve this goal. According to their results, the announcement of the FLAP caused a flattening of the nominal yield curve, with yields at the 3-month in 3-month and in the 1-year in 1-year horizons decreasing by around 50 and 30 basis points, respectively. The real rates fell as well; however, it is not altogether clear whether this fall was solely due to the announcement of the FLAP or if it can be attributed to the decrease in the monetary policy rate that was announced at the same policy meeting.

Although the main goal of liquidity facilities is usually to relax funding restrictions for banks and guarantee the normal working of the financial system, a natural question that arises is whether this provision of liquidity translates into more lending to the private sector. The authors tackle this question, and show that banks that used the FLAP increased their supply of commercial and, to a lesser extent, consumption loans relative to those that did not use it. Mortgage lending did not increase significantly because of the FLAP, which may be attributed to these being long-term loans, whereas the FLAP was intended as a short-term liquidity facility.

The results of this study provide valuable lessons for the conduction of monetary policy in periods when the traditional policy tool is constrained by the zero lower bound. The Chilean evidence suggests that unconventional monetary policy, in the form of liquidity facilities, affects nominal medium-term rates in the desired direction. More importantly, banks use the additional liquidity to increase commercial and consumption lending. To the extent that the most adverse effects of a financial crisis arise because households and firms are credit constrained, as Mian and Calvo, Coricelli and Ottonello argue in their respective contributions, the potential benefits of this credit expansion may be important. Of course, this would be the case as long as the credit expansion reaches directly or indirectly to the more constrained agents. The last paper in this volume tries to provide evidence whether credit expansion during a crisis does reach those agents.

An additional policy implemented in Chile in 2009 to palliate the effects of the international financial crisis was the capitalization of BancoEstado, a state owned commercial bank, for 500 million dollars, which implied an increase of 50% of BancoEstado's capital. The goal of this measure was the provision of loans to credit-constrained firms. This can be regarded as a quasi-fiscal policy measure, as the public sector channeled resources to the private sector in an indirect manner, using BancoEstado as an intermediary. The analysis of this type of measure is particularly interesting, since there was a renewed discussion after the crisis on the potential benefit of state owned banks as liquidity and credit providers of last resort (see Bertay, Demirguc-Kunt, and Huizinga, 2012)

Lagos and Tapia, in this volume, use quarterly data from Chilean banks' balance sheets to study the impact of the capitalization of BancoEstado on commercial credit, finding that, following the measure, BancoEstado quickly expanded commercial credit in a countercyclical manner during a time when other financial institutions were reducing it.

Of course, the expansion of credit does not necessarily mean that it reached those firms that were more severely constrained. Despite being state owned, BancoEstado operates as a profit-maximizing institution with ample margins to decide where to allocate credit. The authors find evidence that firms that benefited may not have been those subject to the tighter credit constraints. BancoEstado expanded its credit operations in segments with large loans, which are usually granted to large firms that have better access to credit markets. Furthermore, the results show that BancoEstado expanded lending to sectors that had not seen a large reduction in credit during the first months of the crisis. This fact may be an indication that credit was expanded in sectors that were not credit-constrained; however, a credit reduction in a particular sector is the outcome of demand and supply effects, so further analysis would be needed to shed light on this assertion. Finally, the authors also provide some evidence that the expansion of lending by BancoEstado may have partially displaced lending by other private banks.

While the empirical exercise conducted in the article of Lagos and Tapia faces the tough challenge of defining the appropriate counterfactual scenario for the policy and the identification of supply and demand effect, it sends a clear warning sign of how difficult it may be to design a credit provision policy that actually reaches the households or firms that need it most. As argued by Mian, such measures may be an important part of a powerful stimulus package, but more research is needed to identify their desirable characteristics and determine effective implementation schemes. With all their potential limitations, macroeconomic tools, such as those discussed in the rest of the volume, may be the only ones at hand when having to face or prevent a future financial crisis.

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Central Banking after the Crisis

Frederic S. Mishkin
Graduate School of Business,
Columbia University and
National Bureau of Economic Research

By the mid-2000s, both academics and central banks had come to a remarkable consensus on what central banks' basic strategy should be. However, with the collapse of Lehman Brothers in September 2008, the world of central banking changed forever. The worldwide financial crisis revealed that some of the basic assumptions underlying the central bank consensus were no longer tenable, requiring some major rethinking on what the role of the central bank should be.

This paper explores where central banking is heading after the recent financial crisis. First it will discuss the central bank consensus before the crisis and will then outline the key facts learned from the crisis that require changes in the way central banks conduct their business. Finally, it will discuss four main areas in which central banks are altering their policy frameworks: 1) the interaction between monetary and financial stability policies, 2) nonconventional monetary policy, 3) risk management, and 4) fiscal dominance and monetary policy. The paper then ends with some concluding remarks.

1. Central Banking Before the Crisis

By the early 2000s, academic research and the experience of central banks led to almost universal support for a monetary policy

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strategy that has become known as "flexible inflation targeting."[1] This strategy involves a strong, credible commitment by the central bank to stabilize inflation in the long run, often with an announcement of an explicit numerical objective, but which also allows for the central bank to pursue policies to stabilize output around its natural level in the short run. The flexible inflation targeting strategy was deemed to be very successful, with central banks in both advanced and emerging market countries that had adopted it, experiencing both low and stable inflation, as well as very moderate output fluctuations. Indeed, from the early 1980s until 2007, the period was dubbed the "Great Moderation."

Central bankers in advanced economies had also come to accept Milton Friedman's (1968) famous adage that "Inflation is always and everywhere a monetary phenomenon."[2]

Although they were aware that profligate fiscal policy could make it difficult for monetary policy to keep inflation under control, they took for granted that the fiscal authorities would not be irresponsible in the long run, and so the monetary authorities could control their own destiny and keep inflation under control if they pursued appropriate policies.

Most central bankers also took the view that there was a natural dichotomy between monetary policy and financial stability policy so that these policies could be conducted independently. Central bankers were clearly aware that financial disruptions could damage the economy and this is why many central banks published financial stability reports to discuss potential threats to the financial system. However, the general equilibrium modeling frameworks used at central banks did not incorporate financial frictions as a major source of business cycle fluctuations, leading to a view that monetary policy would focus solely

1.The phrase "inflation targeting" to describe this monetary policy strategy creates some confusion because central banks have had very different approaches to the communication strategy surrounding it. Some central banks have announced an explicit numerical inflation objective and treat it as a target—these are classified as fully-fledged inflation targeters—while others are reluctant to be so explicit. For example, the Fed only adopted an explicit numerical inflation objective in January of 2012 even though before this it was in essence following a flexible inflation targeting strategy. The academic and central bank research supporting the flexible inflation-targeting framework is discussed in Mishkin (2009a).

2. This general agreement with Friedman's adage did not mean that central bankers subscribed to the view that money growth was the most informative piece of information about inflation, but rather that the ultimate source of inflation was overly expansionary monetary policy.

on minimizing inflation and output gaps, while it would be the job of prudential regulation and supervision to promote financial stability.[3]

In August 2007, financial markets suffered a major disruption when declines in the value of mortgage-backed securities led to a surge in credit spreads in interbank markets with the financial system going over the cliff with the bankruptcy of Lehman Brothers in September 2008 (as discussed in Mishkin, 2011a). The ensuing worldwide financial crisis revealed facts that undermined some of the assumptions underlying the consensus views described above.

2. Key Facts Learned from the Crisis

My reading of the crisis suggests that there are six key facts learned from the crisis that have an important bearing on how central banking should be conducted in the future.

2.1 Financial Disruptions Make the Macroeconomy Highly Nonlinear

Financial disruptions are disruptions to the flow of information in financial markets that prevent them from doing their job of allocating capital to productive investment opportunities.

Financial disruptions are inherently nonlinear because they involve an adverse feedback loop in which the decline in asset values leads to a contraction in economic activity, which then leads to a further decline in asset values, a further contraction of economic activity, and so on.

As discussed in Mishkin (1991), the adverse feedback loop mechanism involves the decline in asset prices lowering the value of collateral, which serves to mitigate adverse selection and moral hazard problems. If a borrower defaults on a loan backed by collateral, the effects of the adverse selection problem are less severe because the lender can take title to the collateral and thus make up for the loss.

3. Although most central bankers supported the dichotomy between monetary policy and financial stability policy, there were pockets of dissent from this view, particularly at the Bank for International Settlements and the Reserve Bank of Australia who advocated that monetary policy should have some focus on financial stability considerations and should be directed at limiting bubbles in asset and credit markets. This will be discussed further below.

In addition, the threat of losing the collateral gives the borrower more of an incentive not to take unmanageable risks that might ultimately lead to a default, and it thus reduces the moral hazard problem. These mechanisms work only as long as the collateral is of sufficient quality. During a financial disruption the decline in asset values causes the value of collateral to fall, so that the problems of adverse selection and moral hazard worsen, which causes economic activity to contract. The contraction of economic activity leads to a further drop in asset values, reducing the value of collateral, causing economic activity to contract further, leading to a further decline in asset values, etc.

The events following the Lehman Brothers bankruptcy showed how nonlinear both the financial system and the macroeconomy could be. Indeed in Mishkin (2011a) I have described the phenomena as going over the cliff. The financial system seized up and both credit spreads (such as the Baa-Treasury or junk bond Treasury spreads) and liquidity spreads (such as the TED or the LIBOR-OIS spreads) shot up dramatically. The contraction of economic activity was then highly nonlinear, with real GDP in the United States declining at an annual rate of 1.3% in the fourth quarter of 2008, 5.4% in the first quarter of 2009 and 6.4% in the second quarter of 2009—but also in the rest of the world, with real GDP falling by 6.4% in the fourth quarter of 2008 and by 7.3% in the first quarter of 2009.

2.2 Disruptions to the Financial Sector Have a Very Negative Impact on Economic Activity for a Long Period of Time

When economies experience deep recessions, typically they subsequently experience very strong recoveries, often referred to as V-shaped recoveries. However, as Reinhart and Reinhart (2010) document, this V-shaped pattern is not characteristic of recessions that follow financial crises because the deleveraging process takes a long time, resulting in strong headwinds for the economy. When analyzing 15 severe post-World War II financial crises, including the Great Depression, the 1973 oil shock period, and the recent crisis; they find that real GDP growth rates were significantly lower during the decade following each of these episodes, with the median decline in GDP growth being about 1%. Furthermore, unemployment rates stay persistently higher for a decade after crisis episodes, with the median unemployment rate 5 percentage points higher in advanced economies. Although we have many years to go until a decade has passed following the most recent crisis, it actually looks like it might have worse outcomes than the average crisis episode studied by Reinhart and Reinhart. They find that 82% of the observations of per capita GDP during the period 2008 to 2010 remain below or equal to the 2007 level, while the comparable number for the fifteen earlier crisis episodes is 60%. We now recognize that the cumulative output losses from financial crises are massive, and the recent crisis is clearly no exception.

2.3 Price and Output Stability do not Ensure Financial Stability

Before the recent financial crisis, the common view, both in academia and in central banks, was that achieving price and output stability would promote financial stability. This was supported by research (Bernanke, Gertler and Gilchrist, 1999; Bernanke and Gertler, 2001) indicating that monetary policy which optimally stabilizes inflation and output is likely to stabilize asset prices, making asset price bubbles less likely. Indeed, central banks' success in stabilizing inflation and the decreased volatility of business cycle fluctuations, which became known as the Great Moderation, made policy-makers complacent about the risks from financial disruptions.

The benign economic environment leading up to 2007, however, surely did not protect the economy from financial instability. Indeed, it may have promoted it. The low volatility of both inflation and output fluctuations may have lulled market participants into thinking there was less risk in the economic system than was really the case. Credit risk premiums fell to very low levels and underwriting standards for loans dropped considerably. Some recent theoretical research even suggests that benign economic environments may promote excessive risk-taking and may actually make the financial system more fragile (Gambacorta, 2009). Although price and output stability are surely beneficial, the recent crisis indicates that a policy focused solely on these objectives may not be enough to produce good economic outcomes.

2.4 Low Interest Rates Can Encourage Excessive Risk-Taking

The fact that the low interest rate policies of the Federal Reserve from 2002 to 2005 were followed by excessive risk-taking suggests to many that overly easy monetary policy might promote financial instability. Using aggregate data, Taylor (2007) has argued that excessively low policy rates led to the housing bubble, while Bernanke (2010), Bean, Paustian, Penalver and Taylor (2010), Turner (2010) and Posen (2009) have argued otherwise. Although it is far from clear that the Federal Reserve is to blame for the housing bubble, the explosion of both theoretical and empirical microeconomic research, provides support for monetary policy playing a role in creating credit bubbles. Borio and Zhu (2008) have called this mechanism the "risk-taking channel of monetary policy."

The literature provides two basic reasons why low interest rates might promote excessive risk-taking. First, as Rajan (2005, 2006) points out, low interest rates can increase the incentives for asset managers in financial institutions to search for yield, and hence increase risk-taking. These incentives could come from contractual arrangements that compensate asset managers for returns above a minimum level, often zero; with low nominal interest rates, only high-risk investments will lead to high compensation. They could also come from fixed-rate commitments such as those provided by insurance companies, forcing the firm to seek out higher-yielding, riskier investments. Or they could arise from behavioral tendencies such as money illusion, as a result of which the managers believe that low nominal rates indicate that real returns are low, encouraging them to purchase riskier assets to obtain a higher target return.

A second mechanism through which low interest rates could promote risk-taking is through income and valuation effects. Low interest rates increase net interest margins and increase the value of financial firms, expanding their capacity to increase their leverage and take on risk (Adrian and Shin, 2009, 2010; Adrian, Moench and Shin, 2010). In addition, low interest rates can boost collateral values, again enabling increased lending. This mechanism is closely related to the financial accelerator of Bernanke and Gertler (1999) and Bernanke, Gertler and Gilchrist (1999), except where it derives from financial frictions for lenders rather than borrowers.

Micro-empirical analysis provides a fair amount of support for the theory of the risk-taking channel of monetary policy. Jimenez, Ongena, Peydro and Saurina (2009), using Spanish credit registry data, find that low nominal interest rates, despite decreasing the probability of defaults in the short term, lead to riskier lending and more defaults in the medium term. Ioannidou, Ongena and Peydro (2009) examine a quasi-controlled experiment in Bolivia and find that lower U.S. federal fund rates increase lending to low-quality borrowers, which leads to a higher rate of defaults, and yet at lower interest rate spreads. Delis and Kouretas (2010), using data from euro area banks, find a negative relationship between the level of interest rates and the risk of bank lending.

Adrian and Shin (2010) discuss and provide evidence relating to the risk-taking channel of monetary policy using more aggregate data. They find that reductions in the federal funds rate increase term spreads, and hence the net interest margin for financial intermediaries. The higher net interest margin, which makes financial intermediaries more profitable, is then associated with higher asset growth; higher asset growth, which they interpret as a shift in credit supply, serves as a prediction for higher real GDP growth.

2.5 The Zero Lower Bound Constraint on Policy Interest Rates Binds More Often than Expected

The constraint that policy interest rates cannot be driven below zero means that conventional expansionary monetary policy becomes ineffective when a sufficiently negative shock hits the economy, so a negative policy rate would be needed to stimulate the economy. This has become known as the zero lower bound problem. In this situation, central banks need to resort to other policy measures which have become known as nonconventional policy which involves either 1) managing expectations in order that the policy rate be viewed as staying low for an extended period, thereby lowering long-term interest rates; 2) lowering risk and term premiums by purchasing securities, and thereby changing their relative supply; or 3) by exchange rate interventions aimed at lowering the value of the domestic currency, which would increase foreign demand for domestic production.[4] Research before the crisis took the view that as long as the inflation objective was around 2%, then the zero lower bound constraint on policy interest rates bind infrequently and are short-lived (Reifschneider and Williams, 2000; Coenen, Orphanides and Wieland, 2004). The fact that the Federal Reserve has had to resort to nonconventional monetary policy rate twice in the last ten years (2003-2004 and starting in 2008) and the fact that the federal funds rate has been at its zero floor for over four years now (since December 2008) with no end in sight, suggests that the zero lower

4. E.g. see Svensson (2001) and Bernanke (2004).

bound constraint may bind far more frequently than earlier research suggested, and not be short-lived at all. The flaw with this research is that it was conducted with models that were essentially linear and, as pointed out above, we now recognize that the macroeconomy is likely to be very nonlinear.

The second reason why it is now clear that the zero lower bound problem is more serious than previously thought is that we now see that contractionary shocks from financial disruptions can be far greater than previously anticipated. Sufficiently large contractionary shocks therefore result in the zero lower bound constraint occurring more frequently. The zero lower bound on policy rates has therefore become of much greater relevance to central banks than was anticipated before the recent financial crisis.

2.6. Financial Crises Often Lead to Fiscal Crises

As pointed out by Reinhart and Rogoff (2009), in the aftermath of financial crises there is almost always a sharp increase in government indebtedness. We have seen this exact situation in the aftermath of the current crisis. The massive bailouts of financial institutions, fiscal stimulus packages, and the sharp economic contractions leading to reductions in tax revenue that occurred throughout the world have adversely affected the fiscal situation in many countries. Budget deficits of over 10% of GDP in advanced countries like the United States have become common; even countries that prior to the crisis, such as Ireland and Spain, which were held up as paragons of fiscal rectitude because their governments were rapidly reducing the amount of government debt to GDP, have found themselves in dire financial straits, with exploding debt-to-GDP ratios. Furthermore, this rise in indebtedness has the potential to lead to sovereign debt defaults, which has become a huge concern in Europe and still has the potential to cause the demise of the euro, and could even threaten the existence of the European Union if default on their sovereign debt leads to countries being forced to leave the EU.

3. Central Banking after the Crisis

How do the six facts above change our thinking about the way central banks need to operate in the aftermath of the financial crisis? The first point is one I have discussed more extensively in another paper (Mishkin, 2011b): None of the key facts learned from the crisis in any way undermine support for central banks adopting a strong, credible commitment to stabilizing inflation in the long run by announcing an explicit, numerical inflation objective, but also having the flexibility to pursue policies aimed at stabilizing output around its natural rate level in the short run. In other words, the rationale for flexible inflation targeting is every bit as strong as it was before the crisis. However, the key facts learned from the crisis do suggest that what is meant by flexibility in an inflation-targeting regime needs to be rethought. There are three areas in which the key facts suggest that central banks need to make major changes in the way they conduct policy: 1) the interaction of monetary and financial stability policies, 2) nonconventional monetary policy, 3) risk management, and 4) fiscal dominance and monetary policy.

3.1 Interaction of Monetary and Financial Stability Policies

As discussed earlier, central banks operated under a view that there was a dichotomy between monetary and financial stability policies, with monetary policy focused solely on stabilizing inflation and output, and not on promoting financial stability. Three of the key facts discussed above indicate that this view based on the dichotomy of monetary and financial stability policies is no longer tenable. The fact that price and output stability do not ensure financial stability, that low interest rates can encourage excessive risk-taking, and that disruptions to financial markets have a very negative impact on economic activity for a long period of time, all suggest that monetary policy may have to be adjusted to promote financial stability.

To see why, we need to examine the origins of financial instability. Although there has been much attention in the literature focused on the role of asset bubbles in promoting financial instability, as I have argued elsewhere (e.g., Mishkin and White, 2003; Mishkin 2011b) that asset bubbles by themselves do not lead to financial disruptions. It is only when asset price bubbles interact with the financial sector to produce what I will refer to as a credit-driven bubble (that is, a credit boom that is divorced from fundamentals) that financial disruption arises.

With this type of bubble, there is the following typical chain of events: as a result of either exuberant expectations about economic prospects or structural changes in financial markets, a credit boom begins, increasing the demand for some assets and thereby raising their prices. The rise in asset values, in turn, encourages further lending against these assets, increasing demand, and hence their prices, even more. This feedback loop can generate a bubble, and the bubble can cause credit standards to ease as lenders become less concerned about the ability of the borrowers to repay loans and instead rely on further appreciation of the asset to shield themselves from losses.

At some point, however, the credit-driven bubble bursts. The collapse in asset prices then leads to a reversal of the feedback loop in which loans go sour: lenders cut back on credit supply, the demand for the assets declines further, and prices drop even more. The resulting loan losses and declines in asset prices erode the balance sheets at financial institutions, further diminishing credit and investment across a broad range of assets. The decline in lending depresses business and household spending, which weakens economic activity and increases macroeconomic risk in credit markets. In extreme cases, the interaction between asset prices and the health of financial institutions following the collapse of an asset price bubble results in a full-fledged financial crisis, which endangers the operation of the financial system as a whole.

However, it is important to note that there is a second type of bubble that is far less dangerous, which can be referred to as an irrational exuberance bubble. This type of bubble is driven solely by overly optimistic expectations and poses much less risk to the financial system than credit-driven bubbles. For example, the bubble in technology stocks in the late 1990s was not fueled by a feedback loop between bank lending and rising equity values, so the bursting of the bubble was not accompanied by a marked deterioration in bank balance sheets. The bursting of the tech-stock bubble thus did not have a very severe impact on the economy, and the recession that followed was quite mild.

The distinction between the two types indicates that there is a strong case for central banks to pursue policies to restrain credit-driven bubbles, but much less support for central banks to attempt to restrain asset price bubbles if they are not associated with a credit boom. As White (2009) and Mishkin (2011b) have pointed out, it is much easier to identify credit-driven bubbles than it is to identify whether asset prices are deviating from fundamental values. Financial regulators and central banks often have information indicating that lenders have weakened their underwriting standards, that risk premia appear to be inordinately low or that credit extension is rising at abnormally high rates. The argument that it is hard to identify asset price bubbles is therefore not a valid argument against leaning against credit-driven bubbles.

Second, as pointed out in Mishkin and White (2003), when irrational asset bubbles burst, they often do not do severe damage to the economy, but credit-driven bubbles do. Indeed, they lead to a highly nonlinear, over-the-cliff phenomenon in which policies to stimulate economic activity are unable to counter the headwinds in the economy, resulting in a prolonged period of subpar economic growth. Hence, cleaning up after a credit-driven bubble is very costly, providing a strong rationale for central banks to pursue polices to lean against this type of bubble to restrain excessive risk-taking.

Although there is a strong case to lean against credit bubbles, what policies will be most effective? First it is important to recognize that the key principle for designing effective policies to lean against credit bubbles is whether they fix market failures. Credit extension necessarily involves risk-taking. It is only when this risk-taking is excessive because of market failures that credit bubbles are likely to develop. Recognizing that market failures are the problem, it is natural to look to prudential regulatory measures to constrain credit bubbles.

Some of these regulatory measures are simply the usual elements of a well-functioning prudential regulatory and supervisory system. These elements include adequate disclosure and capital requirements, liquidity requirements, prompt corrective action, careful monitoring of an institution's risk-management procedures, close supervision of financial institutions to enforce compliance with regulations, and sufficient resources and accountability for supervisors.

The standard measures mentioned above focus on promoting the safety and soundness of individual firms and fall into the category of what is referred to as micro-prudential supervision. However, even if individual firms are operating prudently, there still is a danger of excessive risk-taking because of the interactions between financial firms that promote externalities. An alternative regulatory approach, which deals with these interactions, focuses on what is happening in credit markets in the aggregate, referred to as macro-prudential supervision.

Macro-prudential regulations can be used to dampen the interaction between asset price bubbles and credit provision. For example, research has shown that the rise in asset values that accompanies a boom results in higher capital buffers at financial institutions, supporting further lending in the context of an unchanging benchmark for capital adequacy; in the bust, the value of this capital can drop precipitously, possibly even necessitating a cut in lending.[5] One macro-prudential policy that is now being widely discussed as part of the Basel III process is to adjust capital requirements to dampen the credit cycle, that is, by raising capital requirements during credit booms and lowering them during busts. Other macro-prudential policies to constrain credit bubbles include dynamic provisioning by banks; lower ceilings on loan-to-value ratios or higher haircut requirements for repo lending during credit expansions; and Pigouvian-type taxes on certain liabilities of financial institutions.[6]

Although macro-prudential supervision should be the first line of defense against credit- driven bubbles, there is still the question whether monetary policy should be used to constrain credit-driven bubbles. There are several objections to doing so. First, if monetary policy is used to lean against credit bubbles, it is a violation of the Tinbergen (1939) principle because one instrument is being asked to do two jobs: 1) stabilize the financial sector; and 2) stabilize the economy.[7] Given that there is another instrument with which to stabilize the financial sector—macro-prudential supervision—wouldn't it be better to use macro-prudential supervision to deal with financial stability, leaving monetary policy to focus on price and output stability?

This argument would be quite strong if macro-prudential policies were able to do the job. However, there are doubts in this respect. Prudential supervision is subject to more political pressure than monetary policy because it affects the bottom line of financial institutions more directly. Thus, they have greater incentives to lobby politicians to discourage macro-prudential policies that would rein in credit bubbles. After all, during a credit bubble, financial institutions make the most money, and they therefore have greater incentives

5. For example, see Kashyap and Stein (1994) and Adrian and Shin (2009).

6. For example, see Bank of England (2009) and French, Baily, Campbell, Cochrane, Diamond, Duffie, Kashyap, Mishkin, Rajan, Scharfstein, Shiller, Shin, Slaughter, Stein, and Stulz (2010).

7. Stabilizing the financial sector is not a completely separate objective from stabilizing the economy because financial instability leads to instability in economic activity and inflation. However, because the dynamics of financial instability are so different than the dynamics of inflation and economic activity, for the purposes of the Tinbergen principle, promoting financial instability can be viewed as a separate policy objective from stabilizing the economy.

and more resources to lobby politicians to prevent restrictive macro-prudential policies. A case in point is the recent Basel III accord. Implementation of the accord was put off for ten years, and it did not contain measures to deal with systemic risk considerations such as having higher capital requirements on systemically more important financial institutions. This episode suggests that political considerations may make it extremely difficult to have effective macro-prudential supervision.

The possibility that macro-prudential policies may not be implemented sufficiently well to constrain credit bubbles suggests that monetary policy may have to be used instead.[8] But this raises another objection to using monetary policy to lean against credit bubbles: tightening monetary policy may be ineffective in restraining a particular asset bubble because market participants expect such high rates of return from purchasing bubble-driven assets. On the other hand, the evidence relating to the risk-taking channel of monetary policy suggests more strongly that raising interest rates would help restrain lending growth and excessive risk-taking.

Furthermore, if a central bank credibly commits to raising interest rates when a credit bubble seems to be forming, then expectations in credit markets will work to make this policy more effective. The expectation that rates will go up with increased risk-taking will make this kind of activity less profitable and thus make it less likely to occur. Furthermore, expectations that rates will rise with increased risk-taking means that interest rates will not have to be raised as much to have their intended effect.

Nonetheless, using monetary policy to lean against credit bubbles is not without problems. Doing so could at times result in a weaker economy than the monetary authorities would desire, or inflation that falls below its target. This suggests that there is a monetary policy tradeoff between having the inflation forecast at the target, and the pursuit of financial stability. Also, having monetary policy focus on financial stability might lead to confusion about the central bank's commitment to the inflation target, with potentially adverse effects on economic outcomes.

8. However, as pointed out in Boivin, Lane and Meh (2010), whether monetary policy will be effective in countering financial imbalances depends on the nature of shocks. Boivin, Lane and Meh conduct simulations that show that where financial imbalances reflect specific market failures, and regulatory policies can be directed to such failures, monetary policy is less likely to be effective. Monetary policy is likely to be more effective when financial imbalances arise from economy-wide factors.

Another danger from having monetary policy as a tool to promote financial stability is that it might lead to decisions to tighten monetary policy when it is not needed to constrain credit bubbles. A situation of low interest rates does not necessarily indicate that monetary policy is promoting excessive risk-taking. One lesson from the analysis here is that policymakers, and especially monetary policymakers, will want tools to assess whether credit bubbles are developing. Research is underway (e.g., see Borio and Lowe, 2002; Adrian and Shin, 2010) to find measures that will signal if credit bubbles are likely to be forming. High credit growth, increasing leverage, low risk spreads, surging asset prices and surveys to assess if credit underwriting standards being eased are pieces of data that can help central banks decide if there is imminent danger of credit bubbles. Monitoring of credit market conditions will become an essential activity of central banks in the future, and research on the best ways of doing so will have a high priority in the future.

The discussion above indicates central banks can no longer take the view that there is a dichotomy between monetary and financial stability policies. If macro-prudential policies are implemented to restrain a credit bubble, they will slow credit growth and will slow the growth of aggregate demand. In this case, monetary policy may need to be easier in order to offset weaker aggregate demand. Alternatively, if policy rates are kept low to stimulate the economy, as is true currently, there is a greater risk that a credit bubble might occur. This may require tighter macro-prudential policies to ensure that a credit bubble does not develop. Coordination of monetary and macro-prudential policies becomes of greater value when all three objectives of price stability, output stability and financial stability are pursued.

The benefits of coordination between monetary policy and macro-prudential policy provide another reason for having central banks take on the systemic regulator role besides the ones I discussed in Mishkin (2009b) and in French, Baily, Campbell, Cochrane, Diamond, Duffie, Kashyap, Mishkin, Rajan, Scharfstein, Shiller, Shin, Slaughter, Stein, and Stulz (2010). Coordination of monetary policy and macro-prudential policy is more likely to be effective if one government agency is in charge of both. Coordination of policies is extremely difficult when different entities control these policies. Indeed, in the aftermath of the financial crisis, we have seen a movement to put macro-prudential policies under the control of central banks. Dodd-Frank now specifies that the Federal Reserve will become a systemic regulator, while proposals for a banking union in Europe have the European Central Bank taking on the bank supervision role from national regulators.

3.2 Nonconventional Monetary Policy

During normal times, the monetary authorities conduct monetary policy using conventional tools, principally by conducting open market operations in short-term government debt in order to set a short-term policy rate, for example, the federal funds rate in the United States. However, financial crises require central banks to adopt non-interest rate tools for two reasons, which are referred to as nonconventional monetary policy. First, financial disruptions cause specific credit markets to seize up, and so policy measures directed specifically at these markets are needed to keep these markets functioning. Second, the negative shock to the economy leads to the zero lower bound problem where conventional monetary policy is no longer operational because the monetary authorities cannot drive the policy interest rate below zero. Non-conventional monetary policy takes four forms: 1) liquidity provision in which central banks expand lending to both banks and other financial institutions; 2) asset purchases of both government securities and private assets to lower borrowing costs for households; 3) quantitative easing in which central banks greatly expand their balance sheets; and 4) management of expectations, which involves central banks committing to keeping their policy rate at very low levels for a long period of time.

3.2.1 Liquidity provision

The first set of tools, liquidity provision, was the primary way that central banks tried to keep specific financial markets functioning. To see how this worked, let's look at the Federal Reserve's measures for liquidity provision. At the outset of the crisis in mid-August 2007, the Fed lowered the discount rate (the interest rate on loans it makes to banks) to 50 basis points (0.50 percentage point) above the federal funds rate target from the normal 100 basis points. It then lowered it further in March 2008 to only 25 basis points above the federal funds rate target. However, borrowing from the discount window has a "stigma" because it suggests that the borrowing bank may be desperate for funds and thus in trouble, and this limited its effectiveness during the crisis. To encourage additional borrowing, in December 2007 the Fed set up a temporary Term Auction Facility (TAF) in which it made loans at a rate determined through competitive auctions. It was more widely used than the discount window facility because it enabled banks to borrow at a rate less than the discount rate, and it was determined competitively, rather than being set at a penalty rate. The TAF auctions started at amounts of $20 billion, but as the crisis worsened, the Fed raised the amounts dramatically, with a total of over $400 billion outstanding (the European Central Bank conducted similar operations, with one auction in June of 2008 of over 400 billion euros). The Fed then broadened its provision of liquidity to the financial system well outside of its traditional lending to banking institutions. These actions included lending to investment banks, and lending to promote purchases of commercial paper, mortgage backed-securities, and other asset-backed securities. In addition, the Fed engaged in lending to J.P. Morgan to assist in its purchase of Bearn Stears, and to AIG to prevent its failure.

The enlargement of the Fed's lending programs during the 2007–2009 financial crisis was indeed remarkable, expanding the Fed's balance sheet by over one trillion dollars by the end of 2008, with the balance-sheet expansion continuing into 2009. The number of new programs over the course of the crisis spawned a whole new set of abbreviations, including the TAF, TSLF, PDCF, AMLF, MMIFF, CPFF, and TALF.

In evaluating liquidity provision, some research argues that these types of programs had little effect. Taylor and Williams (2009), for example, do not find that the actual lending from the Term Auction Facility (TAF) had any impact on easing credit markets. Other research challenges this conclusion by arguing that financial markets would react to the announcements of programs rather than the actual lending, and that the dependent variable in the analysis should use changes in spreads and not levels. McAndrews, Sarkar and Wang (2008) find that announcements about TAF did significantly lower credit spreads, and other research supports the conclusion that the TAF and other credit facilities helped lower interest rates (Wu, 2008; Christensen, Lopez and Rudebusch, 2009; and Sarkar and Shrader, 2010). Baba and Packer (2009), McAndrews, Sarkar and Wang (2008) and Goldberg, Kennedy and Miu (2010) find that the U.S. dollar swap facilities helped improve the performance of the dollar swap markets. Using a similar event-study methodology, Ait-Sahalia, Adnritzky, Jobst, Nowak, and Tamirisa (2010) find that liquidity provision, not only in the United States but also in the United Kingdom and Japan, helped lower interbank risk premiums. This research suggests that liquidity provision helped stabilize financial markets during this crisis.

3.2.2 Large-scale asset purchases

The second set of nonconventional monetary policy tools involves large-scale asset purchases to lower interest rates on particular types of assets. In November 2008, the Federal Reserve set up a Government Sponsored Enterprise purchase program in which the Fed eventually purchased $1.25 trillion of mortgage-backed securities (MBS) guaranteed by Fannie Mae and Freddie Mac. Through these purchases, the Fed hoped to prop up the MBS market and to lower interest rates on residential mortgages to stimulate the housing market. This program was dubbed QE1 (which stands for Quantitative Easing 1) because it resulted in a substantial expansion of the Fed's balance sheet. Then, in November of 2010, the Fed announced that it would purchase $600 billion of long-term Treasury securities at a rate of about $75 billion per month. This purchase program, which became known as QE2, was intended to stimulate the economy by lowering long-term interest rates that are more relevant to household and business spending decisions. In September 2011, the Fed implemented a program similar to the Operation Twist program in the 1960s (called the Maturity Extension Program and Reinvestment Policy) to achieve lower long-term rates, in which it would eventually purchase $667 billion of long-term Treasuries by the end of 2012 while selling an equivalent amount of short-term Treasuries. Most recently the Fed announced in September 2012 an open-ended QE3 program in which it would buy $40 billion of MBS per month.

Research on the impact of the Federal Reserve's large-scale asset purchases during the global financial crisis by Gagnon, Raskin, Remache and Sack (2011) finds that these programs lowered 10-year U.S. Treasury bond rates by a cumulative 91 basis points and lowered long-term mortgage-backed (MBS) and agency securities even further (113 and 156 basis points respectively) by improving liquidity in these markets.

Although large-scale asset purchases can stimulate the economy by lowering interest rates on these assets, they are not without costs. First, because these asset market purchases were for long-term securities, this exposes the central bank to interest risk (and credit risk if it buys private securities such as mortgage-backed securities) because these securities can have substantial price fluctuations.

Possible losses on these securities thus mean that there could be an erosion of capital in the central bank's balance sheet, and this could subject it to congressional or parliamentary criticism and actions that could weaken its ability to conduct an independent monetary policy. In addition, if a central bank has bought private securities, their presence on the balance sheet means that the central bank has encroached on the politicians' turf because the central bank has engaged in a form of fiscal policy, which makes its political position more precarious, again, possibly leading to a loss of independence.[9] Purchase of long-term government securities can pose a danger for central banks because it may create the perception that the central bank is willing to accommodate irresponsible fiscal policy by monetizing the debt. This is a particular concern right now in the euro area where the ECB has purchased securities issued by governments that have large fiscal imbalances. This problem is also a serious concern in the United States, where both political parties have been so far unwilling to address long-run trends in entitlements that could cause U.S. government debt to explode. Not only can the purchase of long-term government assets encourage fiscal profligacy, but it can also lead to an unhinging of inflation expectations, which could make it difficult for the central bank to control inflation in the future.[10]

3.2.3 Quantitative easing

The result of these programs of liquidity provision and asset purchases resulted in an unprecedented expansion of the Federal Reserve's balance sheet, from $800 billion before the financial crisis began in September of 2007 to nearly $3 trillion as of November 2012. We have seen that this expansion of the balance sheet has become known as quantitative easing because it has led to a huge increase in the monetary base. Because this increase in the monetary base in normal circumstances results in an expansion of the money supply, it could possibly produce inflation down the road.

9. A particular problem for the Federal Reserve is that its holdings of MBSs on its balance sheet directly involve it in the most politicized financial market in the United States. As discussed in Mishkin (2011b), this could lead to politicians viewing the Federal Reserve as personally responsible for developments in the housing markets, which could expose it to increased political criticism and pressure on its policy decisions, thereby further weakening its independence.

10. See Cochrane (2010) for a discussion of how recent fiscal events could lead to a rise in inflation expectations.

There are reasons to be very skeptical of the efficacy of pure quantitative easing as are outlined in Curdia and Woodford (2010) and Woodford (2012). First, the huge expansion in the Fed's balance sheet and the monetary base did not result in a large increase in the money supply because most of it just flowed into holdings of excess reserves. Second, because the federal funds rate had already hit the zero lower bound when it fell to zero, the expansion of the balance sheet and the monetary base could not lower short-term interest rates any further and thereby stimulate the economy. Third, the increase in the monetary base does not mean that banks will increase lending because they can just add to their holdings of excess reserves instead of making loans, and this is exactly what appears to have happened in recent years. A similar phenomenon seems to have occurred when the Bank of Japan engaged in quantitative easing after the bubble burst in the stock and real estate markets, and yet not only did the economy not recover, but inflation even turned negative (Kuttner, 2004).

Does skepticism about quantitative easing mean that the Fed's nonconventional monetary policy actions that expanded the balance sheet would be ineffective at stimulating the economy? I believe the answer is no for two reasons. First, as Chairman Bernanke repeatedly argued during the crisis, the Fed's policies were not directed at expanding the Fed's balance sheet, but rather were directed at credit easing, that is, altering the composition of the Fed's balance sheet in order to improve the functioning of particular segments of the credit markets. When the Fed provides funds to a particular segment of the credit market that has seized up, it can help unfreeze the market and thereby enable it to again allocate capital to productive uses, thereby stimulating economic activity. Asset purchases might also work by increasing the demand for these securities, thereby lowering the interest rates on those assets relative to other securities and stimulating spending. For example, the purchase of agency and MBS securities, which Gagnon, Raskin, Remache and Sack (2011) found led to over a 100 basis point decline in their interest rates, likely led to a substantial reduction in mortgage rates, thereby spurring the demand for residential housing.

As discussed in Woodford (2012), there are reasons to be skeptical that asset purchases can affect interest rate spreads when markets are functioning normally. Indeed, papers such as Bauer and Rudebusch (2011) and Krishnamurthy and Vissing-Jorgensen (2011) suggest that most of the effect of asset purchases on interest rates operate by affecting expectations of future policy, which is the nonconventional monetary policy that we address in the next subsection.

3.2.4 Management of expectations

Another way for a central bank to lower long-term interest rates to stimulate the economy is to manipulate expectations of the future path of the policy interest rate, a nonconventional monetary policy tool that Michael Woodford (2003) has characterized as management of expectations. One such example is the Federal Reserve's announcement in December of 2008 that it expected to keep the federal funds rate near zero for an extended period of time, later extended to mid-2015. This announcement would lower long-term interest rates through the mechanism provided by the expectations hypothesis of the term structure in which long-term interest rates will equal an average of the short-term interest rates that markets expect to occur over the life of the long-term bond. By committing to the future policy action of keeping the federal funds rate at zero for an extended period, the Fed could lower the market's expectations of future short-term interest rates, thereby causing the long-term interest rate to fall.

There are two types of commitments to future policy actions: conditional and unconditional. The commitment to keep the federal funds rate at zero for an extended period starting in 2008 was conditional because it mentioned that the decision was predicated on a weak economy going forward. If economic circumstances changed, the FOMC was indicating that it might abandon the commitment. Alternatively, the Fed could have made an unconditional commitment by just stating that it would keep the federal funds rate at zero for an extended period without indicating that this decision was based on the state of the economy. An unconditional commitment has the advantage that it is stronger than a conditional commitment because it does not suggest that the commitment will be abandoned and therefore is likely to have a larger effect on long-term interest rates. Unfortunately, it has the disadvantage that even if circumstances change so that it would be better to abandon the commitment, the central bank may feel it cannot go back on its word and do so.

The problem of a commitment being seen as unconditional is illustrated by the Fed's experience in the 2003 to 2006 period. In 2003, the Fed became worried that inflation was too low and that there was a significant probability of a deflation occurring. At the August 12, 2003 FOMC meeting, the FOMC stated, "In these circumstances, the committee believes that policy accommodation can be maintained for a considerable period." Then when the Fed started to tighten policy at its June 30, 2004 FOMC meeting, it changed its statement to say "Policy accommodation can be removed at a pace that is likely to be measured." Then for the next ten FOMC meetings through June of 2006, the Fed raised the federal funds rate target by exactly ¼ percentage point at every single meeting. Many market participants interpreted the FOMC's statements as indicating an unconditional commitment, and this is why the Fed may have been constrained to not deviate from ¼ percentage point moves at every FOMC meeting. In retrospect, this constraint may have led to monetary policy that was too easy for too long, with inflation subsequently rising to well above desirable levels and, as discussed earlier, it may have led to excessive risk-taking through the risk-taking channel of monetary policy.

The problem with unconditional policy commitments suggests that commitments should be conditional, but this raises the crucial question of conditional on what. Eggertson and Woodford (2003, 2004) and Woodford (2012) argue convincingly when there is a zero lower bound problem, the policy commitment should be conditional on a target criterion that makes monetary policy history dependent in a particular way. The policy path will have to be more accommodative than would otherwise be the case if a zero lower bound had not occurred so that the expectation of the easier policy will mitigate the effect of the zero interest rate being too high when the zero lower bound constraint binds it. Specifically, Eggertsson and Woodford (2003, 2004) suggests that the policy rate should be kept at its zero floor until the price level reaches a path of an output-adjusted price level, which is the log of a price index plus the output gap multiplied by a coefficient (which reflects the relative weight on output-gap versus inflation stabilization). Because this concept of an "output-gap adjusted price level" might be somewhat hard for the public to understand, Woodford (2012) suggests that a simpler criterion that would work nearly as well would be to have the target criterion be a nominal GDP path which grows at the inflation target rate (e.g., 2% for the Fed) multiplied by the growth rate of potential GDP and starts at the level that was reached when the zero lower bound constraint first appeared (around the end of 2008 in the United States.) If potential GDP growth were estimated to be 2% annual rate, this would imply a growth rate of the nominal GDP path at a 4% annual rate.

This proposal has several advantages over other target criterion. For example, the 7% unemployment rate and 3% inflation thresholds at which the policy rate would be raised, outlined by the president of the Federal Reserve Bank of Chicago, Charles Evans, described in Campbell, Evans, Fisher and Justiano (2012), or proposals to raise the inflation target to 4%, as discussed by Blanchard, Dell'Ariccia and Maura (2010) and Rogoff (2011). There are two problems with both of these proposals. First neither is history dependent because they are completely forward looking. Hence, if negative shocks to the economy sent output and inflation further below the target path, neither of these policies would lead to a lengthening of the time period where the policy rate would remain at zero, as would be optimal.

The second problem with proposals like this is that they could unhinge long-run inflation expectations. If central banks suggest that it is OK for inflation to rise above its initial target level, the public may come to believe that price stability is no longer a credible goal of the central bank and then the question arises, "If a 3 or 4% level of inflation is OK, then why not 6%, or 8%, and so on." The target criterion proposed by Eggertsson and Woodford (2003, 2004) or Woodford (2012) does not have this feature because it continues the central bank's commitment to a long-run inflation target of, say, 2%. It does allow inflation to temporarily rise above the 2% target level, but makes clear that the long-run inflation objective is unchanged and that once the zero lower bound constraint is no longer binding, then the central bank returns to a conventional, forward-looking, flexible inflation target regime in which the central bank seeks to achieve the inflation target of 2% over the medium term.

There are still formidable challenges to a central bank's adoption of a conditional commitment based on a nominal GDP path. First, it may be more difficult to explain to the public and financial market participants. An inflation target is much simpler to explain than a target path, particularly one that involves nominal GDP, which is a concept that the public is much less familiar with. Second, when inflation temporarily rises above the 2% inflation as the central bank intends, the central bank will have to carefully explain that it is not weakening its commitment to the long-run 2% inflation target. Third, a nominal GDP path requires that the central bank take a stance on the number for the growth rate of potential GDP, a number in which there is a great deal of uncertainty. This last problem would be particularly severe if the central bank ignored what was actually happening to inflation in estimating the output gap, a mistake that the Federal Reserve made in the 1970s.

Although these challenges are serious ones, in the current environment central banks may have little choice. As discussed above, in the current environment, large-scale asset purchases may only be effective by affecting expectations of future policy rates. If this is the case, management of expectations at the zero lower bound is the only effective monetary policy tool that the central bank has at its disposal. Currently, this is particularly relevant (at the time of this writing, November 2012) because the economy in both the United States and Europe is quite weak, and indeed there are major downside risks from the fiscal cliff in the United States and the possibility of financial disruption in Europe if there is a breakup of the Eurozone.

Large-scale asset purchases may have an important role in managing expectations. An announcement of a policy commitment to manage expectations may not be sufficiently credible because talk is cheap. As we have seen, large-scale asset purchases impose costs on a central bank and so combining the announcement of the policy commitment with large-scale asset purchases may make the policy commitment more credible because the central bank has, in effect, put its money where its mouth is.

3.3 Risk Management and Gradualism

The standard models at central banks assume that the economy is linear. With a quadratic objective function, the optimal policy is therefore a certainty equivalent: it can be characterized by a linear time-invariant response to each shock, and the magnitude of these responses does not depend on the variances or any other aspect of the probability distribution of the shocks. In such an environment, optimal monetary policy does not focus on tail risk, which might require risk management. Furthermore, when financial market participants, and wage and price setters are relatively forward-looking, the optimal policy under commitment is characterized by considerable inertia, which is commonly referred to as gradualism.[11]

In the United States, as well as in many other industrial economies, the actual course of monetary policy before the crisis

11. The now classic reference on this approach is Woodford (2003). Also see Goodfriend and King (1997); Rotemberg and Woodford (1997); Clarida, Gali and Gertler (1999); King and Wolman (1999); Erceg, Henderson, Levin (2000).

was typically very smooth. For example, the Federal Reserve usually adjusted the federal funds rate in increments of 25 or 50 basis points (that is, ¼ or ½ of a percentage point) and sharp reversals in the funds rate path were rare. Numerous empirical studies have characterized monetary policy before the crisis using Taylor-style rules, in which the policy rate responds to the inflation gap and the output gap; these studies have generally found that the fit of the regression equation is improved by including a lagged interest rate that reflects the smoothness of the typical adjustment pattern.[12]

Although the linear-quadratic framework might be reasonable under normal circumstances, we have learned that financial disruptions can make the macro economy highly nonlinear. These nonlinearities suggests that policy-makers should not only focus on the modal outcomes, as they would in a certainty equivalent world, which is a feature of the linear-quadratic framework, but should also tailor their policies to cope with uncertainty and with the possible existence of tail risks in which there is a low probability of extremely adverse outcomes. I have argued elsewhere (Mishkin, 2011b) that the importance of financial frictions and nonlinearities in the economy provides a rationale for a particular form of risk management approach to monetary policy in which monetary policy would act pre-emptively when financial disruptions occur. Specifically, monetary policy would move quickly to reduce the policy rate rapidly in order to decrease the probability that a financial disruption will cause significant deterioration in the real economy through the adverse feedback loop described earlier, in which the financial disruption causes a worsening of conditions in the credit markets, which causes the economy to deteriorate further, causing a further worsening of conditions in the credit markets, and so on. In so doing, monetary policy could reduce the likelihood of a financial disruption setting off an adverse feedback loop. The resulting reduction in uncertainty could then make it easier for the markets to collect the information that facilitates price discovery, thus hastening the return of normal market functioning.

The above policy approach is one in which gradualism is abandoned. To achieve normal market functioning most effectively, monetary policy would be timely, decisive, and flexible. First, timely

12. See Clarida, Gali and Gertler (1998, 2000); Sack (2000); English, Nelson and Sack (2003); Smets and Wouters (2003); Levin, Onatski and Williams (2005). Further discussion can be found in Bernanke (2004).

action, which is pre-emptive, is particularly valuable when an episode of financial instability becomes sufficiently severe to threaten the core macroeconomic objectives of the central bank. In such circumstances, waiting too long to ease policy could result in further deterioration of the macroeconomy and might well increase the overall amount of easing that would eventually be required to restore the economy to health. When financial markets are working well, monetary policy can respond primarily to the incoming flow of economic data about production, employment, and inflation. However, in the event of a financial disruption, pre-emptive policy would focus on indicators of market liquidity, credit spreads, and other financial market measures that can provide information about sharp changes in the magnitude of tail risk to the macroeconomy. Indeed, even if economic indicators were strong, monetary policy would act to offset the negative impact of the financial disruption.

Second, policy-makers would be prepared for decisive action in response to financial disruptions. In such circumstances, the most likely outcome (the modal forecast) for the economy may be fairly benign, but there may also be a significant risk of more severe adverse outcomes. In this situation the central bank can take out insurance by easing the stance of policy further than if the distribution of probable outcomes were perceived as fairly symmetric around the modal forecast. Moreover, in such circumstances, the monetary policy authorities can argue that these policy actions do not imply a deterioration of the central bank's assessment of the most likely outcome for the economy, but rather constitute an appropriate form of risk management that reduces the risk of particularly adverse outcomes.

Third, policy flexibility is especially valuable throughout the evolution of a financial market disruption. During the onset of the episode, this flexibility may be evident from the decisive easing of policy that is intended to forestall the contractionary effects of the disruption and provide insurance against the downside risks to the macroeconomy. However, it is important to recognize that, in some instances, financial markets can also turn around quickly, thereby reducing the drag on the economy as well as the degree of tail risk. Therefore, the central bank would monitor credit spreads and other incoming data for signs of financial market recovery and, if necessary, take back some of the insurance; thus, at each stage of the episode, the appropriate monetary policy may exhibit much less smoothing than would be typical in other circumstances. The risk management approach outlined here is one that abandons the prescription of the linear-quadratic framework that the optimal monetary policy would involve gradual changes. Instead, with this approach, aggressive actions by central banks to minimize macroeconomic risk would result in large, pre-emptive changes in monetary policy. This was an important feature of the conduct of conventional monetary policy by the Federal Reserve during the crisis. In September 2007, just after the initial disruption to financial markets in August, the Federal Reserve lowered the federal funds rate target by 50 basis points (0.5 percentage point) even though the economy was displaying substantial positive momentum, with real GDP growth quite strong in the third quarter. The Federal Reserve was clearly not reacting to current economic conditions, but rather to the downside risks to the economy from the financial disruption. Subsequently, the Federal Reserve very rapidly brought the federal funds rate target from its level of 5¼% before the crisis in September 2007, to 2% in April 2008. Then, after the Lehman Brothers collapse in September 2008, the Federal Reserve began another round of rapid interest rate cuts, with the federal funds rate target lowered by 75 basis points in December 2008, bringing it down to the zero lower bound. Clearly, the Federal Reserve had abandoned gradualism.[13] One danger from aggressive pre-emptive actions that are taken as part of the risk management approach is that they might create the perception that the monetary policy authorities are too focused on stabilizing economic activity and not focused enough on price stability. If this perception occurs, the pre-emptive actions might lead to an increase in inflation expectations. The flexibility to act pre-emptively against a

13. One period before the crisis when the Federal Reserve abandoned gradualism was during the LTCM (Long-Term Capital Management) episode, when it lowered the federal funds rate target by 75 basis points within a period of a month and a half in the autumn of 1998. This action fits into the risk management approach described here. However, once the shock dissipated, the Federal Reserve did not take away the insurance provided by the funds rate cuts, as the risk management approach outlined here suggests would have been appropriate. I consider this to be one of the serious monetary policy mistakes made by the Federal Reserve under Greenspan. Not only did inflation subsequently rise above the desired level, but the actions also indicated that the Federal Reserve would react asymmetrically to shocks, lowering interest rates in the event of a financial disruption, but not raising them upon reversal of the adverse shock. This helped contribute to the belief in the "Greenspan put" in which the Greenspan Fed cleaned up after financial disruptions like the LTCM and Russian defaults in the fall of 2008 by lowering interest rates, leading to a form of moral hazard in which financial institutions expect monetary policy to help them recover from bad investments (e.g. see Tirole and Farhi, 2009; Keister, 2010; and Wilson and Wu, 2010).

financial disruption presupposes that inflation expectations are well anchored and unlikely to rise during a period of temporary monetary easing. To work effectively, the risk management approach outlined here thus requires a commitment to a strong nominal anchor. A risk management approach therefore provides an additional rationale for a flexible inflation targeting framework and, as I have argued elsewhere (Mishkin, 2008), a strong nominal anchor can be especially valuable in periods of financial market stress, when prompt and decisive policy action may be required as part of a risk management approach in order to forestall an adverse feedback loop.

3.4 Fiscal Dominance and Monetary Policy

The key fact driven home by the recent financial crisis that financial crises are often followed by fiscal crises indicates that the view that "Inflation is always and everywhere a monetary phenomenon" requires modification. Before the crisis, central banks, at least in advanced countries, could take the view that governments would pursue a long-run budget balance so that the amount of government debt to GDP would be at sustainable levels. In the aftermath of the crisis, we have seen a huge explosion in government debt, either because of decreased revenue and increased government spending to stimulate the economy, as in the United States, or because of bailouts of the financial sector, as in Ireland and Spain. This has raised the prospect that governments may no longer be able or willing to pay for their spending with future taxes. Either this means that the government's intertemporal budget constraint will have to be satisfied by issuing monetary liabilities or, alternatively, by a default on the government debt.

This situation in which government budget deficits are out of control is described as fiscal dominance because the monetary authorities no longer will be able to pursue monetary policies that will keep inflation under control. If a default occurs, the resulting collapse in the value of the domestic currency leads to high inflation, and this is the experience we have seen in many emerging market countries, Argentina in 2002 being one recent prominent example. Even when countries are in a currency union where they do not have their own currency, default is likely to lead to an expulsion from the currency union and the subsequent depreciation of the newly created domestic currency will then result in high inflation. Indeed, this is the prospect that currently faces Greece, where a disorderly default would result in an exit from the Eurozone with not only high inflation, but also a total collapse of the banking system.

If default does not occur, fiscal dominance still results in high inflation even if the central bank does not want to pursue inflationary policies and has a strong commitment to an inflation target. It is still true that inflation will have a monetary element because high-powered money will increase, so in that sense, the famous adage is still true; this is a situation that Sargent and Wallace (1981) in their famous paper described as "unpleasant monetarist arithmetic." Fiscal dominance will at some point in the future force the central bank to monetize the debt, so even tight monetary policy in the present will not prevent inflation. Indeed, as Sargent and Wallace (1981) points out, tight monetary policy might result in inflation being even higher.

To see how this would play out in the current context, we need to recognize that fiscal dominance puts a central bank between a rock and a hard place. If the central bank does not monetize the debt, then interest rates on the government debt will rise sharply, causing the economy to contract. Indeed, the lack of monetization fiscal dominance may result in the government defaulting on its debt, which would lead to a severe financial disruption, leading to an even more severe economic contraction. Hence, the central bank will in effect have little choice and will be forced to purchase the government debt and monetize it, eventually leading to a surge in inflation.

We already are seeing the beginning of this scenario in Europe. The threat of defaults on sovereign debt in countries such as Ireland, Portugal, Spain and Italy has led the ECB to purchase individual countries' sovereign debt, with the latest manifestation the announcement in September 2012 that it will engage in what it has called Outright Monetary Transactions (OMT). These OMT transactions involve purchases of sovereign debt in the secondary markets of these countries subject to their governments accepting a program of conditionality from the European Financial Stability Facility/European Stability Mechanism.

The ECB describes these transactions as monetary in nature because they "aim at safeguarding an appropriate monetary policy transmission," with the reasoning that they are "monetary" because low ECB policy rates are not translating into low interest rates in these countries. Nonetheless, these transactions are in effect monetization of individual countries' government debt (even if they are sterilized for the Eurosystem as a whole). The ECB's purchase of individual countries' sovereign debt arises from the difficult position it faces. If the ECB does not do what ECB President, Mario Draghi, has described as "doing whatever it takes" to lower interest rates in these countries, the alternative is deep recessions in these countries or outright defaults on their debt that would create another "Lehman moment" in which the resulting financial shock would send the Eurozone over the cliff.

It is true that the ECB's bond purchasing programs will not result in inflation if the sovereigns whose debt is being purchased get their fiscal house in order, and so fiscal dominance is avoided. However, this is a big if. Indeed, there is a danger that Europe may find itself with what I will refer to as the "Argentina problem." Argentina has had a long history of fiscal imbalances that have led to high inflation, and this continues to this day. The problem in Argentina is that its provinces overspend and are always bailed out by the central government. The result is a permanent fiscal imbalance for the central government, which then results in monetization of the debt by the central bank and high inflation. Europe could be facing the same problem. With bailouts of sovereigns in the Eurozone, the incentives to keep fiscal policy sustainable in individual countries have been weakened, leading to a serious moral hazard problem. Budget rules have been proposed to eliminate this moral hazard, but as the violation of the Growth and Stability Pact rules by Germany and France a number of years ago illustrates, these budget rules are very hard to enforce. However, we have seen success in some countries in this respect, with Chile being a notable example.

Thus, the Eurozone may be on a path to become more like Argentina (which of course is why Germans are horrified), with fiscal dominance a real possibility, and high inflation the result. This possibility is a very real one despite what the Maastricht Treaty specifies about the role of the ECB and what policymakers in the ECB want.

Although the United States is not in nearly as dire a situation because the no-bailout policy for state and local governments that has evolved over many years avoids the "Argentina problem," the possibility of fiscal dominance is real. The U.S. government is fully capable of avoiding fiscal dominance and achieving long-run fiscal sustainability by reigning in spending on entitlements (Medicare/Medicaid and Social Security) while increasing tax revenue (but not necessarily tax rates). Indeed one such plan was proposed by the Simpson-Bowles Commission appointed by President Obama. However, when the Commission's recommendations were announced, President Obama did not embrace them, nor did the Republican Party, which refused to consider any increase in tax revenue. Hopefully, after the recent election, President Obama and the Republicans will be able to come together to implement legislation to achieve long-run fiscal sustainability, but the failure of the Democrats and the Republicans to come up with a compromise before the election was, to say the least, very discouraging.

There has been a great deal of attention paid to the Federal Reserve's quantitative easing policies as a potential threat to price stability in the United States. The concern is that the expansion of the Federal Reserve's balance sheet, as a result of quantitative easing, will unhinge inflation expectations and thus create inflation in the near future. However, the far greater threat is on the fiscal front. If U.S. government finances are not put on a sustainable path, we could see the scenario I have outlined above, where markets lose confidence in U.S. government debt, so that prices fall and interest rates shoot up, and then the public might expect the Federal Reserve to be forced to monetize this debt. What would then unhinge inflation expectations would be the fear of fiscal dominance, which could then drive up inflation very quickly.

The bottom line is that no matter how strong the commitment of a central bank to an inflation target, fiscal dominance can override it. Without long-run fiscal sustainability, no central bank will be able to keep inflation low and stable. This is why central bankers must lobby both in public and in private to encourage their governments to put fiscal policy on a sustainable path.

4. Concluding Remarks

Events in the recent global financial crisis have changed central banking forever. Although the basic central banking paradigm of flexible inflation targeting in which the central bank makes a credible commitment to stabilize inflation in the long run is still valid; the form of its flexibility requires substantial rethinking. There are four areas in which central banks need to make, and are making, major changes in the way they conduct policy. First, monetary policy at times need to lean against credit-driven bubbles, and there is an interaction of monetary policy with macro-prudential policy, in which tighter macro-prudential policy will require easier monetary policy and vice versa. Second, at the current juncture, the nonconventional monetary policy of managing expectations is needed to stabilize the economy, but the communications challenges are serious ones. Third, the nonlinearities of the macroeconomy imply that central banks will need to develop a risk management approach to cope with financial disruptions. Fourth, fiscal dominance is now a big problem in advanced economies and steps must be taken to get countries' fiscal houses in order.

The bottom line is that central banking is now entering a brave new world in which the challenges have become greater and the conduct of policy has become more complex.

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Does Expansionary Monetary Policy Cause Asset Price Booms? Some Historical and Empirical Evidence

Michael D. Bordo
Rutgers University and National Bureau of Economic Research

John Landon-Lane
Rutgers University

Does expansionary monetary policy lead to asset price booms? There is some extensive theoretical, empirical and policy literature on this topic. The traditional view sees expansionary monetary policy as raising asset prices as part of the transmission mechanism of monetary policy. It works through the adjustment of the community's portfolio as agents replace cash with government securities and then by corporate instruments, immediately followed by stocks, real estate, paintings of the Old Masters and natural resources —eventually leading to global inflation. Another view attributed to the Austrian economists in the 1920s, and more recently the BIS, sees an environment of low inflation and accommodative monetary policy as creating an environment conducive to asset booms and consequent busts.[1]

Asset booms (especially those leading to bubbles) are often followed by busts, which can have serious economic effects. There is

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1. Related approaches emphasize financial liberalization and innovation accommodated by loose monetary policy as conducive to creating booms.

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a long historical incidence of infamous boom busts ranging from the South Sea bubble in the early eighteenth century, to many famous stock market crashes in the nineteenth century, to the 1929 Wall Street Crash, to the U.K. housing boom bust of 1973, to the Nordic crises of the 1980s, to the Japanese housing and equity bubble and crash of 1990, and to the more recent dot-com and subprime mortgage boom busts. This history keeps repeating itself.

The policy implications of asset booms are significant, especially since asset busts have often led to banking crises and serious, prolonged recessions. To the extent monetary policy is a contributing factor, the question arises whether or not the monetary authorities should use their policy tools to defuse booms before they turn into busts. A vociferous debate raged in the early 2000s until the aftermath of the recent financial crisis over the subject of preemptive policy action. Central banks were unwilling to divert much attention away from their traditional concern over price and overall macro stability. However the tide has recently turned and the new emphasis on macro prudential monetary policy suggests that asset price booms have been elevated to the top level of interest.

Finally, the issue still remains that asset price booms, in addition to sometimes ending with damaging busts, can be the precursors to a future run-up in inflation. This leads to the question of when central banks should tighten their policies to prevent inflation from becoming embedded in expectations.

In this paper we develop a method to demarcate asset price booms. We focus on house price booms, stock market booms and commodity booms for 18 OECD countries from 1920 to the present. We then ascertain whether or not our set of boom events can be related to different measures of expansionary monetary policy, deviations from Taylor rules, and monetary aggregate growth. Finally, we use panel regression techniques to control for other determinants of asset booms, including inflation, credit growth, output growth, financial liberalization, and the current account deficit.

Section 1 discusses the debate over the link between monetary policy and asset price booms. Section 2 contains historical narratives on some of the salient asset price booms throughout history. We discuss some booms in nineteenth century Great Britain, the Wall Street stock market boom and the U.S. housing boom of the 1920s, the commodity price boom of the 1970s, the U.K. housing booms in the 1970s and 1980s, the Nordic asset booms in the 1980s, the Japanese boom of the late 1980s, the dot-com boom of the 1990s, and the recent subprime mortgage boom bust. Section 3 discusses our methodology of identifying asset price booms and presents a chronology from 1920 to the present booms so identified. Controlling for other factors, section 4 uses econometrics to isolate the links between expansionary monetary policy and asset price booms. Section 5 concludes with the implications of our findings for monetary policy.

1. The Issues

Debate swirls over the causes of the subprime Mortgage Crisis of 2007-2008 and the Great Recession of 2007-2009, and the subsequent slow recovery. Two views predominate. The first is that it was caused by global imbalances, an excess of global savings in Asia, which financed a consumption boom, and persistent budget deficits and current account deficits in the U.S and other advanced countries. The second is that it reflected domestic imbalances in the U.S., leading to an unprecedented nationwide housing boom, which burst in 2006 precipitating the crisis. This paper focuses on the second view.[2]

A key element of the domestic U.S. story is that the Federal Reserve kept monetary policy too loose from the 2002-2006 period, which fueled a housing boom that had its origins in a long tradition of policies to encourage home ownership in succeeding administrations, financial innovation, lax regulatory supervision and oversight, and corporate malfeasance. John Taylor (2007, 2009) has led to the indictment of the Fed for fueling the housing boom in the early 2000s. Based on the Taylor rule (1993) showing that the Federal Funds rate was as low as 3 percentage points below what a simple Taylor rule would generate for the 2002-2005 period. Taylor then simulated the path of housing starts if the Fed had followed the Taylor rule over the 2000-2006 period. His calculations suggest that most of the run-up in housing starts from the 2002-2005 period would not have occurred.

An earlier OECD study by Ahrend et al. (2008) found a close relationship between negative deviations of the Taylor rule, and

2. The possibility that monetary policy can produce asset price bubbles has also been studied extensively in rational expectations equilibrium models. In such models, poorly designed monetary policies, such as the use of interest rate rules without commitment to a steady long-run inflation rate, can lead to self-fulfilling prophecies and asset price bubbles. Such outcomes are less likely, argues Woodford (2003), if monetary policymakers follow a clear rule in which the interest rate target is adjusted sufficiently to stabilize inflation. Thus, the theoretical literature suggests that consideration of the monetary policy environment may be crucial to understanding why asset booms come about.

several measures of housing market buoyancy (mortgage lending, housing investment, construction investment and real house prices) for a number of OECD countries in the early 2000s. The principal examples are the U.S. (2000-2006), Canada (2001-2007), Denmark (2001-2004) and Australia (2000-2003) periods. For the euro area as a whole, they find that ECB policy rates are not far below the Taylor rule, but for a number of individual members (Portugal, Spain, Greece, Netherlands, Italy, Ireland and Finland), they are well below it. This evidence, as well as evidence in several other papers (Hott and Jakipii, 2012; Gerlach and Assenmacher-Wesche, 2008a), suggests that expansionary monetary policy had a key role to play in fostering recent housing booms, some of which led to devastating busts. Other literature finds evidence linking expansionary monetary policy to equity booms and commodity price booms (Gerlach and Assenmacher-Weshe, 2008b; Pagano, Lombardi, Anzuini, 2010).

Expansionary monetary policy can also generate booms in commodity prices, which can presage a run-up in global inflation. The Great Inflation of the 1970s was first manifested in commodity prices before feeding into overall inflation. This reflected the basic distinction, first pointed out by Okun (1975), between goods that are traded in auction markets and those whose prices react quickly to both nominal and real shocks, and goods traded in customer markets (manufactured goods and services) whose prices are relatively sticky. In the long run, the paths of prices for both types of goods are determined by the long-run growth of the money supply (reflecting monetary neutrality). What happens in episodes of expansionary monetary policy, characterized by falling real interest rates, is that real commodity prices rise much more quickly than the prices of other goods, and according to Frankel (2008), they overshoot the long-run equilibrium price level. At the same time the prices of other goods react slowly to the monetary pressure. Frankel (2008) finds that commodity prices are a good predictor of future inflation. Browne and Cronin (2007) use time series techniques for the U.S. (1959-2005) period to show that the growth of M2 and headline inflation are cointegrated, but that the adjustment mechanism to the long-run equilibrium involves considerable overshooting by commodity prices. Moreover the deviation of commodity prices from their long-run equilibrium values explains the subsequent path of the CPI.

There is some extensive, earlier literature on the relationship between monetary policy and asset prices. Asset prices are viewed as a key link in the transmission mechanism of monetary policy. The traditional view argues that added liquidity causes asset prices to rise as a link in the transmission mechanism of monetary policy actions to the economy as a whole. Another view, the Austrian/BIS's, argues that asset price booms are more likely to arise in environments of low and stable inflation and, thus, asset price booms can arise because monetary policy is geared to credibly stabilizing prices.

The traditional view has a long history. Early Keynesian models like Metzler (1951) showed central bank operations affecting the stock market directly. Friedman and Schwartz (1963a) and later Tobin (1969) and Brunner and Meltzer (1973) spelled out the transmission mechanism following an expansionary Fed open market purchase. It would first affect the prices (rate of return) on short-term government securities, then via a portfolio balance substitution mechanism, the price (rate of return) of long-term government securities, then corporate securities, equities, real estate, paintings of the Old Masters and commodities, including gold, would be bid up (their returns lowered). Thus substitution from more to less liquid assets would occur as returns on the former decline, relative to the latter. Thus the impact of expansionary monetary policy will impact securities, assets, commodities, and finally the overall price level. This view sees asset prices as possible harbingers of future inflation.

The Austrian/BIS view which goes back to Hayek, von Mises, Robbins[3] and others in the 1920s posits that an asset price boom, whatever its fundamental cause, can degenerate into a bubble if accommodative monetary policy allows bank credit to rise to fuel the boom. This view argues that unless policy-makers act to defuse the boom, a crash will inevitably follow that, in turn, may cause a serious recession. The Austrians equated rising asset prices with a rise in the overall price level. Although the level of U.S. consumer prices was virtually unchanged between 1923 and 1929, the Austrians viewed the period as one of rapid inflation, fueled by loose Federal Reserve policy and excessive growth of bank credit (Rothbard 1983).

The Austrian view has carried forward into the modern discussion of asset price booms. It has been incorporated into the BIS view of Borio and Lowe (2002), Borio and White (2004) and others. They focus on the problem of "financial imbalances," defined as rapid growth of credit in conjunction with rapid increases in asset prices and, possibly, investment. Borio and Lowe (2002) argue that

3. See Laidler (2003).

a build-up of such imbalances can increase the risk of a financial crisis and macroeconomic instability. They construct an index of imbalances, based on a credit gap (deviations of credit growth from trend), an equity gap, and an output gap, to identify incipient asset price declines that can lead to significant real output losses and advocate its use as a guide for proactive action. In this vein, Borio (2012) discusses a financial cycle based on property prices and credit growth that has much greater amplitude than the business cycle, and when its peak coincides with a business cycle peak, a housing bust, banking crisis and deep protracted recession can follow, as occurred in 2007.

Borio and Lowe argue that low inflation can promote financial imbalances regardless of the cause of an asset price boom. For example, by generating optimism about the macroeconomic environment, low inflation might cause asset prices to rise more in response to an increase in productivity than they would otherwise. Similarly, an increase in demand is more likely to cause asset prices to rise if the central bank is credibly committed to price stability. A commitment to price stability that is viewed as credible, Borio and Lowe (2002) argue will make product prices less sensitive, and output and profits more sensitive to an increase in demand in the short-run. At the same time, the absence of inflation may cause policy makers to delay tightening as demand pressures build up.[4] Thus, they contend (pp. 30-31) "these endogenous responses to credible monetary policy (can) increase the probability that the latent inflation pressures manifest themselves in the development of imbalances in the financial system, rather than immediate upward pressure in higher goods and service price inflation."[5]

Christiano et al. (2010) present historical evidence showing that stock price booms in the U.S. and Japan often occurred in periods

4. A related issue to the impact of expansionary monetary policy on asset prices is whether or not the price index targeted by the central bank should include asset prices. Alchian and Klein (1973) contend that a theoretically correct measure of inflation is the change in the price of a given level of utility, which includes the present value of future consumption. An accurate estimate of inflation, they argue, requires a broader price index than one consisting only of the prices of current consumption goods and services. To capture the price of future consumption, Alchian and Klein (1973) contend that monetary authorities should target a price index that includes asset prices. Bryan et al. (2002) concur, arguing that because it omits asset prices (especially housing prices), the CPI seriously understated inflation during the 1990s.

5. For evidence that low inflation contributed to the housing booms of the 1990s and 2000s, see Frappa and Mesonnier (2010).

of low inflation. Productivity shocks, which raise the natural rate of interest, are accommodated by expansion in bank credit, which pushes up stock prices. According to their analysis based on a DSGE model, following a Taylor type rule, in the face of low inflation, it will lead to lower interest rates that will further fuel the asset boom.

In section 5 below we present some evidence consistent with the loose monetary policy explanation for asset price booms and the Austrian BIS view that regards monetary policy, dedicated to low inflation and bank credit expansion, as creating an environment conducive to an asset boom.

2. Historical Narrative

2.1 The Nineteenth Century

Asset booms and busts have been a major part of the economic landscape since the early eighteenth century. Classic stock market booms followed by wrenching busts were the South Sea Bubble in England and John Law's Mississippi scheme in France (see Neal, 2011 and Velde, 2003). In the nineteenth century there were major stock market boom busts across the world that accompanied the advent of equities to finance the rapid economic development that followed the industrial revolution. Two famous stock market booms and busts in England occurred in the 1820s and the 1840s.

The earliest and probably most famous stock market boom-bust in the modern era ended with the 1824-1825 stock market crash (Bordo, 1998; Bordo, 2003; Neal, 1998). After the Napoleonic wars and the successful resumption of the gold standard in 1821, the British economy enjoyed a period of rapid expansion stimulated by an export boom to the newly independent states of Latin America, and investment in infrastructure projects (e.g. gas lighting, canals and railroads). The sale of stocks to finance those ventures, in addition to gold and silver mines (some real, some fictitious) in Latin America, propelled a stock market boom fueled by the Bank of England's easy monetary policy. Prices rose by 78% in the boom. Indications are that the April 1825 collapse in stock prices was related to the prior tightening of the Bank of England's monetary policy stance in response to a decline in its gold reserves. The collapse, in which stock prices fell by 34%, triggered bank failures which, once they reached important City of London banks, precipitated a full-fledged panic in early December. Only then did the Bank of England begin to act as a lender of last resort, but it was too late to prevent massive bank failures, contraction of loans, and a serious recession.

The 1840s railroad mania was a precedent to the 1990s dot-com boom. After the first successful railroad was established in 1830, optimistic expectations about potential profits, which later turned out to be overly optimistic, led to massive investment in rails and rolling stock that extended the network across the country. The boom was accommodated by expansionary monetary policy in response to gold inflows. The end of the railroad boom was associated with the banking panic of 1847—one of the worst in British history. The crash, in which stock prices fell by 30%, and tightening of the Bank of England's monetary policy stance may have triggered the panic, as in earlier episodes, reflecting its concern over declining gold reserves (Dornbusch and Frankel, 1984). The panic led to many bank failures and a serious recession.

The U.S. had many stock market booms and busts in its history. Several of them were associated with banking panics and serious recessions. One of the classic boom busts was the railroad boom in the 1870s, which opened up the west. The post-civil war era experienced one of the most rapid growth rates in U.S. history. Much of the financing of railroad investment came from British capital inflows, which, in turn, accompanied by gold inflows, permitted monetary expansion. The boom was also accompanied by corporate malfeasance and corruption (Bordo and Benmelech, 2008). The boom ended with a stock market crash in 1873, once the extent of the corporate fraud was revealed. The stock market crash was followed by a banking panic and a recession that ended in 1879.

2.2 The 1920s

The most famous episode of an asset price boom is the Wall Street Boom beginning in 1923 and ending with the Crash in October 1929. During the boom, stock prices rose by over 200%; the collapse from 1929 to 1932 had prices decline by 66%. The boom was associated with massive investment that brought the major inventions of the late nineteenth century (e.g. electricity and the automobile) to fruition. In addition, major innovations profoundly changed industrial organization and the financial sector, including the increased use of equity as a financial instrument. The economy of the 1920s, following the sharp recession of 1920-1921, was characterized by rapid real growth, rapid productivity advance and slightly declining prices punctuated by two minor recessions. Irving Fisher and other contemporaries believed that the stock market boom reflected the fundamentals of future profits from the high growth industries that were coming on stream, and that it was not a bubble. Recent work by McGrattan and Prescott (2003) concurs with that view; although, many others regard it as a bubble (Galbraith, 1955 and Rappoport and White, 1994).

Debate continues over the role of expansionary Federal Reserve policy in fueling the boom. In 1932, Adolph Miller, a member of the Federal Reserve Board, blamed the New York Fed and its President, Benjamin Strong, for pursuing expansionary open market purchases to help Britain restore the pound to its prewar parity in 1924, and again in 1927, to protect sterling from a speculative attack. In both occasions, the U.S. economy was in recession, justifying expansionary policy (Friedman and Schwartz, 1963b). Miller indicted Strong (who died in 1928) for fueling the stock market boom and the resultant crash. His views were instrumental in legislation in 1933, which prohibited Reserve banks from engaging in international monetary policy actions.

As mentioned in section 2 above, the Austrian economists, later followed by economists at the BIS, saw the 1920s as a credit boom accommodated by monetary policy. Eichengreen and Michener (2004) present evidence for the BIS view for the 1920s as a credit boom gone wild, based on their measures of a credit boom (deviations from trend of the ratio of broad money to GDP, the investment ratio and real stock prices) for a panel of 9 countries.

The 1920s also witnessed a major house price boom in the U.S. from 1923 to 1925. White (2009) argues that the boom was, in part, triggered by expansionary monetary policy. He finds that deviation from a Taylor rule has some explanatory power for the run-up in real housing prices. He also argues that the Fed, established in 1914 to act as a lender of last resort and to reduce the seasonal instability in financial markets, created some elements of a "Greenspan Put"—the view that emerged after Chairman Greenspan engineered a massive liquidity support for the New York money center banks during the October 1987 Wall Street Crash—in which the Fed would bail out the financial sector in the event of a crash. Unlike the Wall Street stock market boom, the housing boom bust in the 1920s had little impact on the financial system or the economy as a whole.

2.3 Post World War II

The post war period has exhibited a large number of housing and stock market boom busts. Many of these episodes occurred in an environment of loose monetary policy. In addition, expansionary monetary policy across the world in the 1960s and 1970s led to a global commodities boom that presaged the Great Inflation. We briefly discuss a number of salient episodes.

2.3.1 Asset booms in the U.K.

The U.K. had a massive house price and stock market boom in the 1971-1974 period, referred to by Congdon (2005) as the Heath Barber Boom. Named after the (then) Prime Minister and Chancellor of the Exchequer. Congdon documents the rapid growth in broad money (M4) after the passage of the Competition and Credit Control Bill in 1971, which liberalized the U.K. financial system and ended the rate-setting cartel of the London clearing banks. He shows both rapid growth in M4 and a shift in its composition towards balances held by the corporate and financial sectors away from the household sectors. Following the Friedman and Schwartz (1963b) transmission story, the excess cash balances went into equities first, and properties second, greatly pushing up their prices. The big asset price booms were soon followed by an unprecedented rise in inflation to close to 20% per year by the end of the 1970s. Congdon also shows a tight connection between expansion in broad money supply in the 1986-1987 period and subsequent asset price booms, which he calls the Lawson boom after the Chancellor of the Exchequer. As in the 1970s boom, rapid growth in M4 and in its holdings by the corporate and financial sectors fueled a stock market boom which burst in 1987, and a housing boom that burst in 1989. Finally, he attributes a big run-up in financial sector real broad money holdings in 1997-1998 to an equities boom in the late 90s and a housing boom that peaked in 2006.

2.3.2 Nordic asset booms in the 1980s

The Nordic countries, Norway, Sweden and Finland, all experienced major asset booms and busts in the 1980s. In each country, the run-up in asset prices followed liberalization of their financial sectors after 5 decades of extensive controls on lending rates and government control over the sectoral allocation of bank lending.

Asset booms were accommodated by expansionary monetary policy as each country adhered to pegged exchange rates, which tended to make monetary policy pro-cyclical.

In the case of Norway, quantitative restrictions on bank lending were lifted in 1984 without allowing interest rates to rise. Real interest rates were low and sometimes negative. Banks used their newborn freedom to expand lending on a large scale: all of them with a firm desire to increase their market shares. This stimulated a massive real estate boom until 1986. The boom ended with tighter monetary policy in 1986. The legacy of the collapse of the real estate boom and the buildup in bad assets in the commercial banks was a banking crisis in 1991 and a recession (Steigum, 2009).

Similar stories occurred in Finland and Sweden (Jonung et al., 2009). Their crises and recessions were much worse than in Norway, largely because their currencies were pegged to the DM in the EMS system, and they were hard hit by tight German monetary policy in reaction to the high fiscal costs of German reunification.

2.3.3 Japan in the 1980s

The Japanese boom-bust cycle began in the mid-1980s with a run-up of real estate prices fueled by an increase in bank lending and easy monetary policy. The Bank of Japan began following a looser monetary policy after the Plaza Accord of 1985 to attempt to devalue the yen and ease the upward pressure on the dollar. The property price boom, in turn, led to a stock market boom as the increased value of property owned by firms raised future profits and, hence, stock prices (Iwaisako and Ito, 1995). Both rising land prices and stock prices, in turn, increased firms' collateral, encouraging further bank loans and more fuel for the boom. The bust may have been triggered by the Bank of Japan's pursuit of a tight monetary policy in 1989 to stem the asset market boom.

The subsequent asset price collapse in the next five years led to a collapse in bank lending with a decline in the collateral backing corporate loans. The decline in asset prices further impinged on the banking system's capital, making many banks insolvent. This occurred because the collapse in asset prices reduced the value of their capital. Lender of last resort policy prevented a classic banking panic, but regulatory forbearance propped up insolvent banks. It took over a decade to resolve the banking crisis and Japan is still mired in slow growth.

2.3.4 The 1994-2000 U.S. dot-com stock market boom

The stock market of the 1990s in the U.S. (and other countries) had many of the elements of the railroad boom in England in the 1840s and the Wall Street boom of the 1920s, including rapid productivity growth and the dissemination and marketing of technologies that had been developed earlier. Massive funds flowed from IPOs and the stock market to finance companies using the new high tech personal computer and internet based technologies. Significant run-ups in the market value of leaders like AOL and Microsoft (even before they reported profits) led others to join in the game. The investment boom in the IT industry led to a stock price boom in the late 1990s, which burst in 2000.

As in earlier booms, easy bank (and non-bank credit) finance was crucial, as well as accommodative monetary policy. As in the 1920s boom, the question arose whether the rise in stock prices reflected underlying fundamentals (referred to as the "New Economy") or a speculative bubble. The BIS view attributed the boom to the environment of low inflation and credibility for low inflation produced by the Federal Reserve and other central banks during the Great Moderation of the 1980s and 1990s. In this opinion, central banks, focused on low inflation, did not see the risks that the benign environment had for fostering an asset boom.

2.4.1 Commodity price booms: the 1930s

The recovery from the Great Contraction after 1933 witnessed a global commodity boom. Friedman and Schwartz (1963a) document the policies of Franklin Roosevelt and his Secretary of the Treasury, Henry Morgenthau, to purchase gold and silver in the London market to reflate the U.S. economy. They were following the approach suggested by Warren and Pearson (1935). The Treasury's gold and silver purchases succeeded in pushing up gold and silver prices in the London commodity market and may have also helped produce the general commodity boom of the mid-1930s. Other factors would have been global recovery and the looming threat of World War II.

2.4.2 Commodity Price Booms: the 1970s

The massive commodities boom in the 1970s has been viewed as a precursor to the Great Inflation. Following the monetarist transmission mechanism, expansionary monetary policy pushed up highly inelastic raw materials prices, which later fed into the prices of intermediate goods and final goods (Bordo, 1980). An alternative, widely held view at the time was that there were a series of negative supply shocks in the 1970s, which accounted for the boom (Blinder and Rudd, 2008). The most memorable events of the time were the two OPEC oil price shocks of 1974 and 1978. However, Barsky and Killian (2001) present evidence that what led to the formation of the OPEC cartel and its constriction of supply was an attempt to compensate the oil producers for a decline in the real value of oil prices in terms of dollars. This reflected global inflation aided by expansionary U.S. (and other countries) monetary policies beginning in the mid-1960s.

2.4.3 Commodity price booms: the 2000s

A run-up in commodity prices in the 2000s has popularly been attributed to globalization and the rapid growth of emerging market economies, especially China, which pushed up the prices of commodities, like copper, crucial to their economic development. However, there is also an argument that the boom reflected expansionary monetary policy in the U.S. and other advanced countries concerned over the threat of deflation after the dot-com boom burst (Frankel, 2008). The rise in commodity prices then fed into global inflation (Browne and Cronin, 2007; Ciccarelli and Mojon, 2010).

2.5 Summary

The wide history of asset price booms displays evidence of a connection between monetary expansion and booms. However, the circumstances of the different episodes varied considerably. In the case of some famous stock price booms (e.g. the 1840s, 1870s, 1920s and 1990s), the fundamental drivers were productivity shocks, such as the advent of the railroads, consumer durables and the internet. The run-up in asset prices was fueled by bank credit in an environment of accommodative monetary policy.

House price booms reflected real shocks on some occasions, such as rapid immigration, financial liberalization, as well as expansionary monetary policy. Commodity price booms also reflected both real shocks and highly expansionary monetary policy. In the rest of the paper we provide some empirical evidence on the contribution of monetary policy and several other factors in a large sample of asset price booms.

3. Identifying Asset Price Booms

Before outlining our econometric approach, we first identify asset price booms for real house prices, real stock prices and real commodity prices. Our approach to identifying boom/bust periods is a mixture of the formal and informal. We first use a well-known dating algorithm to find turning points in our asset price series, and then use our discretion to select those expansions/contraction pairs that meet our criteria. We do this to avoid some well-known problems that dating algorithms can have in identifying cycles when the underlying data are purely random (see, for example, Cogley and Nason, 1995).

The first step of the process is to date the turning points of our asset price series. We do this using the method described in Harding and Pagan (2002) and Pagan and Sossounov (2003). In these two related papers, the authors use the method of Bry and Boschan (1971) to date turning points of time series. The dating algorithm of Bry and Boschan (1971) was formulated to mimic the NBER dating process and is successful in dating turning points in time series. For real house prices and real commodity prices, we look for peaks (troughs) that are higher (lower) than the two nearest observations on each side of the turning point under the constraint that peaks and troughs must alternate. For real stock prices, because of the higher volatility of stock prices and the lower duration that is found for cycles in stock prices, we use a modified rule where a turning point is declared if the observation on each side of the peak (trough) is lower (higher) than the candidate turning point. Note that this is the first stage of our process. It is possible that the rule for the stock price series may identify expansion/contraction pairs that are nothing more than short-term "blips." This is the reason why in the second stage of the process we inspect the cycles found by the algorithm and reject those that do not meet our criteria.

For the second stage of our process we do the following, once turning points are identified, we inspect each expansion (defined as the period from a trough to the next peak) to see if it fits our definition of an asset price boom. To identify asset price booms, we take a "holistic" approach. That is, we first look for expansions that meet our criteria and then we visually inspect each prospective boom to check whether the dates for the boom should be corrected. For example, starting dates are moved to the point where the gradient of the asset price series first significantly picks up if the initial periods of the expansion are relatively flat.

The definition of a boom that we use is that a boom is a sustained expansion in asset prices that ends in a significant correction. The expansion is such that the rate of growth is higher than what would be considered usual based on previous cycles. For an expansion to meet the definition of a sustained expansion, the expansion must last at least two years and average at least 5% per year for real house and commodity prices, and average at least 10% per year for real stock prices. This is similar to the criteria used in Bordo and Wheelock (2009). The second screening that we use is that the price correction that follows the expansion in prices must be greater than 25% of the expansion in price that occurred during the expansion. We believe that this definition rules out secular trends where there can be large increases in asset prices followed by small corrections, followed by another large expansion. The booms that we identify are all followed by significant price corrections which suggest that the price expansion was not sustainable and, hence, a boom/bust period

The identified asset price booms are reported in tables 1, 2 and 3 and are depicted in figures in the appendix. We have annual data on real house prices and real stock prices for 18 countries from 1920 to 2010. We also have a single, real global commodity price index for that period.[6] The approach we follow is similar to that used in IMF WEO (2003), Helbling and Terrones (2004), and Bordo and Wheelock (2009). All of these studies used monthly data for a smaller set of countries. Only the Bordo and Wheelock study covered the pre-World War II period. As in the earlier studies we identify many more stock price booms than house price booms.

3.1 Housing Booms

With the exception of France in the 1930s and the U.S. in the 1920s, in table 1, we did not identify any house price booms before World War II. In the post-World War II period, most countries had house price booms in the 1970s and 1980s. The literature at the time associated them with the liberalization of financial markets that occurred after the breakdown of the Bretton Woods system. Many of the boom-busts were dramatic, especially in Japan, the Scandinavian countries, the Netherlands and Switzerland. The U.S. only experienced mild booms and corrections in that period. Several

6. For definitions of the data that we use, see the data appendix.

dramatic episodes occurred in the late 1990s and early 2000s. The U.S. housing boom of 1997-2006, when real prices rose by 79% and fell by 33%, and the Irish boom of 1996-2007, when real prices rose by 195% and then fell by 40%, really stands out.

Table 1. Identified Real House Price Booms

	Booms				*Corrections*			
	Period	*Duration*	*%Δ*	*APC*[a]	*Period*	*Duration*	*%Δ*	*APC*[a]
Belgium								
	1971-1979	8	58.9	7.36	1979-1985	6	-37.06	-6.18
Canada								
	1984-1989	5	57.52	11.5	1989-1998	9	-14.39	-1.6
Denmark								
	1982-1986	4	53.08	13.27	1986-1990	4	-25.72	-6.43
	2003-2007	4	53.49	13.37	2007-2009	2	-19.24	-9.62
Finland								
	1947-1955	8	50.77	6.35	1955-1958	3	-19.81	-6.6
	1971-1974	3	14.42	4.81	1974-1979	5	-26.82	-5.36
	1986-1989	3	61.85	20.62	1989-1993	4	-45.79	-11.45
France								
	1930-1935	5	37.69	7.54	1935-1941	6	-47.15	-7.86
	1971-1980	9	36.74	4.08	1980-1984	4	-16.76	-4.19
	1985-1991	6	30.84	5.14	1991-1997	6	-16.03	-2.67
U.K.								
	1971-1973	2	59.27	29.64	1973-1977	4	-30.91	-10.30
	1977-1980	3	26.18	8.73	1980-1982	2	-10.17	-5.08
	1985-1989	4	67.18	16.8	1989-1993	4	-26.83	-6.71
Ireland								
	1976-1979	3	40.58	13.53	1979-1987	8	-21.54	-2.69
	1996-2007	11	194.53	17.68	2007-2011	4	-40.52	-10.13
Italy								
	1980-1981	1	24.02	24.02	1981-1985	4	-30.65	-7.66
	1988-1992	4	49.63	12.41	1992-1997	5	-27.58	-5.52
Japan								
	1986-1991	5	34.16	6.83	1991-1994	3	-12.98	-4.33

Table 1. (continued)

	Booms				*Corrections*			
	Period	*Duration*	*%Δ*	*APC*[a]	*Period*	*Duration*	*%Δ*	*APC*[a]
Netherlands								
	1958-1964	6	51.11	8.52	1964-1966	2	-27.51	-13.75
	1976-1978	2	36.09	18.05	1978-1985	7	-47.75	-6.82
New Zealand								
	1971-1974	3	66.96	22.32	1974-1980	6	-38.19	-6.37
Norway								
	1983-1986	3	50.29	16.76	1986-1992	6	-35.2	-5.87
Sweden								
	1974-1979	5	22.02	4.4	1979-1985	6	-36.92	-6.15
	1985-1990	5	36.71	7.34	1990-1993	3	-28.58	-9.53
Switzerland								
	1971-1973	2	21.2	10.6	1973-1976	3	-26.01	-8.67
	1983-1989	6	43.31	7.22	1989-1997	8	-36.61	-4.58
United States								
	1921-1925	4	19.12	4.78	1925-1932	7	-12.57	-1.8
	1976-1979	3	14.47	4.82	1979-1982	3	-12.74	-4.25
	1984-1989	5	18.76	3.75	1989-1993	4	-13.01	-3.25
	1997-2006	9	79.38	8.82	2006-2009	3	-33.09	-11.03

Source: Authors' calculations.
a. APC = annualized percentage change.

3.2 Stock Price Booms

Stock prices show considerably more volatility than house prices, and many more booms and busts (table 2). In the pre-World War II period, most countries had major stock market booms and busts. In the 1920s, many countries had booms similar to that of Wall Street. The Wall Street boom saw real prices rising by 183% between 1923-1928, and collapsing by 63% between 1928-1932. The U.S. was surpassed by Canada and Switzerland, but Australia, Finland and Sweden were not far behind. This pattern of international concordance of stock prices is well known (Goetzmann, Li and Rouwenhorst, 2005). The recovery from the Great Contraction in the mid-1930s also displayed some major booms, especially in Australia, Canada, Finland, the U.K., Sweden, Switzerland and the U.S.

In the post-World War II era, booms reflecting Europe's recovery and catch up in the 1950s occurred in France, Italy and Switzerland. Japan also had a major boom in the 1950s. The Marshall Plan and the Dodge Plan may have been keen drivers of both rapid real growth and the rise in asset values in those years (Bordo and Wheelock, 2009).

The next big wave of stock market booms occurred in the 1980s and especially, the 1990s. The growth of the high tech industry led to dramatic booms in the U.S., U.K., Germany, Ireland, Italy, Spain, Sweden and Switzerland.

3.3 Commodity Price Booms

As discussed in section 3 above, table 3 shows the post-Great Contraction commodity price boom in the mid-1930s. The boom in the 1970s associated with the oil price shocks and the Great Inflation is also evident. The last big boom in the 2000s associated with the rapid growth of emerging markets and expansionary monetary policy is also very visible in the table.

Table 2. Identified Real Stock Price Booms

Booms				*Corrections*			
Period	*Duration*	*%Δ*	*APC*[a]	*Period*	*Duration*	*%Δ*	*APC*[a]
Australia							
1920-1928	8	128.67	16.08	1928-1930	2	-35.73	-17.87
1930-1936	6	154.21	25.7	1935-1941	5	-30.93	-6.19
1956-1959	3	65.71	21.9	1959-1960	1	-15.02	-15.02
1966-1969	3	79.3	26.43	1969-1971	2	-31.71	-15.85
1978-1980	2	61.93	30.96	1980-1982	2	-44.92	-22.46
2002-2007	5	88.03	17.61	2007-2008	1	-45.04	-45.04
Belgium							
1987-1989	2	58.41	29.2	1989-1990	1	-28.21	-28.21
1994-1998	4	141.32	35.33	1998-2002	4	-44.69	-11.17
2002-2006	4	115.02	28.75	2006-2008	2	-53.95	-26.97
Canada							
1920-1928	8	269.07	33.63	1928-1932	4	-64.99	-16.25
1932-1936	4	146.19	36.55	1936-1937	1	-23.19	-23.19
1953-1956	3	67.9	22.63	1956-1957	1	-24.81	-24.81
1977-1980	3	61.95	20.65	1980-1982	2	-29.57	-14.79
1998-2000	2	30.08	15.04	2000-2002	2	-29.22	-14.61
2002-2007	5	88.93	17.79	2007-2008	1	-35.77	-35.77

Table 2. (continued)

Booms				Corrections			
Period	*Duration*	*%Δ*	*APC*[a]	*Period*	*Duration*	*%Δ*	*APC*[a]
Denmark							
1932-1936	4	43.24	10.81	1936-1940	4	-42.37	-10.59
1952-1956	4	32.81	8.2	1956-1957	1	-13.46	-13.46
1957-1960	3	33.99	11.33	1960-1962	2	-11.88	-5.94
1987-1989	2	81.72	40.86	1989-1992	3	-31.93	-10.64
1998-2000	6	127.32	21.22	2000-2002	2	-35.79	-17.9
2002-2007	5	145.41	29.08	2007-2008	1	-50.17	-50.17
Finland							
1924-1927	3	154.64	51.55	1927-1929	2	-30.12	-15.06
1932-1936	4	115.41	28.85	1936-1940	4	-35.82	-8.96
1952-1956	4	87.27	21.82	1956-1958	2	-40.76	-20.38
1969-1973	4	1531.34	382.83	1973-1977	4	-68.6	-17.15
1985-1988	3	176.55	58.85	1988-1991	3	-63.41	-21.14
1995-1999	4	704.66	176.17	1999-2002	3	-62.93	-20.98
2004-2007	3	75.7	25.23	2007-2008	1	-54.95	-54.95
France							
1920-1923	3	82.56	27.52	1923-1926	3	-28.59	-9.53
1926-1928	2	109.19	54.59	1928-1931	3	-51.04	-17.01
1950-1957	7	241.61	34.52	1957-1958	1	-21.13	-21.13
1958-1962	4	76.66	19.17	1962-1967	5	-44.34	-8.87
1977-1979	2	39.84	19.92	1979-1982	3	-31.33	-10.44
1982-1986	4	218.43	54.61	1986-1987	1	-31.57	-31.57
1987-1989	2	84.78	42.39	1989-1990	1	-27.72	-27.72
1995-1999	4	195.91	48.98	1999-2002	3	-48.85	-16.28
2002-2007	4	78.47	19.62	2007-2009	2	-44.86	-22.43
United Kingdom							
1920-1928	8	41.11	5.14	1928-1931	3	-35.11	-11.7
1931-1936	5	73.77	14.75	1936-1940	4	-53.24	-13.31
1952-1954	2	47.91	23.96	1954-1857	3	-21.08	-7.03
1957-1959	2	87.9	43.95	1959-1962	3	-16.48	-5.49
1966-1968	2	70.35	35.17	1968-1970	2	-30.58	-15.29
1970-1972	2	36.77	18.38	1972-1974	2	-76.72	-38.36
1990-1999	9	143.86	15.98	1999-2002	3	-45.25	-15.08
2002-2006	4	49.8	12.45	2006-2008	2	-34.7	-17.35

Table 2. (continued)

	Booms				Corrections			
	Period	*Duration*	*%Δ*	*APC*[a]	*Period*	*Duration*	*%Δ*	*APC*[a]
Germany								
	1956-1960	4	231.36	57.84	1960-1968	2	-34.69	-17.34
	1966-1969	3	64.14	21.38	1969-1971	2	-27.79	-13.9
	1981-1986	5	180.19	36.04	1986-1987	1	-37.81	-37.81
	1987-1989	2	65.88	32.94	1989-1992	3	-29.3	-9.77
	1992-1999	7	189.84	27.12	1999-2002	3	-59.73	-19.91
	2002-2007	5	130.96	26.19	2007-2008	1	-44.98	-44.98
Ireland								
	1957-1968	11	248.42	22.58	1968-1970	2	-33.05	-16.52
	1976-1978	2	106.51	53.25	1978-1982	4	-58.36	-14.59
	1982-1989	7	303.94	43.42	1989-1990	1	-33.33	-33.33
	1992-2000	8	279.45	34.93	2000-2002	2	-36.21	-18.11
	2002-2006	4	109.43	27.36	2006-2008	2	-76.48	-38.24
Italy								
	1922-1924	2	59.29	29.64	1924-1926	2	-44.26	-22.13
	1926-1928	2	65.13	32.57	1928-1932	4	-50.07	-12.52
	1956-1960	4	140.27	35.07	1960-1964	4	-53.85	-13.46
	1977-1980	3	92.61	30.87	1980-1982	2	-29.77	-14.89
	1982-1986	4	212.07	53.02	1986-1987	1	-35.78	-35.78
	1987-1989	2	25.67	12.84	1989-1992	3	-45	-15.00
	1995-2000	5	190.82	38.16	2000-2002	2	-46.2	-23.10
	2002-2006	4	68.33	17.08	2006-2008	2	-55	-27.50
Japan								
	1923-1926	3	43.2	14.40	1926-1930	4	-16.49	-4.12
	1931-1933	2	89.73	44.87	1933-1938	5	-30.73	-6.15
	1957-1960	3	169.68	56.56	1960-1963	3	-25.68	-8.56
	1967-1969	2	66.51	33.26	1969-1970	1	-22.05	-22.05
	1970-1972	2	136.21	68.10	1972-1974	2	-48.76	-24.38
	1977-1989	12	479.01	39.92	1989-1992	3	-59.64	-19.88
	2001-2006	4	101.39	25.35	2006-2008	2	-49.13	-24.56
Netherlands								
	1924-1928	4	41.18	10.30	1928-1931	3	-62.06	-20.69
	1951-1955	4	119.73	29.93	1955-1956	1	-18.80	-18.80
	1956-1959	3	71.87	23.96	1959-1961	2	-14.00	-7.00
	1965-1967	2	56.05	28.02	1967-1970	3	-38.24	-12.75
	1993-1998	5	203.19	40.64	1998-2001	3	-54.89	-18.3
	2001-2006	5	57.64	11.53	2006-2007	1	-52.68	-52.68

Table 2. (continued)

	Booms				Corrections		
Period	*Duration*	*%Δ*	*APC*[a]	*Period*	*Duration*	*%Δ*	*APC*[a]
New Zealand							
1931-1934	3	52.51	17.50	1934-1938	4	-28.15	-7.04
1958-1964	6	117.6	19.60	1964-1966	2	-16.12	-8.06
1967-1969	2	47.54	23.77	1969-1971	2	-27.91	-13.95
1979-1981	2	45.44	22.72	1981-1982	1	-28.34	-28.34
1982-1986	4	324.35	81.09	1986-1988	2	-61.76	-30.88
Norway							
1921-1929	8	70.84	8.85	1929-1937	8	-41.47	5.18
1953-1956	3	36.23	12.08	1956-1958	2	-26.25	-13.12
1967-1970	3	69.70	23.23	1971-1971	1	-28.42	-28.42
1971-1973	2	37.59	18.79	1973-1975	2	-54.25	-27.12
2002-2007	5	231.3	46.26	2007-2008	1	-55.44	-55.44
2008-2010	2	76.58	38.29	2010-2011	1	-15.49	-15.49
Spain							
1950-1956	6	163.74	27.29	1956-1959	3	-48.60	-16.20
1961-1963	2	31.47	15.73	1963-1964	1	-13.87	-13.87
1967-1972	5	112.35	22.47	1972-1982	10	-91.31	-9.13
1982-1989	7	294.4	42.06	1989-1992	3	-38.81	-12.94
1994-1999	5	208.7	41.74	1999-2002	3	-43.39	-14.46
2002-2007	5	120.31	24.06	2007-2008	1	-41.40	-41.40
Sweden							
1923-1928	5	177.56	35.51	1928-1932	4	-62.81	-15.70
1932-1936	4	102.71	25.68	1926-1941	5	-35.40	-7.08
1958-1950	2	29.61	14.8	1950-1952	2	-19.58	-9.79
1952-1954	2	47.97	23.98	1954-1957	3	-17.92	-5.97
1957-1959	2	58.37	29.18	1959-1962	3	-17.90	-5.97
1962-1965	3	36.16	12.05	1965-1966	1	-26.52	-26.52
1970-1972	2	17.60	8.80	1972-1974	2	-18.40	-9.20
1979-1989	10	503.68	50.37	1989-1990	1	-37.86	-37.86
1992-1999	7	443.67	63.38	1999-2002	3	-56.63	-18.88
2002-2006	4	141.66	35.42	2006-2008	2	-48.28	-24.14
2008-2010	2	74.64	37.32	2010-2011	1	-18.09	-18.09
Switzerland							
1920-1928	8	214.08	26.76	1928-1931	3	-46.72	-15.57
1935-1938	3	88.88	29.63	1938-1940	2	-35.94	-17.97
1957-1961	4	187.92	46.98	1961-1966	5	-67.27	-13.45
1990-2000	10	342.77	34.28	2000-2002	2	-44.58	-22.29
2002-2006	4	91.21	22.8	2006-2008	2	-38.88	-19.44

Table 2. (continued)

Booms				*Corrections*			
Period	*Duration*	*%Δ*	*APC*[a]	*Period*	*Duration*	*%Δ*	*APC*[a]
United States							
1923-1928	5	182.59	36.52	1928-1932	4	-63.07	-15.77
1934-1936	2	73.15	36.57	1936-1937	1	-40.34	-40.34
1953-1956	3	83.34	27.78	1956-1957	1	-16.73	-16.73
1962-1965	3	40.03	13.34	1965-1966	1	-16.00	-16.00
1966-1968	2	19.82	9.91	1968-1970	2	-20.86	-10.43
1970-1972	2	19.97	9.98	1972-1974	2	-52.44	-26.22
1994-1999	5	184.55	36.91	1999-2002	3	-44.29	-14.76

Source: Authors' calculations.
a. APC = annualized percentage change.

Table 3. Identified Real Commodity Price Booms

Booms				*Corrections*			
Period	*Duration*	*%Δ*	*APC*[a]	*Period*	*Duration*	*%Δ*	*APC*[a]
1933-1938	5	88.86	17.77	1938-1940	2	-17.7	-8.85
1950-1952	2	38.11	19.06	1952-1954	2	-22.98	-11.49
1963-1967	4	27.52	6.88	1967-1969	2	-19.56	-9.78
1972-1975	3	141.94	47.31	1975-1976	1	-13.23	-13.23
1976-1981	5	113.44	22.69	1981-1983	2	-24.74	-12.37
1986-1989	3	53.3	17.77	1989-1992	3	-24.96	-8.32
1994-1996	2	35.62	17.81	1996-2000	4	-28.96	-7.24
2002-2009	7	139.08	19.87	2009-2010	1	-19.71	-19.71

Source: Authors' calculations.
a. APC = annualized percentage change.

4. Empirical Analysis

In this analysis, we pool data from across the 18 countries in our data set to investigate the impact of loose monetary policy and low inflation on asset prices.[7] By pooling the data across the twentieth century, we are in a sense calculating the impact each of our control variables has on asset prices averaged across all the boom periods that we have identified. Low inflation could reflect the credibility for low inflation that occurred in the 1980s, 1990s and 1920s, according to Borio and Lowe (2002) and Eichengreen and Michener (2004). In this environment, endogenous asset price booms could arise, financed by easy credit accommodated by the central bank. Loose monetary policy refers to deliberately expansionary monetary policy (as evidenced in the policy rate being below the Taylor rule rate) made, for example, to prevent deflation as in the 2000s, or to stimulate recovery from a recession.

The asset price data that we use in the analysis are real house prices, real stock prices, and real commodity prices. We include two different measures of monetary policy: the deviation of a short-term interest rate from the optimal Taylor rule rate, and the deviation of the money growth rate from 3%. The optimal Taylor rule rate is given by the following equation:

$$r^{Taylor} = \pi_t + r^* + 0.5\left(y_t - y_t^*\right) + 0.5\left(\pi_t - \pi^*\right), \tag{1}$$

where the output gap term is given by the deviation in logging real GDP from its long run trend (as determined by the Hodrick-Prescott filter with a smoothing parameter equal to 100, since the data are annual time series) and the inflation target is 2%. It should be noted that we do not use policy rates in this analysis and that we use, for all countries, a target interest rate (r^*) of 2% with coefficients of 0.5 and 0.5 as in Taylor (1993). Thus the optimal Taylor rule rate that we use is a very rough measure of the optimal policy rate for each country.[8] The same goes for our measure of monetary policy using the

7. The countries in our sample are Australia, Belgium, Canada, Denmark, Finland, France, Germany, Great Britain, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Spain, Sweden, Switzerland and the U.S. Countries are included in our regressions if data is available. When the number of countries reported for a regression is less than 18, it is because data for a country is missing.

8. As we collect more data, in particular data on policy rates, we will check the sensitivity of our results to this rough measure of the optimal policy rate.

growth rate of broad money. We use the deviation of the growth rate of money from 3% as a simple measure of the stance of monetary policy present at the time. It also represents Milton Friedman's original (1960) monetary rule—to set money growth equal to the underlying trend growth rate of real output.[9] If we assume the trend growth rate in velocity is constant, this rule would give stable prices.[10] Money growth is also a useful measure of the stance of monetary policy in earlier periods when central banks engaged in monetary targeting or in episodes when it is more difficult to estimate a Taylor rule.

The three main controls that we use in our regressions are the deviation of monetary policy from the "optimal" policy rule, either the Taylor rule or the Friedman money growth rule, a measure of the inflationary state of the economy—a measure of the deviation of inflation from its long run trend, and a measure of the credit conditions present as measured by the deviation of the share of bank loans to GDP from its long run mean.

The deviation of the short-term interest rate (money growth rate) from the optimal rate is included to control for possible correlations between "loose" monetary policy and asset booms. The inflation control is included to control for possible correlations between low inflation policy and booms, and the credit control variable is included to determine if loose or "easy" credit has a role in asset booms. These variables are consistent with the Austrian BIS story, as well as recent papers by Schularick and Taylor (2012), Jorda, Schularick and Taylor (2012) and Christiano et al. (2010).

These are the three main alternative variables that have been argued to play a role in asset booms, and the aim of this paper is to use data over the whole twentieth century to shed light on their roles. Of course these are not the only determinants of asset prices, so we also include other controls, such as the growth rate of GDP, a measure of current account imbalances and a measure of financial liberalization.[11]

The data in their raw form are non-stationary, either through the presence of a unit root or a time trend. In this paper we are mainly interested in the role that our three main controls play in boom/

9. The trend growth rate of real output would roughly hold for the U.S. 1920-2010 but may be too high for some countries like the U.K., and too low for others.

10. Over the 1920-2010 period, the trend growth rate of velocity was close to zero, averaging a decline to the 1960s and an increase since Bordo and Jonung (1987).

11. See the Data Appendix for a description of the sources for the data used in this analysis.

bust periods. These periods are identified earlier as periods where there were sustained run-ups in asset prices followed by significant corrections. That is, these asset price booms are periods in which asset prices move away from their long-run trend. Our interest is to see whether or not there is a systematic relationship between deviations of our three main variables from their long-run trend, or in the case of the policy variable, the optimal rate, and the deviation of asset prices from its long-run trend. Thus, we are not focusing on secular movements and the relationship between asset price levels and the rate of inflation, interest rates, or the amount of credit available in the economy, but rather we are focusing on examining the departures from the norm.

Because of this, we convert all variables to deviations from a long-run trend. The policy variables, the short-term interest rate and the growth rate of M2 are deviated from the "optimal" rate. We do this using the Hodrick-Prescott (HP) filter with a smoothing parameter set to 100, since our data are collected at the annual frequency. [12]

Therefore, the variables used in our regression analysis are negative when the value is below the long-run trend, and positive when the variable is above the long run trend. Our regression analysis then investigates the relationship between the deviation from the long run trend of asset prices, the deviation of inflation and credit from their long term trend, and the deviation of the short term interest rate from the "optimal" Taylor rule rate (or deviation of the growth rate of money from 3% in the case where we use money growth rates in our regression). When the short term rate is below the "optimal" Taylor rule rate or the money growth rate is above 3%, then the monetary policy conditions are "loose".

The model that is used is an autoregressive distributed lag (ARDL) model given by

$$\hat{p}_t = \alpha + \sum_{j=1}^{p} \beta_j \hat{p}_{t-j} + \sum_{k=1}^{3} \sum_{j=0}^{q} \gamma_{kj} \hat{x}_{kt-j} + \varepsilon_t. \tag{2}$$

12. In order to make the current account variable stationary, we use deviations from its long-run (HP) trend. Thus, if the deviation is negative, the current account has worsened relative to its recent past; and if the value of this gap is positive, the current account has improved relative to its recent past. A positive value does not necessarily mean the current account is in surplus, and a negative value does not necessarily mean the current account is in deficit.

Here, variables in "hats" refer to deviations from trend, or in the case of the monetary policy variables, the "hats" refer to deviations from the optimal policy—the Taylor rule for interest rates and the Friedman rule for money growth. We include the three main control variables into the regression with lags in order to investigate the dynamic structure of low inflation, "loose" monetary policy, and relatively abundant or "easy" credit on asset prices. In determining the number of lags to include from each variable in our regression equation, sequential likelihood ratio tests are used. For simplicity we do not allow for different numbers of lags for each of the right hand side control variables.

Tables 4, 5 and 6 show the results for real house prices, real stock prices and real commodity prices for each of the monetary variables, respectively. The first two sets of regressions—the ones with house and stock prices as dependent variables—are panel regressions, and in these two regression equations country specific fixed effects are included. For the regression for real commodity prices, because the market for commodities is a global market, lacking measures of global monetary policy, we use U.S. data as covariates.

4.1 Real House Prices

Tables 4A and 4B report the results from our panel regressions where real house prices are the dependent variable. In all tables the numbers in parentheses are p-values. Country specific fixed effects are included, but their estimates are not reported for space considerations. There are four regressions reported in each table. The first regression is the basic ARDL model with only current and lagged deviations of trend of the three main control variables included. In table 4A the "policy" variable that is included is the deviation of the short-term interest rate from the "optimal" rate given by the Taylor rule in (1). Table 4B includes the deviation of the growth rate of M2 from 3%. In both regressions it was determined that one lag of the dependent variable, the current value and two lags of the control variables should be included. In order to allow for the possibility that the three main covariates are only important during the boom periods, we include interactions between a dummy variable (D), that for each country takes a value of 0 if period t is not in a boom, and a value of 1 if period t is in a boom. Thus, we are able to tell if there are any nonlinearities present in the relationship between the controls and asset price deviations.

Regression (1) reported in table 4A reports the estimates of (2) when we include the policy variable, the inflation variable, and the credit variable. For the policy variable, which is the deviation of the short-term interest rate from the Taylor rule rate, the coefficient on the first lag is significant and negative. This means that for every 1 percentage point you lower the short-term interest rate below the implied Taylor rule rate, real house prices would increase by 0.40% in the next period.[13] This is obviously a very small impact and given that the second lag is significant and positive the overall impact of a sustained period with the short-term interest rate below its target would not have a large initial impact on house prices.

As for the deviation of inflation from its long-run trend, again, the first lag is significant and negative. Thus a negative deviation of one percentage point in the inflation from its long-run trend would lead to an increase in house prices of 0.85%. Again, this initial impact is small. As for the variable that measures the deviation of credit from its long-run trend, there are no significant terms.

The results above are what you would expect in "normal" situations, that is, when $D = 0$. During boom periods, when $D = 1$, the impacts of deviations from trend are more striking. For the policy deviation variable, $(r^s - r^{Taylor})_t$,there is a significant and large negative coefficient on the second lag. Thus, when in a boom period the initial impact of a negative deviation from the Taylor-rule rate of one percentage point leads to a 2.15 percent increase in house prices two periods later. This large and significantly negative estimate is consistent across all specifications of our regression models and indicates that "loose" monetary policy is associated with increases in house prices during the identified boom periods.

The same results are apparent for the inflation deviation and the credit deviation. For inflation during boom periods, there are significant and negative coefficients on the current period and the second lag. The first lag is also significant but is positive, which means that the impact of a sustained one percentage point fall in inflation will be negative and in the range of 2.5%, initially.

13. Note that all variables are in decimals, so that a 1 percentage point change is equivalent to a change of 0.01. Also note that the presence of a lagged dependent variable means that the long-run cumulative impact of this change can be higher than the initial impacts, but for the purposes of this discussion we will discuss only the initial impacts.

Table 4A. Panel Regression Results for Real House Prices (Taylor Rule)[a]

Dependent Variable: Deviation of log Real House Prices from lon–run trend (HP trend)

Regressors	*(1)*	*(2)*	*(3)*	*(4)*
$(p - \bar{p})_{t-1}$	0.77*** (0.00)	0.80*** (0.00)	0.80*** (0.00)	0.79*** (0.00)
$(r^s - r^{Taylor})_t$	0.04 (0.77)	0.10 (0.42)	-0.02 (0.90)	-0.16 (0.35)
$(r^s - r^{Taylor})_{t-1}$	-0.40** (0.02)	-0.24 (0.16)	-0.06 (0.78)	-0.05 (0.80)
$(r^s - r^{Taylor})_{t-2}$	0.26** (0.03)	0.05 (0.66)	0.03 (0.87)	0.02 (0.88)
$(\pi - \bar{\pi})_t$	0.17 (0.43)	0.26 (0.21)	-0.06 (0.84)	-0.17 (0.59)
$(\pi - \bar{\pi})_{t-1}$	-0.85*** (0.00)	-0.55** (0.04)	-0.07 (0.83)	-0.07 (0.85)
$(\pi - \bar{\pi})_{t-2}$	0.12 (0.57)	-0.15 (0.50)	-0.35 (0.26)	-0.44 (0.17)
$(L/Y - \overline{L/Y})_t$	-0.07 (0.17)	0.01 (0.89)	-0.12 (0.12)	-0.11 (0.15)
$(L/Y - \overline{L/Y})_{t-1}$	-0.03 (0.67)	-0.08 (0.21)	-0.06 (0.49)	-0.05 (0.56)
$(L/Y - \overline{L/Y})_{t-2}$	0.01 (0.89)	0.03 (0.57)	0.08 (0.23)	0.14** (0.05)
$D^*(p - \bar{p})_{t-1}$	0.17** (0.02)	0.14* (0.09)	0.10 (0.29)	0.00 (1.00)
$D^*(r^s - r^{Taylor})_t$	0.22 (0.48)	0.26 (0.42)	0.15 (0.68)	1.01 (0.06)
$D^*(r^s - r^{Taylor})_{t-1}$	0.47 (0.27)	0.49 (0.26)	0.68 (0.16)	0.24 (0.75)
$D^*(r^s - r^{Taylor})_{t-2}$	-1.30*** (0.00)	-1.19*** (0.00)	-1.33*** (0.00)	-1.69*** (0.00)
$D^*(\pi - \bar{\pi})_t$	-0.80* (0.09)	-0.71 (0.14)	-0.75 (0.19)	-0.13 (0.85)
$D^*(\pi - \bar{\pi})_{t-1}$	1.11* (0.10)	1.16* (0.09)	1.27 (0.11)	0.79 (0.38)
$D^*(\pi - \bar{\pi})_{t-2}$	-2.32*** (0.00)	-2.17*** (0.00)	-2.16*** (0.00)	-2.13*** (0.01)
$D^*(L/Y - \overline{L/Y})_t$	0.51*** (0.00)	0.44*** (0.00)	0.55*** (0.00)	0.56*** (0.00)
$D^*(L/Y - \overline{L/Y})_{t-1}$	-0.11 (0.58)	-0.18 (0.38)	-0.19 (0.41)	-0.20 (0.43)
$D^*(L/Y - \overline{L/Y})_{t-2}$	-0.35** (0.02)	-0.31** (0.03)	-0.35** (0.04)	-0.39** (0.03)

Table 4A. (continued)

Regressors	*(1)*	*(2)*	*(3)*	*(4)*
GDP growth		0.01*** (0.00)	0.01*** (0.00)	0.01*** (0.00)
Current account			-0.01*** (0.00)	-0.01*** (0.00)
Change in financial innovation				0.00 (0.65)
R^2	0.69	0.72	0.75	0.75
$\bar{R}^2$	0.67	0.70	0.73	0.72

Source: Authors' calculations.
a. Fixed effects included in regression but not reported. Numbers in parentheses are p-values.

The credit variable showed little impact during normal periods, but during the identified boom periods the coefficients are significant and positive for the current period and significant and negative for the second lag. This suggests that a one percent increase in loans, as a proportion of GDP, would lead house prices increasing in the short term but that this increase would be small and to the order of 0.25% to 0.5%. It should be noted that the modest size of this effect is in contrast to results reported in Jorda et al. (2012) and Christiano et al. (2010). Our estimates are based on panel estimates using evidence for booms across most of the twentieth century and so the estimates we report are essentially averages of the impact of credit expansion for each of the booms. It could be that the credit expansion story is appropriate for the most recent boom but not for earlier booms. The fact that we get a lower impact, on average, does not necessarily contradict the results from these authors.

As in the case of the policy variable, the evidence points to there being a bigger effect during booms than in calmer periods. This result that "loose" monetary policy, low inflation, and "easy" credit are associated with increases in house prices during boom periods is consistent across the other specifications and the impact of these variables is higher in magnitude than GDP growth and the measure of current account imbalance. The financial liberalization variable does not have any impact.[14]

14. Data for the financial liberalization variable are only available from 1970 onwards; so this regression only includes data after 1970.

Thus, there is evidence that during boom periods the relationship between interest rates, low inflation, credit conditions and house prices is heightened and conducive to fueling even higher prices.

Table 4B reports the same regression results as above, except this time the deviation of money growth (M2) is used as our measure of expansionary monetary policy instead of the deviation of the short term interest rate from the optimal Taylor-rule rate. The results are reasonably consistent with the one reported above. A "loose" monetary condition which, in this case, means having a growth rate of money larger than the Friedman rule rate of 3%, is associated with an increase in house prices and this impact is greater during the identified boom periods than during normal periods. The same goes for credit, in that "easy" credit is associated with higher house prices; again, this is heightened during boom periods.

However, the one result that is different from the results reported in Table 4A for the interest rate variable is that low inflation does not appear to have a heightened impact during boom periods. Low inflation does have a significant and negative effect in normal times, but the interaction term where the boom dummy is interacted with the deviation of inflation from its long-run trend is not significant. Our conjecture is that money growth and inflation have been correlated in the past, for example during the 1960's and 1970's, and this is why the impact of inflation in the money growth regressions is reduced.

Overall, the results reported in table 4B do indicate that the impact of the three variables is to increase house prices, and this impact is heightened during the identified boom periods. Again, the results are reasonably consistent across the different specifications.

Another reason why there might be differences between the two approaches is that some of the bigger booms occurred in the late 1980s and early 1990s in a period when the use of interest rates became more prevalent than money growth rates as policy instruments for the countries in our sample. This is obviously only speculation but does warrant further investigation.

Table 4B. Panel Regression Results for Real House Prices
(Money Growth Rate Rule)

Dependent Variable: Deviation of log Real House Prices from long–run trend (HP trend)

Regressors	*(1)*	*(2)*	*(3)*	*(4)*
$(p - \bar{p})_{t-1}$	0.72*** (0.00)	0.73*** (0.00)	0.80*** (0.00)	0.78*** (0.00)
$(\Delta\log(m) - 0.03)_t$	0.01 (0.86)	0.07 (0.29)	0.13 (0.11)	0.12 (0.17)
$(\Delta\log(m) - 0.03)_{t-1}$	0.14*** (0.01)	0.13* (0.08)	0.01 (0.88)	0.06 (0.51)
$(\Delta\log(m) - 0.03)_{t-2}$	-0.04 (0.45)	-0.06 (0.33)	-0.13* (0.09)	-0.12 (0.15)
$(\pi - \bar{\pi})_t$	-0.12 (0.26)	-0.12 (0.26)	0.06 (0.77)	0.14 (0.52)
$(\pi - \bar{\pi})_{t-1}$	-0.08 (0.41)	0.00 (0.98)	-0.06 (0.74)	-0.04 (0.85)
$(\pi - \bar{\pi})_{t-2}$	-0.51*** (0.00)	-0.45*** (0.00)	-0.33*** (0.08)	-0.44*** (0.04)
$(L/Y - \overline{L/Y})_t$	-0.05 (0.33)	0.00 (0.92)	-0.14 (0.06)	-0.14 (0.08)
$(L/Y - \overline{L/Y})_{t-1}$	0.03 (0.60)	0.01 (0.86)	-0.02 (0.83)	-0.02 (0.83)
$(L/Y - \overline{L/Y})_{t-2}$	-0.02 (0.62)	-0.03 (0.58)	0.07 (0.32)	0.12 (0.08)
$D^*(p - \bar{p})_{t-1}$	0.29*** (0.00)	0.30*** (0.00)	0.19** (0.04)	0.17* (0.10)
$D^*(\Delta\log(m) - 0.03)_t$	0.17 (0.16)	0.17 (0.24)	0.32** (0.05)	0.26 (0.15)
$D^*(\Delta\log(m) - 0.03)_{t-1}$	0.30** (0.02)	0.07 (0.67)	-0.02 (0.93)	-0.14 (0.49)
$D^*(\Delta\log(m) - 0.03)_{t-2}$	0.23* (0.06)	0.29* (0.06)	0.25 (0.15)	0.32* (0.09)
$D^*(\pi - \bar{\pi})_t$	-0.18 (0.55)	-0.40 (0.26)	-0.55 (0.17)	-0.75 (0.14)
$D^*(\pi - \bar{\pi})_{t-1}$	0.17 (0.63)	0.31 (0.46)	0.27 (0.54)	0.67 (0.29)
$D^*(\pi - \bar{\pi})_{t-2}$	0.06 (0.82)	-0.24 (0.43)	-0.24 (0.48)	-0.25 (0.61)
$D^*(L/Y - \overline{L/Y})_t$	0.27** (0.04)	0.22 (0.14)	0.33** (0.04)	0.32* (0.06)
$D^*(L/Y - \overline{L/Y})_{t-1}$	-0.09 (0.66)	-0.07 (0.76)	-0.05 (0.83)	-0.06 (0.80)
$D^*(L/Y - \overline{L/Y})_{t-2}$	-0.15 (0.28)	-0.21 (0.18)	-0.28* (0.10)	-0.32* (0.07)

Table 4B. (continued)

Regressors	*(1)*	*(2)*	*(3)*	*(4)*
GDP growth		0.00*** (0.00)	0.01*** (0.00)	0.01*** (0.00)
Current account			-0.01*** (0.00)	-0.01*** (0.00)
Change in financial innovation				0.00 (0.50)
R^2	0.69	0.72	0.75	0.75
$\bar{R}^2$	0.67	0.70	0.73	0.72

Source: Authors' calculations.
a. Fixed effects included in regression but not reported. Numbers in parentheses are p-values.

4.2 Real Stock Prices

Tables 5A and 5B repeat the analysis for real stock prices. The specification used in his regression was to include one lag of the dependent variable and the current value, and one lag of the three control variables. The results for the case, when the interest rate deviation is used as a measure of the looseness of monetary policy, are reported in table 5A.

For the "normal" periods, that is, for periods that are not designated to be boom periods, the interest rate deviation and the inflation deviation variables have significant coefficients. For the interest rate deviation, the results are mixed, in that while the coefficient on the current value of the interest rate deviation is negative and highly significant, the coefficient on the first lag of the interest rate deviation is equally large and positive. In fact, the sum of the two estimates is slightly positive. The same qualitative result also occurs for the inflation deviation, but this time the sum of the two estimates is negative. For the normal period, at least, "easy" credit does not appear to be associated with increases in stock prices.

As in the case of house prices there is evidence of nonlinearity in the results, in that there are significant coefficients on the interaction terms. In fact, the coefficient on the lag of the interest rate deviation is very negative and significant. Given that the regular coefficients on the interest rate deviation "wash out," there only appears to be a relationship between "loose" monetary policy and higher stock prices

Table 5A. Panel Regression Results for Real Stock Prices
(Taylor Rule)[a]

Dependent Variable: Deviation of log Real Stock Prices from long–run trend (HP trend)

Regressors	*(1)*	*(2)*	*(3)*	*(4)*
$(p-\bar{p})_{t-1}$	0.32*** (0.00)	0.27*** (0.00)	0.25*** (0.00)	0.30*** (0.00)
$(r^s - r^{Taylor})_t$	-2.02*** (0.00)	-1.94*** (0.00)	-1.76*** (0.01)	-1.99*** (0.01)
$(r^s - r^{Taylor})_{t-1}$	2.33*** (0.00)	2.29*** (0.00)	2.14*** (0.00)	2.22*** (0.01)
$(\pi-\bar{\pi})_t$	-3.45*** (0.00)	-3.08*** (0.00)	-2.90*** (0.01)	-3.59*** (0.01)
$(\pi-\bar{\pi})_{t-1}$	2.48*** (0.00)	2.49*** (0.00)	2.60** (0.03)	3.16** (0.03)
$(L/Y-\overline{L/Y})_t$	0.14 (0.47)	0.25 (0.24)	0.40 (0.22)	0.52 (0.14)
$(L/Y-\overline{L/Y})_{t-1}$	-0.20 (0.29)	-0.29 (0.16)	-0.26 (0.37)	-0.30 (0.35)
$D^*(p-\bar{p})_{t-1}$	0.35*** (0.00)	0.38*** (0.00)	0.43*** (0.00)	0.31*** (0.01)
$D^*(r^s - r^{Taylor})_t$	0.61 (0.44)	0.92 (0.27)	0.80 (0.46)	1.31 (0.28)
$D^*(r^s - r^{Taylor})_{t-1}$	-1.45** (0.06)	-1.74** (0.03)	-1.49 (0.17)	-1.54 (0.19)
$D^*(\pi-\bar{\pi})_t$	-0.36 (0.77)	-0.10 (0.94)	0.05 (0.98)	1.01 (0.62)
$D^*(\pi-\bar{\pi})_{t-1}$	-2.19 (0.11)	-2.49* (0.08)	-3.04 (0.13)	-4.72* (0.04)
$D^*(L/Y-\overline{L/Y})_t$	0.65** (0.03)	0.44 (0.16)	0.39 (0.38)	0.12 (0.79)
$D^*(L/Y-\overline{L/Y})_{t-1}$	-0.30 (0.30)	-0.13 (0.67)	-0.30 (0.48)	-0.11 (0.81)
GDP growth		0.01*** (0.01)	0.01* (0.06)	0.01* (0.06)
Current account			0.02** (0.04)	0.01* (0.08)
Change in financial innovation				0.00 (0.89)
R^2	0.38	0.38	0.39	0.39
$\bar{R}^2$	0.35	0.35	0.34	0.33

Source: Authors' calculations.
a. Fixed effects included in regression but not reported. Numbers in parentheses are *p*-values.

during the identified boom periods. The initial impact of the interest rate being one percentage point below the optimal rate is between 1.5% and 1.75% on stock prices. This negative and significant result is not consistent across all specifications. Once the current account variable is added, the significance disappears, but we must be careful to point out that the data for the current account variable is limited, and only goes back to the 1950's. Because of these data's limitations, not all the stock market booms before World War II are included in regression (3) or (4).

For the inflation variable, there is some evidence of an extra kick during the booms. The impact is quite large—to the order of +2.5% in the case of regression (2)—but the significance is marginal. As for the credit variable—except for regression (1), where the coefficient is significant and positive for the interaction term—there is little evidence that "easy" credit has any impact on stock price booms.

Overall, there is, again, evidence that "loose" monetary policy and low inflation acts to boost stock prices and that this boost was heightened during the identified boom periods.

Next we re-estimate our model using the other measure of monetary policy; namely, the deviation of the growth rate of M2 from the Friedman 3% rule. The results are reported in table 5B. The results are qualitatively similar to the ones reported in table 5A. The monetary variable has inconsistent signs during "normal" periods, but it is large and, in this case, positive during the boom periods. This, again, suggests a relationship between "loose" monetary policy and increases in stock prices, especially during boom periods.

Interestingly, just as in the house price regressions, the impact of low inflation is only significant during the "normal" periods and there is no added "boost" during the boom periods. What is different however is that credit is not significant and positive. As in the case with the inflation variable, this positive impact on prices from "easy" credit—a value of the loans to GDP ratio that is above trend—is only evident during the "normal" periods. Again, there is no heightened effect during the booms.

This is an interesting result and one conjecture could be that the results, when we use the money growth variable, are being driven by the early periods where it is more likely that there is a strong relationship between credit conditions and the growth rate of money (Schularick and Taylor, 2012). It may be that the low inflation and credit story is more relevant during the latter part of twentieth century than in the early part.

Table 5B. Panel Regression Results for Real Stock Prices
(Money Growth Rate Rule)[a]

Dependent Variable: Deviation of log Real House Prices from long–run trend (HP trend)

Regressors	*(1)*	*(2)*	*(3)*	*(4)*
$(p - \bar{p})_{t-1}$	0.36*** (0.00)	0.32*** (0.00)	0.25*** (0.00)	0.30*** (0.00)
$(\Delta\log(m) - 0.03)_t$	0.28* (0.06)	0.42** (0.05)	0.46 (0.16)	0.20 (0.58)
$(\Delta\log(m) - 0.03)_{t-1}$	-0.34** (0.02)	-0.66*** (0.00)	-1.01*** (0.00)	-0.75** (0.03)
$(\pi - \bar{\pi})_t$	-0.66* (0.06)	-0.43 (0.25)	-1.21* (0.09)	-1.78 (0.07)
$(\pi - \bar{\pi})_{t-1}$	-0.73** (0.04)	-0.60 (0.11)	-0.40 (0.58)	0.22 (0.82)
$(L/Y - \overline{L/Y})_t$	0.30* (0.06)	0.48*** (0.01)	0.59* (0.06)	0.61* (0.08)
$(L/Y - \overline{L/Y})_{t-1}$	-0.23 (0.16)	-0.39 (0.03)	-0.32 (0.27)	-0.33 (0.31)
$D^*(p - \bar{p})_{t-1}$	0.32*** (0.00)	0.35*** (0.00)	0.42*** (0.00)	0.29*** (0.01)
$D^*(\Delta\log(m) - 0.03)_t$	1.07*** (0.00)	1.02*** (0.00)	0.22 (0.66)	0.27 (0.64)
$D^*(\Delta\log(m) - 0.03)_{t-1}$	-0.38 (0.17)	-0.32 (0.35)	0.22 (0.67)	-0.14 (0.80)
$D^*(\pi - \bar{\pi})_t$	-0.58 (0.29)	-0.80 (0.18)	-0.29 (0.81)	0.14 (0.92)
$D^*(\pi - \bar{\pi})_{t-1}$	-0.17 (0.75)	-0.14 (0.80)	-1.01 (0.41)	-2.80 (0.06)
$D^*(L/Y - \overline{L/Y})_t$	0.23 (0.36)	-0.01 (0.96)	0.09 (0.83)	-0.05 (0.92)
$D^*(L/Y - \overline{L/Y})_{t-1}$	0.00 (1.00)	0.25 (0.35)	-0.07 (0.87)	0.08 (0.86)
GDP growth		0.01*** (0.00)	0.01** (0.03)	0.01** (0.04)
Current account			0.02** (0.03)	0.02* (0.06)
Change in financial innovation				0.00 (0.74)
R^2	0.37	0.39	0.39	0.39
$\bar{R}^2$	0.35	0.36	0.35	0.33

Source: Authors' calculations.
a. Fixed effects included in regression but not reported. Numbers in parentheses are p-values.

4.3 Real Commodity Prices

Tables 6A and 6B report our estimated results for real commodity prices. Because of the global nature of the commodity price market, in lieu of global monetary policy measures, we use U.S. data in these regressions. This means that we are unable to use a panel for this estimation; therefore, the number of observations available to us for these regressions is quite small.

For the interest rate deviation there are mixed results for the "normal" period in that the coefficient on the current period is significant and positive, while the coefficient on the first lag is negative and significant. Thus, during normal periods, the cumulative impact of a sustained decrease in the interest rate below the Taylor-rule rate would have a positive—but small—impact on commodity prices. However, during the boom periods, the impact of the interest rate deviation is significant and negative. Again, there appears to be a heightened impact on commodity prices of "loose" monetary policy during boom periods.

There is some evidence that low inflation also has a positive impact on commodity prices, but there is no "boost" during the boom periods, while there is no evidence that "easy" credit has a positive impact on commodity prices.

Table 6A. Panel Regression Results for Real Commodity Prices (Taylor Rule)[a]

Dependent Variable: Deviation of log Real Commodity Prices from long—run trend (HP trend)

Regressors	*(1)*	*(2)*	*(3)*	*(4)*
$(p - \bar{p})_{t-1}$	0.71*** (0.00)	0.66*** (0.00)	0.38*** (0.27)	0.35*** (0.53)
$(r^s - r^{Taylor})_t$	5.40** (0.02)	7.78*** (0.00)	6.15 (0.35)	7.01 (0.64)
$(r^s - r^{Taylor})_{t-1}$	-6.36* (0.07)	-7.94** (0.02)	-5.49 (0.51)	-5.74 (0.62)
$(r^s - r^{Taylor})_{t-2}$	2.30 (0.28)	1.64 (0.42)	-0.08 (0.99)	-0.46 (0.96)
$(\pi - \bar{\pi})_t$	4.62* (0.07)	6.32*** (0.01)	10.02* (0.09)	10.66 (0.45)
$(\pi - \bar{\pi})_{t-1}$	-7.68** (0.02)	-7.21** (0.02)	-6.25 (0.52)	-6.10 (0.67)

Table 6A. (continued)

Regressors	*(1)*	*(2)*	*(3)*	*(4)*
$(\pi - \overline{\pi})_{t-2}$	2.07 (0.52)	0.26 (0.93)	-1.03 (0.89)	-2.14 (0.90)
$(L/Y - \overline{L/Y})_t$	-0.72 (0.47)	-1.11 (0.24)	-0.62 (0.75)	-1.33 (0.78)
$(L/Y - \overline{L/Y})_{t-1}$	0.88 (0.35)	0.86 (0.32)	1.46 (0.44)	1.64 (0.67)
$(L/Y - \overline{L/Y})_{t-2}$	-0.73 (0.49)	-0.14 (0.89)	-2.57 (0.27)	-2.27 (0.46)
$D^*(p - \overline{p})_{t-1}$	-0.22 (0.42)	-0.28 (0.28)	-0.44 (0.31)	-0.53 (0.52)
$D^*(r^s - r^{Taylor})_t$	-5.64* (0.10)	-7.05** (0.03)	-7.19 (0.37)	-10.12 (0.55)
$D^*(r^s - r^{Taylor})_{t-1}$	6.95 (0.16)	7.80 (0.09)	16.52 (0.14)	22.90 (0.26)
$D^*(r^s - r^{Taylor})_{t-2}$	-4.31 (0.15)	-3.30 (0.25)	-12.08 (0.11)	-16.41 (0.43)
$D^*(\pi - \overline{\pi})_t$	-3.21 (0.43)	-2.52 (0.51)	-10.08 (0.14)	-14.06 (0.34)
$D^*(\pi - \overline{\pi})_{t-1}$	6.50 (0.32)	5.70 (0.35)	16.67 (0.20)	24.70 (0.30)
$D^*(\pi - \overline{\pi})_{t-2}$	-4.53 (0.38)	-2.28 (0.64)	-15.81 (0.14)	-20.25 (0.52)
$D^*(L/Y - \overline{L/Y})_t$	1.40 (0.33)	2.13 (0.13)	2.99 (0.30)	4.57 (0.48)
$D^*(L/Y - \overline{L/Y})_{t-1}$	-1.08 (0.54)	-1.51 (0.36)	-5.12 (0.15)	-6.44 (0.27)
$D^*(L/Y - \overline{L/Y})_{t-2}$	0.49 (0.73)	0.22 (0.87)	5.46 (0.07)	5.67 (0.17)
GDP growth		0.02** (0.02)	0.03 (0.22)	0.03 (0.53)
Current account			0.08 (0.17)	0.05 (0.64)
Change in financial innovation				0.02 (0.75)
R^2	0.70	0.74	0.84	0.81
$\bar{R}^2$	0.53	0.59	0.60	0.28

Source: Authors' calculations.
a. Numbers in parentheses are p-values

Table 6B reports the results for the regression when money growth rate deviations are used in place of interest rate deviations, but for this case, the results are poor. Almost all coefficients are insignificant, and except for the "credit" impact during booms, there is no difference between "normal" periods and "boom" periods.

Table 6B. Panel Regression Results for Real Commodity Prices (Money growth rate rule)[a]

Dependent Variable: Deviation of log Real House Prices from long–run trend (HP trend)

Regressors	*(1)*	*(2)*	*(3)*	*(4)*
$(p - \bar{p})_{t-1}$	0.62*** (0.00)	0.66*** (0.00)	0.68** (0.03)	1.07 (0.17)
$(\Delta\log(m) - 0.03)_t$	-0.72 (0.45)	-0.64 (0.50)	-0.88 (0.54)	-0.71 (0.76)
$(\Delta\log(m) - 0.03)_{t-1}$	-1.84 (0.22)	-2.22 (0.14)	-2.82 (0.23)	-5.90 (0.24)
$(\Delta\log(m) - 0.03)_{t-2}$	0.31 (0.76)	0.80 (0.46)	1.33 (0.39)	4.29 (0.44)
$(\pi - \bar{\pi})_t$	-0.36 (0.89)	0.38 (0.88)	6.15 (0.22)	11.13 (0.36)
$(\pi - \bar{\pi})_{t-1}$	-2.35 (0.36)	-1.79 (0.48)	-0.11 (0.98)	-5.31 (0.57)
$(\pi - \bar{\pi})_{t-2}$	0.90 (0.56)	1.02 (0.50)	2.50 (0.37)	4.76 (0.34)
$(L/Y - \overline{L/Y})_t$	0.55 (0.54)	0.39 (0.66)	0.14 (0.92)	-1.48 (0.64)
$(L/Y - \overline{L/Y})_{t-1}$	0.22 (0.76)	-0.07 (0.92)	1.24 (0.34)	2.49 (0.38)
$(L/Y - \overline{L/Y})_{t-2}$	-0.54 (0.55)	-0.31 (0.74)	-4.13 (0.07)	-5.55 (0.26)
$D^*(p - \bar{p})_{t-1}$	-0.13 (0.57)	-0.23 (0.34)	-0.36 (0.30)	-0.66 (0.43)
$D^*(\Delta\log(m) - 0.03)_t$	1.69 (0.18)	1.52 (0.22)	2.32 (0.23)	2.25 (0.48)
$D^*(\Delta\log(m) - 0.03)_{t-1}$	1.24 (0.46)	1.45 (0.39)	0.70 (0.79)	3.34 (0.50)
$D^*(\Delta\log(m) - 0.03)_{t-2}$	-0.10 (0.93)	-0.37 (0.76)	-0.86 (0.64)	-3.68 (0.51)
$D^*(\pi - \bar{\pi})_t$	3.96 (0.17)	3.61 (0.20)	-0.37 (0.95)	-6.05 (0.62)
$D^*(\pi - \bar{\pi})_{t-1}$	-0.27 (0.92)	-0.04 (0.99)	-2.74 (0.64)	2.34 (0.81)

Table 6B. (continued)

Regressors	*(1)*	*(2)*	*(3)*	*(4)*
$D^*(\pi - \overline{\pi})_{t-2}$	-0.21 (0.91)	-0.19 (0.92)	-1.45 (0.72)	-3.94 (0.62)
$D^*(L/Y - \overline{L/Y})_t$	0.50 (0.67)	0.81 (0.49)	1.76 (0.41)	3.46 (0.49)
$D^*(L/Y - \overline{L/Y})_{t-1}$	-1.34 (0.31)	-1.06 (0.42)	-3.34 (0.18)	-5.32 (0.19)
$D^*(L/Y - \overline{L/Y})_{t-2}$	0.64 (0.59)	0.38 (0.74)	5.32** (0.05)	7.35 (0.16)
GDP growth		0.01 (0.12)	0.04** (0.05)	0.03 (0.38)
Current account			0.03 (0.46)	0.01 (0.88)
Change in financial innovation				0.04 (0.58)
R^2				
$\overline{R}^2$				

Source: Authors' calculations.
a. Fixed effects included in regression but not reported. Numbers in parentheses are p-values.

4.4 Discussion

The results presented above show that "loose" monetary policy, that is, having an interest rate below the target rate or having a growth rate of money above the target growth rate positively impacts asset prices, and this correspondence is heightened during periods when asset prices grew quickly and then subsequently suffered a significant correction. This result was robust across multiple asset prices and different specifications and was present even when we controlled for other alternative explanations, such as low inflation or "easy" credit. The initial impacts are relatively small, especially when you consider that the run-up of asset prices in the boom periods are almost all greater than 5% per year, with some much higher than that.

It should also be noted that in alternative specifications not reported here, for reasons of brevity but available upon request, the result that "loose" monetary policy is associated with increases in asset prices was found in different sub-periods of the data and when the first difference of the variables was used instead of the deviations from trend. The size and significance of the estimates were very similar across all specifications.

We also found that low inflation and, to a lesser degree, "easy" credit are also associated with increases in asset prices. There does not appear to be one variable that is associated with increases in asset prices more than another. The monetary variable was consistently important during the boom periods; whereas, the other two controls were not always important. Again, the initial impacts were quite small relative to the sizes of the overall price increases during the booms.

Before moving to our policy lessons that we draw from this exercise, we must note the limitations of the empirical exercise we undertook. The regression model that we estimated is not a structural model, and so we cannot draw any conclusions about causality from these results. In fact, we try very hard to only say that we found associations between asset prices and the three control variables we use. The model, because of its atheoretical nature, does not have any explicit statement of the channel with which the three control variables impact asset prices. We do find evidence of nonlinear effects, but that is as far as we go. We also do not model the feedback of each of the three variables upon each other. This is obviously very important if we were to try to contrast the magnitudes of the effects these three controls had on asset prices during the identified boom periods. This last point is an important consideration and it is part of our ongoing and future research on this topic.

5. Policy Lessons

Our evidence that loose monetary policy (along with low inflation and credit expansion) does contribute significantly to booms in house prices, stock prices and commodity prices, leads to the question about what central banks should do about it. Should they use their policy tools to target housing prices, stock prices or commodity prices directly? Or, should they give important weight to asset prices when setting their policy instruments as a possible contingency to depart from their central goals (high employment) of low inflation? This subject received considerable attention during the tech boom of the late 1990s and again during the housing boom in the mid-2000s (Bordo and Wheelock, 2009). Since periods of explosive growth in asset prices have often preceded financial crises and contractions in economic activity, some economists have argued that by defusing asset price booms, monetary policy can limit the adverse impact of financial instability on economic activity.

However, the likelihood of a price collapse and subsequent macroeconomic decline might depend on why asset prices are rising in the first place. Many analysts believe that asset booms do not pose a threat to economic activity or the outlook for inflation, as long as they can be justified by realistic prospects of future earnings growth, in the case of stock prices; or reflect real fundamentals such as population growth, in the case of housing booms; or real side shocks or changing conditions of supply, like natural disasters or demand (like the growth of China), in the case of commodity price booms.

On the other hand, if rising stock prices reflect "irrational exuberance," or rising house prices reflect a bubble, they may pose a threat to economic stability and justify a monetary policy response to encourage market participants to revalue equities more realistically or to deter speculation in real estate. In the case of commodity prices, to the extent a boom does not reflect fundamentals, policy tightening could defuse the real effects of a sudden bust.

The traditional view holds that monetary policy should react to asset price movements only to the extent that they provide information about future inflation. This view holds that monetary policy will contribute to financial stability by maintaining stability of the price level (Bordo et al., 2002, 2003; Schwartz, 1995), and that financial imbalances or crises should be dealt with separately by regulatory policies or lenders of last resort policies (Schwartz, 2002). Bernanke and Gertler (1999, 2001) presented the traditional view in the context of a Taylor rule.

Many economists do not accept the traditional view, at least not entirely. Smets (1997), for example, argued that monetary policy tightening is optimal in response to "irrational exuberance' in financial markets. Similarly, Cecchetti et al. (2000) contended that monetary policy should react when asset prices become misaligned with fundamentals. Bernanke and Gertler (2001) expressed doubts that policymakers can judge reliably whether asset prices are being driven by "irrational exuberance," or if an asset price collapse is imminent. However, Cecchetti (2003) replied that asset price misalignments are no more difficult to identify than other components of the Taylor rule, such as potential output.[15]

Bordo and Jeanne (2002a, 2002b) offered a different argument in support of a monetary policy response to asset price booms. They

15. For the debate within the FOMC over the 1990s stock market boom, see Bordo and Wheelock (2004).

argued that preemptive actions to defuse an asset price boom can be regarded as insurance against the high cost of lost output should a bust occur. They contended that policy makers should attempt to contain asset price misalignments when the risk of a bust (or the consequences of a bust) is large, or when the cost of defusing a boom is low in terms of foregone output. Bordo and Jeanne showed that a tension exists between these two conditions. As investors become more exuberant, the risks associated with a reversal in market sentiment increases; however, leaning into the wind of investor optimism requires more costly monetary actions. Thus, the monetary authorities must evaluate both the probability of a costly crisis and the extent to which they can reduce this probability.

Since this earlier debate, where the warnings of Bordo and Jeanne and others were not largely heeded, the housing bust of 2006 in the U.S. and the subsequent financial crisis and Great Recession led many policy makers to decide that financial stability should be an important goal of central banks along with low inflation (and overall macro stability). The new view argued that central banks should be closely monitoring asset price developments and the state of the financial system (including non-banks and banks) and be willing to use policy to defuse threatening imbalances. This became known as the case for macro prudential regulation, which promoted the use of policy tools such as countercyclical capital requirements and liquidity ratios (Kashyap, Rajan and Stein, 2008). This case, fostered by the BIS and many others, has led to important changes in the central banking and financial regulatory landscape, including the 2010 Dodd Frank Bill in the U.S., which has given the Federal Reserve greatly expanded powers over the financial system as a whole, and in the U.K. where the Bank of England has taken over some of the responsibilities of the Financial Stability Authority.

The question arises if the new financial stability powers of central banks will work to prevent the next crisis, also whether or not the new impetus has gone too far in encroaching on the traditional role of central banks to maintain price stability, acting as lenders of last resort to the banking system and protectors of the integrity of the payments system. The history of financial regulation after big financial crises (e.g. the Great Depression) suggests that the government often overreacts and, in the name of safety, suppresses financial development and the price discovery mechanism of financial markets. The regime of the 1930s through the 1970s gave us financial stability at the expense of unworkable firewalls between complementary financial functions (Glass-Steagall) and price controls and ceilings like regulation Q in the U.S. and the prohibition of the payment of interest on demand deposits. Similar regulations were put in place across the world. These regulations and controls broke down in the face of the Great Inflation, financial market arbitrage, and financial innovation. In addition, in this immediate post World War II period, central banks lost their independence to the fiscal authorities that had other politically driven objectives in mind. It would not be surprising if that happened again.

More fundamentally, many of the recent institutional changes pose threats to the independence of central banks and their ability to perform their core mission, which is to maintain the value of money (Bordo, 2010; Svennson, 2010). Central banks were also supposed to act as lenders of last resort to provide emergency liquidity to the banking system. They were not responsible for the solvency of banks or any other entities, or the financing of government deficits (except in wartime) (Bordo, 2012).

The bottom line is that asset price booms (stock market and housing market) are important and potentially dangerous to the real economy and should be closely monitored and possibly defused. However, the policy tools to do this should not be the traditional tools of monetary policy. Other tools, such as margin requirements for stock prices, minimum down payments for housing, and risk and bank-size weighted capital requirements for banks could be used. Authorities other than central banks could perform these tasks to prevent central banks from being diverted from their main functions.

To the extent that asset price booms—including commodity price booms—do not reflect real fundamentals, they should also be viewed as harbingers of future inflation, and as part of the normal transmission mechanism of monetary policy as has occurred in earlier historical episodes. In this case, they serve as a signal for tighter monetary policy.

Finally, our evidence—for the close to a century, for many countries, and for three types of asset booms—that expansionary monetary policy is a significant trigger, makes the case that central banks should follow stable monetary policies. These should be based on well understood and credible monetary rules.

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APPENDIX A

Identified Boom/Busts

Figure A1. Identified Housing Price Booms

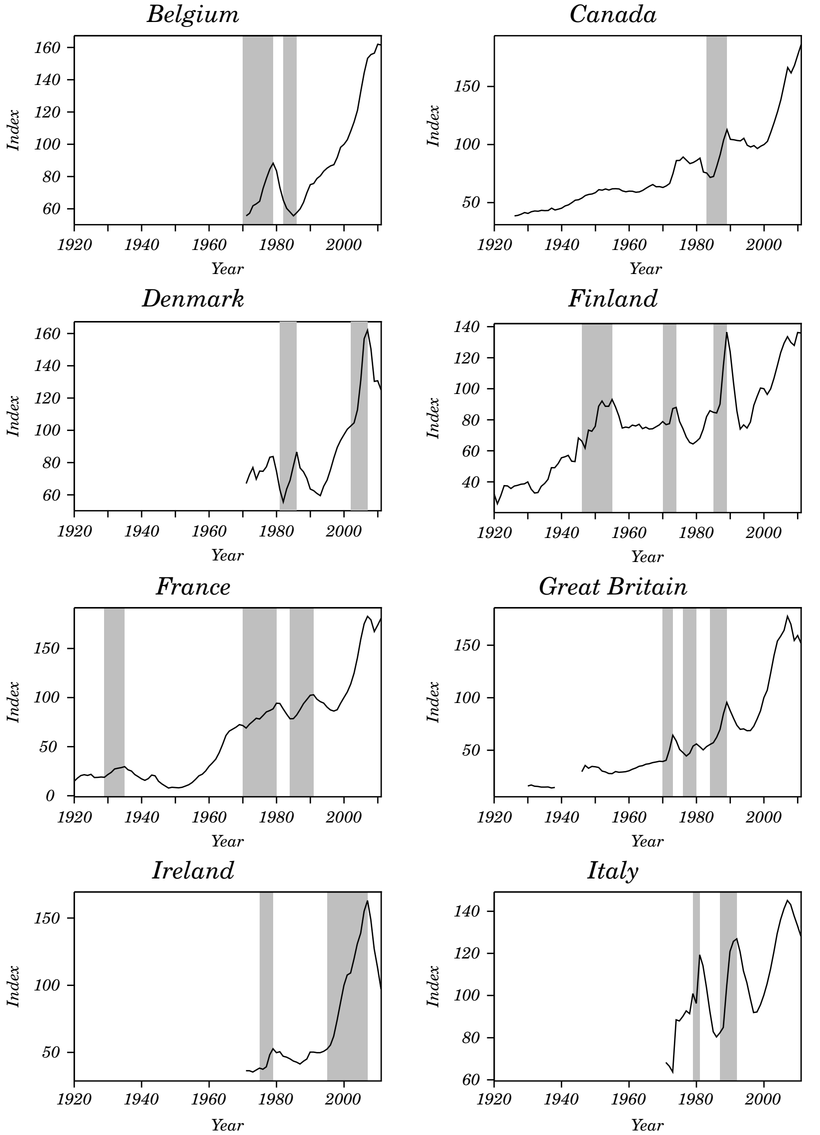
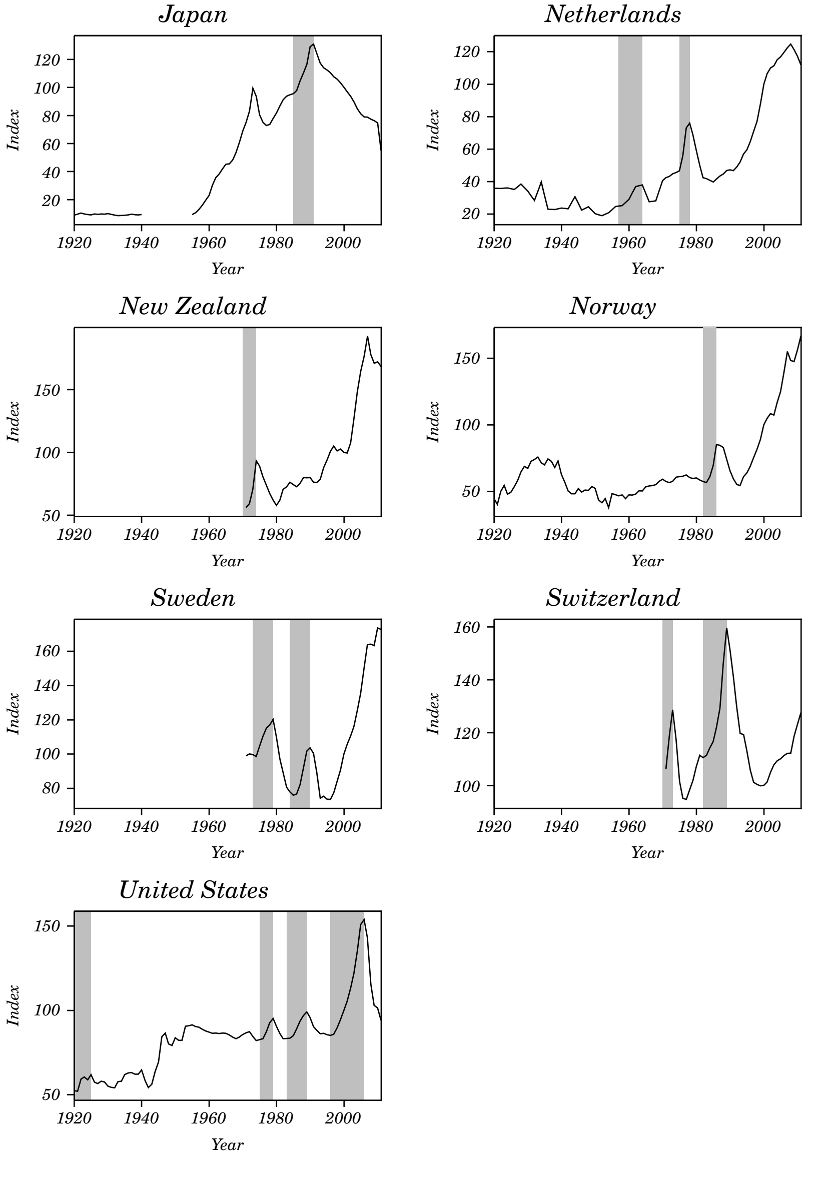


Figure A1. (continued)



Source: Authors' elaboration.

Figure A2. Identified Stock Price Booms

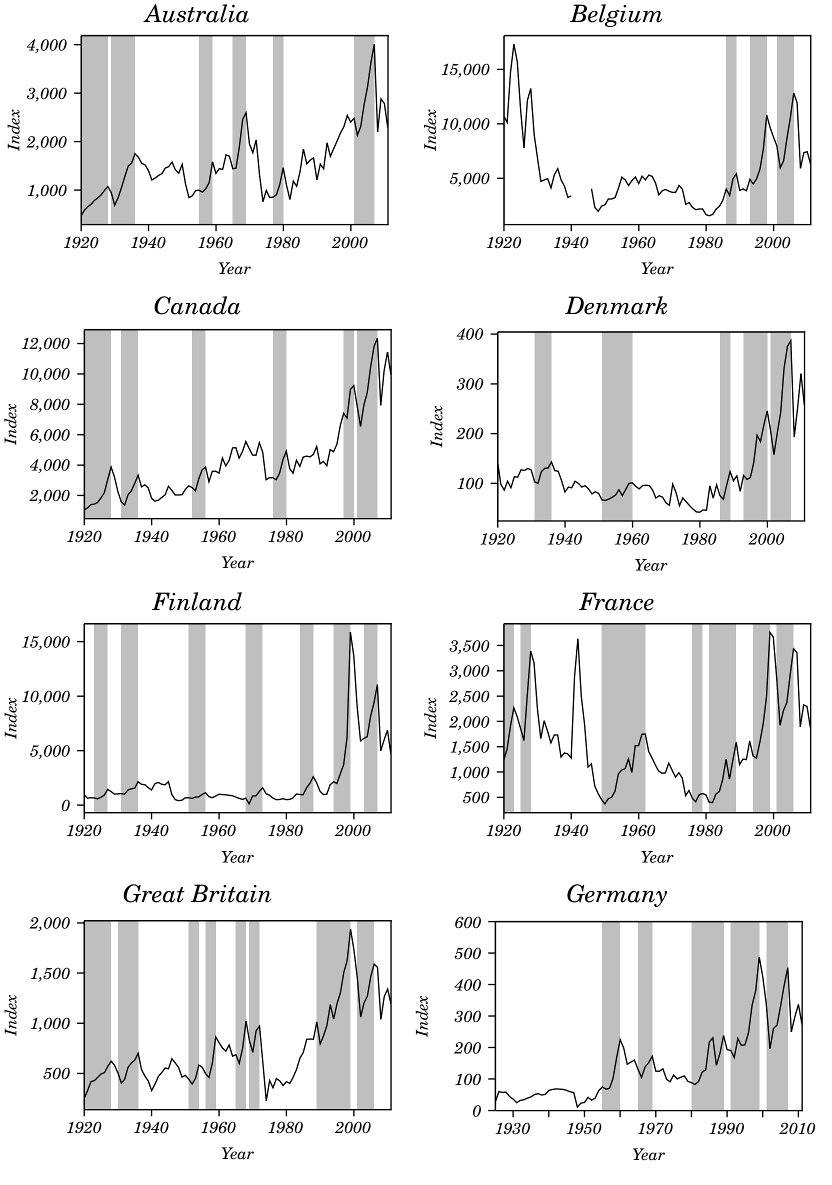


Figure A2. (continued)

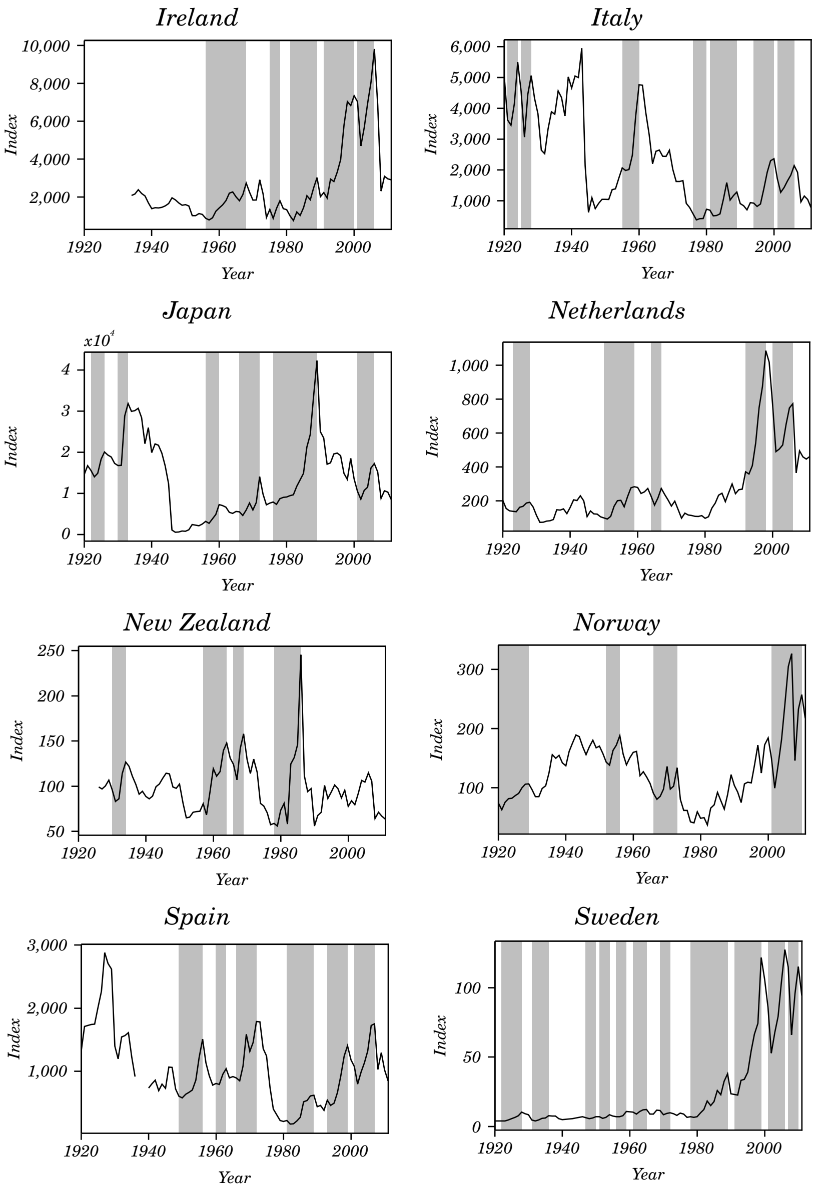
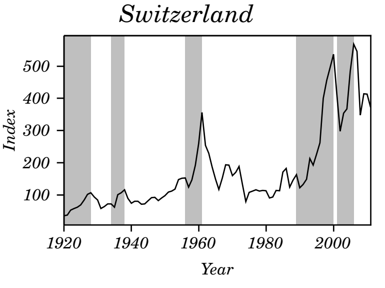
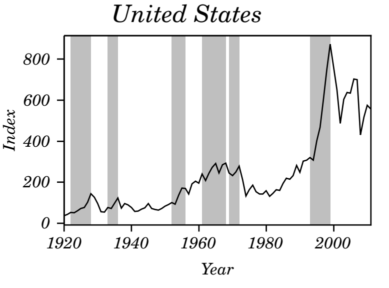


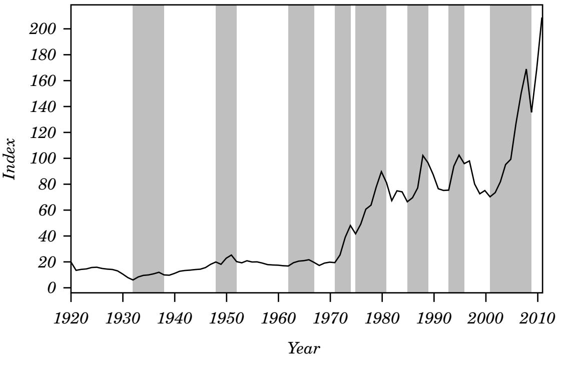
Figure A2. (continued)





Source: Authors' elaboration.

Figure A3. Identified Commodity Price Booms



Source: Authors' elaboration.

Appendix B

Data Sources

Real GDP:

See Michael D. Bordo and Christopher M. Meissner, "Does Inequality Lead to a Financial Crisis?" NBER Working Paper No. 17896.

Real house price index, 2000=100:

Detailed description: U.S. [*Robert J. Shiller, Irrational Exuberance, 2nd. Edition, Princeton University Press, 2005, 2009, Broadway Books 2006, also Subprime Solution, 2008, as updated by author*], Norway [*Norges Bank; Eitrheim, Ø. og Erlandsen, S. "Monetary aggregates in Norway 1819-2003," 349-376 Chapter 9 in Eitrheim, Ø., J.T. Klovland and J.F. Qvigstad (eds.),Historical Monetary Statistics for Norway 1819-2003, Norges Bank Occasional Papers No. 35, Oslo, 2004*], U.K. [*Department for Communities and Local Government, Housing statistics*], France [*conseil général de l'Environnement et du Développement (CGEDD), Home Prices in France, 1200-2012 : Historical French Property Price Trends, home price index of Paris*], Netherlands *[Piet M.A. Eichholtz, 1997, "The long run house price index: The Herengracht index, 1628-1973," Real Estate Economics, (25), 175-192., this index is based on the transactions of the buildings on the Herengracht, one of the canals in Amsterdam; for recent data the source is OECD*], Australia [*Stapledon, Nigel David, "Long-term housing prices in Australia and Some Economic Perspectives," The University of New South Wales, Sept. 2007; Australian median city house prices*], Spain [*before 1970 - source: Prados de la Escosura; after 1970 source is OECD*]; Finland *[Hjerppe, Riitta, Finland's Historical National Accounts 1860-1994: Calculation Methods and Statistical Tables, Jyvaskylan Yliopisto Historian Laitos Suomen Historian Julkaisuja, 24, pp. 158-160; and OECD for recent data*], Canda [*Statistics Canada and OECD*], Japan [*The Japan Real Estate Institute, for data between 1910 and 1940 Nanjo, Takashi, "Developments in Land Prices and Bank Lending in Interwar Japan: Effects of the Real Estate Finance Problem on the Banking Industry," IMES Discussion Paper Series, 2002-E-10, Bank of Japan, 2002*]. For the cases of Denmark, Germany, Ireland, Italy, Sweden, Belgium, Switzerland and New Zealand, the OECD house price index was used.

Short-term interest rate:

See Michael D. Bordo, Christopher M. Meissner "Does Inequality Lead to a Financial Crisis?" NBER Working Paper No. 17896

Money:

M2 or M3 – depending on the country. Source: Moritz Schularick and Alan M. Taylor. "Credit Booms Gone Bust: Monetary Policy, Leverage Cycles, and Financial Crises, 1870–2008" American Economic Review 2012, 102(2): 1029–1061

Stock market index (close, end of December):

The source is Global Financial Data.com

Real commodity prices:

The Economist All-Commodity Dollar Index (close, end of December). The source is Global Financial Data.com

Financial liberalization index, 0 to 21:

Sum of seven components [creditcontrols, intratecontrols, entrybarriers, bankingsuperv, privatization, intlcapital, securitymarkets]. Abdul Abiad, Enrica Detragiache, and Thierry Tressel "A New Database of Financial Reforms" IMF WP/08/275

Credit:

Loans to GDP ratio. Total lending, or bank loans, is defined as the end-of-year amount of outstanding domestic currency lending by domestic banks to domestic households and nonfinancial corporations (excluding lending within the financial system). Banks are defined broadly as monetary financial institutions and include: savings banks, postal banks, credit unions, mortgage associations, and building societies; whenever the data are available. We excluded brokerage houses, finance companies, insurance firms, and other financial institutions. See Michael D. Bordo, Christopher M. Meissner "Does Inequality Lead to a Financial Crisis?" NBER Working Paper No. 17896

Current account:

Current account to GDP ratio. See Michael D. Bordo, Christopher M. Meissner "Does Inequality Lead to a Financial Crisis?" NBER Working Paper No. 17896

Private Information in the Mortgage Market: Evidence and a Theory of Crises

Robert Shimer
University of Chicago

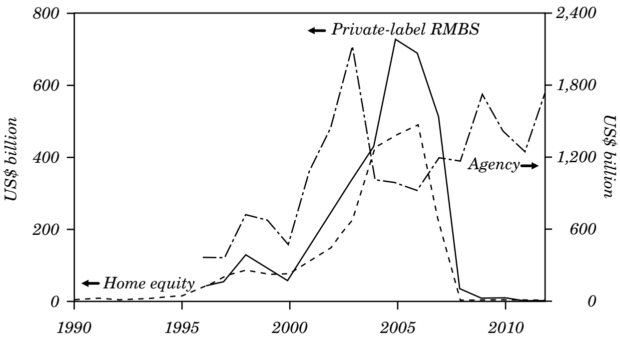
The securitization boom in the United States mortgage market from 2000 to 2005 was enormous (figure 1). According to the Securities Industry and Financial Markets Association (SIFMA), new issuance of securities backed by mortgages that were not insured by the U.S. government rose by a factor of twelve during that five year period, from $58 billion in 2000 to $726 billion in 2005. Issuance of securities backed by home equity loans also soared from $75 billion to $460 billion over the same five year span. The subsequent collapse was even faster. By 2008, issuance of these two types of securities had fallen to $36 billion, further declining to $8 billion by 2012. In contrast, the market for securities backed by insured mortgages has boomed since 2005, nearly doubling from $983 billion to $1.731 trillion by 2012 in the face of declining interest rates. This paper summarizes existing empirical evidence that private information was important in the uninsured mortgage market and then describes recent theoretical models that explain how the emergence of private information can lead to a decline in trade in these securities.

The link between savers and borrowers typically involves a chain of intermediation; the mortgage market is no exception. This paper starts off in section 1 by describing that chain. This is important because private information may arise in one part of the chain but affect intermediation in another part. In particular, I argue in

University of Chicago, Department of Economics, 1126 East 59th Street, Chicago, IL, 60637 (e-mail: robert.shimer@gmail.com). I am grateful for comments from Larry Christiano, Robert Hall, and conference participants on an earlier draft of this paper and to the National Science Foundation for research support.

Macroeconomic and Financial Stability: Challenges for Monetary Policy, edited by Sofía Bauducco, Lawrence Christiano and Claudio Raddatz. Santiago, Chile.

Figure 1. New Issuance of Securities[a]



Source: SIFMA, http://sifma.org/research/statistics.aspx, U.S. Mortgage-Related Issuance and Outstanding (private-label RMBS and agency MBS) and U.S. ABS Issuance and Outstanding (home equity loans).
a. New issuance of private-label residential mortgage-backed securities (left axis), home equity loans (left axis), and agency mortgage-backed securities (right axis).

section 2 that mortgage originators obtained private information about the quality of their loans during the origination process. Private information was particularly acute for mortgages that were not insured by the U.S. government because of the very real risk of default on an uninsured mortgage; however, although private information was gathered during the origination process, its consequences were felt in the securitization process. The buyers of mortgage-backed securities (MBSs) were rightly concerned that mortgage securitizers were better informed about the MBSs' default risk.

It is not news that private information is an issue in the MBS industry, and indeed the industry has developed a number of techniques to moderate the amount of private information and mitigate its consequences (section 3). MBSs offer warranties, which were valued by independent specialists and traded as part of a long-term relationship between the buyer and seller. Each of these institutions should reduce buyers' concern that sellers will attempt to profit from their private information. Moreover, tranching was designed to create safe debt from risky mortgage pools, ideally eliminating the relevance of the seller's private information. Similarly, haircuts in repurchase agreements left repo sellers as the residual claimants on an income stream and created a safe, information-insensitive asset for repo buyers.

Unfortunately, all these safeguards were insufficient to prevent the emergence of private information and risk in the MBS industry once house prices began to decline in 2005. Section 4 discusses recent theoretical models that I have jointly developed with Veronica Guerrieri, which offer a framework for analyzing how buyers and sellers set prices in the presence of private information. The key insight is that an endogenous shortage of buyers at high prices allows sellers who have favorable information to separate themselves from those with unfavorable information. This is because sellers with favorable information are more willing to accept a reduction in the probability of trading in return for an increase in the price since they hold onto a better MBS if they fail to sell. I use this model to offer two related stories about the emergence of a crisis in the market for MBSs. In one, a crisis occurs because of a change in fundamentals. In the other, a crisis is a shift in equilibrium in the absence of any intrinsic change in the environment, perhaps caused by contagion from another market. Finally, I conclude in section 5 with a brief discussion of how a crisis in the market for MBS affects the ability of current homeowners to refinance their loans and potential homeowners to obtain loans.

1. Participants in the MBS Market

The MBS market effectively borrows money from large savers, such as insurance companies and pension funds, and lends it to homeowners and homebuyers. Because the large savers typically do not have any expertise in making loans, there are usually multiple intermediaries lying between the ultimate lenders and ultimate borrowers. In principle, since private information problems could arise at each stage of the intermediation process, this section briefly summarizes who those intermediaries are.

Broadly speaking, there are two main stages in the lending process: origination and securitization. Origination involves making a loan to an individual homeowner. Securitization involves bundling loans together and reselling them to the ultimate lenders. While this paper focuses more on securitization than origination, many of the information issues that arise in the securitization market start in the origination market; therefore, it is useful to think about both stages of this process together.

The main intermediary in the origination process is the mortgage broker. In the United States, a homeowner (or homebuyer) typically deals directly with a mortgage broker. The broker collects relevant information from the homeowner and then connects the homeowner with a mortgage originator who actually grants the loan. Some homeowners bypass this process, obtaining their loan directly from a retail lender rather than a broker. Smaller mortgage originators then typically resell their loans to wholesale aggregators, while larger originators may skip this step.

At this stage, a securitizer bundles together a large number of mortgages and tranches them, creating a series of bonds with different promised coupon payments, maturities, and seniority. The coupon payments are supposed to be covered by the homeowners' principal and interest payments on the underlying loans. If cash flows ultimately turn out to be too small to support the payments, then the bonds go into default, with junior bonds defaulting before the more senior ones. Finally, the bonds are rated by one or more of the major credit rating agencies and then sold.

Ultimate lenders, including insurance companies and pension funds, purchase some of these investment-grade bonds, which raise capital that the securitizer can reinvest into new mortgages. Foreign and domestic banks purchase other high-grade bonds, holding some on their balance sheet and offloading others into asset-backed commercial paper (ABCP) programs. Banks issue deposits and debt to fund their asset holdings, while ABCP programs typically sell very short-term debt to money market funds to finance their holdings. In both cases, the loan is ultimately funded by a lender who invests in the bank or ABCP program, thus completing the chain from borrower to lender. Finally, securitizers typically hold the junior bonds with junk ratings and the still riskier "equity" tranches on their balance sheet.[1]

2. Evidence of Private Information in MBS Markets

MBS in the United States are divided into two broad categories, agency and private-label, distinguished by the entity that issues the security. Agency MBSs are issued by a government-sponsored enterprise (GSE), especially the Federal National Mortgage Association (Fannie Mae) and the Federal Home Loan Mortgage

1. Prior to the financial crisis, the junior tranches were frequently bundled and retranched as Collateralized Debt Obligations; however, that market has largely disappeared.

Corporation (Freddie Mac), or directly by the U.S. government through the Government National Mortgage Association (Ginnie Mae). Agency MBS aggregate and tranche a large number of underlying residential mortgages, promising a coupon payment linked to the homeowners' principal and interest payments. The sponsor, eliminating an important source of risk, in turn guarantees those payments. Still, some residual sources of risk remain, particularly the risk that the mortgage is pre-paid when interest rates fall.

Private-label MBSs are issued by private financial institutions with no guarantee of principal or interest payments. The underlying mortgages are both commercial and residential, but this essay focuses on residential MBSs. These loans typically do not conform to the guidelines imposed by the GSEs because, for example, the loan is too large either in absolute terms or relative to the value of the collateral, or relative to the borrower's income. While pre-payment risk exists for private label securities, default is a bigger source of risk. When a borrower fails to make a payment on his mortgage, some portion of the MBS's promised coupon may be lost.

Data from the Securities Industry and Financial Markets Association (SIFMA) shows that the issuance of private-label MBS collapsed during the financial crisis, from a peak of $883 billion in 2005 to a trough of $18 billion in 2009. In contrast, the agency market performed very well as home owners refinanced to take advantage of low interest rates; issuance increased sharply from $983 billion to $1.734 trillion over the same time period. If private information is likely to be important for understanding the financial crisis, the private-label MBS market is therefore a natural place to look for evidence of it. I start my review there. The underlying mortgages backing private-label MBSs are usually well documented. A prospectus describes many characteristics of both the loan and the borrower, such as the distribution of interest rates, maturities, and loan-to-value ratios, as well as the credit score, income, and owner occupancy status of the borrowers. A spreadsheet containing all this information is available to prospective buyers. Despite this, there are several reasons why a mortgage originator may have superior information to the MBS's ultimate buyer, which is often a money market fund, pension fund, or insurance company.

First, many private-label loans had low or no documentation (low-doc loans). In this case, the homeowner was either not asked about his income and assets, or his reports were not verified. Instead, the collateral was supposed to protect the mortgage originator against the borrower's inability to pay. In practice, however, originators had other "soft" information that they used when making these loans, information that could not easily be quantified and was not reported in the prospectus. To the extent that this information is useful for predicting future payments and default, it creates a natural and potentially quantitatively significant source of private information.

Second, it appears that borrowers sometimes provided incorrect answers to questions on loan applications in order to borrow at a better rate. Those misrepresentations naturally carried over to the prospectus and any other information available to MBS buyers. To the extent that mortgage originators could observe these misrepresentations, they were another source of private information. Again, there is some evidence that this is quantitatively significant.

Third, the mortgage originator specializes in evaluating the quality of loans and may therefore be better than the MBS buyer at valuing the fundamentals described in the prospectus, even if the two parties observe the same information. While I believe that this is a reasonable hypothesis, I am unaware of any direct information supporting it. Nevertheless, indirect information suggests that this too may be a relevant source of private information both in the agency and private-label market: mortgage issuers held onto better quality loans and securitized lower quality ones.

I turn next to a more detailed description of these three types of evidence.

2.1 Low Documentation Loans

Unquantified, soft information, such as the mortgage originator's expectation about the buyer's income stability, plays a key role in qualifying borrowers for low-doc mortgages. Since, by its nature, soft information cannot be reported in the MBS prospectus, low-doc loans offer the widest scope of private information. Indeed, the literature has found compelling evidence that supports this hypothesis.

Keys, Mukherjee, Seru and Vig (2010) show that when originators expect to retain (rather than resell) a low-doc mortgage, they screen the loan more carefully. This is consistent with the hypothesis that some aspects of low-doc mortgages are not properly priced in the MBS market because the information is unavailable to mortgage buyers.

The paper uses a regression discontinuity approach to analyze how the likelihood of retaining a mortgage affects screening.

Due to a historical anomaly, it was more difficult for a mortgage originator to securitize a loan if the borrower's credit (FICO) score was below 620, and so the originator was more likely to hold the loan to maturity. The FICO distribution is smooth by construction and it is nearly impossible for a borrower to precisely manipulate his FICO score. Despite this, Keys, Mukherjee, Seru and Vig (2010) show that mortgage originators made roughly twice as many loans to homeowners whose FICO score was slightly above 620 than to homeowners just below this threshold. This suggests that lower quality borrowers were screened more carefully than higher quality ones. In itself, that is not surprising, but the discontinuity in lending practices is most apparent at this critical threshold for securitization.

Next, Keys, Mukherjee, Seru and Vig (2010) document that the few loans made to borrowers with a FICO score just below the key threshold were much less likely to default than the loans made to borrowers just above the threshold. For example, a one-year-old low-doc loan to a borrower with a FICO score between 615 and 619 was about twenty percent (or two percentage points) less likely to default than a similar loan to a similar borrower with a slightly higher FICO score (between 620 and 624). To emphasize, the borrowers with a worse credit rating were less likely to default than those with a better credit rating.

Also, Keys, Mukherjee, Seru and Vig (2010) show that there was no difference in the lending terms to these two groups of borrowers. They paid the same mean interest rate, had the same loan-to-value ratio, and came from zip codes with the same median income. In other words, whatever information mortgage originators used to successfully screen out some low quality loans to the group of borrowers with a FICO score just below 620 was unavailable to the investors who purchased the MBS backed by loans to borrowers with a slightly higher credit score.

Finally, they document a similar discontinuity in the ease of securitizing full documentation loans, albeit at a slightly different threshold (a FICO score of 600). Once again, mortgage originators are much more likely to lend to borrowers just above the threshold than to those just below it. This reflects the fact that mortgage originators wish to avoid holding loans on their balance sheet due to the ensuing risk and capital requirements. Despite the difference in the amount of lending, they find that loans just above the threshold perform as well as those just below the threshold. The distinctive behavior of the low-doc market strongly suggests the importance of private information in that market, while there is a narrower scope for private information in the market for full documentation loans.

In a recent paper, Jiang, Nelson and Vytlacil (2011b) extend these results using proprietary data from a major, unidentified mortgage-origination bank. The particular bank specialized in broker-originated, low-doc, privately securitized lending. The data include all the information that the bank collected on all the loans it made from January 2004 to February 2008. They verify that the bank sold far fewer loans just below the "620" threshold (compared to just above it) with the density jumping about five-fold at the critical threshold. Moreover, the delinquency rate also jumps up at the threshold by about eight percentage points. Both of these results are consistent with the findings in Keys, Mukherjee, Seru and Vig (2010).

In contrast to the earlier paper, Jiang, Nelson and Vytlacil (2011b) are able to observe not just the ex-ante probability that the loan will be securitized, but also the ex-post outcome. Surprisingly, they find that securitized loans are actually less likely to default, even in a neighborhood at the critical "620" threshold. Their interpretation lies in the timing. For example, a fraction of loans go delinquent immediately upon issue because the homeowner never makes a payment. The terms of the MBS do not allow such loans to be included in the security, and so the originator is left holding the loan. Similarly, investors may be able to select higher quality loans by using additional aggregate information that is revealed between the time of origination and securitization, such as the behavior of the local housing market. This indicates that symmetric lack of information at the time of origination works against the origination bank. Note, however, that the evidence in Jiang, Nelson and Vytlacil (2011b) does not speak against the possibility that the adverse selection problem remains in the market for MBS.

Demiroglu and James (2012) also look for evidence that mortgage originators have private information on low-documentation loans, but they use a different empirical approach. They look at how an originator's exposure to potential losses affects the quality of their loans. More precisely, some mortgage originators also securitize their loans to create MBSs. They then typically sell off the safest tranches to MBS buyers, but hold onto the riskiest (equity) tranches, exposing themselves to potential losses. Other originators sell their entire portfolio of loans to an unaffiliated mortgage securitizer, which performs the same function: it creates the MBS, sells off the safe tranches, and holds onto the riskiest ones.

The important difference is that when an originator has private information about loan quality but retains some exposure to losses through its affiliation with the securitizer, it may screen the loans more carefully. Demiroglu and James (2012) find evidence that these loans outperform loans where the originator and securitizer are unaffiliated. Low-documentation loans issued in affiliated deals, after conditioning on all the information available to the buyer of the MBS, are about twenty percent less likely to default than those issued in unaffiliated deals.

Demiroglu and James (2012) offer another piece of evidence that private information is important in this market. They look exclusively at loans in which the originator and securitizer are unaffiliated, and so one would expect that the loans perform badly. They show that loan performance depends on whether the originator also services the loans, i.e. collecting and distributing the mortgage payments for a fee. A one standard deviation increase in the fraction of loans for which the originator is also the servicer implies about a 25 percent lower cumulative loss rate. Again, this suggests that originators screen loans more carefully if they expect to enjoy some of the benefits from the loans' performance.

Finally, Demiroglu and James (2012) show that neither of these results carries over to the full documentation loan market. The likelihood that a loan defaults depends neither on whether the originator is affiliated with the sponsor, nor on whether the originator services the loan. Since there is a narrower scope for the private information problem, this is again consistent with private information driving the results in the low documentation market.

2.2 Misrepresentation

Homeowners sometimes misrepresent important loan characteristics in their application. To the extent that the mortgage originator is aware of the misrepresentation, this creates another potential source of asymmetric information between the originator and the MBS buyer.

In the popular press, low documentation loans are often called "liar's loans," reflecting the temptation for a borrower to lie about his income and assets when these are not verified. Using the same proprietary data from the same mortgage originator as Jiang, Nelson and Vytlacil (2011b), Jiang, Nelson and Vytlacil (2011a) uncover evidence suggesting that income misreporting was pervasive in low documentation loans.

Low documentation loans were 5 to 8 percentage point more likely to go delinquent than full documentation loans, even after conditioning on all observable characteristics of the loan. This is not necessarily evidence of misreporting, since borrowers who select low documentation loans are less desirable. But Jiang, Nelson and Vytlacil (2011a) uncover two other pieces of evidence that strongly suggest misreporting.

First, they show that borrower information is much better for predicting the performance of full documentation loans than low documentation loans. One would expect this result if there were systematic misreporting for low documentation loans. Second, they show that for full documentation loans, higher income reduces the likelihood of default, but the opposite is true for low documentation loans. An increase in a borrower's self-reported income raises the likelihood that he defaults on his loan, an unexpected correlation if income is truthfully reported. Unfortunately, Jiang, Nelson and Vytlacil (2011a) do not have any direct evidence on borrowers' true income and so cannot definitively establish that borrowers in fact lied about their income.

A recent paper by Piskorski, Seru and Witkin (2013) uncovers direct evidence that borrowers misrepresented another important characteristic of their loan: whether the property is owner-occupied. Moreover, their paper suggests that the mortgage originator knew about some portion of this misrepresentation.[2]

Owner occupancy status is an important predictor of future default risk. This may be because owners place greater value on living in their dwelling than the market rent, while investors simply compute the option timing of default given expectations about future prices and rents, or it may be because investors are more financially sophisticated. In any case, after conditioning on a large number of other controls, Piskorski, Seru and Witkin (2013) use loan-level data on mortgages originated between 2005 and 2007 to show that when a borrower truthfully reports that he does not intend to occupy a property, he is about 3.5 percentage points

2. They also uncover evidence that borrowers misrepresented whether there was a second lien on the property; however, they do not find that mortgage originators were aware of this misrepresentation.

more likely to default than a borrower who truthfully reports that he intends to occupy the property.

They then turn to evidence of misrepresentation. They match their loan-level data to subsequent mailing addresses reported to a major credit bureau. If a borrower reports that he will occupy a property but does not move to the appropriate zip code at any time during the subsequent year, Piskorski, Seru and Witkin (2013) record him as a misrepresented non-owner occupant. This group comprises about 6.4 percent of reported owner-occupied mortgages. A misrepresented non-owner occupant is about 9.5 percentage points more likely to default on his loan than an owner-occupant after conditioning on the same large set of controls. In other words, a misrepresented non-owner occupant is a far worse risk than a truthfully reported non-owner occupant. Perhaps the fact that an individual is willing to lie on a loan application is a signal of his financial sophistication.

Piskorski, Seru and Witkin (2013) also uncover evidence that mortgage originators knew about some of the misrepresenting. Borrowers who truthfully reported their non-owner occupancy paid an interest rate that was 35 basis points higher than owner-occupants, reflecting the increased risk of default. Borrowers who misrepresented their non-owner occupancy status also paid a higher interest rate, but only 23 basis points higher than owner-occupants. With the benefit of hindsight, it is clear that neither of these surcharges compensated for the subsequent higher default rates, which presumably reflects the general underpricing of risk during their pre-crisis sample period. But the fact that misrepresented, non-owner occupants paid a premium indicates that banks were able to partially distinguish them from owner-occupants. The fact that the premium is smaller than the one for truthful non-owner occupants, despite the higher default risk, suggests that the distinction was imperfect.

Investors who purchased MBS backed by a high percentage of misrepresentations were not compensated for the resulting low quality of the security. For example, the safest tranches of the securities were not protected by a greater amount of subordinated debt. Potentially, however, these investors may be protected by the MBS's warranty, depending on the outcome of pending court cases. Originators may have a reasonable defense by arguing that they simply asked borrowers to state whether they intended to occupy the home. Once the loan closed, there was little the originator could do to force the homeowner to move in. In any case, I further discuss both tranching and warranties in section 4 below.

2.3 Superior Valuation Models

A third potential source of asymmetric information is that mortgage originators may simply be better at valuing mortgages and the securities backed by them than MBS buyers are. This seems plausible because of gains from specialization: mortgage originators were in the business of giving mortgages, while valuing MBSs were comparatively unimportant for money market funds, pension funds, and insurance companies.

To my knowledge, there is no direct test of this hypothesis, but it is possible to look for indirect evidence. In the presence of this type of asymmetric information, one might expect mortgage originators to retain the best mortgages and securitize the worst, anticipating that the unsophisticated buyers would underprice quality. In fact, this is exactly the pattern in the data.

Krainer and Laderman (2013) look at mortgages originated between 2000 and 2007 for properties in California. Their main empirical results rely on estimates of a proportional hazard model for the risk of a loan going into default. After conditioning on other loan characteristics, they find that adjustable-rate loans that were privately securitized defaulted at a 13 to 16 percent higher rate than comparable loans that the originator retained, a statistically and economically significant difference. Curiously, they find no robust difference for fixed-rate loans. On the other hand, they find that adjustable rate loans which were privately securitized charged about 50 basis points lower interest than similar loans which the originator retained. That is, originators retained loans with a high interest rate and a low default risk and sold off loans with the opposite characteristics. It is difficult to understand why this would happen unless MBS buyers did not understand how to value the loans.

Downing, Jaffee and Wallace (2009) look at the agency MBS market where the main risk lies in early pre-payment. In particular, a mortgage performs badly from the lender's perspective if it is prepaid early in an environment with lower-than-expected interest rates and if it is prepaid late in the opposite environment. They study all the MBS issued by Freddie Mac Gold Participation Certificates from 1991 to 2002, a period well before the housing crash. These MBS were constructed in two stages. The first stage simply pooled the mortgages without creating tranches. The second stage tranched the assets to create Real Estate Mortgage Investment Conduits (REMICs) that were then resold in the private market. Their main result is that MBS that were converted into REMICs performed worse from the lender's perspective than MBS that were not converted; however, the spread is small, about four to six basis points. The source of this spread appears to lie in the originator's superior model of prepayment risk.

3. How Markets Deal with Private Information

Sophisticated investors understand that private information can be a problem when trading securities. Well-functioning markets therefore develop techniques to mitigate the impact of private information. In some sense, these techniques are the "dog that didn't bark": they provide indirect evidence that adverse selection must be an issue in securities markets since it would be hard to understand why these techniques would be employed if buyers and sellers had the same information. This section reviews a number of those techniques and explains how they help to mitigate adverse selection.

3.1 Warranties

The prospectus for an MBS summarizes a number of characteristics of the underlying mortgages and warrants the buyer against defects. More precisely, an MBS is administered by an independent third party, the trustee. The trustee has a specified amount of time, typically 90 days after the execution of the MBS, to uncover any material defects in the underlying loans. If the trustee uncovers such defects, the securitizer must either purchase the loan by paying off the principal and interest, or it must replace the loan with a similar asset.

This type of warranty is useful in the presence of asymmetric information. It reduces the incentive of the securitizer to misrepresent the characteristics of the securitized assets and mitigates the need of the buyer to look for evidence of such misrepresentation. In addition, the 90-day window suggests that detecting such defects is time-consuming and difficult, which is important for understanding both why warranties are useful and the extent to which they are limited. A warranty enables an unsophisticated buyer to quickly purchase an MBS, despite being unable to evaluate the accuracy of the underlying documentation.

In light of the evidence in Piskorski, Seru and Witkin (2013), it is important to note that warranties are restrictive. In particular, the prospectus for an MBS would typically limit the securitizer's responsibility for a borrower misrepresenting his intent to occupy the property. A typical prospectus states, "The sole basis for a representation that a given percentage of the loans are secured by single family property that is owner-occupied will be either (i) the making of a representation by the mortgagor at origination of the loan, either that the underlying mortgaged property will be used by the mortgagor for a period of at least six months every year or that the mortgagor intends to use the mortgaged property as a primary residence, or (ii) a finding that the address of the underlying mortgaged property is the mortgagor's mailing address as reflected in the servicer's records."[3] It seems that courts will have to determine whether the evidence in Piskorski, Seru and Witkin (2013) establishes that securitizers engaged in fraud or whether the language in this type of clause applies. Still, this example suggests that warranties protected a MBS buyer against certain risks, but still left considerable scope for private information. Some of this had a significant impact on buyers' realized returns.

3.2 Credit Rating Agencies

MBS issued in the U.S. are typically rated by one of the three big credit ratings agencies (CRAs): Moody's, Standard & Poor's, and Fitch. These ratings serve at least two important roles. The first is regulatory: regulators forbid certain financial entities, such as money market funds, from holding any asset that does not have the highest credit rating; furthermore, under the Basel Accords, banks are required to hold more capital against assets with lower ratings. The second role is informational: CRAs specialize in offering independent, objective, and reliable assessments of an asset's quality. Of course, the two roles are linked. Financial regulators rely on CRAs because determining an asset's quality is difficult.

Since CRAs specialize in evaluating the quality of a security, it seems possible that they will actually have superior information to the buyer and seller of a MBS, thus entirely eliminating the adverse selection problem. But even if they do not have superior information, they can mitigate the extent of the private information problem, helping buyers distinguish between securities that might otherwise appear indistinguishable. As I discuss further in the

3. This quote comes from Bear Stearns Asset Backed Securities Trust 2006-1, form 424(B)(5). Similar language was used in many other prospectuses.

theoretical section of this essay, anything that mitigates asymmetric information may help to facilitate trade in a security. Thus the fact that MBS are graded by the CRAs, and that regulators place weight on these ratings, suggests that private information may be pervasive in these markets.

During the financial crisis from 2007 to 2009, there was a widespread perception that the CRAs had not been providing independent, objective, and reliable assessments of assets' quality. For example, early in the financial crisis, investors started to realize substantial losses on AAA-rated Collateralized Debt Obligations (CDOs). CDOs are created by combining junior tranches of MBSs. The models employed by the CRAs assumed that the losses suffered by the MBS would be uncorrelated, which meant that the senior tranches of CDOs would be nearly risk-free. This assumption turned out to be incorrect, resulting in massive losses. To date, nearly 40 percent of AAA-rated CDOs have suffered some losses. By contrast, Moody's idealized expected loss rate over a 5-year period for an AAA security is 0.0016 percent.

Whether the CRAs provided independent, objective, and reliable assessments prior to the financial crisis remains in dispute.[4] What is indisputable is that their reputation was damaged by the crisis, and that no third party could immediately step in to provide their traditional services. The loss of these key players at a critical juncture exacerbated private information problems and contributed to the collapse in financial intermediation during this period.

3.3 Reputation

In markets in which a seller's private information is revealed slowly over time, a seller may obtain a reputation for truthfully revealing the quality of its product. Moreover, if a particular buyer frequently purchases assets from a particular seller, the value of

4. See Foote, Gerardi and Willen (2012), especially their fact 12. They point out that among all the residential MBS and home equity loans that Moody's had originally rated AAA, about 15 percent were impaired —suffered losses or had been downgraded to junk status— by the end of 2011 (Moody's Investors Services, 2012). While 15 percent impairment is much higher than one would normally expect from a AAA security, these losses occurred during the deepest recession since the Great Depression. Indeed, it seems that conditional on the size of the national house price decline, the models used by the CRAs correctly forecast the losses suffered by MBS, although they severely underestimated the size of the house price decline.

future interactions may guarantee that the seller wishes to ensure the buyer's survival, relaxing any incentive constraints.

The market for MBSs was certainly a small market. Relatively few large banks provided most of the mortgages to a small number of securitizers, which in turn sold many of the MBS to large institutional investors. For example, in 2006 the three largest "Alt A" lenders accounted for over 45 percent of the market,[5] while the six largest underwriters accounted for 53 percent of private-label mortgage purchases and the six largest MBS issuers accounted for 43 percent of the private-label market.[6] This means that the opportunities for sellers to obtain and maintain a reputation for honesty were abundant.

Unfortunately, important forces conspired against sellers obtaining a good reputation before the financial crisis and maintaining one during it. Prior to the crisis, mortgage originators and securitizers may have correctly perceived that the boom in mortgage issuance would be temporary. A good reputation is hard to sustain when the short-run profits from exploiting buyers are large relative to the long-run loss from a bad reputation, exactly the situation during a temporary boom. And then during the financial crisis, many originators and securitizers experienced bankruptcy or a forced sale to a competitor, while all surviving financial intermediaries were concerned that these undesirable outcomes were possible. Again, intermediaries may be tempted to boost short-run cash-flow if that significantly increases their survival probability, even if doing so significantly reduces their long-run value through a loss in reputation and the ensuing bankruptcy of their clients.

As was the case with CRAs, the usefulness of financial intermediaries' reputation as a device that ensured truthful revelation of information collapsed at a key juncture during the financial crisis. This meant that buyers had to be more aware than ever of sellers taking advantage of short-run profit opportunities. The MBS market was therefore rife with private information.

3.4 Tranching

A securitizer originates or purchases a large number of loans, combines them into a single pool, and then issues MBSs backed by the revenue stream coming into the pool. The securitizer creates several

5. See Inside Mortgage Finance (2011a) p.161.
6. See Inside Mortgage Finance (2011b) p. 39.

different securities from a single pool of mortgages distinguished, in large part, by their seniority. For a private-label bond, about 80 percent of the notional stream of interest and principal payments are typically promised to the most senior tranche. This means that if 40 percent of the homeowners default on their mortgage payments and the mortgage holder is able to recover half the value of those loans by selling the collateral, the holders of the most senior tranche will still receive the full promised coupon payment. Indeed the size of the most senior tranche is typically set so as to ensure that it receives the highest (AAA) rating from the CRAs, with enough collateral and buffer from junior tranches to protect bondholders against losses in any likely scenario.[7] The next few percent of the notional income stream is then promised to a more junior investment-grade bond. That bond experiences losses before the AAA-rated tranches, but is still buffered against losses by lower-grade securities. Finally, the securitizer typically retains the rights to the marginal income streams, often called the equity tranche.

Widespread tranching is evidence that private information is an issue in this market. Tranching divides a stochastic stream of payments into several assets, ranging from risk free debt to levered equity. The buyers of the risk-free debt, in turn, are protected against the need to understand the stochastic process of the underlying payment stream. In the terminology of Gorton and Pennacchi (1990), risk-free debt is "information insensitive." As long as a buyer is (almost) certain that a MBS will pay off at face value, he does not need to understand the risks to the mortgage pool. In contrast, equity is information sensitive since it absorbs all the variation in the payment stream. This means that if a securitizer has superior information about the quality of a mortgage pool, tranching allows the securitizer to sell much of the payment stream without encountering private information problems. The most senior tranches are safe and, hence, private information does not distort their sale. The securitizer then retains the junior tranches with the associated risk and information problems.

Still, the ability of tranching to mitigate private information problems is limited by the underlying amount of risk. If there is a chance that the stream of payments to a mortgage pool will dry up

7. In the aftermath of the financial crisis, these buffers were insufficient and some AAA-rated MBS did default on payments (see footnote 4). Still, AAA-securities performed significantly better than lower-rated securities, with 58 percent of AA-rated MBS impaired by 2011 (Moody's Investors Services, 2012).

completely, then it is impossible to create any risk-free debt from the promised revenue stream. Risk in itself is of course not a problem for financial markets. The problem is that a seller may have superior information about the stochastic process for the revenue stream. Indeed, as noted by Dang, Gorton and Holmström (2012), once debt is risky, investors have an incentive to acquire information about the nature of the risk. "The crisis is not just the bad shock about fundamentals that back debts. Instead, the crisis is a bad enough shock to cause information-insensitive debt to become information acquisition sensitive."[8] The crisis is the emergence, or threat of emergence, of private information in a market that was previously immune from this problem.

In summary, tranching represents an attempt to turn a risky stream of income into a safe bond, in part, to suppress private information problems. The prevalence of tranching in the MBS market therefore suggests that private information may be relevant to those markets. Moreover, a worsening of the left tail of the income stream lowers the maximum amount of risk-free debt that can be created. As the supply of risk-free debt disappears, either securitizers must stop creating MBS or the MBS market must deal with the existence of private information.

3.5 Repurchase Agreement Haircuts

A repurchase agreement (repo) consists of the sale of a security together with the promise to buy it back at a specified date and price. In other words, in its simplest form, a repo is a collateralized loan. For example, a repo seller gives a repo buyer an MBS in return for some cash, then the contract specifies that the seller must repay the cash with interest at a later date in return for the securities. The haircut in a repo contract is defined as one hundred percent, minus the ratio of the cash lent by the repo buyer for the market price of the securities lent by the repo seller. In other words, if the repo seller receives $70 in cash in return for $100 in securities, the haircut is 30 percent.

For my purpose, the relevant aspect of a repo agreement is how it treats a default. Repos are governed by a Global Master Repurchase Agreement, which contains detailed rules following a default. To be

8. See Dang, Gorton and Holmström (2012) p. 32.

concrete, suppose the repo seller does not repay the repo buyer on the specified date. At this point, the repo buyer is permitted to sell or retain enough of the MBS so as to compensate himself for the lost payment, returning the rest to the repo seller.

It is in this instance that the repo haircut is important. If the haircut is sufficiently large (i.e. the loan is sufficiently over-collateralized), then the repo buyer does not need to worry about the value of the collateral. In the event of default, the repo buyer simply sells the collateral to make up for the lost payment, ensuring that the loan is risk-free. This means that if the repo buyer is concerned that the repo seller has superior information about the value of the collateral, he can simply demand a larger haircut to protect himself against the risk of loss.

These arguments imply that repo haircuts are effectively equivalent to tranching.[9] A repo seller has private information about the quality of a risky asset that it owns. By demanding the entire asset as collateral against a relatively small loan, a repo buyer is protected against the seller's default, even if he has little information about the collateral's quality. The repo buyer therefore effectively purchases the senior tranche of the asset, while the repo seller is left holding the residual (i.e. the equity tranche). In short, a repo haircut effectively circumvents the seller's private information, allowing the repo seller to sell a safe stream of income secured by a risky asset.

Conversely, it is difficult to understand why repo haircuts would exist in an environment with symmetric information. For example, if MBS are risky but the buyer and seller have the same information about their value, the market price of the MBS would compensate for the risk. A haircut would shift the risk to the seller, but since there is no general reason to believe that repo sellers are better at bearing risk than repo buyers, this cannot give a satisfactory theory of repo haircuts.

Gorton and Metrick (2010) show that haircuts increased as the financial crisis worsened. In the first half of 2007, there was no haircut on subprime-related structured products. By the time Lehman Brothers collapsed in September 2008, the haircut had increased to 100 percent (i.e. the products were worthless as

9. The notion that a repo is equivalent to tranching comes from Gorton and Metrick (2010). That paper stresses a different type of private information that the repo buyer may be less well informed about than a potential trading partner in the secondary market. For the purpose of this paper, it is enough to note that private information was likely prevalent in the MBS market.

collateral). This suggests again that, although private information problems were suppressed prior to the crisis, they emerged in the private label MBS market as the underlying income streams dried up.

4. Modeling Markets With Private Information

The previous sections offered a subtle and nuanced view of the sources of private information in the MBS market. This section describes a stark and abstract framework for analyzing how private information can lead to illiquidity in financial markets. The analysis here is based on Guerrieri and Shimer (2013a) and Guerrieri and Shimer (2013b), and I refer the reader to those papers for a formal treatment of these ideas.

The basic idea is that illiquidity acts as a costly signal of an asset's quality. The notion of "costly signals" dates back to Spence (1973) in the context of school enrollment. Gale (1996) first proposed that illiquidity could serve as a costly signal. Illiquidity is costly because there are gains from trade, and so the failure to trade imposes a cost on the seller. Illiquidity can serve as a signal because the costs depend on the asset's quality. If an asset does not sell, the seller is left holding it, which is more costly to the seller if the asset is of lower quality. This means that any observable action that a seller takes to make an asset illiquid can serve as a useful signal to potential buyers about the asset's quality.

DeMarzo and Duffie (1999) propose that a seller may commit to hold onto a fraction of a stream of payments to signal its quality. Even if the senior tranche remains risky, the willingness to retain an equity tranche is a useful signal about the quality of a mortgage pool. While this security design literature offers important insights into how markets cope with private information, it leaves one important question unanswered: how can a seller credibly commit to hold onto the equity tranche? After selling the senior tranche, there are still gains from selling the equity tranche. But if the initial buyer knows that the seller can do this, then holding onto the equity tranche is no longer a costly signal. Put differently, retaining a portion of an asset as a signal of its quality leads to a classic time-inconsistency problem.

I propose that in addition to tranching, markets use a different costly signal: the seller's ask price for a security. I construct a market economy in which sellers can potentially sell a security at a range of different prices, but are more likely to sell it at a lower price. Demanding a high price therefore incurs the potential cost of illiquidity. Sellers who value an asset less, either because of the characteristics of the seller or the characteristics of the asset, will set a lower price and sell their security with a higher probability. Buyers understand this and are willing to pay a higher price only to the extent that they expect that this will give them a higher quality security.

This insight leads to a theory of how illiquidity arises naturally in a market economy, even without any commitment. If it were too easy to sell a security at a high price, then the holders of low quality securities would offer them at a high price, driving away the buyers. The equilibrium I construct has the minimum amount of illiquidity required to induce sellers to offer different prices depending on their value of holding onto their security. I turn next to a detailed description of the environment to flesh this idea out.

4.1 Model

There are many investors. The number of investors is large in the sense that each of them believes that they cannot, acting individually, change the nature of the illiquidity problem. There are two assets in the economy: "cash" and "mortgage-backed securities." Initially each investor holds some cash and some MBSs. Cash is homogeneous, but MBSs are of heterogeneous quality or payoff. The private information problem is that only the initial owner of the MBS knows its quality. For example, the initial owner may be the securitizer, with all the informational advantages described in section 3. I denote the quality of an MBS by $\delta \in (\underline{\delta}, \overline{\delta})$.

Investors can trade cash for an MBS and receive a payoff that depends on their final cash and quality-adjusted MBS holdings. All investors are risk-neutral and I normalize the marginal utility of quality-adjusted MBS holdings to 1 for each investor. I allow different investors to have a different marginal utility (or value) of cash, which I denote by $\alpha \in (\underline{\alpha}, \overline{\alpha})$. For example, pension funds may have an ample cash flow with few direct investment possibilities, while securitizers can use the cash to purchase more MBSs (in some un-modeled market). In this case, I would expect α to be low for a pension fund and high for a securitizer.

The difference in the value of cash is critical because it implies that there are gains from trade. If all investors had the same value of cash and rational expectations, then there would be no gains from trade and hence, no trade (Milgrom and Stokey, 1982). The only reason one investor would be willing to sell a security at a particular price is if he believed it to be worth less than that price. But every other investor should understand this and so be unwilling to purchase the security at that price. All trade would cease. The realistic assumption that there are some intrinsic gains from trade means that it may be possible to construct an equilibrium with trade. The interesting question is how private information affects the amount of trade.

I look at two versions of the model. In the first, an investor's value of cash α is observable (Guerrieri and Shimer, 2013a), but the quality of the investor's MBS is not. For example, it is possible to distinguish a pension fund from an investment bank. In the second, both the value of cash and the quality of MBSs are the investor's private information (Guerrieri and Shimer, 2013b). For example, some investment banks may have better investment opportunities than others at any point in time. While outcomes are fairly similar in the two environments, I highlight some important differences in sections 5.2 and 5.3 below. For expositional purposes, my description of the environment focuses on the (notationally simpler) case in which both an investor's value of cash and the quality of its MBS is its private information.

I assume that investors can simultaneously sell their MBSs for cash, and use that cash to buy other MBSs. They do this by setting an ask price for each MBS, and a bid price to purchase other MBSs for cash. When they do this, two considerations are paramount: First, an investor anticipates that he can raise the probability of finding a buyer by reducing his ask price. Let $\Theta(p)$ denote the probability that a seller finds a buyer if he sets an ask equal to p per unit of MBS. Since it is a probability, impose $0 \leq \Theta(p) \leq 1$ for all p.[10] Second, an investor anticipates that he can raise the quality of the MBS that he buys by raising his bid price. Let $D(p)$ denote the expected payoff from a unit of MBS purchased at a price p. The functions Θ and D are not arbitrary but must be consistent with investors' optimization, with rational expectations, and with markets clearing, as I explain in the following paragraphs.

10. In the full model, buyers also anticipate that they can raise the probability of finding a seller by raising their bid. In equilibrium, however, buyers' bids are always satisfied, and so I ignore that issue for expositional simplicity.

First consider the optimal ask price for an investor who values cash at α and who has a MBS with value δ. This satisfies

$$P_s(\alpha, \delta) = \arg\max_p \Theta(p)(\alpha p - \delta). \tag{1}$$

If he succeeds in selling the MBS, he gets cash p that he values at α. Otherwise he retains the MBS, which he values at δ. Therefore, $\alpha p - \delta$ represents the gain from selling, which occurs with probability $\Theta(p)$.

Similarly, consider the optimal bid price for an investor who values cash at some α. This satisfies

$$P_b(\alpha) = \arg\max_p \left(\frac{D(p)}{p} - \alpha\right). \tag{2}$$

He values each MBS that he buys at price p at $D(p)$ and a unit of cash allows him to buy $1/p$ of this security. His opportunity cost of each unit of cash is α. The bid price must solve this maximization problem given buyers' beliefs encapsulated in $D(p)$. If, however, $\alpha > D(p)/p$ for all p, then an investor with cash value α will not bid for MBSs.

A word on notation is in order. The notation in the previous two paragraphs imposes that all investors with the same cash value and same quality asset set the same ask price, and all investors with the same cash value set the same bid price. I could easily relax this assumption and allow identical investors to sell identical assets at different prices, and similarly for buying. For example, I could allow an investor to offer one MBS at a high price and an identical MBS at a low price. Although such an environment would be notationally cumbersome, one can verify that relaxing this assumption would not affect the equilibrium.

In equilibrium, the functions Θ and D must be consistent with rational expectations. Broadly speaking, there are two types of prices p, those that are an ask price for some seller (formally, there is a (α, δ) such that $P_s(\alpha, \delta) = p$) and those that are not. If there are sellers with ask price p, then $D(p)$ is the average quality of the MBS offered by those sellers and $\Theta(p)$ reflects any shortfall of buyers bidding that price; if the amount of cash that buyers use to purchase MBS at price p exceeds the amount of MBS offered for sale at that price times the price, then all sellers are satisfied and $\Theta(p) = 1$; otherwise $\Theta(p)$ is the ratio of the buyers' total bids to the cost of the sellers' total asks at price p.

Next consider prices p that are not an ask price for any seller. In this case, there are two possibilities. First, it may be the case that, even if $\Theta(p) = 1$, no seller would find it optimal to offer this price. In this case, buyers believe they cannot buy at this price, or equivalently they would only be able to buy a worthless asset, $D(p) = 0$. Second, it may be the case that there is some $0 < \Theta(p) < 1$ at which one or more seller is indifferent about this price or his ask price, while all other sellers prefer their ask price. In this case, sellers believe that if they set this ask price, this is the sale probability; buyers believe that if they set this bid price, they would purchase some combination of the assets offered by the sellers who are indifferent about offering this price.

The previous paragraph describes restrictions on beliefs that seem reasonable in this environment. If no seller sets ask price p, then a buyer should think about which sellers would be most willing to be rationed at that price. He should then anticipate that if he bids that price, only these types of sellers would set that ask price. But if no seller is willing to accept that price, even if there is no rationing as may be true at a very low price, then buyers should anticipate that they would be unable to buy anything at that price.

These restrictions on beliefs reduce the set of possible equilibria and so lead to strong predictions about the nature of equilibrium. Such restrictions are necessary because this is a signaling game, and signaling games typically have multiple equilibria. Different equilibria impose different assumptions on how one economic agent interprets the signals sent by another. Here, prices are signals and buyers must interpret which seller asks which price. For prices that are asked in equilibrium ($p = P_s(\alpha, \delta)$ for some (α, δ)), are pinned down by rational expectations. For other prices, these beliefs are potentially arbitrary. For example, buyers might choose not to bid a particular high price because they believe that only low-quality assets are offered at that price; sellers do not ask that price because it is impossible to find a buyer at that price. Therefore, the buyers' beliefs are never invalidated. I preclude this particular belief through the assumption that buyers believe that each price would be asked by the seller who is most willing to be rationed at that price. This helps to discipline what can happen in equilibrium in a reasonable way.

In closing, I discuss the critical assumption in this pricing game: an ask price represents a commitment to buy at that price. This means that an investor cannot ask two prices for one security, selling it at the higher price if he manages to find a buyer, or otherwise, selling it at the lower price.[11] If he succeeds in selling at the higher price, he would not be able to fulfill his commitment to sell it at the lower price. The question is what real world institution this model captures. MBSs are sold over-the-counter (OTC) and the price is determined by bargaining, something that is absent from this model. Still, the basic economic forces in this model are likely to be present in an OTC market. The model has bilateral asymmetric information since the seller knows both his cash value and the quality of the security, while the buyer knows his cash value. In such an environment, a seller may correctly perceive that a high ask price signals to a buyer that she is not too motivated to sell. This may reduce the chance that the seller ultimately transacts with the buyer but raise the price if trade does take place. I do not model such a bargaining game because there is generally no agreement on how to model bargaining with bilateral asymmetric information. Instead, I expect that the economic forces that I identify in this competitive framework are also relevant in decentralized markets.

4.2 Observable Value of Cash

I start by describing the equilibrium of the model in which sellers' value of cash α is observable (Guerrieri and Shimer, 2013a).[12] There exists a unique equilibrium outcome in this environment. In it, investors are endogenously partitioned into two groups, sellers and buyers, at a critical threshold for the value of cash, $\alpha = \hat{\alpha}$. Sellers are investors with a high value of cash, $\alpha > \hat{\alpha}$. They attempt to sell all

11. As previously noted, I can allow the investor to ask a high price for one tranche of his security and a low price for the remainder, without affecting the equilibrium allocation. In addition, it is straightforward to extend the model to allow for multiple rounds of trading; however, with no opportunity cost of delay, all trading must take place in the final round and so the equilibrium is unchanged.

12. The model setup is slightly different because the two key equilibrium objects Θ and D are functions of both the price and the seller's value of cash. The ask price of a seller (α, δ) satisfies

$$P_s(\alpha, \delta) = \arg\max_p \Theta(p, \alpha)(\alpha p - \delta), \tag{3}$$

recognizing that the sale probability depends on both its ask price and its type. This is an immediate extension of equation (1). Buyers choose both a bid price, p, and the type of seller that they buy from, α_s, to solve

$$(P_b(\alpha), A_b(\alpha)) = \arg\max_{p,\alpha_s}\left(\frac{D(p,\alpha_s)}{p} - \alpha\right), \tag{4}$$

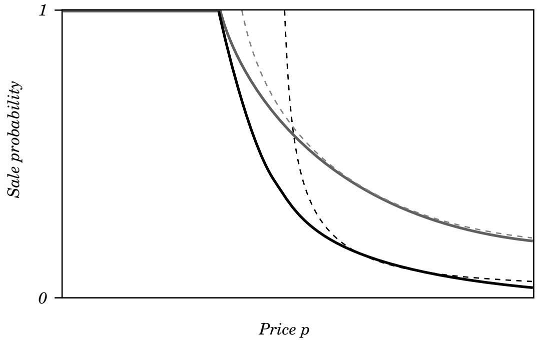
where $D(p,\alpha_s)$ is the average quality asset sold at price p by a seller with cash value α_s. Here $P_b(\alpha)$ denotes the price that a buyer with cash value α pays and $A_b(\alpha)$ denotes the seller's type. The remainder of the setup is common across the two models.

of their MBSs and do not buy MBSs (or equivalently, set a bid price at which MBSs are unavailable). Their ask price is proportional to the quality of their MBS, while the sale probability depends on both the seller's value of cash and the quality of the seller's MBS. Buyers are investors with a low value of cash, $\alpha < \hat{\alpha}$. They are unable to sell their MBS but use all their cash to buy MBSs. All buyers are indifferent about purchasing from any seller at any bid price.

In equilibrium, a seller with the worst quality MBS, $\delta = \underline{\delta}$, is able to sell his security with probability 1, while other sellers are rationed. If the lower bound of the quality distribution is positive, $\underline{\delta} > 0$, rationed sellers trade with a strictly positive probability but not with certainty. The probability of sale is lower when the seller knows that his security has a higher quality (δ is higher), when the worst quality MBS is lower ($\underline{\delta}$ is lower), or when the investor values cash less ($\alpha > \hat{\alpha}$ is smaller) but $\delta > \underline{\delta}$. This reflects the fact that the sale probability must prevent the sellers of lower quality MBSs from misrepresenting them as being of higher quality. Illiquidity is more effective as a separating device when investors value cash more, and so less illiquidity is required in that case.

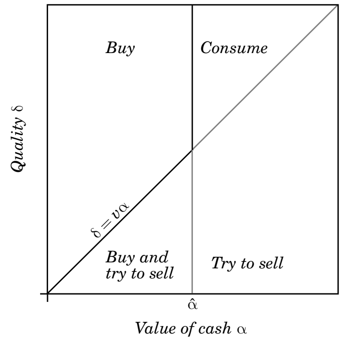
Figure 2 illustrates these points by showing the sale probability as a function of price for two sellers with a different value of cash. They

Figure 2. Equilibria of Sale Probabilities[a]
(US$ billion)



Source: Authors' elaboration.
a. The solid curves illustrate the sale probability for two different investors. The grey (flat) one has a higher value of cash than the black (steep) one. The dashed curves illustrate the indifference curves of two different investors. Both have the same quality asset, but the gray (flat) one has a higher value of cash than the black (steep) one. Both investors set the same price, but the investor with the higher value of cash sells with a higher probability.

Figure 3. Investors' Decisions and Value of Cash



Source: Authors' elaboration.

coincide at the price of the lowest quality MBS, but at higher prices, the seller with a higher value of cash sells with higher probability. This reflects his relatively flat indifference curve. Even a small reduction in the sale probability compensates for an increase in the price when a seller has a high value of cash. Indeed, the sale probability is the lower envelope of the indifference curves of all sellers with that value of cash but different quality MBSs, and therefore is also flatter when the seller has a higher value of cash.

The equilibrium allocation is sensitive to the support of the MBS quality distribution. A reduction in $\underline{\delta}$ reduces the sale probability for all MBSs conditional on the marginal investor $\hat{\alpha}$. In particular, if $\underline{\delta} = 0$, there is no trade in any MBS with positive quality, $\Theta(p) = 0$ for all $p > 0$. This means that the equilibrium allocation depends on the exact specification of the model. For example, suppose there is a negligible probability that $\delta < \hat{\delta}$ for some $\hat{\delta} > \underline{\delta}$. Markets that disregard this possibility will have much more trade than markets that recognize the small chance that $\delta < \hat{\delta}$.

It is worth noting that all sellers with an MBS $\delta > \underline{\delta}$ wish they could mislead other investors into believing that they have a higher value of cash α. This would raise their sale probability without affecting the price. The assumption that buyers can observe sellers' value of cash therefore matters for the structure of equilibrium. I turn next to the other case.

4.3 Unobservable Value of Cash

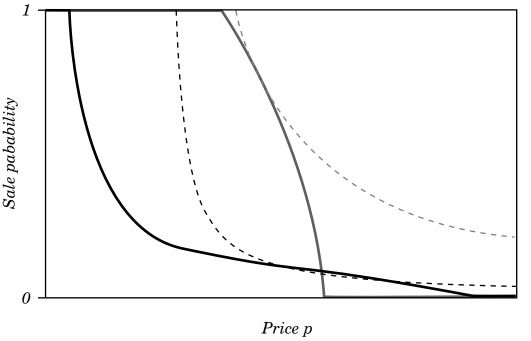
When investors' value of cash is private information, the structure of equilibrium is necessarily different (Guerrieri and Shimer, 2013b). In this case, a continuum of equilibria may exist. In any equilibrium, there is again a critical threshold $\hat{\alpha}$ such that any investor with a lower value of cash, $\alpha < \hat{\alpha}$, uses all his cash to buy any MBS, and any investor with a higher value of cash does not purchase MBSs. But this threshold no longer determines whether an investor sells his MBS. Instead, this depends on the ratio of the quality of his MBS to his value of cash, δ/α. When this ratio is low, an investor sells his MBS at a low price with a high probability. As this ratio rises, the price rises and the sale probability falls. Finally, at some critical value $\delta/\alpha = v$, the sale probability falls to zero and the investor no longer attempts to sell his MBS. Figure 3 illustrates the equilibria outcomes. Investors with a low quality MBS and a low value of cash use their cash to buy MBSs while simultaneously attempting to sell their MBSs. If their MBS quality is higher, they do not attempt to sell, while if their cash value is higher they do not buy. Finally, investors with both a good quality MBS and a high value of cash simply consume their endowment.

The equilibrium has "partial pooling" in the sense that all investors with the same value of δ/α set the same price for their MBS and sell with the same probability. This follows from equation (1), which indicates that if one investor (α, δ) finds ask price p optimal, then any other investor $(\lambda\alpha, \lambda\delta)$ with $\lambda > 0$ finds the same ask price weakly optimal. On the other hand, investors with a higher value of δ/α are more willing to accept a reduction in the sale probability in return for an increase in the price and so, send the noisy signal of a high price in equilibrium.

The solid lines in figure 4 illustrate the equilibrium sale probability as a function of the price in two different equilibria. The dashed lines indicate the indifference curve of one particular seller. The seller is on a lower indifference curve (in one equilibrium) than the other because of a shortage of buyers. Once again, in each equilibrium, the sale probability is the lower envelope of all sellers' indifference curves.

The figure does not illustrate buyers' indifference curves. Buyers' behavior is similar to the model with observable cash values. In any equilibrium, higher expected quality exactly compensates for higher price; therefore, buyers are willing to purchase at any price. The only

Figure 4. Equilibria of Sale Probabilities[a]



Source: Authors' elaboration.
a. The solid curves illustrate the sale probability in two different equilibria. In the grey (steep) equilibrium, the value of cash for the marginal buyer is higher than in the black (flat) equilibrium, and so there are more buyers. The solid curves indicate the indifference curve of an investor with a particular value of δ/α. The investor chooses a higher price and has a lower sale probability in the black (flat) equilibrium where buyers are more scarce.

subtle issue is that different types of sellers set a common price, so buyers do not know exactly what type of MBS they will purchase at each price. Still, under the risk-neutrality assumption, only the expected quality matters.

The set of equilibria now depends in an intricate way on the entire joint distribution of cash values and MBS quality. To be concrete, suppose that the distribution of the value of cash in the population is *Pareto* with parameter $\alpha > 0$, so a fraction $1 - \alpha^{-a}$ of the population value cash less than any level $\alpha > 1$. Also suppose that the fraction of MBSs with quality less than $\delta \in [0.1]$ is δ^d for some parameter $d > 0$. Finally, suppose that the quality of an MBS held by an investor is independent of the investors' value of cash.

For all parameters a and d, Guerrieri and Shimer (2013b) prove that there exists an equilibrium with no trade: $\Theta(p) = 0$ for all $p > 0$. Buyers believe that any seller who is willing to sell at any positive price has an MBS with quality less than p. Since every investor values cash more than MBSs, no one is willing to purchase MBSs.

In addition, if $d > a$, so there are few low quality MBSs relative to the number of investors with a high value of cash, there is a continuum of equilibria with trade. In any equilibrium, the relative illiquidity for two investors depends not just on their value of cash and MBS quality, but also on the distributional parameters a and d.

These parameters affect buyers' perception of the average quality of MBSs available for sale at any price and affect buyers' willingness to pay a marginal increase in the price. In contrast, in the model with observable seller characteristics, illiquidity for any particular seller depended only on the minimum MBS quality $\underline{\delta}$.

Another important difference between the two models is that with observable seller characteristics and $\underline{\delta} = 0$, all trade breaks down. With unobservable characteristics, trade may continue to take place, even in this case, as the concrete example above shows. This seems like an attractive feature. Trade can occur even in markets in which a seller can have arbitrarily bad information about the quality of his MBS. A necessary condition for trade is that extremely motivated sellers are more likely, in some sense, to have an extremely high value of cash, rather than an extremely low quality MBS.

Finally, in the model with observable investor characteristics, there is a neat partition between buyers ($\alpha < \hat{\alpha}$) and sellers ($\alpha > \hat{\alpha}$). With unobservable characteristics, the set of buyers is qualitatively unchanged (although of course the threshold $\hat{\alpha}$ will, in general, be different). However, the set of sellers changes so that any investor with δ/α below a critical threshold v attempts to sell his MBS. This implies in particular that some investors are engaged only in buying, some only in selling, some do not participate in markets, and still others both buy and sell assets, as shown in figure 3. Such trade may be inefficient in the sense that an investor with a low value of cash may sell to an investor with a somewhat higher value of cash, reducing aggregate welfare.

4.4 Two Theories of Breakdown in Financial Markets

The model offers two mechanisms through which trade in financial markets can break down. The first is a change, or the perception of a change, in the joint distribution of the model's fundamentals: investors' cash value α and securities' quality δ. The second is a change in equilibrium for a given joint distribution. I describe how each of these crises might look in turn.

I start with a shift in the joint distribution of fundamentals. In the pre-crisis environment, the AAA-rated tranche of a mortgage pool is perceived to be riskless. All investors believe that the promised coupon will be paid with say, $\delta = 1$ certainty. Whether this is exactly correct or not is unimportant. Sellers do not pay attention to trivial risks in their MBS portfolio, so buyers can neglect this potential issue as well. This means that a mortgage securitizer can quickly purchase a pool of mortgages, tranche them, and sell off most of the earnings, giving himself enough cash to repeat the process.

The crisis begins with a decline in house prices. This has two effects. First, homeowners start to default at higher rates. Previously safe assets become risky and so information-insensitive debt becomes information *sensitive*. Buyers become aware that sellers may have private information about the quality of securities and scale back their demand appropriately. Since fewer securities are sold, and the securities that are sold, sell at lower prices reflecting the default risk, there must be less cash in the market. That is, some investors stop buying and the marginal buyer has a lower cash value. And since the marginal buyer prices the securities, the reduction in the marginal buyer's cash value implies that there is offsetting upward pressure on MBS prices.

The extent of the increase in MBS prices is dictated by the distribution of buyers' cash value and by the ability of buyers to substitute by purchasing other securities. In the model described here, buyers can only invest in MBSs, but in reality, buyers can easily purchase other assets, such as treasury bonds. In this case, the crisis will also cause a flight to quality, with buyers' excess cash driving up the price of treasury bonds.

The second effect of the reduction in house prices is to reduce the value of investing in new mortgage pools, and hence the value of cash to mortgage securitizers. If the value of cash is observable, this directly reduces the liquidity of the securities market, as shown in figure 2. If it is unobservable, the thinning of the right tail of the distribution of α means that buyers anticipate getting a lower quality asset conditional on the value of δ/α and therefore willing to pay less. The simultaneous reduction in the demand and supply of MBS has an ambiguous impact on prices but, to the extent that prices rise, further accelerates the flight to quality.

If under the new distribution $\underline{\delta} = 0$, then all trade may break down in a crisis. More generally, some trade may continue to take place, but at depressed prices and liquidity relative to the pre-crisis environment. Securitizers retain a greater share of the mortgage pools and ultimately the availability of new loans dries up.

The second type of crisis can arise only when the value of cash is unobservable. There is no change in fundamentals, just a reduction in the number of investors who use their cash to purchase securities. This means that the value of cash to the marginal buyer is lower, driving up MBS prices. If buyers are able to purchase other securities, they will do so. This means that the crisis can again generate a flight to quality. This second type of crisis is accompanied by a shift in the illiquidity function Θ, as shown in figure 2. This illiquidity induces sellers to willingly charge higher prices, despite the collapse in the probability of trade, because the percentage reduction in the sale probability for an increase in price is smaller.

This type of crisis looks like a buyers' strike. Nothing fundamental has changed in the market, but buyers have disappeared. Still, sellers are unwilling to cut prices because this has little impact on their sale probability. Indeed, they take advantage of the inelastic demand to raise prices. Sellers of course would be willing to charge the old price if they could sell with the old probability, but that is simply not possible any more.

What can cause this second type of crisis? A full answer goes beyond the scope of the model. One possibility, however, is that the buyers' strike is caused by a collapse in another related market. For example, a shift in fundamentals may cause a collapse in the market for private-label MBS. A shift in equilibrium may then cause a similar collapse in the agency MBS market or the market for securities backed by car loans.

5. Conclusions

If a crisis in the MBS market simply slowed the sale of MBSs from securitizers to pension funds, it would not matter for ordinary individuals who are not engaged in financial intermediation. But the crisis matters for them because when the intermediation chain breaks down, lending breaks down as well. Securitizers will not buy mortgage pools if they anticipate it taking too long to sell the MBSs. Originators will be reluctant to make loans if they anticipate that they will have to hold the loans in their portfolios since the capital requirements on these undiversified risks are high. And so in the end, the perception that securitizers have private information hurts potential homeowners who wish to buy their first home, and existing homeowners who wish to refinance or move to a bigger home. The reduced demand for new housing hurts construction workers who cannot find jobs as residential investment collapses. A crisis in the MBS market causes a widespread decline in individuals' well being.

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Trade with Asymmetric Information

Robert E. Hall
Hoover Institution and Department of Economics, Stanford University and National Bureau of Economic Research

Events in financial markets before and during the crisis of late 2008 have stimulated renewed interest in modeling trade with asymmetric information. Robert Shimer's contribution to this volume joins the literature focusing on trade in securities that are claims on mortgages, where issuers of the securities had, in some important cases, superior information over investors about the probability distribution of payoffs from the mortgages.

The modern literature on trade with asymmetric information began with Akerlof (1970), a paper with 17,134 google scholar citations. The paper has been gaining citations recently at the astonishing rate of 161 per month. Consider the following setup that captures Akerlof's ideas: Two agents, one a buyer and the other a seller, are considering trading an object. The seller has private value S, a random variable unknown to the buyer. That buyer has a value $B = B(S) + \varepsilon$. The random variable ε is known by the buyer and unknown by the seller. To the extent that $B(S)$ depends on S, the buyer's value is unknown to the buyer.

In a desirable trade, the buyer's realized value exceeds the seller's value ($B > S$), while in an undesirable trade, the reverse holds. A trading protocol is a set of rules governing the interaction of buyer and seller as they attempt to make a trade. A protocol can be like an auction where both sides submit bids, or can involve bargaining, where the parties make alternating offers until some stopping condition is satisfied. The central question in the literature is the

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efficiency of a protocol. A fully efficient protocol maximizes the gains to trade by generating every desirable trade and excluding every undesirable trade.

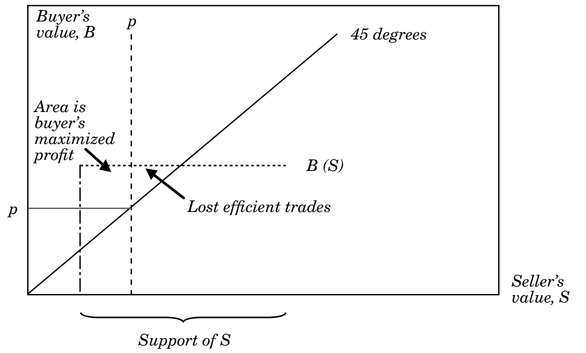
A threshold question in this literature is whether a third agent can hold an equity position in the trade. If so, a Vickrey protocol may deliver outstanding results. For example, in the case where B does not depend on S, that protocol would have both parties submit bids, with each party paying the amount the other bid, provided the buyer's bid exceeds the seller's. For all desirable trades, the third party would be making up the difference, paying the seller the difference between the two bids. The literature almost invariably excludes this possibility—protocols are limited to those where the seller receives what the buyer pays. The exclusion seems realistic, as it is hard to think of any practical examples of protocols with third parties who pay in.

Chatterjee & Samuelson (1983) was an early contribution in this framework, without the extra complication of the dependence of the buyer's value on the seller's value—the lemons problem. In their protocol, the buyer and the seller submit bids and the transaction occurs if the buyer submits a higher price than the seller. The buyer pays the seller a weighted average of the two bids, so the buyer always pays less than bid and the seller always receives a price higher than bid. Thus the protocol gains some of the efficiency of Vickrey while excluding any third-party pay in. The authors observed that the protocol supported many (but not all) desirable trades and excluded all undesirable ones. In the case of no correlation between the buyer's and seller's values, private information is not a big obstacle to trade. The desirable trades that the Chatterjee-Samuelson auction failed to consummate were those with lower joint value, so the failure is not too costly to the parties.

Myerson & Satterthwaite (1983) then proved a famous theorem showing the impossibility of achieving fully efficient trade with bilateral uncorrelated values (B not a function of S) using any balanced-budget protocol.

Samuelson (1984) was an early discussion of the full Akerlof problem including the dependence of the buyer's realized value B on the seller's value—the lemons problem. Akerlof demonstrated that trade could fail completely with a sufficiently strong dependence. Samuelson confirmed that the no-trade result is especially likely when the buyer's realized value moves one-for-one with the seller's value ($B'(S) = 1$). In this case, the buyer really cares about the

Figure 1. Buyer Sets Price; Buyer's Value Constant



Source: Authors' elaboration.

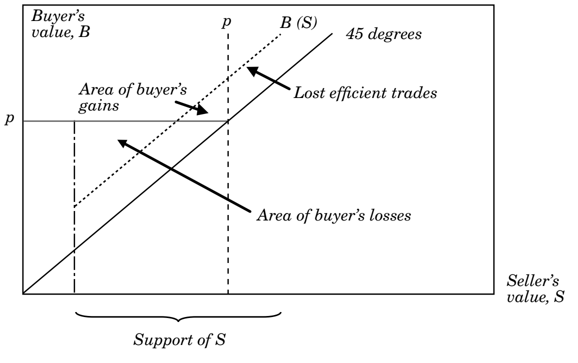
possibility that the seller has offered the object because it has a low value. Samuelson went on to show that a bargaining protocol where the buyer offers the seller a take-it-or-leave-it price is optimal for the buyer and maximizes the frequency of trading, though it leaves many efficient trades unexecuted. See also Kennan & Wilson (1993) and Chiu and Koeppl (2011) on this topic.

Figure 1 is the first of a sequence of graphs illustrating the basic issues. In all of the graphs, the horizontal axis is the seller's value and the vertical axis is the buyer's realized value. Points above the 45° line correspond to desirable trades. The buyer's take-it-or-leave-it price is the vertical line headed p and the horizontal line also labeled p. In figure 1, there is no connection between the buyer's value and the seller's value—that is, no lemons problem. For simplicity, I omit the uncorrelated element called ε above, so all trades take place along a line in the graphs.

In figure 1, there is a line of lost desirable trades where the buyer's value exceeds the price the buyer is offering. Trade occurs whenever the seller's value is below p, to the left of the vertical line. Because p is less than B, the buyer gains from all trades. The area of the rectangle between p and B is the buyer's profit (integrated over that part of the distribution of S). The buyer picks the price p to maximize that area.

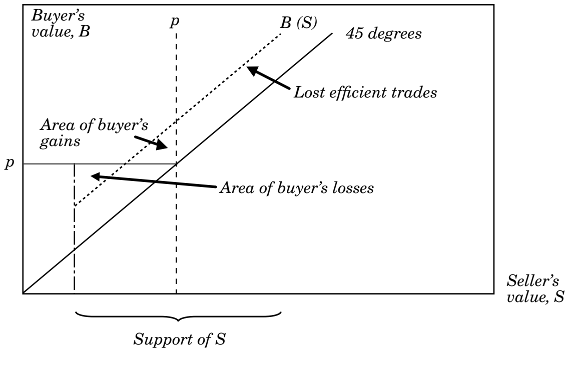
Figure 2 considers the case where the buyer's value *B(S)* rises point-for-point with S, so it is a parallel line above the 45° line. Trade

Figure 2. Buyer Sets Price; Buyer's Value Rises with Seller's Value; High Price



Source: Authors' elaboration.

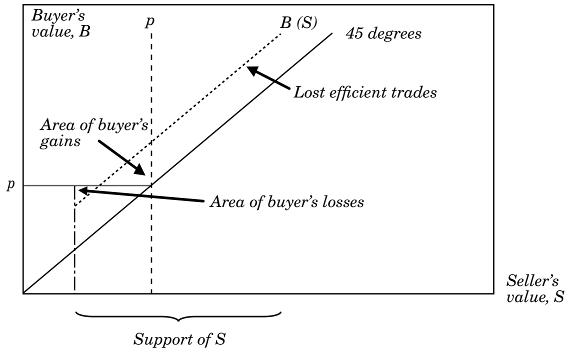
Figure 3. Buyer Sets Price; Buyer's Value Rises with Seller's Value; Lower Price



Source: Authors' elaboration.

is always desirable. In this figure, the buyer has chosen a high price, well up the support of S. The high price means that the line of non-trade is short. On the other hand, the line upon which trade occurs now extends deeply into the territory where the buyer incurs a loss from the transaction. Recall that this cannot occur in the uncorrelated

Figure 4. Buyer Sets Price; Buyer's Value Rises with Seller's Value; Even Lower Price



Source: Authors' elaboration.

case, but it is the big danger with positive correlation. The area of the triangle above the horizontal *p* line measures the gains when the buyer's value is above *p*, but that area may be more than offset by the area of the triangle where S is less than *p* and the buyer is incurring losses. Again, these areas are integrals over the distribution of *S*; they are literally areas only if the distribution of *S* is uniform.

Figure 3 shows the potential benefit to the buyer of setting a lower price. That price lengthens the line of missed beneficial trades, but lowers the area of buyer's losses. Still, in the case of a uniform distribution of *S*, the net benefit to the buyer is zero.

Figure 4 shows the consequences of an even lower price. Even more beneficial high-seller-value trades are lost, but the area where the buyer trades, but at a loss, is much smaller.

Figure 5 shows the optimal price (in the case of a uniform distribution) where the buyer loses a large fraction of the potential benefit of higher-value trades but avoids all losing trades. This graph makes Akerlof's main point—the lemons problem may drive a market to the point of low volumes of trade even though the potential benefits of trade are high.

Finally, figure 6 shows what happens in the case where the buyer's value rises more than point-for-point with the seller's value. It is no longer the case that the buyer can pick a price that avoids any chance of trading at a loss while retaining a positive probability of

Figure 5. Buyer Sets Price; Buyer's Value Rises with Seller's Value; Optimal Low Price

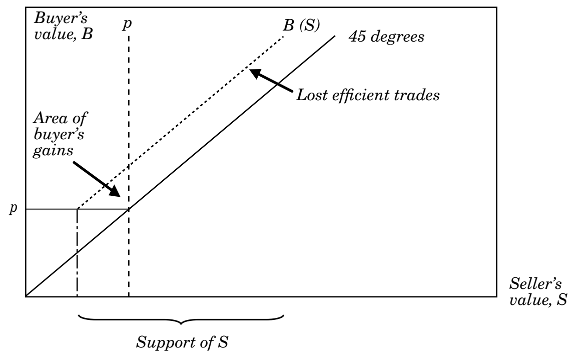


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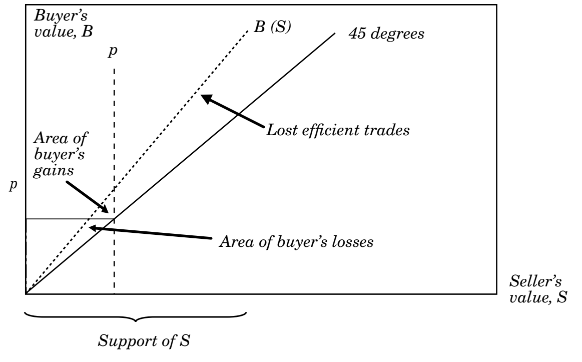
Figure 6. Buyer Sets Prices; *B*'(*S*) > 1



Source: Authors' elaboration.

trading at all. Akerlof's point that markets can collapse completely is particularly strong in this case. Models explaining the complete cessation of trading in many types of mortgage-related securities during and after the crisis rest on this analysis.

Recently, some literature has emerged considering the possibility of a second dimension of private information. With one dimension, as in Akerlof's original model, buyers make inferences about the quality of a car based on a single bit of information, the seller's decision to offer the car for sale. With a second dimension of private information—for example, urgency of the seller's desire to sell—buyers still have only that single bit of information, but interpret it in terms of both dimensions. To the extent that the population of sellers has a lot of urgent ones, the adverse selection problem is alleviated. In the real-estate market, it is common to see the claim of a "motivated seller." In general, sellers will try to offer some reason for selling other than a desire to dispose of a lemon.

There is an interesting interaction between the lemons theory and another line of research stimulated by the financial crisis, the theory of fire sales. That theory considers the decline in selling prices suffered when large numbers of holders of a type of security try to sell simultaneously. If the sales occur because of events exogenous to the sellers—as surely occurred during the crisis in many cases—the Akerlof adverse selection problem would be alleviated, because the fraction of sellers offering lemons falls in those cases.

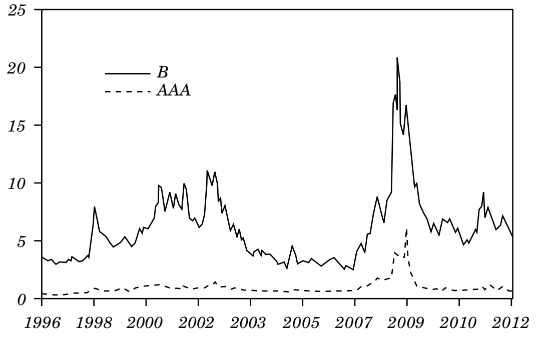
See Rochet and Choné (1998) to see how complex the theory becomes with more than one dimension of asymmetric information.

Where are adverse selection problems most severe in the real world? Definitely for goods and property—Akerlof chose the natural example of the used-car market. In securities markets, adverse selection has long been an explanation of the low volume of issuance of new equity by established companies. Bonds, especially mortgage-backed bonds with ample backing, such as overcollateralized senior tranches, traditionally traded as cash-like, with little concern about adverse selection. With large declines in the value of the collateral, the information-sensitivity of the bonds became much higher.

What aspects of asset-pricing events in the crisis do a model emphasizing adverse selection address? I would say meltdown in MBSs, for sure. But the apparent mispricing of government and corporate bonds requires other explanations, including fire sales. Figure 7 shows the wild movements of corporate bond spreads over Treasurys during the crisis. And even within Treasurys, the behavior of some spreads was remarkable and surely not the result of any information factors. Figure 8 shows the spread of inflation-protected Treasury bonds adjusted for the inflation protection by subtracting the expected rate of inflation from the inflation swap market.

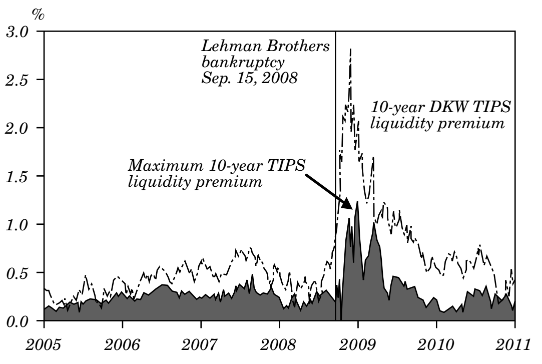
Because much of the attention currently being given to adverse selection in securities markets focuses on mortgage-backed bonds, it

Figure 7. Corporate Bond Spreads over Comparable Treasurys



Source: Board of Governors of the Federal Reserve System.

Figure 8. TIPS Spread over Treasurys Less Inflation Swap Rate



Source: Board of Governors of the Federal Reserve System.

is useful to note how these markets work. Generally, in normal times, the bonds are sold in a thick primary dealer market shortly before issuance to buy-and-hold investors. The secondary market is a thin dealer market where buyers and sellers dicker with dealers (who are mostly large banks). Search with recall seems the best description (see Zhu, 2012 and McAfee and McMillan, 1988).

The standard view of the freeze-up of MBS markets is the following: Before the crisis, overcollateralized claims on mortgage portfolios had zero perceived default probabilities and traded as safe bonds. Investors had essentially no concern about the compositions of the portfolios, so adverse selection was not a factor in transactions.

In the crisis, investors learned that overcollateralization was inadequate, given the magnitude of real-estate price declines, so they changed mode and adverse selection became a big issue. As all adverse-selection models predict, the result was a decline in transaction prices and in the likelihood that a seller could make a deal with a buyer. Fire sales occurred as financial institutions came under pressure from funding sources, so normally inactive secondary markets saw large volumes of selling interest.

The insights of Akerlof's 1970 paper continue to shape thinking about the performance of markets, especially securities markets since the financial crisis.

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The Leverage Cycle, Default, and Foreclosure

John Geanakoplos
Yale University and
National Bureau of Economic Research

At least since the time of Irving Fisher, economists, as well as the general public, have regarded the interest rate as the most important variable in the economy. But in times of crisis, collateral rates (margins or leverage equivalently) are far more important. Despite the cries of newspapers to lower the interest rates, the Fed would sometimes do much better to attend to the economy-wide leverage and leave the interest rate alone.

When a homeowner (or hedge fund or a big investment bank) takes out a loan using, say, a house as collateral, he must negotiate not just the interest rate, but how much he can borrow. If the house costs \$100 and he borrows \$80 and pays \$20 in cash, we say that the margin, or *haircut* is 20%, the loan to value is \$80/\$100 = 80%, and the collateral rate is \$100/\$80 = 125%. The leverage is the reciprocal of the margin, namely, the ratio of the asset value to the cash needed to purchase it, or \$100/\$20 = 5. These *ratios* are all synonomous.

In standard economic theory, the equilibrium of supply and demand determines the interest rate on loans. It would seem impossible that one equation could determine two variables, the interest rate and the margin. But in my theory, supply and demand do determine both the equilibrium leverage (or margin) and the interest rate.

It is apparent from everyday life that the laws of supply and demand can determine both the interest rate and leverage of a loan: the more impatient borrowers are, the higher the interest rate; the more nervous the lenders become, or the riskier the asset prices become, the higher the collateral they demand. But standard economic theory fails to properly capture these effects, struggling to see how a single supply-equals-demand equation for a loan could

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determine two variables: the interest rate and the leverage. The theory typically ignores the possibility of default (and thus the need for collateral), or else it fixes the leverage as a constant, allowing the equation to predict the interest rate.

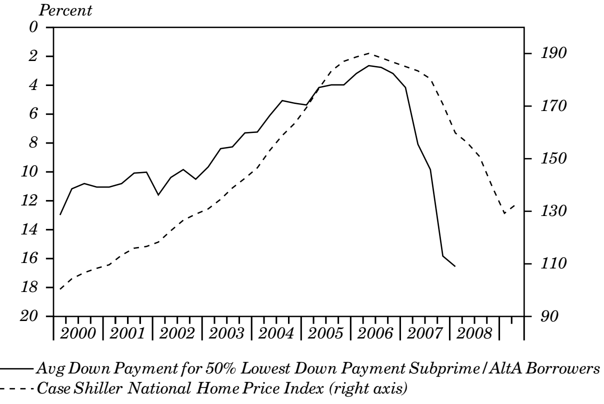
Yet, variation in leverage has a huge impact on the price of assets, contributing to economic bubbles and busts. This is because for many assets there is a class of buyers for whom the asset is more valuable than it is for the rest of the public (standard economic theory, in contrast, assumes that asset prices reflect some fundamental value). These buyers are willing to pay more, perhaps because they are more optimistic, or they are more risk tolerant, or they simply like the assets more, or they are important hedges for them and not for the others. If they can get their hands on more money through more highly leveraged borrowing (that is, getting a loan with less collateral), they will spend it on the assets and drive those prices up. If they lose wealth, or lose the ability to borrow, they will buy less, so the asset will fall into more pessimistic hands and be valued less.

In the absence of intervention, leverage becomes too high in times when markets have been stable and apparently devoid of risk for long periods of time, and too low in scary times when asset prices are very uncertain. The high leverage during the safe period makes the economy much more vulnerable when uncertainty returns. As a result, in boom times asset prices are too high, and in crisis times they are too low. This is the leverage cycle.

Leverage dramatically increased in the United States and globally from 1999 to 2006. A bank that in 2006 wanted to buy a AAA-rated mortgage security could borrow 98.4% of the purchase price, using the security as collateral, and pay only 1.6% in cash. The leverage was thus 100 to 1.6, or about 60 to 1. The average leverage in 2006 across all of the US$2.5 trillion of so-called 'toxic' mortgage securities was about 16 to 1, meaning that the buyers paid down only $150 billion and borrowed the other $2.35 trillion. Home buyers could get a mortgage leveraged 35 to 1, with less than a 3% down payment. Security and house prices soared.

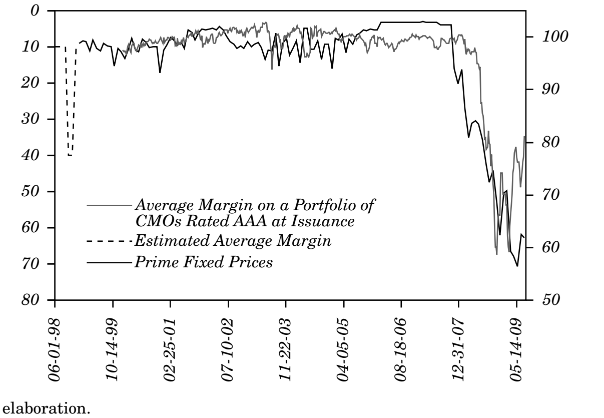
By 2009 leverage had been drastically curtailed by nervous lenders wanting more collateral for every dollar loaned. Those toxic mortgage securities were leveraged on average only about 1.2 to 1. A homeowner who bought his house in 2006 by taking out a subprime mortgage with only 3% down could not take out a similar loan in 2009 without putting down 30% (unless he qualified for one of the government rescue programs). The odds are great that he wouldn't

Figure 1. Securities Leverage Cycle, Margins Offered and AAA Securities Prices



Source: Author's elaboration.
The chart represents the average margin required by dealers on a hypothetical portfolio of bonds subject to certain adjustments noted below. Observe that the Margin % axis has been reversed, since lower margins are correlated with higher prices.The portfolio evolved over time, and changes in average margin reflect changes in composition as well as changes in margins of particular securities. In the period following Aug. 2008, a substantial part of the increase in margins is due to bonds that could no longer be used as collateral after being downgraded, or for other reasons, and hence count as 100% margin.

Figure 2. Housing Leverage Cycle, Margins Offered (Down Payments Required) and Housing Prices

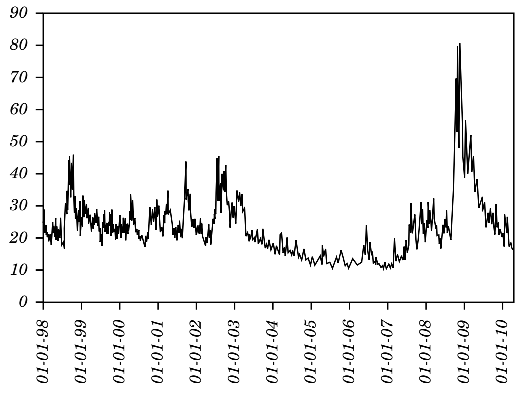


Source: Author's elaboration.
Observe that the Down Payment axis has been reversed, because lower down payment requirements are correlated with higher home prices. For every AltA or Subprime first loan originated from Q1 2000 to Q1 2008, down payment percentage was calculated as appraised value (or sale price if available) minus total mortgage debt, divided by appraised value. For each quarter, the down payment percentages were ranked from highest to lowest, and the average of the bottom half of the list is shown in the diagram. This number is an indicator of down payment required: clearly many homeowners put down more than they had to, and that is why the top half is dropped from the average. A 13% down payment in Q1 2000 corresponds to leverage of about 7.7, and 2.7% down payment in Q2 2006 corresponds to leverage of about 37. Subprime/AltA issuance stopped in Q1 2008.

have the cash to do it, and reducing the interest rate by 1 or 2% wouldn't change his ability to act.

Seven and a half years after the crash of subprime mortgages in February 2007, the economy still has not returned to normal. The Fed has lowered interest rates to near 0 and kept them there for five years. But it has not tried to boost leverage, except for a brief successful period in 2009 and 2010.

Figure 3. VIX Index



Source: Author's elaboration.

The leverage cycle is a recurring phenomenon. The financial derivatives crisis in 1994 that bankrupted Orange County in California was the tail end of a leverage cycle. So was the emerging markets mortgage crisis of 1998, which brought the Connecticut-based hedge fund Long-Term Capital Management to its knees, prompting an emergency rescue by other financial institutions. The crash of 1987 also seems to be at the tail end of a leverage cycle. The Tulip Bulb mania and the Japanese land boom of the 1980s were leverage cycles.

The policy implication of my theory of equilibrium leverage is that the Fed should manage system wide leverage, curtailing leverage in normal or ebullient times, and propping up leverage in anxious times. The theory challenges the "fundamental value" theory of asset pricing and the efficient markets hypothesis.

If agents extrapolate blindly, assuming from past rising prices that they can safely set very small margin requirements, or that falling prices means that it is necessary to demand absurd collateral levels, then the cycle will get much worse. But a crucial part of my leverage cycle story is that every agent is acting perfectly rationally from his own individual point of view. People are not deceived into following illusory trends. They do not ignore danger signs. They do not panic. They look forward, not backward. But under certain circumstances the cycle spirals into a crash anyway. The lesson is that even if people remember this leverage cycle, there will be more leverage cycles in the future, unless the Fed acts to stop them.

The leverage cycle always involves the same elements. First, a sustained period of calm leads lenders to increase loan to value ratios, both because they feel safe and because financial innovation is given time to further stretch collateral. This leads to higher asset prices as more people can afford the downpayment to buy more assets or with indivisible assets, to buy the asset at all. Borrowing thus goes up for a squared reason: a higher percentage is borrowed of higher valued assets. Next a little bit of bad news occurs. This causes prices to drop a little, which in turn leads to huge losses for the most optimistic, leveraged buyers. The redistribution of wealth from optimists to pessimists further erodes prices, causing more losses for optimists. If lenders gauge future uncertainty by extrapolating from the past, then these price declines make them nervous and cause them to set tighter margins. Alternatively, even if they rationally forecast the future, and the news is not just bad, but scary, in the sense that it increases uncertainty, they will also tighten margins. This leads to steeper price declines, which causes leveraged optimists to lose more money, which causes rational lenders to anticipate further price declines, leading then demanding more collateral, and so on. All three elements feed back on each other.

The best way to stop a crash is to act long before it occurs, by restricting leverage in ebullient times. The best time for an investor to enter the market is just after the crash.

My theory is of course not completely original. Over 400 years ago in the Merchant of Venice, Shakespeare explained that to take out a loan, one had to negotiate both the interest rate and the collateral level. It is clear which of the two Shakespeare thought was the more important. Who can remember the interest rate Shylock charged Antonio? (It was zero percent.) But everybody remembers the pound of flesh that Shylock and Antonio agreed on as collateral. The upshot of the play, moreover, is that the regulatory authority (the court) decides that the collateral Shylock and Antonio freely agreed upon was socially suboptimal, and the court decreed a different collateral: a pound of flesh but not a drop of blood. The Fed should also decree different collateral rates sometimes.

In more recent times there has been pioneering work on collateral by Shleifer and Vishny SV (1992), Bernanke, Gertler, Gilchrist BGG (1996, 1999), and Holmström and Tirole (1997). This work emphasized the asymmetric information between borrower and lender, leading to a principal agent problem. In Holmström and Tirole (1997) the managers of a firm are not able to borrow all the inputs necessary to build a project because lenders would like to see them put skin in the game, by putting their own money down, to guarantee that they exert maximal effort. The BGG (1999) model, adapted from their earlier work, is cast in an environment with costly state verification. I do not invoke any asymmetric information. I believe that it is important to note that endogenous leverage need not be based on asymmetric information. Of course the asymmetric information revolution in economics was a tremendous advance, and asymmetric information plays a critical role in many lender-borrower relationships; however, sometimes the profession becomes obsessed with it. In the crisis of 2007 – 2009, it does not appear to me that asymmetric information played a critical role in setting margins. Certainly the buyers of mortgage securities did not control their payoffs. In my model the only thing backing the loan is the physical collateral. Because the loans are no-recourse, there is no need to learn anything about the borrower. All that matters is the collateral. Repo loans, and mortgages in many states, are literally no-recourse. In the rest of the states, lenders rarely come after borrowers for more money beyond taking the house. And for subprime borrowers, the hit to the credit rating is becoming less and less tangible. In looking for determinants of (changes in) leverage, one should start with the distribution of collateral payoffs, and not the level of asymmetric information.

Another important paper on collateral is Kiyotaki and Moore (1997). Like BGG (1996), this paper emphasized the feedback from the fall in collateral prices to a fall in borrowing capacity, such as would occur from a constant loan to value ratio. By contrast, my work defining collateral equilibrium focused on what determines the *ratios* (LTV, margin, or leverage) and why they change. In practice, I believe the change in ratios has been far bigger and more important for borrowing than the change in price levels. The possibility of changing ratios is latent in the BGG models, but not emphasized by them. In my 1997 paper I showed how one supply-equals-demand equation can determine leverage as well as interest even when the future is uncertain. In my 2003 paper on the anatomy of crashes and margins (it was an invited address at the 2000 World Econometric Society meetings), I argued that in normal times leverage and asset prices get too high, and in bad times, when the future looks worse and more uncertain, leverage and asset prices fall too low. In the certainty model of Kiyotaki and Moore, to the extent leverage changes at all, it goes in the opposite direction, getting looser after bad news. In Fostel and Geanakoplos (2008b), on leverage cycles and the anxious economy, we noted that margins do not move in lockstep across asset classes, and that a leverage cycle in one asset class might spread to other unrelated asset classes. In Geanakoplos and Zame (2009, 2014) we describe the general properties of collateral equilibrium. In Geanakoplos and Kubler (2005), we show that managing collateral levels can lead to Pareto improvements.[1]

The recent crisis has stimulated a new generation of important papers on leverage and the economy. Notable among these are Brunnermeier and Pedersen (2009), anticipated partly by Gromb and Vayanos (2002), and Adrian and Shin (2009), and Simsek (2013).

This paper emphasizes two dangers to leverage. The first is that the roller coaster of leverage, caused by changes in risk perceptions, leads to a roller coaster in asset prices. That has all sorts of implications for the risk exposure of agents who are forced to hold these assets and cannot hedge them (like households who own houses or banks whose major business is holding mortgages). Second, when a boom is followed by a bust, many borrower will find themselves under water, owing more than the value of the collateral. There are typically large losses in turning over the collateral, partly because of vandalism and so on, and partly because agents have no incentive to invest in their collateral when they know it may be seized anyway. Subprime lenders (bondholders) received on average less than 25% of the loan amount back when they foreclosed on a home during the years 2007–12. We shall see that in the model even though every lender rationally anticipates the incentives his borrowers will face, they still collectively extend too much leverage because no lender takes into account that if he reduced his loan size the price of housing would be slightly higher in the future and some other homeowner might not go underwater and stop fixing his house.

1. For Pareto improving interventions in credit markets, see also Gromb-Vayanos (2002) and Lorenzoni (2008).

Section 2 describes a very simple two period model of collateral equilibrium with one risky asset. This enables me to introduce the notation gently and to display the connection between uncertainty, leverage, and asset prices in graphical form. There it is explained why the limits to borrowing that arise when collateral is needed to guarantee delivery can paradoxically increase the price of assets that need to be purchased with borrowed funds. In section 3, I introduce general notation for collateral equilibrium. Then I describe the leverage cycle. In section 4, I introduce delays in unencumbering collateral and the resulting costs of foreclosure. This brings out one of the negative externalities caused by increased leverage.

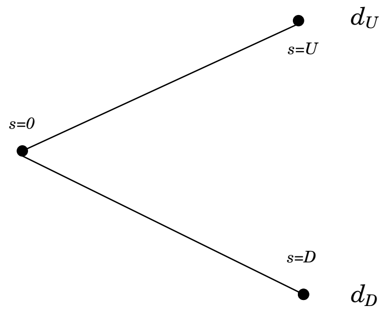
1. A Two-Period, Binomial Economy with One Risky Asset

To introduce our notation and to illustrate some of the analytical ideas in a simple environment, let us consider the following family of examples taken from Geanakoplos (2003). For this family of examples we define equilibrium without financial contracts, Arrow Debreu equilibrium, and collateral equilibrium. We end by comparing asset prices across the different equilibria.

Consider two time periods 0,1 , and two states of nature U and D in the last period and agents or households $h \in H$. Suppose that there are three commodities at time 0, whose holdings are denoted by $x_0 = (x_{01}, x_{02}, x_{03}) = (c_0, y_0, w_0)$ which we call the perishable consumption good C, the durable asset Y, and the durable ("warehousable") consumption good W. Suppose there is just one commodity in each state U and D, which we think of as the perishable consumption good, and whose holdings we denote by $x_s = c_s$, $s = U, D$. We think of the durable consumption good as something like cigarettes or canned food or oil in a well, that can be stored costlessly until the next period, or costlessly transformed one to one into the consumption good and used up immediately, by lighting the cigarette or opening the can of sardines, or drawing the oil out of the well.

Each unit of Y pays either d_U or $d_D < d_U$ of the consumption good in the two states U (as in Up) or D (as in Down), respectively. Imagine the asset as a mortgage that either pays in full or defaults with recovery d_D. (All mortgages will either default together or pay off together). But it could also be an undrilled oil well that could be a gusher or a small one. The only difference between W and Y is that the output of W is known for sure to be 1 next period, while the output of Y is uncertain.

Figure 4. Simple Binomial Tree



Source: Author's elaboration.

Let us assume that every agent h has a continuous, concave and monotonic von Neumann Morgentern utility u^h for the perishable consumption good in each state, discount factor δ_h, and probability belief γ_U^h for state U and probability belief $\gamma_D^h = 1 - \gamma_U^h$ for the down state D. The agents are characterized by their utilities and endowments

$$U^h(c_0, y_0, w_0, c_U, c_D) = u^h(c_0) + \delta_h[\gamma_U^h u^h(c_U) + \gamma_D^h u^h(c_U)]$$

$$e^h = (e^h_{C_o}, e^h_{Y_o}, e^h_{W_o}, e^h_{C_U}, e^h_{C_D})$$

The durable consumption good and the asset provide no direct utility to their holders at time 0, they just increase income in the future. Moreover their future value does not depend on who holds them at time 0. We call such assets financial assets, in contrast to houses, that do provide immediate utility at time 0 to those who hold them.

To complete the formal description of our example, we must also specify the production technology. We let the matrices

$$E_U = [0 \;\; d_U \;\; 1], E_D = [0 \;\; d_D \;\; 1]$$

denote what happens next period to each of the commodities at time 0. The first column of each matrix corresponds to the dividend in states U and D of holding the perishable consumption good at time 0. The second column corresponds to the dividend in states U and D of holding the durable asset Y, and the third column corresponds to holding holding the durable consumption good W ("warehousing" or "storing" it). Thus an agent who holds $x_0 = (x_{01}, x_{02}, x_{03}) = (c_0, y_0, w_0)$ in period 0 receives E_U, x_0 of dividends at U and E_D, x_0 of dividends at D.

We also describe the intraperiod technology

$$Z_0 = \{z = (z_{01}, z_{02}, z_{03}) : z \leq (\lambda, 0, -\lambda), \lambda \in \mathbb{R}\}$$

which respresents the idea that the durable consumption good can be transformed one to one into the perishable consumption good and vice versa. We suppose every agent has access to this technology.

1.1 A Continuum of Risk Neutral Agents and the Marginal Buyer

Let us consider the simplest possible agents. Suppose the agents $h \in H$ only care about the total expected consumption they get, no matter when they get it. They are not impatient.

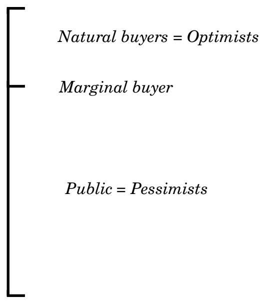
Thus $\delta_h = 1$ and $u^h(c) = c$ for all $h \in H$. The difference between the agents is thus only in the probabilities $\gamma_U^h, \gamma_D^h = 1 - \gamma_U^h$ each attaches to the good outcome of Y and the bad outcome. We suppose that γ_U^h is strictly monotonically increasing and continuous in h so that the higher h is, the more optimistic is the agent. When H is a finite set, the continuity hypothesis is vacuous. But we consider the case where H is the unit interval with the uniform Lebesgue measure. For this continuum case, the summation over $h \in H$ must always be understood as the integral over $H = [0,1]$ with respect to the standard Lebesgue measure.

The advantage of the continuum of agents approach is that every agent will always be able to optimize by going to one extreme or another, for example putting all its wealth into the risky asset Y or into the riskless asset W. But one agent, which we shall call the marginal buyer, will be indifferent to both extremes.

1.2 Equilibrium Asset Pricing without Credit

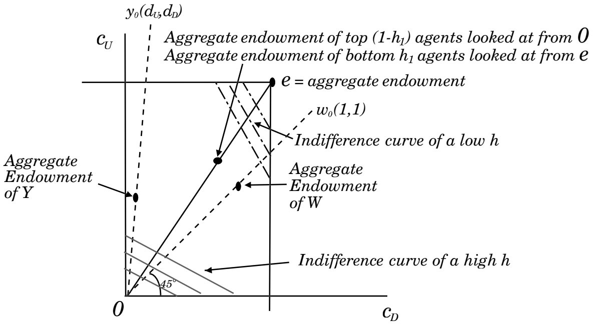
We can always choose the perishable consumption good as the numeraire in every state 0,1 and 2; hence we take its price to be 1 in every state. Since the storable consumption good is transformable

Figure 5. Marginal Buyer Theory of Price



Source: Author's elaboration.

Figure 6. Edgeworth Box with a Continuum of Risk Neutral Agents



Source: Author's elaboration.

one to one into the perishable consumption good, we can also take the price of W_0 to be 1. Suppose the price of the asset per unit at time 0 is p_Y , somewhere between 0 and 1.

If borrowing were not allowed, and agents could only trade the commodities among themselves in period 0, then the budget set for each agent would be

$$B_0^h(p) = \{(c_0, y_0, w_0, c_U, c_D) \in \mathbb{R}_+^5 : c_0 + w_0 + p_Y(y_0 - e_{Y_o}^h) = e_{C_o}^h + e_{W_o}^h$$

$$c_U = 1w_0 + d_U y_0 + e_{C_U}^h$$

$$c_D = 1w_0 + d_D y_0 + e_{C_D}^h\}.$$

Given the price p_Y, each agent chooses the consumption plan $(c_0^h, y_0^h, w_0^h, c_1^h, c_2^h)$ in $B_0^h(p_Y)$that maximizes his utility U^h defined above. In equilibrium all markets must clear

$$\sum_{h \in H}(c_0^h + w_0^h) = \sum_{h \in H}(e_{C_o}^h + e_{W_o}^h)$$

$$\sum_{h \in H} y_0^h = \sum_{h \in H} e_{Y_o}^h$$

$$\sum_{h \in H} c_U^h = d_U \sum_{h \in H} e_{Y_o}^h + 1 \sum_{h \in H} w_0^h + \sum_{h \in H} e_{C_U}^h$$

$$\sum_{h \in H} c_D^h = d_D \sum_{h \in H} e_{Y_o}^h + 1 \sum_{h \in H} w_0^h + \sum_{h \in H} e_{C_D}^h$$

The agents h who believe that

$$\gamma_U^h d_U + (1 - \gamma_U^h) d_D > p_Y$$

will spend all their wealth at 0 to buy the risky asset Y, since by paying p_Y now they get something with expected payoff next period greater than p_Y and they are not impatient. Those who think

$$\gamma_U^h d_U + (1 - \gamma_U^h) d_D < p_Y$$

will sell their share of the asset and buy either consumption good (between which they are indifferent).

Under the assumption that γ_U^h is strictly monotically increasing and continuous in h, there must be a unique agent h^* who is indifferent between W and Y. We call him the marginal agent. Those above h^* will spend all their money on Y, and those below h^* will spend all their money on W. The presence of the marginal agent makes it easy to describe and compute equilibrium.

Without borrowing, equilibrium (h^*, p_Y) must solve two equations

$$\gamma_U^{h^*} d_U + (1 - \gamma_U^{h^*}) d_D = p_Y$$

$$(1 - h^*)(1 + p_Y) = p_Y$$

where the first says that the marginal agent h^* is indifferent between W and Y, and the second equation says that if the top $(1-h^*)$ agents spend all their income they should just be able to afford to buy the one unit outstanding of Y.

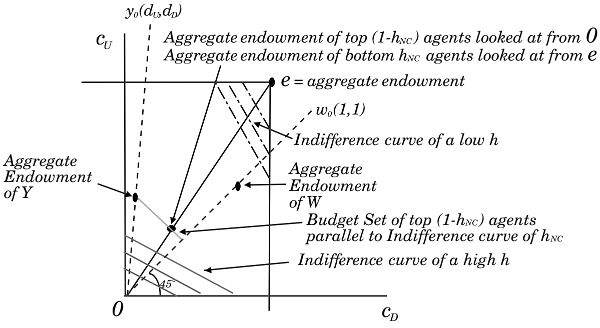
In the numerical examples that follow we shall always suppose that every agent owns one unit of the risky asset at time 0 and also one unit of the warehousable consumption good at time 0, $e_0^h = (e_{01}^h, e_{02}^h, e_{03}^h) = (e_{C_o}^h, e_{Y_o}^h, e_{W_o}^h) = (0, 1, 1)$, and that the output from the risky asset is 1 in the up state U and 0.2 in the down state D. The endowments and asset payoffs are thus

$$e^h = (e_{C_o}^h, e_{Y_o}^h, e_{W_o}^h, e_{C_U}^h, e_{C_D}^h) = (0, 1, 1, 0, 0)$$

$$(d_U, d_D) = (0, 0.2)$$

Suppose $\gamma_U^h = h$ for all h. Then solving the system of two equations gives equilibrium $(h^*, p_Y) = (0.596, 0.677) \approx (0.60, 0.68)$. Agent $h = 0.60$ values the asset at $0.68 = 0.60(1) + 0.40\ (0.2)$. Each agent above 0.60 will spend all his 1.68 of wealth on asset Y. The total cost of Y is 0.68, and indeed $0.40(1.68) = 0.67 \approx 0.68$ units in aggregate. Since the market for risky assets clears at time 0, and everybody is optimizing, by the Walras Law, the market for all the other goods must clear as well and this is the equilibrium with no borrowing. In this equilibrium agents are indifferent to storing or consuming right

Figure 7. No Credit Equilibrium



Source: Author's elaboration.

away, so we can describe equilibrium as if everyone warehoused and postponed consumption by taking

$p = 0.68$

$(c_0^h, y_0^h, w_0^h, c_U^h, c_D^h) = (0, 2.5, 0, 2.5, 0.5)$ for $h \geq 0.60$

$(c_0^h, y_0^h, w_0^h, c_U^h, c_D^h) = (0, 0, 1.68, 1.68, 1.68)$ for $h < 0.60$.

Similarly if agents are more optimistic, and $\gamma_U^h = 1 - (1-h)^2 > h$ for all $h \in (0,1)$, then equilibrium $(h^*, p_Y) = (0.545, 0.835)$. On the other hand, if agents are more pessimistic and $\gamma_U^h = 1 - (1-h)^{0.1} < h$ for all $h \in (0,1)$, then equilibrium $(h^*, p_Y) = (0.764, 0.308)$.

1.3 Arrow Debreu Equilibrium

If agents can commit to delivering fully on state contingent promises, then we get Arrow Debreu equilibrium. Arrow Debreu equilibrium is defined by Arrow prices (π_U, π_D) of the promise to deliver one unit of the consumption good in U, and the promise to deliver one unit in D, together with consumption $(c_0^h, w_0^h, c_U^h, c_D^h)_{h\in H}$ such that supply equals demand

$$\sum_{h\in H}(c_0^h + w_0^h) = \sum_{h\in H}(e_{C_o}^h + e_{W_o}^h)$$

$$\sum_{h\in H} c_U^h = d_U \sum_{h\in H} e_{Y_o}^h + 1\sum_{h\in H} w_0^h + \sum_{h\in H} e_{C_U}^h$$

$$\sum_{h\in H} c_D^h = d_D \sum_{h\in H} e_{Y_o}^h + 1\sum_{h\in H} w_0^h + \sum_{h\in H} e_{C_D}^h$$

and such that each agent h is choosing $(c_0^h, w_0^h, c_U^h, c_D^h)$ to maximize $U^h(c_0, c_U, c_D)$ such that

$$c_0 + \pi_U c_U + \pi_D c_D \leq (e_{C_o}^h + e_{W_o}^h) + \pi_U(e_U^h + d_U e_{Y_o}^h) + \pi_D(e_D^h + d_D e_{Y_o}^h)$$

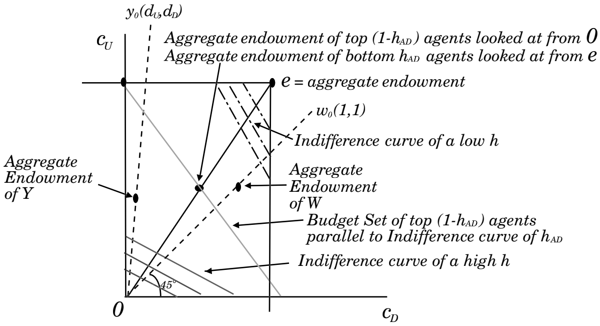
For the economy with a continuum of risk neutral agents who do not discount the future, it is evident that again there must be a marginal buyer h^* such that the agents $h > h^*$ spend all their wealth on c_U and the agents $h < h^*$ spend all their wealth on c_D All the time 0 goods will be warehoused to the future.

Taking endowments $e^h = (0, 1, 1, 0, 0)$ and risky asset payoffs $(d_U, d_D) = (1, 0.2)$ as before, total consumption in U must be 2 and in D it must be 1.2. Suppose $\gamma_U^h = h$ for all h. Then the Arrow Debreu equilibrium is $(h^*, \pi_U, p_Y) = (0.436, 0.436, 0.549) \approx (0.44, 0.44, 0.55)$. Agent $h = 0.44$ values the asset at $0.55 = 0.44(1) + 0.56(0.2)$. Every agent above 0.44 will buy as much as he can afford of the Up Arrow security. Each of these agents can spend 1.55, hence spending 0.56 $(1.55) = 0.87$ in aggregate. Since the cost of all the Arrow up is 2 $(0.436) = 0.87$, the markets clear.

Similarly if agents are more optimistic, and $\gamma_U^h = 1 - (1-h)^2$ for all h then equilibrium $(h^*, \pi_U, p_Y) = (0.33, 0.55, 0.64)$ On the other hand, if agents are more pessimistic and $\gamma_U^h = 1 - (1-h)^{0.1}$ for all h then equilibrium $(h^*, \pi_U, p_Y) = (0.783, 0.142, 0.314)$.

Observe that the asset price in the no borrowing equilibrium can be higher than the Arrow Debreu asset price. Thus when $\gamma_U^h = h$, the Arrow Debreu price is higher $0.68 > 0.55$ and when $\gamma_U^h = 1 - (1-h)^2$ the Arrow Debreu price is also higher, $0.83 > 0.64$. But when $\gamma_U^h = 1 - (1-h)^{0.1}$, the Arrow Debreu price is lower $0.308 < 0.314$. The difference between the two economies is essentially that in the no borrowing economy, there is also no short selling; with short selling of both assets (and delivery fully guaranteed) we would get the Arrow Debreu outcome. If short selling were allowed, the agents

Figure 8. Arrow Debreu Equilibrium



Source: Author's elaboration.

who thought one of the assets was overvalued would sell it short. That can sometimes lower the price of Y, but it can other times lower the price of W.

1.4 Collateral Equilibrium

When credit markets are created, the first question that arises is why should borrowers keep their promises? In the Arrow Debreu model, the implicit assumption is made that anyone who defaults faces an infinite penalty. We shall now suppose to the contrary that no penalties are available, but that there is a state-run court system that is able to seize pledged collateral in case of default and turn it over to he lender.

1.4.1 Collateral

We shall restrict attention to loans that are non-contingent, that is that involve promises of the same amount j in both states. We have not yet determined how much people can borrow or lend. In conventional economics they can do as much of either as they like, at the going interest rate. But in real life lenders worry about default. Suppose we imagine that the only way to enforce deliveries is through collateral. A borrower can use one unit of the asset Y itself as collateral, so that if he defaults the collateral can be seized.[2] Of course a lender realizes that if the promise is j in both states, then with no-recourse collateral he will only receive

$\min(j, d_U)$ if good news

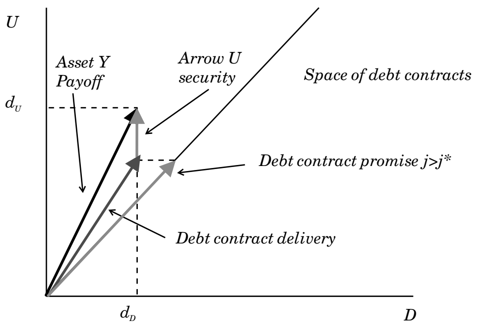
$\min(j, d_D)$ if bad news

Observe that because the owner of the collateral has no influence on the cash flows of the asset, and with no recourse collateral and one period loans, every agent delivers the same on a given contract, namely the promise or the collateral, whichever is worth less. The

2. The other durable good W could also be used as collateral. But since its payoff is the same in both states, and the coontracts are all non-contingent, nobody would ever both to borrow on it. They could simply sell the asset to raise cash. In the case of Y, borrowing on Y gives a net payoff that is different from simply holding Y.

loan market is thus completely anonymous; there is no role for asymmetric information about the agents because every agent delivers the same way. Lenders need only worry about the collateral, not about the identity or actions of the borrowers.

Figure 9. Contract Promises and Deliveries



Source: Author's elaboration.

The introduction of collateralized loan markets introduces two more parameters: how much can be promised *j*, and at what interest rate *r*? At first glance there seems to be only one additional market clearing condition, namely, that demand equals supply for loans. How can one equation determine two variables?

1.4.2 The credit surface

Before 1997 there had been virtually no work on equilibrium margins. Collateral was discussed almost exclusively in models without uncertainty (as in Kiyotaki and Moore, 1997), or in corporate finance models in which moral hazard reasons like the potential theft of loans restrained borrowing (as in Holmström and Tirole, 1997). But the 2007–09 crisis revealed that massive shifts in collateral rates or leverage occurrred in assets like mortgage securities, in which the owners of the securities had absolutely no influence on the cash flows, or spccial knowledge of the cash flows. Even now the few writers who try to make collateral endogenous in general equilibrium do so by taking an ad hoc measure of risk, like volatility or value at risk, and assume that the margin is some arbitrary function of the riskiness of the repayment.

It is not surprising that economists have had trouble modeling equilibrium haircuts or leverage. We have been taught that the only equilibrating variables are prices. It seems impossible that the demand equals supply equation for loans could determine two variables.

The key idea, as shown in Geanakoplos (1997), is to think of many loans, not one loan. Irving Fisher and then Ken Arrow taught us to index commodities by their location, or their time period, or by the state of nature, so that the same quality apple in different places or different periods might have different prices. So we must index each promise by its collateral. A promise of $j = d_D$ backed by Y is different from a promise of $j = d_D$ backed by 1/2 of Y. The former delivers d_D in both states, but the latter might deliver d_D in the good state (if $d_U \geq 2d_D$) and $(1/2)d_D$ in the bad state. Doubling the promise does not double the payoff. The collateral matters.

Conceptually we must replace the notion of contracts as promises with the notion of contracts as ordered pairs of promises and collateral, so that each ordered pair-contract will trade in a separate market, with its own price.

$$Contract_j = (Promise_j, Collateral_j) = (A_j, C_j)$$

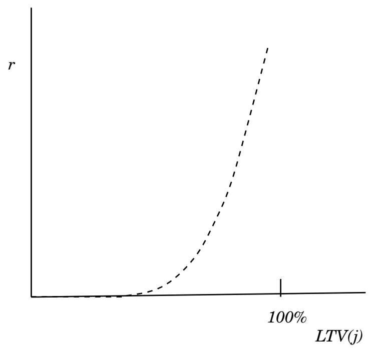
Though the contract payoffs are not homogeneous in the promise with a fixed collateral, the payoffs are indeed homogeneous in the ordered pair. Doubling the promise and the collateral *does* double the payoff of the contract. Trading via the former contract is the same as trading through the latter contract; only the units change. So without loss of generality, we can always normalize the collateral. In our example we shall focus on contracts in which the collateral C_j is simply one unit of Y.

So let us denote by j the promise of j in both states in the future, backed by the collateral of one unit of Y. We take an arbitrarily large set J of such assets, but include $j = d_D = 0.2$. Each contract j type trades at its own price π_j.

Given the price π_j, and given that the promises are all non-contingent, we can always compute the implied nominal interest rate as $1 + r_j = j/\pi_j$. When the collateral is so big that there is no default, $\pi_j = j/(1 + r)$, where r is the riskless rate of interest. But when there is default, the price cannot be derived from the riskless interest rate alone.

In the end we have a menu of contracts, each trading for a different price or, equivalently, a different interest rate. The amalgam of all contracts traces out a surface if we think of the terms of the contract as the argument and the interest rate as a function of these terms. I call this the credit surface. In standard monetary theory we describe credit conditions by the riskless interest rate. The riskless interest rate appears on one end of the credit surface, where the collateral is very big compared to the promise. But credit, and thus activity in the economy, often relies more on the parts of the credit surface that lie beyond the riskless interest rate.

Figure 10. Credit Surface



Source: Author's elaboration.

1.4.3 Collateral budget set and equilibrium

We must distinguish between sales $\varphi_j > 0$ of these collateralized promises (that is borrowing) from purchases $\theta_j > 0$ of these promises (that is lending). The two differ more than in their sign. A sale of a promise obliges the seller to put up the collateral, whereas the buyer of the promise does not bear that burden. The marginal utility of buying a promise will often be much less than the marginal disutillity of selling the same promise, at least if the agent does not otherwise want to hold the collateral.

We can describe the budget set formally with our extra variables.

$$B^h(p_Y, \pi) = \{(c_0, y_0, (\theta_j, \varphi_j)_{j\in J}, w_0, c_U, c_D) \in \mathbb{R}^2_+ \times \mathbb{R}^{2J}_+ \times \mathbb{R}^3_+ : \tag{1}$$

$$c_0 + w_0 + p_Y(y_0 - e^h_{Y_o}) + \sum_{j=1}^{J}(\theta_j - \varphi_j)\pi_j \leq (e^h_{C_o} + e^h_{W_o})$$

$$\sum_{j=1}^{J} \max(\varphi_j, 0) \le y_0 \tag{2}$$

$$c_U - e^h_{C_U} \le 1w_0 + d_U y_0 + \sum_{j=1}^{J} (\theta_j - \varphi_j)\min(d_U, j) \tag{3}$$

$$c_D - e^h_{C_D} \le 1w_0 + d_D y_0 + \sum_{j=1}^{J} (\theta_j - \varphi_j)\min(d_D, j)\}. \tag{4}$$

The first inequality says that expenditure on consumption goods (perishable and warehousable) plus net expenditure on the asset Y plus net expenditure on contracts must be less than or equal to the value of the consumption good endowments. The seond inequality describes the crucial collateral or leverage constraint. Each promise must be backed by collateral, and so the sum of the collateral requirements across all the promises must be met by the Y on hand. The last two equations show the wealth carried into states U and D.

Equilibrium is defined exactly as before, except that now we must have market clearing for all the contracts $j \in J$ Equilibrium is defined by the price of Y and the contract prices (p_Y, π) and agent choices $(c^h_0, y^h_0, (\theta^h_j, \varphi^h_j)_{j\in J}, w^h_0, c^h_U, c^h_D$ in $B^h(p_Y, \pi)$ that maximize U^h defined above such that all markets clear

$$\sum_{h\in H} (c^h_0 + w^h_0) = \sum_{h\in H} (e^h_{C_o} + e^h_{W_o})$$

$$\sum_{h\in H} y^h_0 = \sum_{h\in H} e^h_{Y_o}$$

$$\sum_{h\in H} \theta^h_j = \sum_{h\in H} \varphi^h_j, \quad \forall j \in J$$

$$\sum_{h\in H} c^h_U = d_U \sum_{h\in H} e^h_{Y_o} + 1\sum_{h\in H} w^h_0 + \sum_{h\in H} e^h_{C_U}$$

$$\sum_{h\in H} c^h_D = d_D \sum_{h\in H} e^h_{Y_o} + 1\sum_{h\in H} w^h_0 + \sum_{h\in H} e^h_{C_D}$$

1.4.4 Equilibrium leverage

In equilibrium we can define the loan to value (LTV) of each contract by the ratio of the borrowed amount to the value of the collateral

$$LTV(j) = \frac{\pi_j}{p_Y}$$

The loan to value of the collateral Y is the weighted average (according to trading volume) of the leverage on each contract that uses Y as collateral

$$LTV(Y) = \frac{\sum_{h \in H} \pi_j \phi_j^h}{\sum_{h \in H} p_Y \phi_j^h}$$

Equilibrium thus determines the interest rate on each contract, and the LTV of each contract and the asset.

Surpisingly, we shall find that when there are only two states, then all the traded contracts have the same interest rate, and for each asset, every contract using it as collateral has the same loan to value.

Consider again the our numerical example where

$$e^h = (e^h_{C_o}, e^h_{Y_o}, e^h_{W_o}, e^h_{C_U}, e^h_{C_D}) = (0, 1, 1, 0, 0)$$

$$(d_U, d_D) = (0, 0.2)$$

Let $\gamma_U^h = h$ for all $h \in H = [0,1]$. Geanakoplos (2003) proved that there is a unique equilibrium, which we shall describe momentarily. In that equilibrium, the only asset that is traded is $((0.2, 0.2),1)$, namely, $j = 0.2$. All the other contracts are priced, but in equilibrium neither bought nor sold. Furthermore, there is a marginal buyer $h^* = 0.69$ who is indifferent to buying the asset Y and every contract j. Their prices can therefore be computed by using state prices corresponding to the value the marginal buyer $h^* = 0.69$ attributes to them. The price of the asset is therefore

$$P_Y = 0.69(1) + 0.31\ (0.2) = 0.75$$

Similarly the price of the contracts are calculated as

$$
\begin{aligned}
\pi_j &= 0.69 \min(1, j) + 0.31 \min(0.2, j) \\
1 + r_j &= j/\pi_j \\
\pi_{0.2} &= 0.69\ (0.2) + 0.31\ (0.2) = 0.2 \\
1 + r_{0.2} &= 0.2/0.2 = 1.00 \\
\pi_{0.3} &= 0.69\ (0.3) + 0.31\ (0.2) = 0.269 \\
1 + r_{0.3} &= 0.3/0.269 = 1.12 \\
\pi_{0.4} &= 0.69\ (0.4) + 0.31\ (0.2) = 0.337 \\
1 + r_{0.4} &= 0.4/0.337 = 1.19
\end{aligned}
$$

Thus an agent who wants to borrow 0.2 using one house as collateral can do so at 0% interest. An agent who wants to borrow 0.269 with the same collateral can do so by promising 12% interest. An agent who wants to borrow 0.337 can do so by promising 19% interest. The puzzle of one equation determining both a collateral rate and an interest rate is resolved; each collateral rate corresponds to a different interest rate. It is quite sensible that less secure loans with higher defaults will require higher rates of interest.

The surprise is that in this kind of example, with only one dimension of risk and one dimension of disagreement, only one margin will be traded! Everybody will voluntarily trade only the $j = 0.2$ loan, even though they could all borrow or lend different amounts at any other rate.

How can this be? Agent $h = 1$ thinks for every 0.75 he pays on the risky asset, he can get 1 for sure. Wouldn't he love to be able to borrow more, even at a slightly higher interest rate? The answer is no! In order to borrow more, he has to substitute say a 0.4 loan for a 0.2 loan. He would then deliver the same amount in the bad state D, but deliver more in the good state U, in exchange for getting more at the beginning. But that is not rational for him. He is the one convinced the good state U will occur, so he definitely does not want to pay more just where he values money the most.[3]

3. More precisely, buying Y while simultaneously using it as collateral to sell any non-contingent promise of at least 0.2 is tantamount to buying up Arrow securities at a price of 0.69 per unit of net payoff in state U. So $h > 0.69$ is indifferent to trading on any of the loan markets promising at least 0.2. By promising 0.4 per unit of Y instead of 0.2 he simply is buying fewer of the up Arrow securities per contract (because he must deliver more in the up state), but he can buy more contracts (since he is receiving more money at date 0). He can accomplish exactly the same thing selling less 0.2 promises.

The lenders are people with $h < 0.69$ who do not want to buy the asset. They are lending instead of buying the asset because they think there is a substantial chance of bad news. It should be no surprise that they do not want to make risky loans, even if they can get a 19% rate instead of a 0% rate, because the risk of default is too high for them. Indeed the risky loan is perfectly correlated with the asset which they have already shown they do not want. Why should they give up more money at time 0 to get more money in a state U that they think will not occur? If anything, these pessimists would now prefer to take the loan rather than give it. But they cannot take the loan, because that would force them to hold the collateral to back their promises, which they do not want to do.[4]

Thus the only loans that get traded in equilibrium involve margins just tight enough to rule out default. That depends of course on the special assumption of only two outcomes. But often the outcomes lenders have in mind are just two. And typically they do set haircuts in a way that makes defaults very unlikely. Recall that in the 1994 and 1998 leverage crises, not a single lender lost money on repo trades. In the massive crisis of 2007 only a few tens of millions of dollars of repo defaulted, out of trillions loaned. Of course in more general models, one would imagine more than one margin and more than one interest rate emerging in equilibrium. The upshot is that equilibrium leverage for the asset Y must be

$$LTV(Y) = \frac{d_D}{(1 + r_{d_D})\, p_Y} = \frac{0.2}{(1+0)(0.75)} = 29\%$$

To summarize, in the usual theory a supply equals demand equation determines the interest rate on loans. In my theory equilibrium often determines the equilibrium leverage (or margin) as well. It seems surprising that one equation could determine two variables, and to the best of my knowledge I was the first to make the observation (in 1997 and again in 2003) that leverage could be uniquely determined in equilibrium. I showed that the right way to think about the problem of endogenous collateral is to

4. More precisely, agents with $h < b$ will want to trade their wealth for as much consumption as they can get in the down state. But on account of the incompleteness of markets, no combination of buying, selling, borrowing on margin and so on can get them more in the down state than in the up state. So they strictly prefer making the 0.2 loan to lending, or borrowing with collateral, any loan promising more than 0.2 per unit of Y.

consider a different market for each loan depending on the amount of collateral put up, and thus a different interest rate for each level of collateral. A loan with a lot of collateral will clear in equilibrium at a low interest rate, and a loan with little collateral will clear at a high interest rate. A loan market is thus determined by a pair (promise, collateral), and each pair has its own market clearing price. The question of a unique collateral level for a loan reduces to the less paradoxical sounding, but still surprising, assertion that in equilibrium everybody will choose to trade at the same collateral level for each kind of promise. I proved that this must be the case when there are only two successor states to each state in the tree of uncertainty, with risk neutral agents differing in their beliefs, but with a common discount rate. More generally, I conjecture that the number of collateral rates traded endogenously will not be unique, but will be robustly much less than the dimension of the state space, or the dimension of agent types.

The following theorem extends my binomial leverage theorem for risk neutral agents to any agents with any kind of discounting. We have not yet introduced the notation needed to state a formal theorem, but we can informally mention the theorem taken from Fostel-Geanakoplos (2014a) that we shall formally state in the next section.

Binomial No Default Theorem: *Consider the two-period two-state economy described above with concave (not just risk-neutral) utilities. Suppose the risky financial asset pays $d_U > d_D$ in the two states. Then any equilibrium is equivalent to another one (in the sense that all consumptions, commodity prices and contract prices are the same) in which the only traded contract using the risky financial asset as collateral promises $j^* = d_D$ in both states. Thus there is no equilibrium default.*

In binomial economies with financial assets (assets that provide no immediate utility to hold them beyond their dividends), all the trade takes place at the unique cusp of the credit surface where the riskless rate is about to become a risky rate.

1.4.5 Risk reduces leverage

Since there is a unique contract picked out by equilibrium in binomial economies, we can easily define equilibrium leverage and see what determines it. The following is taken from Fostel and Geanakoplos (2014a)

Risk-Leverage Theorem for Binomial Economies: *Consider a two period, two state economy such as the one described above. Suppose the risky financial asset pays $d_U > d_D$ in the two states. Then any equilibrium is equivalent to another one (in the sense that all consumptions, commodity prices and contract prices are the same) in which leverage on every loan backed by the risky asset is*

$$LTV(Y) = \frac{\text{worst case return}}{\text{gross riskless rate}} = \frac{d_D/p_Y}{1+r}$$

This follows immediately from the previous theorem because $\pi_{j^*} = d_D/(1+r)$, hence $LTV(Y) = \pi_{j^*}/p_Y = d_D/(1+r)p_Y$.

Thus we have the very important result that risk reduces leverage, where greater risk is defined by a lower worst case return. It is worth noting that this formula does not link leverage with volatility in general. At best, it links leverage with downside volatility. Of course when risks are symmetric, downside volatility and volatility are the same. But in general they are not.

1.4.6 Tight credit markets

One of the most important concepts in macroeconomics is the idea that at certain times credit is too tight or too loose; these are the moments at which the Fed or the Central Bank is often called upon to act by changing interest rates.

What does it mean for credit markets to be tight? That the interest rate is too high? In collateral equilibrium there is a different meaning. Agents who want to borrow more than they have in collateral equilibrium have to put up more collateral or pay a higher interest rate. Observe that in the equilibrium in our example, every agent $h > h^*$ is borrowing at the riskless interest rate $r = 0\%$, but would dearly like to borrow more at the same rate. They cannot because then they would have to pay a higher interest rate, which they would not like to do, or put up more collateral, which they cannot afford (since any collateral purchase requires a positive downpayment).

The tightness of the credit market for any agent h can be measured by the ratio of the gross interest rate he would be willing to promise to borrow an additional dollar (assuming he was also obligated to deliver the same way he already was deliverying on the money he previously borrowed) divided by the gross interest rate he is paying on the money he is borrowing. In the example, this ratio is higher the higher h is. Agent $h = 1$ thinks that by borrowing 75 cents he can make \$1 for sure at U. Hence, he would be willing to pay a 33% interest rate for an additional penny loan, but cannot borrow any more at 0% than he is already borrowing. In order to borrow a penny more, he would be required to pay a higher interest rate on all the money he borrows.[5]

1.4.7 Computing equilibrium: The marginal buyer

Once we know that only one contract will be traded, and that this contract will not involve default and therefore trade at the riskless interest rate, it becomes very easy to compute equilibrium. As was the case with the no credit economy and the Arrow Debreu economy, when there is a continuum of risk neutral agents, there will be a marginal buyer h^* who is just indifferent to buying the asset, and in the collateral economy, also indifferent to buying every contract. Those $h < h^*$ will sell all the Y they have, and those $h > h^*$ will buy all they can with their cash and with the money they can borrow by trading contract $j = d_D$.

And what interest rate would the the lenders $h < h^*$ get? 0% interest, because they are not lending all they have in cash. (They are lending at most $d_D/h^* = 0.2/0.69 = 0.29 < 1$ per person). Since they are not impatient and they have plenty of cash left, they are indifferent to lending at 0%.Competition among these lenders will drive the interest rate to 0%.

More formally, letting the marginal buyer be denoted by $h = h^*$ we can define the equilibrium equations as

$$p_Y = \gamma_U^{h^*} d_U + (1 - \gamma_U^{h^*}) d_D \tag{5}$$

$$p_Y = (1 - h^*)(1 + p_Y) + d_D$$

Let us return to our numerical example where

$$e^h = (e^h_{C_o}, e^h_{Y_o}, e^h_{W_o}, e^h_{C_U}, e^h_{C_D}) = (0, 1, 1, 0, 0)$$

$$(d_U, d_D) = (0, 0.2)$$

5. The attentive reader will notice that we do not allow tranching or senioriry of loans in this survey. I have treated these subjects elsewhere.

Let $\gamma_U^h = h$ for all $h \in H = [0,1]$. Equation (1) says that the marginal buyer h^* is indifferent to buying the asset. Equation (2) says that the price of Y is equal to the amount of money the agents above h^* spend buying it. As we said, the large supply of the durable consumption good, no impatience, and no default implies that the equilibrium interest rate must be 0.

Solving equations (1) and (2) for p_Y and h^* when beliefs are given by $\gamma_U^h = h$ for all $h \in H$, and plugging these into the agent optimization gives equilibrium

$h^* = 0.69$

$(p_Y, r) = (0.75, 0),$

$(c_0^h, y_0^h, (\theta_{d_D}^h, \varphi_{d_D}^h), w_0^h, c_U^h, c_D^h) = (0, 3.2, (0, 3.2), 0, 2.6, 0)$ for $h \geq 0.69$

$(c_0^h, y_0^h, (\theta_{d_D}^h, \varphi_{d_D}^h), w_0^h, c_U^h, c_D^h) = (0, 0, (1.45, 0), 1.45, 1.75, 1.75)$ for $h < 0.69.$

Compared to the previous equilibrium with no leverage, the price rises from 0.69 to 0.75 because the optimists can borrow to buy more. Notice also that even at the higher price, fewer agents hold all the assets (because they can afford to buy on borrowed money).

Equilibrium can be described picturesquely by observing that the asset price must correspond to the valuation of the marginal buyer. The final holders of the asset are all those whose valuation is higher than the marginal buyer's. Leverage raises the asset price because it enables fewer buyers to hold all the assets (since they can purchase not just by spending the cash they have on hand, but also by borrowing), thus raising the marginal buyer. A higher marginal buyer has a higher valuation for the asset.

We can also compute the equilibrium in the case where agents are more optimistic, and $\gamma_U^h = 1 - (1-h)^2 > h$ for all h. Then equilibrium $(h^*, p_Y) = (0.63, 0.89)$. On the other hand, if agents are more pessimistic and $\gamma_U^h = 1 - (1-h)^{0.1} < h$ for all h, then equilibrium $(h^*, p_Y) = (0.83, 0.44)$. In all three cases, the leverage price is higher than the corresponding no credit price and higher than the corresponding Arrow Debreu price.

Before leaving this example, it is worth noting that the final utility of each agent $h < h^*$ is $1 + p_Y$, while the final utility of each agent $h > h^*$ is $\gamma_U^h / \gamma_U^{h^*}(1 + p_Y)$. To see how to derive the latter expression, observe that by leveraging the risky asset one can effectively purchase the up Arrow security. The prices of all assets are determined by h^*, hence, it can easily be verified that the price of one Arrow up security is $\gamma_U^{h^*}$. But the value to h of that security is γ_U^h. Hence the formula.

1.4.8 Leverage raises asset prices

The lesson here is that the looser the collateral requirement, the higher the prices of assets will be. Had we defined another equilibrium by arbitrarily specifying the collateral limit by prohibiting the selling of contracts unless $j \leq k < d_D$, we would have found an equilibrium price p_Y intermediate between the no borrowing price 0.68 and the fully leverage price 0.75. This has not been properly understood by economists. The conventional view is that the lower the interest rate is, then the higher asset prices will be, because their cash flows will be discounted less. But in the example I just described, where agents are patient, the interest rate will be zero regardless of the collateral restrictions (up to 0.2). The fundamentals do not change, but because of a change in lending standards, asset prices rise. Clearly there is something wrong with conventional asset pricing formulas. The higher the leverage, the higher and thus more optimistic the *marginal buyer* is; it is his probabilities that determine value.

We can state this formally as was done in Fostel-Geanakoplos (2013)

Leverage Pricing Theorem: *Consider the two period, two state economy described above, with a riskless numeraire asset and a risky financial asset paying $d_U > d_D$ in the two states, and a continuum of risk neutral agents with strictly monotonic and continuous beliefs γ_U^h, who each begin with the same endowment of the risky and riskless assets. The collateral equilibrium price of the risky asset will always be higher than the no borrowing equilibrium price of the risky asset.*

Putting together the risk-leverage theorem and the leverage-pricing theorem we see that changes in risk affect asset prices, even if all agents are risk neutral. When risk goes up (say from a mean preserving spread in what everybody thinks the asset payoffs will be), leverage on the risky asset will fall. And when leverage falls, its price falls. Conversely, when risk diminishes, leverage rises and asset prices rise.

Historically, the theory predicts that periods of moderation in asset prices lead to higher leverage which leads to higher asset prices, and conversely.

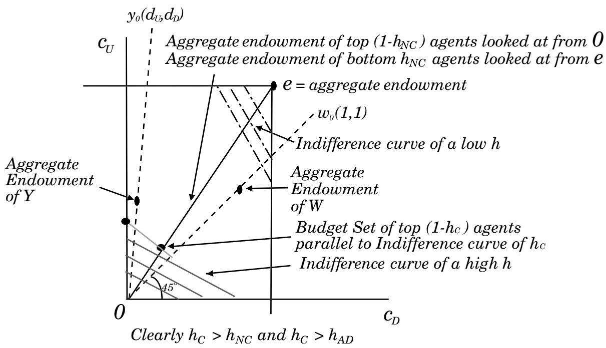
1.4.9 Collateral-Leverage Bubbles

The conventional view of credit markets has been that the need to post collateral in order to borrow to carry out investment (say in education) or to buy essential goods (like housing) lessens demand and therefore reduces the flow compared to a first best Arrow Debreu world in which agents could borrow freely and without limit, as long as they paid back their debts in the end. Our examples show that this intuition is wrong. The following theorem is from Fostel-Geanakoplos (2014b).

Collateral Bubbles Theorem: *Suppose that in the economy described in the Leverage Pricing Theorem there is no endowment of commodities in states U and D. Then the collateral equilibrium price of the risky asset will always be higher than the Arrow Debreu price of the risky asset.*

It follows that if it were possible to produce the risky asset from the riskless asset in period 0, then there would be overproduction instead of underproduction.

Figure 11. Collateral Equilibrium



Source: Author's elaboration.

2. The Collateral Economy in General

Having introduced some of the main ideas of the leverage cycle and collateral equilibrium, we are now in a better position to introduce notation defining a more general collateral economy consisting of many time periods and states of nature, an arbitrary number of perishable goods and durable goods, and one period contracts that can be written on all of them. We use this general model to describe the leverage cycle, which is necessarily part of a dynamic economy.

2.1 Tree of Date-Events

Let S be a finite tree with root 0 and terminal nodes S_T Every node $s \in S\backslash\{0\}$ has a unique immediate predecessor s^*, and every node $s \in S\backslash S_T$ has a set of immediate successors $S(s) = \{t \in S: t^* = s\}$. Let $(0, s]$ be the collection of all the points along the path from 0 to s, including s but not 0, and let the time of s, $\tau(s)$, denote the number of points on the path. In a binary tree, every node s $\in S\backslash S_T$ has a set of immediate successors consisting of two elements $S(s) = \{sU, sD\}$.

2.2 Commodities and Assets

At each date-event $s \in S$ the commodity space $\mathbb{R}^{L_S}$ consists of L_S commodities. At the end of trading in the state, each agent h can hold $x_S \in \mathbb{R}^{L_S}_+$ commodities, which provide him utility. These commodities can be perishable or durable or anything in between. To the extent that they are durable, they are sometimes called assets. If they are completely perishable, they will be called goods or perishable commodities. The set of feasible consumption plans is denoted by

$$X = \times_{s \in S} \mathbb{R}^{L_s}_+$$

Given a state $s \in S\backslash S_T$ and an immediate successor $t \in S(s)$, the $L_t \times L_s$ matrix E_t describes the durability of every commodity between s and t. If at node s agent h holds one unit of commodity ℓ after trading is done, then at node t he will have an additional $E_{t\ell'\ell}$ units of each commodity $\ell' \in L_{t.}$ Thus if he holds the bundle $x_s \in \mathbb{R}^{L_s}_+$ at s, he will augment his endowment by $E_t x_s$ at each successor $t \in S(s)$. Note that since every state t has a unique predecessor state, the notation E_t conveys as much information as the more cumbersome notation E_{st} .

Commodity prices are denoted by $p_s \in \mathbb{R}^{L_s}_+$ for all $s \in S$. We denote the set of commodity prices by

$$P = \times_{s \in S} \mathbb{R}^{L_s}_+$$

2.3 Utilities

Each agent h has a utility function

$$U^h : X = \times_{s\in S}\mathbb{R}_+^{L_s} \to \mathbb{R}$$

depending on the holding of all the commodities in every state, that is on consumption plans x We assume U^h is continuous, concave, and weakly monotonic state by state (more of everything in any one state strictly increases utility). Often we specialize to the case of von Neumann Morgenstern utilities u^h. For each $s \in S\backslash\{0\}$ let $\gamma_s^h > 0$ denote the probability that agent h thinks nature will choose s, conditional on having chosen s^*. (Take $\gamma_0^h = 1$). For each $s \in S$ define $\bar{\gamma}_s^h = \Pi_{t\in(0,s]}\gamma_s^h = \dots \gamma_{s^*}^h\gamma_s^h$. Let $0 = \delta_h \leq 1$ denote the discount factor of agent h. We often write

$$U^h(x) = \sum_{s\in S}\bar{\gamma}_s^h \delta_h^{\tau(s)} u^h(x_s)$$

Notice that in our general model we allow for agents to obtain utility from holding every commodity, whether it is perishable or not. Thus in contrast to the simplified two period model described earlier, we allow for nonfinancial asssets such as houses, which give immediate utility and pay dividends in later periods.

2.4 Production

Every agent has access to the same instantaneous, constant returns to scale production technology $Z_s \subset \mathbb{R}^{L_s}$ for each state s. If $z \in Z_s$, then $z_\ell < 0$ means commodity ℓ is an input into production z, and $z_\ell > 0$ means commodity ℓ is an output from production z. We assume that Z_s is a closed, convex, cone and that $0 \in Z_s$. We also assume that there exists some $p \in \mathbb{R}_{++}^{L_s}$ with $p \cdot z \leq 0$ for all $z \in Z_s$. The assumption that Z_s is a cone means that there is constant returns to scale, which allows us to simplify the notation for equilibrium because we can assume that equilibrium production will make zero profits, and so we do not need to keep track of agent income from production. It is well known that the assumption of constant returns to scale can be made without any loss of generality once we have competitive markets and convexity. Define the set of feasible production plans by

$$Z = \times_{s\in S} Z_s$$

2.5 Contracts

At each node $s \in S \setminus S_T$, any agent h can sell a one period contract $j \in J_s$ which promises delivery of $D_{tj} \in \mathbb{R}_+^{L_t}$ in each successor state $t \in S(s)$. The contract must be collateralized by a bundle of commodities $c_j \in \mathbb{R}_+^{L_s}$ at node s. Thus each contract $j \in J = \cup_{s\in S\setminus S_T} J_s$ is characterized by its issuance date $s(j)$, its collateral c_j, and its promise $D_{tj} \in \mathbb{R}_+^{L_t}$ in each successor state $t \in S(s(j))$ of $s(j)$.

There is no punishment for failure to keep promises, except for the confiscation of collateral. Hence actual money delivery per unit promise in each successor state $t \in S(s)$ is given by

$$\bar{D}_{tj} = \min(p_t \cdot D_{tj}, p_t \cdot E_t c_j)$$

Deliveries depend on the future prices p_t; even if the promise D_{tj} and the collateal $E_t c_j$ are non-contingent, the delivery might be if the prices are contingent. The vector of deliveries across contracts in any state s is denoted by $\bar{D}_s \in \Delta_{sj} = \mathbb{R}_+^{J(s^*)}$. The whole vector of deliveries is denoted by

$$\bar{D} \in \Delta = \times_{s\in S} \Delta_s$$

We denote the purchase of contract j by the holding $\theta_j \geq 0$ and the sale (or issuance) of contract j by $\phi_j \geq 0$. We denote the vector of contract purchases in any state $s \in S$ by $\theta_s \in \Theta_s = \mathbb{R}_+^{J(s)}$ and the set of contract purchase plans by

$$\Theta = \times_{s\in S} \Theta_s$$

Similarly we denote the vector of contract sales in any state $s \in S$ by $\varphi_s \in \Phi_s = \mathbb{R}_+^{J(s)}$ and the vector of contract sale plans by

$$\Phi = \times_{s\in S} \Phi_s$$

Contract prices are denoted by π_{sj}. An agent who chooses $\phi_{sj} > 0$ for $j \in J(s)$ is borrowing $\pi_{sj}\phi_{sj}$ dollars in state s and the agent who chooses $\theta_{sj} > 0$ is lending $\pi_{sj}\theta_{sj}$ dollars in state s. We denote the vector of contract prices in state s by $\pi_s \in \Pi_s = \mathbb{R}_+^{J(s)}$ and the set of all contract prices by

$$\Pi = \times_{s \in S} \Pi_s$$

2.6 Budget Set

Assuming $\theta_{0^*} = \phi_{0^*} = 0$, and $x_{0^*}^h = 0$, we define the budget set for each agent h by

$$B^h(p, \pi, \bar{D}) = \{(x, \theta, \phi) \in X \times \Theta \times \Phi : \forall s \in S$$

$$p_s \cdot (x_s - e_s^h - E_s x_{s^*}) + \pi_s \cdot (\theta_s - \phi_s) \leq \bar{D}_s \cdot (\theta_{s^*} - \phi_{s^*})$$

$$\sum_{j \in J} c_j \phi_{sj} \leq x_s\}$$

where

$$\bar{D}_{sj} = \min(p_s \cdot D_{sj}, p_s \cdot E_s c_j)$$

2.7 Collateral Equilibrium

$$(p, \pi, z, \bar{D}, (x^h, \theta^h, \phi^h)_{h \in H}) \in P \times \Pi \times Z \times \Delta \times (X \times \Theta \times \Phi)^H$$

such that

$$\sum_h x_s^h = \sum_h (e_s^h + E_s x_{s^*}^h) + z_s \quad \text{for all } s \in S$$

$$\sum_h \theta_s^h = \sum_h \phi_s^h \quad \text{for all } s \in S$$

$$\bar{D}_{sj} = \min(p_s \cdot D_{sj}, p_s \cdot E_s c_j) \quad \text{for all } s \in S, j \in J_s$$

$$p_s \cdot z_s = 0 \geq p_s \cdot z_s' \quad \text{for all } s \in S, z_s' \in Z_s$$

$$(x^h, \theta^h, \phi^h) \in \arg \max_{(x, \theta, \phi) \in B^h(p, \pi, \bar{D})} U^h(x) \quad \text{for all } h \in H.$$

2.8 Binomial No Default and Leverage Theorem

We now have enough notation in place to formally state a theorem from Fostel and Geanakoplos (2013) about default and leverage for financial assets in binomial economies.

Binomial No Default and Risk-Leverage Theorem: *Consider a collateral equilibrium* $(p, \pi, z, \bar{D}, (x^h, \theta^h, \phi^h)_{h\in H})$ *for a collateral economy described in the last section. Suppose the tree S of date events is binomial. Consider any contract j whose collateral* c_j *does not affect any agent's utility in the issuance date* $s(j)$.[6] *Suppose there is another contract* $j^* \in J$ *with* $s(j^*) = s(j)$ *and some* $\lambda > 0$ *with* $p_t \cdot D_{tj^*} = \lambda p_t \cdot D_{tj} \leq p_t \cdot E_t c_j$ *for all* $t \in S(s)$ *and* $p_t \cdot D_{tj^*} = \lambda p_t \cdot D_{tj} = p_t \cdot E_t c_j$ *for some* $t \in \bar{S}(s)$. *Then there is another collateral equilibrium* $(p, \pi, z, \bar{D}, (x^h, \bar{\theta}^h, \bar{\phi}^h)_{h\in H})$ *with the same consumptions and prices in which contract j is not traded (unless* $j = j^*$*). In particular, every collateral equilibrium is equivalent to one in which there is no default on contracts collateralized by financial assets. Furthermore, suppose that all contracts j written in state s that use some bundle* c_j *as collateral are non-contingent,* $p_{sU} \cdot D_{sUj} = p_{sD} \cdot D_{sDj}$. *Then the leverage of collateral* c_j *can be taken to be*

$$LTV(c_j) = \frac{1}{1+r_s} \frac{\min(p_{sU} \cdot E_{sU} c_j, p_{sD} \cdot E_{sD} c_j)}{p_s \cdot c_j}$$

where r_s *is the unambiguously defined riskless interest rate in state s. In particular, the loan to value (hence, leverage) on any collateral in state s is inversely related to the worst case return or "risk" of the collateral.*

The theorem shows that in binomial economies we do not need to consider default on loans collateralized by financial assets. The only non-contingent contracts that need to be considered are those that promise the maximum amount that can be delivered for sure in both states. But that does not mean the spectre of default is irrelevant. Indeed, the leverage of any financial asset depends crucially on the possibility of default, so that the more risky the asset's payoffs, the less it can be leveraged.

6. By the definition of collateral economy we have described above, the productivity of the collateral $E_t c_j$ does not depend on who owns it either, for any $t \in \bar{S}(s)$. Hence we are talking about a financial asset (bundle) c_j.

3. The Leverage Cycle

In the two period economy we already clearly saw how risk can reduce leverage, and how reduced leverage causes asset prices to fall. Conversely, moderations of risk tend to increase leverage and increase asset prices. In the two-period leverage example of section 2 the price of the leveraged risky asset starts off too high in period 0. When bad news occurs and the value plummets in the last period to 0.2, there is a crash. But this is a crash in the fundamentals. There is nothing the government can do to avoid it.

The point of the leverage cycle is that excess leverage followed by excessive deleveraging will cause a crash even before there has been a crash in the fundamentals, and even if there is no subsequent crash in the fundamentals. When the price crashes *everybody* will say it has fallen more than their view of the fundamentals warranted. The asset price is excessively high in the initial period (compared to the first best Arrow Debreu price) because volatility is low and there is too much leverage, and it crashes after just a little bit of bad news, provided the news increases volatility, which leads to deleveraging. The fluctuations in fundamental volatility create fluctuations in leverage which itself creates excess volatility of the asset price. Had leverage been curtailed by government regulation in the initial period, the initial asset price would have been lower and the asset price after the bad news would have been higher, smoothing the cycle.

3.1 A Three-Period Model

Let us consider the same example but with three periods instead of two, taken from Geanakoplos (2003) and Geanakoplos (2010). The state space is now $S = \{0, U, D, UU, DU, DD\}$. Notice that after U there is no uncertainty, because the only successor state is UU, whereas after D there is still uncertainty because there are two successor states DU and DD. If going from 0 to D is bad news, it is also scary bad news because it also means an increase in volatility. Suppose that in the three states 0,U, D there are three commodities: the perishable consumption good, risky asset, and durable consumption good C,Y,W as before. The holdings of these three commodities are denoted by $x_s = (x_{s1}, x_{s2}, x_{s3}) = (c_s, y_s, w_s)$, for $s \in \{0, U, D\}$. Suppose there is just one commodity in each state UU, DU, DD, which we think of as the perishable consumption good, and whose holdings we denote by $x_s = c_s$, $s \in \{UU, DU, DD\}$. Let every agent own one unit of the risky asset at time 0 and also one unit of the warehousable consumption good at time 0, $e_0^h = (e_{01}^h, e_{02}^h, e_{03}^h) = (0,1,1)$, and nothing in every other state. But now suppose the asset Y pays off after two periods instead of one period. After good news in either period the asset pays 1 unit of the perishable consumption good at the end, otherwise 0.2 of the perishable consumption good. Thus at UU and DU it pays off 1, and only with two pieces of bad news at DD does the asset pay 0.2.

More precisely

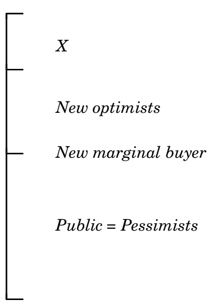
$$E_U = E_D = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

meaning that one unit of C at time 0 becomes nothing of any of the commodities at U or D (represented by the first column of the matrix), while one unit of Y at time 0 becomes 1 unit of Y at U and D (represented by the second column) and one unit of W becomes 1 unit of W at U and at D (represented by the third column of each matrix). Furthermore,

$$E_{UU} = [\,0 \quad 1 \quad 1\,], E_{DU} = [\,0 \quad 1 \quad 1\,], E_{DD} = [\,0 \quad 0.2 \quad 1]$$

meaning that the perishable good at U or D turns into nothing at the terminal nodes (represented by the first column of each matrix), while one unit of Y at U turns into 1 unit of the perishable good at

Figure 12. Leverage Cycle Tree



Source: Author's elaboration.
Leverage Cycle starts before scary news. Uncertanity and disagreement grow from U to D.

UU (represented by the second column of the first matrix), as does one unit of W (represented by the third column of the first matrix), while one unit of Y at D turns into 1 unit of C at DU and only 0.2 units of C at DD (as represented by the second column of the last two matrices), while one unit of W at D turns into 1 unit of C at both DU and DD (as represented by the last column of the final two matrices).

This is a situation in which two things must go wrong (i.e., two down moves) before there is a crash in fundamentals. Investors differ in their probability beliefs over the odds that either bad event happens. The move of nature from 0 to D lowers the expected payoff of the asset Y in every agent's eyes, and also increases every agent's view of the variance of the payoff of asset Y. The news creates more uncertainty, and more disagreement.

As before we suppose that the agents can all turn the durable consumption good into the perishable consumption good at any time, so we describe the intraperiod technology

$$Z_s = \{z = (z_{01}, z_{02}, z_{03}) : z \leq (\lambda, 0, -\lambda), \lambda \in \mathbb{R}\} \quad \text{for } s = 0, U, D$$

$$Z_s = \{0\} \quad \text{for } s = UU, DU, DD$$

Suppose again that agents have no impatience, and care only about their expected consumption of the perishable consumption good C. We suppose as before that there is a continuum of agents $h \in [0,1]$ and that

$$U^h(c_0, c_U, c_D, c_{UU}, c_{DU}, c_{DD})$$
$$= c_0 + \gamma_U^h c_U + \gamma_D^h c_D + \gamma_U^h c_{UU} + \gamma_D^h \gamma_{DU}^h c_{DU} + \gamma_D^h \gamma_{DD}^h c_{DD}$$
$$((e_{0c}^h, e_{0y}^h, e_{0w}^h), (e_{Uc}^h, e_{Uy}^h, e_{Uw}^h), (e_{Dc}^h, e_{Dy}^h, e_{Dw}^h), e_{UU}^h, e_{DU}^h, e_{DD}^h)$$
$$= ((0,1,1), (0,0,0), (0,0,0), 0,0,0)$$

We suppose that γ_U^h and γ_{DU}^h are strictly increasing in h. Note that agent h assigns only a probability of $\gamma_D^h \gamma_{DD}^h$ to reaching the only state, DD, where the asset pays off 0.2.

3.1.1 Equilibrium

In each state s let the price of the perishable consumption good be normalized to 1. Since the perishable consumption good can be produced one to one from the durable consumption good, the latter must also have a price of 1 in states $s = 0, U, d$. We denote the price of the asset by p_{sy} in each state $s \in S \backslash S_T$.

We suppose that at each state $s \in S \backslash S_T$ it is possible to promise any amount i of the perishable consumption good in both of the following two states sU, sD, using one unit of Y as collateral at s. Denote each such contract by si.

The crucial question again is how much leverage will the market allow at each state s? From the Binomial No Default and Leverage Theorem described in the previous section, it can be shown that in every state s, the only promise that will be actively traded is the one that makes the maximal promise on which there will be no default. Since there will be no default on this contract, it trades at the riskless rate of interest r_s per dollar promised. It will result in equilibrium that the interest rate is zero in every state. Thus at time 0, agents can borrow the minimum of the price of Y at U and at D, for every unit of Y they hold at 0. At U agents can borrow 1 unit of the consumption good, for every unit of Y they hold at U. At D they can borrow only 0.2 units of the consumption good, for every unit of Y they hold at D. In normal times, at 0, there is not very much bad that can happen in the short run. Lenders are therefore willing to lend much more on the same collateral, and leverage can be quite high.

Geanakoplos (2003, 2010) proved that the unique equilibrium in this model is of the following form. At time 0 agents $h \in [a,1]$ leverage as much as they can to buy all of asset Y. At U their bets pay off and after delivering fully on their loans, they hold their remaining wealth in Y until consumption at UU. At D, however, they owe the totality of the value of their asset holdings. They pay off their debts but are left penniless. At D a new class of buyers $h \in [b, a)$ leverage as much as they can to buy all the assets. The price of the asset tumbles at D not just because the news is bad, but much more importantly, because the marginal buyer drops from a to $b < a$. The drop from a to b is so big because all the agents in $[a,1]$ are wiped out because they took such huge losses from being so leveraged, and because, at D equilibium *LTV* is so much smaller than at U or than it was at 0, so it requires far more agents to hold the assets, and thus $a - b > 1 - a$.

3.1.2 Finding the equilibrium: The marginal buyers

To see how to find this equilibrium, let b be the marginal buyer in state D and let a be the marginal buyer in state 0. Then we must have

$$p_{DY} = (a - b)(1 + p_{0Y}) + 0.2 \tag{6}$$

$$p_{DY} = \gamma^b_{DU} 1 + \gamma^b_{DD}(0.2) \tag{7}$$

$$p_{0Y} = (1 - a)(1 + p_{0Y}) + p_D \tag{8}$$

$$\frac{\gamma^a_U 1 + \gamma^a_D p_D \frac{\gamma^a_{DU}}{\gamma^b_{DU}}}{p_{0Y}} = \gamma^a_U 1 + \gamma^a_D 1 \frac{\gamma^a_{DU}}{\gamma^b_{DU}} \tag{9}$$

Equation (6) says that all the money spent from the wealth $(1 + p_{0Y})$ carried over from 0 by each agent $h \in [b, a)$ plus all the money 0.2 they can borrow using Y as collateral will be spent to buy the single outstanding unit of Y. Equation (7) says that the price at D is equal to the valuation of the marginal buyer b at D. Because he is also indifferent to borrowing, he will then also be indifferent to buying on the margin, as we saw in the collateral section.

Equation (8) is similar to equation (6). It explains the price of Y at 0 must be equal to the expenditure of money used to buy it. Notice that at 0 it is possible to borrow p_D using each unit of Y as collateral. So the top $(1 - a)$ agents have $(1 - a)(1 + p_{0Y}) + p_D$ to spend on the one unit of Y outstanding.

Equation (9) is the most subtle one. It says that the marginal utility at 0 to a of holding one dollar's worth of the durable consumption good, on the right, must be equal to the marginal utility of one dollar of the asset on the left.

To see where the right hand side of equation (9) comes from, observe first that agent a can do better by inventorying the dollar (i.e., warehousing the consumption good by taking $w_0 > 0$) at time 0 rather than consuming it. With probablity γ^a_U, U will be reached and this dollar will be worth one utile. With probability γ^a_D, D will be reached and a will want to leverage the dollar into as big a purchase of Y as possible. As we saw in our two period example, this will result in a gain at D of $\gamma^a_{DU}/\gamma^b_{DU}$. The right hand side is derived similarly.

3.1.3 Crash because of bad news, de-leveraging, and bankrupt optimists

Consider now the case from Geanakoplos (2010) in which $\gamma^h_U = \gamma^h_{UD} = h$ for all $h \in [0,1]$ Plugging that into the equations and solving gives $a = 0.87$, $p_{0Y} = 0.95$, $b = 0.61$, and $p_{DY} = 0.69$. The price of Y at time 0 of 0.95 occurs because the marginal buyer is $h = 0.87$. Assuming the price of Y is 0.69 at D and 1 at U, the most that can be promised at 0 using Y as collateral is 0.69. With an interest rate $r_0 = 0$, that means 0.69 can be borrowed at 0 using Y as collateral. Hence the top 13% of buyers at time 0 can collectively borrow 0.69 (since they will own all the assets), and by adding their own 0.13 of money they can spend 0.82 on buying the 0.87 units that are sold by the bottom 87%. The price is $0.95 \approx 0.82/0.87$.

Why is there a crash from 0 to D? Well first there is bad news. But the bad news is not nearly as bad as the fall in prices. The marginal buyer of the asset at time 0, $h = 0.87$, thinks there is only a $(0.13)^2 = 1.69\%$ chance of ultimate default, and when he gets to D after the first piece of bad news he thinks there is a 13% chance for ultimate default. The news for him is bad, accounting for a drop in price of about $[0.9831(1) + 0.0169\,(0.2)] - [0.87(1) - 0.13(0.2)] \approx 0.986 - 0.896 \approx 9$ points, but it does not explain a fall in price from 0.95 to 0.69 of 26 points. In fact, no agent h thinks the loss in value is nearly as much as 26 points. The biggest optimist $h = 1$ thinks the value is 1 at 0 and still 1 at D. The biggest pessimist $h = 0$ thinks the value is 0.2 at 0 and still 0.2 at D. The biggest loss attributable to the bad news of arriving at D is felt by $h = 0.5$, who thought the value was 0.8 at 0 and thinks it is 0.6 at D. But that drop of 20 points is still less than the drop of 26 points in equilibrium.

The second factor is that the leveraged buyers at time 0 all go bankrupt at D. They spent all their cash plus all they could borrow at time 0, and at time D their collateral is confiscated and used to pay off their debts: they owe 0.69 and their collateral is worth 0.69. Without the most optimistic buyers, the price is naturally lower.

Finally, and most importantly, the margins jump from $(0.95 - 0.69)/0.95 = 27\%$ at 0 to $(0.69 - 0.2)/0.69 = 71\%$ at D. In other words, leverage plummets from $3.6 = 0.95/(0.95 - 0.69)$ to $1.4 = 0.69/(0.69 - 0.2)$.

All three of these factors working together explain the fall in price.

3.1.4 Quantifying the contributions of bad news, deleveraging, and bankruptcy of the optimists

In the crisis of 2007–09 there was bad news, but according to most financial analysts, the price of assets fell much farther than would have been warranted by the news. And indeed as the theory (of 2003!) predicted, there were numerous bankruptcies of the most optimistic mortgage companies, and even of great investment banks.

And the drop in leverage was enormous. The marginal buyer of 2009 was different from the marginal buyer of 2007.

These kind of events had occured before in 1994 and 1998. The cycle was more severe this last time because the leverage was higher, and the bad news was worse.

Of the three symptoms of the leverage cycle collapse, which is playing the biggest role in our example? This is an easy calculation to make, because we can introduce each of the three effects on its own into the model and then see how much the price 0.95 declines.

The bad news has the effect of increasing the probability each agent h assigns to the low payoff of 0.2 at DD from $(1-h)^2$ to $(1-h)$. So we can recalculate equilibrium in the same tree, but with $\gamma_{sD}^{h} \equiv \sqrt{(1-h)} > (1-h)$ for all $s = 0, U, d$. The result is that at node 0 the price is now 0.79. Thus roughly 60% of the drop in value from 0.95 to 0.69 comes from the bad news itself.

But that still leaves 40% of the drop explainable only by non-fundamentals (or technicals as they are sometimes called). We can decompose this 40% into the part that comes from the bankruptcy and disappearance of the most optimistic buyers, and the rest due to the deleveraging.

In the main example, the most optimistic 13% went bankrupt at D. We can isolate this effect simply by beginning with an economy without these agents. Replacing the set of traders $[0,1]$ with $[0, 0.87]$, and therefore the value 1 with 0.87 in the appropriate equations, one can repeat the calculation and find that the price at the original node is 0.89, a drop of 6 points from the original 0.95, and roughy 20% of the original 26 point drop in the example from 0 to D.

In the main example the deleveraging occurred at D when the maximal promise was reduced to 0.2. We can simulate the deleveraging effect alone by reducing our tree to the old one-period model, but replacing the probability of down of $1-h$ with $(1-h)^2$. In that new model the equilibrium promise at node 0 will be just 0.2, but investors will still assign the 0.2 payoff probability $(1-h)^2$. This gives an initial price for the asset of 0.89. Thus deleveraging also explains about 20% of the price crash.

The roughly linear decomposition of the three factors is due to the linearity of the beliefs $\gamma_{sU}^{h} = h, \gamma_{sD}^{h} = 1-h$ in h. In my 2003 paper I analyzed exactly this same model but with more optimistic beliefs because I wanted to avoid this linearity, and also to illustrate a smaller crash consistent with the minor leverage cycle crash of 1998. I assumed $\gamma_{U}^{h} = 1-(1-h)^2 = \gamma_{DU}^{h}$, giving probability $(1-h)^4$ of reaching DD from 0. In that specification there are many investors with γ_{sU}^{h} near to 1, but once h moves far from 1, the decline in optimism happens faster and faster. Solving the four equilibrium equations with this specification of probabilities gives $(p_{0Y}, p_{DY}, a, b) = (0.99, 0.87, 0.94, 0.60)$. The price falls only 12 points from $p_{0Y} = 0.99$ at 0 to $p_{0Y} = 0.87$ at D. Only the top 6% of investors buy at 0, since they can leverage so much, and thus go bankrupt at D. Without them from the beginning, the price would still be 0.99, hence the loss of the top tier itself contributes very little. Bad news alone in that model reduces to the example we just computed at great length, which has a starting price of $p_{0Y} = 0.95$. Deleveraging alone in the 2003 example results in a starting price of $p_{0Y} = 0.98$. Hence the three factors independently add up to much less than the total drop. Thus in the 2003 example it was the feedback between the three causes that explained much of the drop. In the 2010 example, the total drop is very close to the sum of the parts.

3.1.5 Conservative optimists

It is very important, and very characteristic of the leverage cycle, that after the crash, returns are much higher than usual. Survivors of the crash always have great opportunities. One might well wonder why investors in the example do not foresee that there might be a crash, and keep their powder dry in cash (or in assets but without leverage) at 0, waiting to make a killing if the economy goes to D. The answer is that many of them do exactly that.

The marginal buyer at 0 in our first example is $h = 0.87$. He assigns probability $1.69\% = (0.13)^2$ to reach DD. So he values the asset at 0 at more than 0.986, as we saw, yet he is not rushing to buy at the price of 0.95. The reason is that he is precisely looking toward the future. These calculations are embodied in the fourth leverage equilibrium equation. The marginal utility to a of reaching the down state with a dollar of dry powder is not $(1-a)$, but $(1-a)\,(a/b)$ precisely because a anticipates that he will have a spectacular gross expected return of a/b at D.

In fact all the investors between 0.87 and 0.74 are refraining from buying what they regard as an underpriced asset at 0, in order to keep their powder dry for the killing at D. If there were only more of them, of course, there would be no crash at D. But as their numbers rise, so does the price at D, and so their temptation to wait ebbs. It is after all a rare bird who thinks the returns at D are so great, yet thinks D is sufficiently likely to be worth waiting for. This is owing to my assumption that investors who think the first piece of bad news is relatively unlikely (high h), also think the second piece of bad news is relatively unlikely (high h again), even after they see the first piece of bad news. This assumption corresponds to my experience that hedge fund managers generally are the ones saying things are not that bad, even after they start going bad.

3.1.6 Endogenous maturity mismatch

Many authors have lamented the dangers of short term borrowing on long term assets, as we have in this example. It is important to observe that the short term loans I described in the three period model arise endogenously. If long, two period, non-contingent loans were also available, then by the previous arguments, since there are only two outcomes even in the final period, the only potentially traded long term loan would promise 0.2 in every state. But the borrowers would much prefer to borrow 0.69 on the short term loan. So the long term loans would not be traded.

This preference for short term loans is an important feature of real markets. Lenders know that much less can go wrong in a day than in a year, and so they are willing to lend much more for a day on the same collateral than they would for a year. Eager borrowers choose the larger quantity of short term loans, and presto, we have an endogenous maturity mismatch. Endogenous collateral can resolve the puzzle of what causes maturity mismatch.

4. Foreclosure Losses

In this section we introduce the hypothesis that if a good is held as collateral in state s by some agent h, then only he can use the good for production. If a borrower finds himself so far underwater that even after repairs the collateral will not be worth as much as the loan, then he will default without making the repairs, and there will be a social loss because it will then be too late for the lender who confiscates the collateral to make the repairs. This situation becomes much more interesting if some borrowers are efficient enough to make repairs and climb back into the money, and some are not. To include that possibility we must allow for heterogeneous production. Encumbered collateral and heterogeneous production complicate the notation.

The example we present in the next section imagines that if a house is put up as collateral, the owner may be able to improve it by building gardens on its land. Some owners may be better at building gardens than others. Suppose that agent h can build $\alpha(h)$ gardens at a small utility of effort cost. If the debt is j and the house plus $\alpha(h)$ gardens are worth more than j, the owner h will build his gardens and fully repay. But if the house plus $\alpha(h)$ gardens are worth less than j, the owner h will not build any gardens and will default not by $[j -$ (house price + value of $\alpha(h)$ gardens)$]$ but instead by the much bigger amount $[j -$ house price$]$. Whether or not default occurs, we suppose that unencumbering the house takes so much time that the new owner cannot build the gardens. As a result, default will result in a deadweight loss to the economy of missed production.

Lenders of course rationally anticipate that some of their borrowers will become so far underwater that it will be optimal for them to choose not to make repairs that cost less than the increase in value they would bring to the house if they were done. Each lender fully understands that if he lowers j, his borrowers will owe less and so more of them will build gardens and he will get a higher repayment rate. He maintains a high j because he is getting a good return and making fewer loans at a higher rate is less profitable. But he does not take into account that if he and all his brother lenders reduced the size of their loans, the future price of housing would go up, and they would all receive more money back because fewer homeowners would be underwater and more gardens would get built.

4.1 Collateral Encumbrances with Heterogeneous Production

Combining delay with heterogeneity forces us to change the notation from the last section. We assume that every individual has access to his own idiosyncratic technology

$$Z_s^h$$

for each $s \in S$ which is a closed, convex, cone in $\mathbb{R}^{L_s}$ that contains 0. We denote the technology of agent h or the set of all his feasible production plans by

$$Z^h = \times_{s \in S} Z_s^h$$

Let $L_s^C \subset L_s$ denote goods that have been sequestered as collateral. If an agent hasn't put up one of these goods himself as collateral for some contract j he himself wrote, then he cannot use it in production. We require that $Z^h_{s\ell} \geq 0$ for all $\ell \in L^C_s$. This means that if a good $\ell \in L^C_s$ is purchased, freeing it from its encumbrance takes so much time that it is too late to use in production in state s.

We do however allow agents to use their own collateral goods in production. Production from goods that nobody else can use allows for the possibility of profitable production in equilibrium even with constant returns to scale. The damaged house has a low value even if it can be fixed for free, because only its owner can do the fixing. But once he fixes it, he can sell it for a high price. Once we allow for profitable production, we must take care to see which contract gets the profits. At one extreme we could combine all the promises into one total promise, and all the collateral into one big collateral portfolio. But we wish to allow for the possibility that an agent raises money from different lenders, posting separate collateral for each. These collaterals cannot be combined, unless an auxiliary rule is prescribed that spells out which contract has claim on the output. To keep the notation manageable, we suppose the collateral backing contract j cannot be used for any production unless all the output using this collateral is encumbered by contract j.

Suppose an agent holds $E_t c_j \phi_j$ goods as collateral for contract j written in state s. These he can use in production, provided that he does not destroy any value, and that any additional value he creates goes to paying off loan j before he keeps any of it. We formalize this as follows.

We denote the set of possible production plans an agent h has with his goods used as collateral for promise j by

$$Z^{hj} = \times_{t \in S(s(j))} Z^h_t$$

But we limit these plans further by supposing that in each state $t \in S(s)$, $z_t = 0$ or z_t must lie in $\phi_j \mathcal{D}^{hj}_t$ where

$$\mathcal{D}^{hj}_t = \{z \in Z^h_t : p_t E_t c^j + p_t \cdot z_t \geq p_t \cdot D_{tj} \text{ and } z_{t\ell} + [E_t c^j]_\ell \geq 0 \ \forall \ell \in L^C_t\}$$

The first inequality says that if $z_t \neq 0$, then it must add so much value to the collateral that the loan can be fully repaid. The second inequality says that z_t does not use any encumbered goods as inputs except those encumbered by the borrower himself for loan j.

4.1.1 Pooling

Since different agents have different production possibilities, one agent might be able, by virtue of superior productivity, to use his collateral to pay off loan j while leaving a profit for himself, while another agent might choose to produce nothing and so default on loan j. If the lender treats all borrowers as anonymous, he effectively lends to anybody who chooses to borrow via contract j. We represent this formally by considering the whole pool of borrowers.

We let $\bar{D}^h_{tj}$ denote the dollars lenders expect to be delivered by agents of type h in state t per unit of contract j sold in state $s = s(j)$. Lenders assume that each dollar they lend will be split among the borrowers in proportion to how much each borrows, that is, if a lender lends 1% of the money lent on contract j (that is if he purchases 1% of contract j sold) then he expects 1% of the deliveries of contract j. We let $\bar{D}_{tj}$ denote the average delivery in state t per unit of contract j sold in state s. An agent who buys contract j in state s is therefore getting $\bar{D}_{tj}$ in each state $t \in S(s)$ per unit of contract j purchased in state s. We shall denote by δ^h_{tj} the money deliveries actually made by borrowers of type h on contract j in state t. In equilibrium we shall suppose that lenders are rational and so $\bar{D}^h_{tj} = \delta^h_{tj}$.

4.2 Foreclosure and Heterogeneous Production Budget Set

We now describe the budget set.

$$B^h(p, \pi, \bar{D}) = \{(x, z, (z^j)_{j\in J}, \theta, \phi, \delta) \in X \times Z^h \times \times_{j\in J} Z^{hj} \times \Phi \times \Theta \times \Delta : \forall s \in S$$

$$p_s \cdot (x_s - e^h_s - E_s x_{s^*}) + \pi_s \cdot (\theta_s - \phi_s) \le p_s \cdot (z_s + \sum_{j\in J(s^*)} z^j_s) + \bar{D}_s \cdot \theta_{s^*} - \delta_s \cdot \phi_{s^*}$$

$$\sum_{j\in J_s} c_j \phi_{sj} \le x_s$$

$z_{s\ell} \ge 0$ if $\ell \in L^C_s$, and for all $j \in J(s^*)$

if $\mathcal{D}^{hj}_s = \emptyset$, then $z^j_s = 0$ and $\delta_{sj} = p_s \cdot E_s c^j$

if $\mathcal{D}^{hj}_s \neq \emptyset$, then $z^j_s \in \phi_s \mathcal{D}^{hj}_s$ and $\delta_{sj} = p_s \cdot D_{sj}\}$

where for all $j \in J(s^*)$

$$\mathcal{D}^{hj}_t = \{z \in Z^h_t : p_t E_t c^j + p_t \cdot z_t \ge p_t \cdot D_{tj} \text{ and } z_{t\ell} + [E_t c^j]_\ell \ge 0 \; \forall \ell \in L^C_t\}$$

4.3 Foreclosure and Heterogeneous Production Equilibrium

$$(p, \pi, \bar{D}, (x^h, z^h, (z^{hj})_{j \in J}, \theta^h, \phi^h, \bar{D}^h)_{h \in H})$$

$$\in P \times \Pi \times \Delta \times (X \times Z^h \times \times_{j \in J} Z^{hj} \times \Theta \times \Phi \times \Delta)^H$$

such that

$$\sum_h x_s^h = \sum_h [(e_s^h + E_s x_{s^*}^h) + (z_s^h + \sum_{j \in J(s^*)} z_s^{hj})] \text{ for all } s \in S$$

$$\sum_h \theta_s^h = \sum_h \phi_s^h \text{ for all } s \in S$$

$$\bar{D}_{sj} = \frac{\sum_h \bar{D}_{sj}^h \varphi_{s^*j}^h}{\sum_h \varphi_{s^*j}^h} \text{ if } \sum_h \varphi_{s^*j}^h > 0 \text{ and } \bar{D}_{sj} \geq p_s \cdot E_s c_j$$

$$(x^h, z^h, (z^{hj})_{j \in J}, \theta^h, \phi^h, \bar{D}^h) \in \arg \max_{(x, z, (z^j)_{j \in J}, \theta, \phi, \delta) \in B^h(p, \pi, \bar{D})} U^h(x) \text{ for all } h \in H.$$

4.4 Example

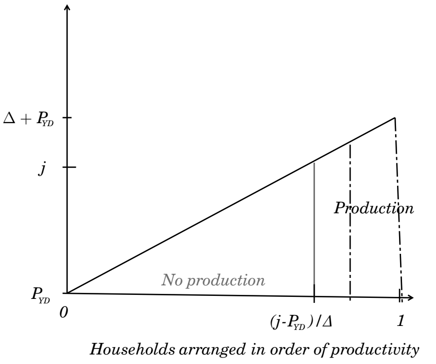
We extend our example from the leverage cycle to include collateral encumbrances and heterogeneous production. So suppose in that model that in the middle period, every agent h can create $\alpha(h)$ units of W with only a very small disutility of effort, where the $\alpha(h)$ are independent, and uniformly distributed on the interval $[0, \Delta]$ where for concreteness we take the parameter $\Delta = 0.1$.

For ease of calculation, we suppose there are just two contracts available, rather than the whole range $j > 0$. In particular, we suppose that the natural contract promise $j^* = p_{DY}$ is still available, as it was in the Leverage Cycle section. Furthermore, we suppose that the contract promise

$$j' = p_{DY} + 0.4\Delta$$

is also available. The most optimistic agents will not be able to resist borrowing more by selling the j' contract than they would be able to

Figure 13. Garden Productivity and Foreclosure Losses



Source: Author's elaboration.

borrow selling the j^* contract. The rational lenders anticipate that 40% of these borrowers will obtain $\alpha(h) < 0.4\Delta$ that are so low that they will default and build no gardens at all rather than pay j'. The price the lenders are willing to pay for the promise j' must reflect this, namely that in the up state U, j' will be fully repaid, while in state D payments will only be

$$0.6(p_{DY} + 0.4\Delta) + 0.4p_{DY} = p_{DY} + \Delta(1 - 0.4)(0.4)$$

The price of the j^* contract will reflect the fact that it is paid back in full in both states; nevertheless the most optimistic agents will prefer to write the j' contract rather than the j^* contract.

We take $\Delta = 0.1$ and solve for equilibrium using the model of the previous section with $\gamma_U^h = h$ for all $h \in H = [0,1]$. In equilibrium there will be four marginal agents h_1, h_2, h_3, h_4. We find that agents $h \in h_1 = [0.959,1]$ buy the risky asset at time 0 for a price $p_{0Y} = 0.993$ by leveraging and borrowing 0.734 using the promise j'. Agents $h \in (h_2 = 0.858, h_1 = 0.959)$ buy the risky asset at time 0 for a price $p_{0Y} = 0.993$ by leveraging and borrowing 0.701 using the promise j^*. Agents $h \in [h_3 = 0.743, h_1 = 0.858)$ buy the risky bonds issued by the most optimistic agents $h \in [h_1, 1]$ and the agents below h_3 hold all the W plus all the safe promises made by the agents $h \in (h_2, h_1)$.

In state U the risky as well as the safe bonds pay off in full. Every Y owner builds a garden, and so $0.05 = 0.5\Delta$ gardens are built.

In state D, the safe bond pays off in full, but there is default on the risky bond. Indeed, the least productive 40% of the agents in the interval $[h_1 = 0.959, 1]$ default on the risky bonds they issued. The other 60% sell off their Y and pay off their risky bonds in full, and with their small surplus of $(0.5)\ (0.6^2)\ \Delta = 0.018$ per unit of Y they borrow more money on the safe bond at D and buy back as much as they can of the risky bonds. Similarly the agents $h \in (h_2 = 0.858, h_1 = 0.959)$ pay off all their safe bond debts, and with their somewhat larger surplus of 0.05 per bond they go on to leverage as much as they can in order to buy back as much Y as they can. Nevertheless, these two groups together will not be able to afford to buy back all the Y.

A more conservative group $h \in [h_4 = 0.626, h_1 = 0.743)$ buys up the remaining Y at D, leveraging as much as they can by selling the riskless promise at D for a price of 0.2. The price $p_{DY} = 0.701$.

Introducing the variable $Q_{0j'}$ to denote the aggregate quantity of risky contracts j' written t time 0, the equilibrium equations are

$$\frac{\gamma_U^{h_1}(1+0.5\Delta - j') + \gamma_D^{h_1}\frac{\gamma_{DU}^{h_1}}{\gamma_{DU}^{h_4}}(0.5)(0.6^2)\Delta}{p_{0Y} - \pi_{j'}} = \frac{\gamma_U^{h_1}(1+0.5\Delta - j^*) + \gamma_D^{h_1}\frac{\gamma_{DU}^{h_1}}{\gamma_{DU}^{h_4}}(0.5)\Delta}{p_{0Y} - \pi_{j^*}}$$

$$\frac{\gamma_U^{h_2}(1+0.5\Delta - j^*) + \gamma_D^{h_2}\frac{\gamma_{DU}^{h_2}}{\gamma_{DU}^{h_4}}(0.5)\Delta}{p_{0Y} - \pi_{j^*}} = \frac{\gamma_U^{h_2} j' + \gamma_D^{h_2}\frac{\gamma_{DU}^{h_2}}{\gamma_{DU}^{h_4}}(j' - (0.4^2)\Delta)}{\pi_{j'}}$$

$$\frac{\gamma_U^{h_3} j' + \gamma_D^{h_3}\frac{\gamma_{DU}^{h_3}}{\gamma_{DU}^{h_4}}(j' - (0.4^2)\Delta)}{\pi_{j'}} = \frac{\gamma_U^{h_3} j^* + \gamma_D^{h_3}\frac{\gamma_{DU}^{h_3}}{\gamma_{DU}^{h_4}}\, j^*}{\pi_{j^*}} = \frac{\gamma_U^{h_3} + \gamma_D^{h_3}\frac{\gamma_{DU}^{h_3}}{\gamma_{DU}^{h_4}}}{1}$$

$$\frac{\gamma_U^{h_1} + \gamma_D^{h_1}(0.2)}{p_{0Y}} = 1$$

$$\frac{\gamma_U^{h_1} + \gamma_D^{h_1}(0.2)}{p_{0Y}} = 1$$

$$(1-h_1)(1+p_{0Y})+Q_{0j'}\pi_{j'}=Q_{0j'}p_{0Y}$$

$$(h_1-h_2)(1+p_{0Y})+(1-Q_{0j'})\pi_{j^*}=(1-Q_{0j'})p_{0Y}$$

$$(h_2-h_3)(1+p_{0Y})=Q_{0j'}\pi_{j'}$$

$$Q_{0j'}(0.5)(0.6^2)\Delta+(1-Q_{0j'})(0.5)\Delta+Q_{0j'}(j'-(0.4^2)\Delta)+(h_3-h_4)(1+p_{0Y})+0.2=p_{DY}$$

The first equation says that h_1 is indifferent between buying the risky asset by leveraging with j' or with j^*. Note that he fully takes into account that by borrowing on j' he will deprive himself of producing all the gardens he can at D. The second equation says that h_2 is indifferent to buying Y by leveraging with the riskless bond and buying the risky contract. Notice that he fully takes into account that he will not get fully repaid at D on his j'. The third equation says that h_3 is indifferent between spending on the risky contract j' and the safe contract j^*. The fourth equation says that at D, h_4 is indifferent between Y and W.

The fifth equation says that the top $1-h_1$ agents buy $Q_{0j'}$ units of the risky asset by issuing $Q_{0j'}$ units of the risky contract j'. The sixth equation says that the next h_1-h_2 agents buy $1-Q_{0j'}$ units of the risky asset Y by selling $1-Q_{0j'}$ units of the safe contract j^*. The seventh equation says that the next h_2-h_3 agents buy $Q_{0j'}$ units of the risky contract j' by selling all their W and Y at 0. The *LHS* of the last equation adds all the spending at D on the risky asset Y and asserts it must equal revenue from the sales of Y at D on the *RHS*. The top $1-h_1$ agents spend all their surplus after paying their debts from the $Q_{0j'}$ risky assets they bought and the next h_1-h_2 agents spend all their surplus after paying their debts from the $1-Q_{0j'}$ risky assets they bought and the next h_2-h_3 agents spend all their returns from their $Q_{0j'}$ units of the risky contract j' and also the next h_3-h_4 agents spend all the income they carried over from period 0 and in addition they collectively borrow and spend 0.2 by using the risky asset as collateral.

By restraining leverage in period 0, for example by prohibiting trade in j', the leverage cycle can be smoothed out, raising the price at D. Less debt means more income for the upper classes at D, which means a higher price p_{DY}. Also there will be more gardens produced and retained by the upper two classes of buyers, which will increase demand for Y at D, and therefore again lead to a higher price p_{DY}. All agents are better off except the conservative optimists at the top of the $[h_4 = 0.626, h_3 = 0.743)$ range who now do not have as wonderful an opportunity to take advantage of the depressed price of Y at D.

In Geanakoplos and Kubler (2005, 2014) the agents are assumed to be risk averse, and a second source of inefficiency is identified. The risky asset Y becomes riskier the more leverage there is, and its natural buyers still must hold it. Since they are risk averse this puts them in a riskier position. In that model, curtailing leverage at time 0 smoothes the leverage cycle and makes everybody better off.

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Leverage Restrictions in a Business Cycle Model

Lawrence Christiano
Northwestern University and
National Bureau of Economic Research

Daisuke Ikeda
Bank of Japan

We seek to develop a business cycle model with a financial sector, which can be used to study the consequences of policies to restrict the leverage of financial institutions (banks).[1] Because we wish the model to be consistent with basic features of business cycle data, we introduce our banking system into a standard medium sized DSGE model such as Christiano, Eichenbaum and Evans (2005) (hereinafter, CEE) or Smets and Wouters (2007). Banks in our model operate in perfectly competitive markets. Our model implies that social welfare is increased by restricting bank leverage relative to what leverage would be if financial markets were unregulated. With less leverage, banks are in a position to use their net worth to insulate creditors in case there are losses on bank's balance sheets. Our model implies that by reducing risk to creditors, agency problems are mitigated and the efficiency of the banking system is improved. We explore the economics of our result by studying the model's steady state.

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1. By "banks" we mean all financial institutions, not just commercial banks.

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We also display various dynamic features of the model to assess its empirical plausibility.

There are two types of motivations for restrictions on banking leverage. One motivates leverage restrictions as a device to correct an agency problem in the private economy. Another motivates leverage restrictions as a device to correct a commitment problem in the government.[2] In this paper we focus on the former type of rationale for leverage restrictions.

We posit the existence of an agency problem between banks and their creditors. By bank creditors, we have in mind real-world depositors, holders of debt securities like bonds and commercial paper, and also holders of bank preferred stock.[3] As a result, bank credit in our model is risky. To quantify this risk, we calibrate the model to the premium paid by banks for funds in the interbank market. This premium is on average about 50 basis points at an annual rate.[4] To simplify the

2. For example, Chari and Kehoe (2012) show that a case for leverage restrictions can be built on the assumptions that (i) bankruptices are ex post inefficient and (ii) governments are unable to commit ex ante to not bailout failed banks. See also Gertler, Kiyotaki and Queraltó (2012) for a discussion. In the general discussion of Adrian, Colla and Shin (2013), Robert Hall draws attention to the implications of, for bank leverage decisions, the expectation of government intervention in a crisis episode.

3. Our logic for including bank preferred stock in bank "credit" is as follows. In our model, the liability side of banks' balance sheets has only "bank debt" and "bank net worth." For the vast majority of banks in our model, their asset portfolio performs well enough that debt holders receive a high return, and bank net worth generally earns a positive return. In the case of banks in our model whose portfolio of assets performs poorly, net worth is wiped out and debt holders earn a low return. The reason we think of preferred stock as part of bank debt in the model is: (i) dividend payments on preferred stock are generally not contingent on the overall performance of the bank's assets, unless the performance of the assets is so bad that common stock holders are wiped out; and (ii) like ordinary debt, holders of preferred stock do not enjoy voting rights. Our model abstracts from the differences that do exist between the different components of what we call bank debt. For example, dividends on preferred stock are paid after interest and principal payments on bank's bonds, commercial paper and deposits. In addition, the tax treatment of preferred stock is different from the tax treatment of a bank's bond and commercial paper. The reason we identify the common stock portion of bank liabilities with bank net worth in our model is that holders of common stock are residual claimants. As a result, they are the recipients of increases in bank earnings (magnified by leverage) and they suffer losses when earnings are low (and, these losses are magnified by leverage). Financial firms are very important in the market for preferred stock. For example, Standard and Poor's computes an overall index of the price and yield on preferred stock. In their index for December 30, 2011, 82 percent of the firms belong to the financial sector (see https:// www.sp-indexdata.com/idpfiles/strategy/prc/active/factsheets/fs-sp-us-preferred-stock-index-ltr.pdf).

4. We measure the interest rate on the interbank market by the 3-month London interbank offer rate (Libor). The interest rate premium is the excess of Libor over the 3-month rate on U.S. government Treasury bills.

analysis, we assume there is no agency problem on the asset side of banks' balance sheets. The role of banks in our model is to exert costly effort to identify good investment projects. The source of the agency problem in our model is our assumption that bank effort is not observed. Under these circumstances, it is well known that competitive markets do not necessarily generate the efficient allocations. In our analysis, the fact that banker effort is unobserved has the consequence that restricting the amount of liabilities a bank may issue raises welfare.

As in any model with hidden effort, the resulting agency problem is mitigated if the market provides the agent (i.e., the banker) with the appropriate incentives to exert effort. For this, it is useful if the interest rate that the banker pays to its creditors is not sensitive to the performance of the asset side of its balance sheet. In this case, the banker reaps the full reward of its effort. But, this requires that the banker have sufficient net worth on hand to cover the losses that will occasionally occur even if a high level of effort is expended. The creditors in low net worth banks that experience bad outcomes on their portfolio must necessarily share in bank losses. Understanding this in advance, creditors require that low net worth bankers with well-performing portfolios pay a high interest rate. Under these circumstances, the banker does not enjoy the full fruits of its effort and so its incentive to exert effort is correspondingly reduced.

We analyze the steady state properties of the model and show that a leverage restriction moves equilibrium consumption and employment in the direction of the efficient allocations that would occur if effort were observable. In particular, when banks are restricted in how many liabilities they can issue, then they are more likely to be able to insulate their creditors from losses on the asset side of their balance sheet. In this way, leverage restrictions reduce the interest rate spread faced by banks and promote their incentive to exert effort. We calibrate our model's parameters so that leverage is 20 in the absence of regulation. When a regulation is imposed that limits leverage to 17, steady state welfare jumps to an amount that is equivalent to a permanent 1.19 percent jump in consumption.[5]

After obtaining these results for the steady state of the model, we turn to its dynamic properties. We display the dynamic response

5. In our analysis, we do not factor in the bureaucratic and other reporting costs of leverage restrictions. If we do so, presumably the steady state welfare benefit of leverage would be smaller. However, because the benefits reported in this paper are so large, we expect our finding that welfare increases to be robust.

of various variables to four shocks. Of these, one is a monetary policy shock, two are shocks to bank net worth and a fourth is a shock to the cross-sectional dispersion of technology.[6] In each case, a contractionary shock drives down consumption, investment, output, employment, inflation and bank net worth, just as in actual recessions. In addition, all four shocks raise the cross-sectional dispersion of bank equity returns. We use the Center for Research on Security Prices (CRSP) data to show that this implication is consistent with the data. The countercyclical nature of various measures of dispersion has been a subject of great interest since Bloom (2009) drew attention to the phenomenon. A factor that may be of independent interest is that our paper provides examples of how this increase in dispersion can occur endogenously.[7]

The paper is organized as follows. The next section describes the circumstances of the bankers. We then describe the general macroeconomic environment into which we insert the bank. After that we report our findings for leverage and for the dynamic properties of our model. The last section includes concluding remarks.

1. Banks, Mutual Funds and Entrepreneurs

We begin the discussion in period t, after goods production for that period has occurred. There is a mass of identical bankers with net worth N_t. The bankers enter into competitive and anonymous markets, acquire deposits from mutual funds and lend their net worth and deposits to entrepreneurs. Mutual funds take deposits from households and make loans to a diversified set of banks. The assumption that mutual funds stand between households and banks is made for convenience. Our bankers are risky and if households placed deposits directly with banks they would choose to diversify across banks. The idea that households diversify across a large set of banks seemed awkward to us. Instead, we posit that households hold deposits with mutual funds, and then mutual funds diversify across banks. Another advantage of our assumption that mutual

6. For the latter we consider a risk shock, which is similar to the one considered in Christiano, Motto and Rostagno (2014).

7. For examples in which exogenous fluctuations in uncertainty can account for a substantial fraction of business cycle fluctuations, see Bloom (2009) and Christiano, Motto and Rostagno (2014).

funds stand between households and banks is that this allows us to define a risk-free rate of interest. However, nothing of substance hinges on the presence of the mutual funds.

Each entrepreneur has access to a constant returns-to-scale investment technology. The technology requires, as input, an investment at the end of goods production in period t and produces output during production in $t + 1$. Entrepreneurs are competitive, earn no rent and there is no agency problem between entrepreneurs and banks. The bank from which an entrepreneur receives its loan receives the full rate of return earned by entrepreneurs on their projects.

There are "good" and "bad" entrepreneurs. We denote the gross rate of return on their period t investment by R^g_{t+1} and R^b_{t+1} respectively, where $R^g_{t+1} > R^b_{t+1}$ in all period $t + 1$ states of nature. These represent exogenous stochastic processes from the point of view of entrepreneurs. We discuss the factors that determine these rates of return in the next section. There, we situate entrepreneurs and bankers in the broader macro economy.

A key function of banks is to identify good entrepreneurs. To do this, bankers exert a costly effort. In our baseline model this effort is not observable to the mutual funds that supply the banks with funds, and this creates an agency problem on the liability side of a bank's balance sheet. As a convenient benchmark, we also consider the version of the model in which banker effort is observable to the mutual fund that supplies the bank with deposits d_t.

At the end of production in period t, each banker takes deposits d_t and makes loans in the amount $N_t + d_t$ to entrepreneurs. We capture the idea that banks are risky with the assumption that a bank can only invest in one entrepreneur.[8] The quantities N_t and d_t are expressed in per capita terms.

We denote the effort exerted by a banker to find a good entrepreneur by e_t. The banker identifies a good entrepreneur with probability $p(e_t)$ and a bad entrepreneur with the complementary

8. We can describe the relationship between a bank and an entrepreneur in search theoretic terms. Thus, the bank exerts an effort e_t, to find an entrepreneur. Upon exerting this effort a bank meets exactly one entrepreneur in a period. We imagine that the outside option for both the banker and the entrepreneur at this point is zero. We suppose that upon meeting, the bank has the option to make a take-it-or-leave-it offer to the entrepreneur. Under these circumstances, the bank will make an offer that puts the entrepreneur on its outside option of zero. In this way, the banker captures all the rent in their relationship.

probability. For computational simplicity, we adopt the following simple representation of the probability function:

$$p(e) = \min\{1, \bar{a} + \bar{b}e\},\ \ \bar{a}, \bar{b} \geq 0$$

Because we work with equilibria in which $p(e_t) > 1/2$, our model implies that when bankers exert greater effort, the mean return on their asset increases and its variance decreases.

Mutual funds are competitive and perfectly diversified across good and bad banks. As a result of free entry, they enjoy zero profits:

$$p(e_t)\, R^d_{g,t+1} + (1 - p(e_t))\, R^d_{b,t+1} = R_t \tag{1}$$

in each period $t + 1$ state of nature. Here, $R^d_{g,t+1}$ and $R^d_{b,t+1}$ denote the gross return received from good and bad banks, respectively. In (1), $p(e_t)$ is the fraction of banks with good returns, and $1 - p(e_t)$ is the fraction of banks with bad returns.[9] The following two subsections discuss the deposit contracts between banks and mutual funds that emerge in equilibrium. The first discussion reviews the case when mutual funds observe e_t .The case that we consider empirically relevant is the one in which the e_t selected by a bank is not observed by the mutual fund that provides the bank with deposits. The latter case is considered in the subsequent section. After that we describe the aggregate law of motion of banker net worth. Finally, we describe the changes to the environment when there are binding leverage restrictions.

1.1 Deposit Contracts When Banker Effort is Observable

A loan contract between a banker and a mutual fund is characterized by four objects,

9. We obtain (1) as follows. The period t measure of profits for mutual funds is

$$E_t \lambda_{t+1} [p(e_t)\, R^d_{g,t+1} + (1 - p(e_t))\, R^d_{b,t+1} - R_t],$$

where the product of λ_{t+1} and the associated conditional probability is proportional to the state contingent price of cash. In addition, we assume the only source of funds for mutual funds in period $t + 1$ is the revenues from banks, so that mutual funds have the following state-by-state non-negativity constraint:

$$p(e_t)\, R^d_{g,t+1} + (1 - p(e_t))\, R^d_{b,t+1} - R_t \geq 0.$$

Equation (1) is implied by the zero profit condition and the above non-negativity constraint.

$$(d_t, e_t, R^d_{g,t+1}, R^d_{b,t+1}). \tag{2}$$

In this section, all four elements of the contract are assumed to be directly verifiable by the mutual fund. Throughout this paper, we assume that sufficient sanctions exist so that verifiable deviations from a contract never occur.

The representative mutual fund takes R_t as given. We assume the banker's only source of funds for repaying the mutual fund is the earnings on its investment. Regardless of the return on its asset, the banker must earn enough to pay its obligation to the mutual fund:

$$R^g_{t+1}(N_t + d_t) - R^d_{g,t+1}d_t \geq 0, \quad R^b_{t+1}(N_t + d_t) - R^d_{b,t+1}d_t \geq 0.$$

Mutual funds are obviously only interested in contracts that are feasible, so the above inequalities represent restrictions on the set of contracts that mutual funds are willing to consider. In practice, only the second inequality is ever binding.

In equilibrium, each bank has access to a menu of contracts, defined by the objects in (2) which satisfy (1) and

$$R^b_{t+1}(N_t + d_t) - R^d_{b,t+1}d_t \geq 0. \tag{3}$$

as well as non-negativity of e_t and d_t. The problem of the banker is to select a contract from this menu.

A banker's ex-ante reward from a loan contract is:

$$\begin{aligned} &E_t\lambda_{t+1}\{p(e_t)\,[R^g_{t+1}(N_t + d_t) - R^d_{g,t+1}d_t] \\ &\quad + (1 - p(e_t))[R^b_{t+1}(N_t + d_t) - R^d_{b,t+1}d_t]\} - \frac{1}{2}e_t^2, \end{aligned} \tag{4}$$

where $e_t^2/2$ is the banker's utility cost of expending effort and λ_{t+1} denotes the marginal value of profits to the household. As part of the terms of the banker's arrangement with its own household, the banker is required to seek a contract that maximizes (4).[10] Formally, the banker maximizes (4) by choice of e_t, d_t, $R^d_{g,t+1}$, and $R^d_{b,t+1}$ subject

10. Throughout the analysis we assume the banker's household observes all the variables in (4) and that the household has the means (say, because the household could threaten to withhold the perfect consumption insurance that it provides) to compel the banker to do what the household requires of it.

to (1) and (3). In appendix A of the working paper[11], we show that (3) is non-binding and that the following are the optimization conditions:

$$e \quad : \quad e_t = E_t \lambda_{t+1} p_t' (e_{t+1}) (R_{t+1}^g - R_{t+1}^b) (N_t + d_t) \tag{5}$$

$$d \quad : \quad E_t \lambda_{t+1} [p_t(e_t) R_{t+1}^g + (1 - p_t(e_t)) R_{t+1}^b - R_t] = 0 \tag{6}$$

$$\mu \quad : \quad R_t = p_t(e_t) R_{g,t+1}^d + (1 - p_t(e_t)) R_{b,t+1}^d. \tag{7}$$

Here, the character before the colon indicates the variable being differentiated in the Lagrangian version of the bank's optimization problem. The character μ denotes the multiplier on (1). Note from (5) how the size of the base $N_t + d_t$ on which banks make profits affects effort e_t. Also, note from (5) that in setting effort e_t, the banker looks only at the sum $N_t + d_t$, and not at how this sum breaks down into the component reflecting the banker's own resources N_t and the component reflecting the resources d_t supplied by the mutual fund. By committing to care for d_t as if these were the banker's own funds, the banker is able to obtain better contract terms from the mutual fund. The banker is able to commit to the level of effort in (5) because e_t is observable to the mutual fund.

The values of the state contingent return on the deposits of banks with good and bad investments $R_{g,t+1}^d, R_{b,t+1}^d$ are not uniquely pinned down. These returns are restricted only by (7) and (3). For example, the following scenario is compatible with the equations $R_{g,t+1}^d = R_{t+1}^g$, $R_{b,t+1}^d = R_{t+1}^b$. It may also be possible for the equations to be satisfied by a non-state contingent pattern of returns, $R_{g,t+1}^d = R_{b,t+1}^d = R_t$. However, (3) indicates that the latter case requires N_t to be sufficiently large.

1.2 Deposit Contracts When Banker Effort is Not Observable

We now suppose that the banker's effort, e_t is not observed by the mutual fund. Thus, whatever $d_t, R_{g,t+1}^d, R_{b,t+1}^d$ and e_t are specified in the contract, a banker always chooses e_t ex post to maximize (4). The first order condition necessary for optimality is:

11. Working Papers of the Central Bank of Chile: http://www.bcentral.cl/Estudios/documentos-trabajo/fichas/726.htm

$$e \quad : \quad e_t = E_t \lambda_{t+1} p_t'(e_t)[(R_{t+1}^g - R_{t+1}^b)(N_t + d_t) - (R_{g,t+1}^d - R_{b,t+1}^d)d_t]. \tag{8}$$

Note that $R_{g,t+1}^d > R_{b,t+1}^d$ reduces the banker's incentive to exert effort. This is because, in this case, the banker receives a smaller portion of the marginal increase in expected profits caused by a marginal increase in effort. The representative mutual fund understands that e_t will always be selected according to (8). Since the mutual fund is only interested in contracts that will actually be implemented, it will only offer contracts that satisfy not just (3), but also (8). Thus, we assume that the menu of contracts that exists in equilibrium is the set of $(d_t, e_t, R_{g,t+1}^d, R_{b,t+1}^d)$'s that satisfy (1), (3) and (8). The banker's problem now is to maximize (4) subject to these three conditions. In the appendix, we show that the conditions for optimization are:

$$e \quad : \quad E_t(\lambda_{t+1} + \nu_{t+1}) p_t'(e_t)(R_{g,t+1}^d - R_{b,t+1}^d) d_t + \eta_t) = 0 \tag{9}$$

$$d \quad : \quad 0 = E_t(\lambda_{t+1} + \nu_{t+1})[p_t(e_t)(R_{t+1}^g - R_{g,t+1}^d) + (1 - p_t(e_t))(R_{t+1}^b - R_{b,t+1}^d)]$$

$$R_g^d : \quad \nu_{t+1} p_t(e_t) + \eta_t \lambda_{t+1} p_t'(e_t) = 0$$

$$\mu \quad : \quad R_t = p_t(e_t) R_{g,t+1}^d + (1 - p_t(e_t)) R_{b,t+1}^d$$

$$\eta \quad : \quad e_t = E_t \lambda_{t+1} p_t'(e_t)[(R_{t+1}^g - R_{t+1}^b)(N_t + d_t) - (R_{g,t+1}^d - R_{b,t+1}^d) d_t]$$

$$\nu \quad : \quad \nu_{t+1}[R_{t+1}^b (N_t + d_t) - R_{b,t+1}^d d_t] = 0, \; \nu_{t+1} \geq 0,$$

$$[R_{t+1}^b (N_t + d_t) - R_{b,t+1}^d d_t] \geq 0.$$

Here, η_t is the multiplier on (8), ν_{t+1} is the multiplier on (3). The date on a multiplier indicates the information on which it is contingent. Thus, η_t, ν_t and μ_t are each contingent on the period t realization of aggregate shocks. For computational simplicity, we only consider parameter values such that the cash constraint (3) is always binding. The first three equations in (9) correspond to first order conditions associated with the Lagrangian representation of the banker problem, with the names corresponding to the variable being differentiated.

The magnitude of the multiplier, $\nu_{t+1} \geq 0$, is a measure of the inefficiency of the banking system. If ν_{t+1} is zero, then $\eta_t = 0$ is zero by the R_g^d condition in (9). Then, combining the e equation with the

η equation, we see that e_t is set efficiently, in the sense that it is set according to (5). When $\nu_{t+1} > 0$ then $\eta_t < 0$ and e_t is below the level indicated by (5).[12]

A notable feature of the model concerns its implication for the cross-sectional variance on the rate of return on bank equity. In period $t + 1$ the realized rate of return on bank equity for the $p(e_t)$ successful banks and for the $1 - p(e_t)$ unsuccessful banks is, respectively,

$$\frac{R^g_{t+1}\left(N_t + d_t\right) - R^d_{g,t+1}d_t}{N_t}, \frac{R^b_{t+1}\left(N_t + d_t\right) - R^d_{b,t+1}d_t}{N_t}.$$

Given our assumption that the cash constraint is binding for unsuccessful banks, the second of the above two returns is zero. So, the period t cross-sectional standard deviation s^b_{t+1} and mean E^b_{t+1} of bank equity returns are:[13]

$$s^b_{t+1} = \left[p\left(e_t\right)\left(1 - p\left(e_t\right)\right)\right]^{1/2} \frac{R^g_{t+1}\left(N_t + d_t\right) - R^d_{g,t+1}d_t}{N_t}, \tag{10}$$

$$E^b_{t+1} = p\left(e_t\right)\frac{R^g_{t+1}\left(N_t + d_t\right) - R^d_{g,t+1}d_t}{N_t}.$$

When e_t increases, banks become safer in the sense that their Sharpe ratio E^b_{t+1}/s^b_{t+1} increases.

1.3 Law of Motion of Aggregate Bank Net Worth

In the next section, we assume that each banker is a member of one of a large number of identical households. Each household has sufficiently enough bankers that the law of large numbers applies. We assume that the bankers in period t all have the same level of net worth, N_t. We assume in $t + 1$ they pool their net worth after their period $t + 1$ returns are realized. In this way, we avoid the potentially distracting problem of having to model the evolution of the

12. In appendix A we show that v_{t+1} is positive in any period $t + 1$ state of nature if, and only if, it is positive in all period $t + 1$ states of nature.

13. Recall that if a random variable has a binomial distribution and takes on the value x^h with probability p and x^l with probability $1 - p$, then the variance of that random variable is $p(1 - p)(x^h - x^l)^2$.

distribution of banker net worth. After bankers have pooled their net worth in period $t + 1$ an exogenous fraction $1 - \gamma_{t+1}$ of this net worth is transferred to their household. At this point, the representative household makes an exogenous lump sum transfer N_{t+1} to the net worth of its banker. After pooling and transfers, the net worth of a banker in the representative household in period $t + 1$ is given by:

$$N_{t+1} = \gamma_{t+1} \left\{ \begin{array}{l} p(e_t)\left[R^g_{t+1}(N_t + d_t) - R^d_{g,t+1} d_t \right] \\ \\ +(1 - p(e_t))\left[R^b_{t+1}(N_t + d_t) - R^d_{b,t+1} d_t \right] \end{array} \right\} + T_{t+1}. \tag{11}$$

We assume that γ_{t+1} and T_{t+1} are exogenous shocks, realized in $t + 1$. A rise in T_{t+1} is equivalent to an influx of new equity into the banks. Similarly, a rise in γ_{t+1} also represents a rise in equity. Thus, we assume that the inflow or outflow of equity into the banks is exogenous and is not subject to the control of the banker. The only control bankers have over their net worth operates through their control over deposits and the resulting impact on their earnings.

In the unobserved effort model, where we assume the cash constraint is always binding in the bad state, we have:

$$N_{t+1} = \gamma_{t+1} p(e_t) \left[R^g_{t+1}(N_t + d_t) - R^d_{g,t+1} d_t\right] + T_{t+1}. \tag{12}$$

The object in square brackets is the realized profits of good banks. It is possible for those to make losses on their deposits (i.e., $R^g_{t+1} < R^d_{g,t+1}$), however we assume that those profits are never so negative that earnings on net worth cannot cover them.

When there is no aggregate uncertainty, the d and μ equations (9) imply that the expected earnings of a bank on deposits is zero. Then,

$$p_t(e_t) R^g_{t+1} + (1 - p_t(e_t)) R^b_{t+1} = R_t. \tag{13}$$

Equation (13) and the μ equation in (9) together imply that the law of motion has the following form:

$$N_{t+1} = \gamma_{t+1} R_t N_t + T_{t+1}. \tag{14}$$

When there is aggregate uncertainty, equation (13) holds only in expectation. It does not hold in terms of realized values.

1.4 Restrictions on Bank Leverage

We now impose an additional constraint on banks, which they must satisfy:

$$\frac{N_t + d_t}{N_t} \leq L_t, \tag{15}$$

where L_t denotes the period t restriction on leverage. The banker problem now is to maximize (4) subject to (1), (3), (8) and the additional constraint $N_t L_t - (N_t + d_t) \geq 0$. Let $\Lambda_t \geq 0$, denote the multiplier on that constraint. It is easy to verify that the equilibrium conditions now are (9) with the zero in the d equation replaced by Λ_t, plus the following complementary slackness condition:

$$\Lambda_t \left[N_t L_t - (N_t + d_t)\right] = 0, \quad \Lambda_t \geq 0, \quad N_t L_t - (N_t + d_t) \geq 0.$$

Thus, when the leverage constraint is binding, we use the d equation to define Λ_t and add the equation

$$N_t L_t = (N_t + d_t).$$

Interestingly, since the d equation does not hold any longer with Λ_t=0, the expected profits of banks in steady state are positive. As a result, (14) does not hold in steady state. Of course, (11) and (12) both hold. Using the μ equation to simplify (11):

$$N_{t+1} = \gamma_{t+1}\{[p_t(e_t) R^g_{t+1} + (1 - p_t(e_t))R^b_{t+1}]\,(N_t + d_t) - R_t d_t] + T_{t+1}. \tag{16}$$

The modified d equation in the version of the model without aggregate uncertainty is:

$$\Lambda_t = (\lambda_{t+1} + \nu_{t+1})\;[p_t(e_t)(R^g_{t+1} - R^d_{g,t+1}) + (1 - p_t(e_t))\,(R^b_{t+1} - R^d_{b,t+1})]. \tag{17}$$

Substituting this into (16):

$$N_{t+1} = \gamma_{t+1}\left\{\left[\frac{\Lambda_t}{\lambda_{t+1} + \nu_{t+1}} + R_t\right]\left(N_t + d_t\right) - R_t d_t\right\} + T_{t+1},$$

or

$$N_{t+1} = \gamma_{t+1}\left\{R_t N_t + \left[\frac{\Lambda_t}{\lambda_{t+1} + \nu_{t+1}}\right](N_t + d_t)\right\} + T_{t+1}.$$

From here we see that banks make profits on deposits when the leverage constraint is binding, so that $\Lambda_t > 0$.

2. The General Macroeconomic Environment

In this section, we place the financial markets of the previous section into an otherwise standard macro model, along the lines of Christiano, Eichenbaum and Evans (2005) or Smets and Wouters (2007). The financial market has two points of contact with the broader macroeconomic environment. First, the rates of return on entrepreneurial projects are a function of the rate of return on capital. Second, there is a market clearing condition in which the total purchases of raw capital by entrepreneurs $N_t + d_t$ is equal to the total supply of raw capital by capital producers. In the following two subsections, we first describe goods production and the problem of households. The second subsection describes the production of capital and its links to the entrepreneur. Later subsections describe monetary policy and other aspects of the macro model.

2.1 Goods Production

Goods are produced according to a Dixit-Stiglitz structure. A representative, competitive final goods producer combines intermediate goods $Y_{j,t}$, $j \in [0,1]$, to produce a homogeneous good Y_t using the following technology:

$$Y_t = \left[\int_0^1 Y_{j,t}^{\frac{1}{\lambda_f}} dj\right]^{\lambda_f}, 1 \leq \lambda_f < \infty. \tag{18}$$

The intermediate good is produced by a monopolist using the following technology:

$$Y_{j,t} = \begin{cases} \bar{K}_{j,t}^{\alpha}\left(z_t l_{j,t}\right)^{1-\alpha} - \Phi z_t^* & \text{if } \bar{K}_{j,t}^{\alpha}\left(z_t l_{j,t}\right)^{1-\alpha} > \Phi z_t^* \\ 0 & \text{otherwise} \end{cases}, 0 < \alpha < 1. \quad (19)$$

Here, z_t follows a determinist time trend. Also, $\bar{K}_{j,t}$ denotes the services of capital and $l_{j,t}$ denotes the quantity of homogeneous labor, respectively, hired by the j^{th} intermediate good producer. The fixed cost in the production function (19), is proportional to z_t^* which is discussed below. The variable z_t^* has the property that Y_t/z_t^* converges to a constant in non-stochastic steady state. The monopoly supplier of $Y_{j,t}$ sets its price $P_{j,t}$ subject to Calvo-style frictions. Thus, in each period t a randomly selected fraction of intermediate good firms $1 - \xi_p$ can re-optimize their price. The complementary fraction sets its price as follows:

$$P_{j,t} = \pi P_{j,t-1}.$$

Let π_t denote the gross rate of inflation P_t/P_{t-1}, where P_t is the price of Y_t. Then, π denotes the steady state value of inflation.

There exists a technology that can be used to convert homogeneous goods into consumption goods C_t one-for-one. Another technology converts a unit of homogenous goods into investment goods Υ^t, where $\Upsilon > 1$. This parameter allows the model to capture the observed trend fall in the relative price of investment goods. Because we assume these technologies are operated by competitive firms, the equilibrium prices of consumption and investment goods are P_t and

$$P_{I,t} = \frac{P_t}{\Upsilon^t},$$

respectively. The trend rise in technology for producing investment goods is the second source of growth in the model, and

$$z_t^* = z_t \Upsilon^{\left(\frac{\alpha}{1-\alpha}\right)t}.$$

Our treatment of the labor market follows Erceg, Henderson and Levin (2000), and parallels the Dixit-Stiglitz structure of goods production. A representative, competitive labor contractor aggregates the differentiated labor services $h_{i,t}$ and $i \in [0,1]$ into homogeneous labor l_t using the following production function:

$$l_t = \left[\int_0^1 \left(h_{i,t} \right)^{\frac{1}{\lambda_w}} di \right]^{\lambda_w}, 1 \leq \lambda_w < \infty. \tag{20}$$

The labor contractor sells labor services l_t to intermediate good producers for a given nominal wage rate W_t. The labor contractor also takes as given the wages of the individual labor types $W_{i,t}$.

A representative, identical household supplies each of the differentiated labor types $h_{i,t}$ and $i \in [0,1]$, used by the labor contractors. By assuming that all varieties of labor are contained within the same household (this is the "large family" assumption introduced by Andolfatto, 1996 and Merz, 1995) we avoid confronting difficult distributional issues. For each labor type $i \in [0,1]$, there is a monopoly union that represents workers of that type belonging to all households. The i^{th} monopoly union sets the wage rate $W_{i,t}$ for its members, subject to Calvo-style frictions. In particular, a randomly selected subset of $1 - \xi_w$ monopoly unions set their wage to optimize household utility (see below), while the complementary subset sets the wage according to:

$$W_{i,t} = \mu_{z^*} \pi W_{i,t-1}$$

Here, μ_{z^*} denotes the growth rate of z_t^*. The wage rate determines the quantity of labor demanded by the competitive labor aggregators. Households passively supply the quantity of labor demanded.

2.2 Households

The representative household is composed of a unit measure of agents. Of these, a fraction ρ are workers and the complementary fraction are bankers. Per capita household consumption is C_t, which is distributed equally to all household members. Average period utility across all workers is given by:

$$\log(C_t - b_u C_{t-1}) - \tilde{\psi}_L \int_0^1 \frac{h_{i,t}^{1+\sigma_L}}{1 + \sigma_L} di, \tilde{\psi}_L, \sigma_L \geq 0.$$

The object $b_u \geq 0$ denotes the parameter controlling the degree of habit persistence. The period utility function of a banker is:

$$\log(C_t - b_u C_{t-1}) - \tilde{\rho} e_t^2, \tilde{\rho} \equiv \frac{1}{2\left(1-\rho\right)}. \tag{21}$$

The representative household's utility function is the equally-weighted average across the utility of all the workers and bankers:

$$\log(C_t - b_u C_{t-1}) - \psi_L \int_0^1 \frac{h_{i,t}^{1+\sigma_L}}{1+\sigma_L} di - \frac{1}{2} e_t^2, \psi_L \equiv \rho \tilde{\psi}_L.$$

The representative household's discount value of a stream of consumption, employment and effort is valued as follows:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \log(C_t - b_u C_{t-1}) - \psi_L \int_0^1 \frac{h_{i,t}^{1+\sigma_L}}{1+\sigma_L} di - \frac{1}{2} e_t^2 \right\}, \psi_L, b_u, \sigma_L > 0. \tag{22}$$

Bankers behave as described in section 2. They are assumed to do so in exchange for the perfect consumption insurance received from households. Although the mutual funds from which bankers obtain deposits do not observe banker effort e_t, we assume that a banker's own household observes everything that it does. By instructing the bankers to maximize expected net worth (taking into account their own costs of exerting effort), the household maximizes total end-of-period banker net worth.[14]

The representative household takes e_t and labor earnings as given. It chooses C_t and the quantity of a nominal bond B_{t+1}, to maximize (22) subject to the budget constraint:

14. A brief observation about units of measure: We measure the financial objects that the banker works with, N_t and d_t in per capita terms. Bankers are a fraction $1-\rho$ of the population, so that in per banker terms, bankers work with $N_t/(1-\rho)$ and $d_t/(1-\rho)$. We assume the banker values profits net of the utility cost of its effort as follows:

$$E_t \lambda_{t+1} \left\{ p\left(e_t\right) \left[R_{t+1}^g \left(\frac{N_t + d_t}{1-\rho} \right) - R_{g,t+1}^d \frac{d_t}{1-\rho} \right] + \left(1 - p\left(e_t\right)\right) \left[R_{t+1}^b \left(\frac{N_t + d_t}{1-\rho} \right) - R_{b,t+1}^d \frac{d_t}{1-\rho} \right] \right\} - \tilde{\rho} e_t^2.$$

Multiplying this expression by$1-\rho$ and using (21), we obtain (4).

$$P_t C_t + B_{t+1} \leq \int_0^1 W_{i,t} h_{i,t} di + R_t B_t + \Pi_t.$$

Here, Π_t denotes lump sum transfers of profits from intermediate good firms and bankers and taxes. In addition, the household has access to a nominally non-state contingent one-period bond with gross payoff R_t in period $t + 1$. Loan market clearing requires that, in equilibrium:

$$B_t = d_t. \tag{23}$$

2.3 Monetary Policy

We express the monetary authority's policy rule directly in linearized form:

$$R_t - R = \rho_p \left(R_{t-1} - R\right) + \left(1 - \rho_p\right) \begin{bmatrix} \alpha_\pi \left(\pi_{t+1} - \pi\right) \\ +\alpha_{\Delta y} \frac{1}{4}\left(g_{y,t} - \mu_{z^*}\right) \end{bmatrix} + \frac{1}{400} \varepsilon_t^p, \tag{24}$$

where ε_t^p is a shock to monetary policy and ρ_p is a smoothing parameter in the policy rule. Here, $R_t - R$ is the deviation of the period t net quarterly interest rate R_t from its steady state. Similarly, $\pi_{t+1} - \pi$ is the deviation of anticipated quarterly inflation from the central bank's inflation target. The expression $g_{y,t} - \mu_{z^*}$ is quarterly GDP growth, in deviation from its steady state. Finally, ε_t^p is an *iid* shock to monetary policy with standard deviation $\sigma_{p.}$ Note that the shock is in units of annual percentage points.

2.4 Capital Producers, Entrepreneurial Returns and Market Clearing Conditions

In this section we explain how entrepreneurial returns are linked to the underlying return on physical capital. In addition, we discuss the agents that produce capital, the capital producers. Finally, we present the final goods market clearing condition and the market clearing for capital.

The sole source of funds available to an entrepreneur is the funds $N_t + d_t$ received from its bank after production in period t.

An entrepreneur uses these funds to acquire raw capital, $\tilde{K}_{t+1}$ and convert it into effective capital units,

$$P_{k',t}\,\tilde{K}_{t+1} = N_t + d_t$$

where $P_{k',t}$ is the nominal price of a unit of new, raw capital. This is the market clearing condition for capital. Good and bad entrepreneurs convert one unit of raw capital into e^{g_t}, e^{b_t}, units of effective capital, respectively, where $g_t > b_t$. Once this conversion is accomplished, entrepreneurs rent their homogeneous effective capital into the $t + 1$ capital market. Thus, in period $t + 1$ the quantity of effective capital is K_{t+1} where

$$\bar{K}_{t+1} = [p(e_t)\, e^{g_t} + (1 - p(e_t))\, e^{b_t}]\, \tilde{K}_{t+1}. \tag{25}$$

Here, e_t is the level of effort expended by the representative banker in period t. Note that if e_t is low in some period, then the effective stock of capital is low in period $t + 1$. This reduction has a persistent effect, because—as we shall see below—effective capital is the input into the production of new raw capital in later periods. This effect of banker effort into the quantity of effective capital reflects their role in allocating capital between good and bad entrepreneurs. The object in square brackets in (25) resembles the "capital destruction shock" adopted in the literature, though here it is an endogenous variable. We refer to it as a measure of the allocative efficiency of the banking system.

Entrepreneurs rent the services of effective capital in a competitive, period $t + 1$ capital market. The equilibrium nominal rental rate in this market is denoted by $P_{t+1}r^k_{t+1}$[15] Entrepreneurs' effective capital $\bar{K}_{t+1}$ depreciates at the rate δ while it is being used by firms to produce output. The nominal price at which entrepreneurs sell used effective capital to capital producers is denoted $P_{k,t+1}$. The rates of return enjoyed by good and bad entrepreneurs are given by:

15. Here, the real rental rate on capital has been scaled. That actual real rental rate of capital is $r^k_{t+1}\Upsilon^{-t-1}$. The latter is a stationary object, according to the model. In the model, the rental rate of capital falls in steady state because the capital stock grows at a rate faster than z_t due to the trend growth in the productivity of making investment goods.

$$R_{t+1}^{g} = e^{g_t} R_{t+1}^{k}, R_{t+1}^{b} = e^{b_t} R_{t+1}^{k}, \tag{26}$$

where

$$R_{t+1}^{k} \equiv \frac{r_{t+1}^{k} \Upsilon^{-t-1} P_{t+1} + (1-\delta) P_{k,t+1}}{P_{k',t}}.$$

Here, R_{t+1}^{k} is a benchmark return on capital. The actual return enjoyed by entrepreneurs scales the benchmark according to whether the entrepreneur is good or bad.

We assume there are a large number of identical capital producers. The representative capital producer purchases the time t stock of effective capital and time t investment goods I_t and produces new, raw capital using the following production function:

$$\tilde{K}_{t+1} = (1-\delta)\bar{K}_t + (1 - S(I_t/I_{t-1}))\, I_t, \tag{27}$$

where S is an increasing and convex function defined below. The number of capital producers is large enough that they behave competitively. However, there is no entry or exit by entrepreneurs in order to avoid complications that would otherwise arise due to the presence of lagged investment in the production function for new capital. The representative capital producer takes the price of "old" effective capital $P_{k,t}$ as given, as well as the price of new, raw capital $P_{k't}$. If we denote the amount of effective capital that the capital producer purchases in period t by x_t, and the amount of raw capital that it sells in period t by y_t, then its objective is to maximize:

$$\sum_{j=0}^{\infty} \lambda_{t+j} \left\{ P_{k',t+j} y_{t+j} - P_{k,t+j} x_{t+j} - P_{I,t+j} I_{t+j} \right\},$$

where λ_t denotes the multiplier on the household budget constraint and $P_{I,t}$ denotes the price of investment goods. The multiplier and the prices are denominated in money terms. Substituting out for y_t using the production function, we obtain:

$$\max_{\{x_{t+j}, I_{t+j}\}_{j=0}^{\infty}} \sum_{j=0}^{\infty} \lambda_{t+j} \left\{ \begin{array}{l} P_{k',t+j} \left[x_{t+j} + \left(1 - S\left(I_{t+j} / I_{t+j-1}\right)\right) I_{t+j} \right] \\ - P_{k,t+j} x_{t+j} - P_{I,t+j} I_{t+j} \end{array} \right\}$$

From this expression, we see that the capital producer will set $x_t = \infty$ if $P_{k',t} < P_{k,t}$ or set $x_t = 0$ if $P_{k',t} < P_{k,t}$. Since neither of these conditions can hold in equilibrium, we conclude that

$$P_{k',t} = P_{k,t} \text{ for all } t.$$

Thus, the problem is simply to choose I_{t+j}, to maximize:

$$\lambda_t\{P_{k',t}[(1 - S(I_t/I_{t-1}))\, I_t] - P_{I,t}\, I_t\}$$

$$+ E_t\, \lambda_{t+1}\{P_{k',t+1}(1 - S(I_{t+1}/I_t))\, I_{t+1} - P_{I,t+1}\, I_{t+1}\} + ..$$

The first order necessary condition for a maximum is:

$$\begin{aligned} &\lambda_t \left[P_{k',t} \left(1 - S\left(I_t \,/\, I_{t-1}\right) - S'\left(I_t \,/\, I_{t-1}\right) \frac{I_t}{I_{t-1}} \right) - P_{I,t} \right] \\ &+ E_t \lambda_{t+1} P_{k',t+1} S'\left(I_{t+1} \,/\, I_t\right) \left(\frac{I_{t+1}}{I_t} \right)^2 = 0. \end{aligned} \tag{28}$$

Market clearing in the market for old capital requires:

$$x_t = (1 - \delta)\, \bar{K}_t.$$

Combining (27) with (25), we have the equilibrium law of motion for capital:

$$\bar{K}_{t+1} = [p_t(e_t)\, e^{g_t} + (1\; p_t(e_t))\, e^{b_t}]\, [(1 - \delta)\, \bar{K}_t + (1 - S(I_t/I_{t-1}))\, I_t].$$

Finally, we have the market clearing condition for final goods Y_t, which is:

$$Y_t = G_t + C_t + \frac{I_t}{\Upsilon^t}.$$

2.5 Shocks, Adjustment Costs, Resource Constraint

The adjustment cost function on investment is specified as follows:

$$S\left(\frac{I_t}{I_{t-1}}\right)=\left(\exp\left[\frac{1}{2}\sqrt{S''}\left(\frac{I_t}{I_{t-1}}-\mu_{z^*}\Upsilon\right)\right]+\exp\left[-\frac{1}{2}\sqrt{S''}\left(\frac{I_t}{I_{t-1}}-\mu_{z^*}\Upsilon\right)\right]-2\right),$$

where the parameter S'' controls the curvature of the adjustment cost function. Also, we specify that T_t and G_t evolve as follows:

$$T_t = z_t^* \tilde{T}_t, \quad G_t = z_t^* \tilde{g}_t,$$

where $\tilde{g}$ is a parameter and the additive equity shock $\tilde{T}_t$ obeys the following law of motion:

$$\log(\tilde{T}_t/\tilde{T}) = \rho_T \log(\tilde{T}_{t-1}/\tilde{T}) - \varepsilon_t^T.$$

The multiplicative equity shock, γ_t, obeys the following law of motion:

$$\log(\gamma_t/\gamma) = \rho_\gamma \log(\gamma_{t-1}/\gamma) - \varepsilon_t^\gamma.$$

Our third financial shock is a risk shock, Δ_t, which is similar to the one considered in Christiano, Motto and Rostagno (2014). In particular, let

$$b_t = b - \Delta_t$$

$$g_t = g.$$

Thus, Δ_t is a shock to the return to bad banks.
We assume

$$\Delta_t = \rho_\Delta \Delta_{t-1} + \varepsilon_t^\Delta.$$

The innovations to our three financial shocks are iid and

$$E(\varepsilon_t^T)^2 = (\sigma_T)^2, \quad E(\varepsilon_t^\gamma)^2 = (\sigma_\gamma)^2, \quad E(\varepsilon_t^\Delta)^2 = (\sigma_\Delta)^2.$$

3. Results

We first consider the steady state implications of our model for leverage. We then turn to the dynamic implications.

3.1 Model Parameterization

Our baseline model is the one in which banker effort is not observable and there are no leverage restrictions on banks. There are four shock processes, and these are characterized by 7 parameters

$$\sigma_p = 0.25, \quad \sigma_T = \sigma_\gamma = 0.01, \quad \sigma_\Delta = 0.05$$

$$\rho_T = \rho_\gamma = \rho_\Delta = 0.95.$$

The monetary policy shock is in annualized percentage points. Thus, its standard deviation is 25 basis points. Two of the other three shocks are in percent terms. Thus, the innovation to the equity shocks is 1 percent each, and the innovation to risk is 0.1 percent. The autocorrelations are 0.95 in each.

Apart from the parameters of the shock processes, that model has the 25 parameters displayed in table 1. Among these parameters, values for these eight:

$$b, g, \bar{a}, \tilde{T}, \tilde{g}, \Phi, \mu_{z^*}, \Upsilon,$$

where chosen to hit the eight calibration targets listed in table 2.

The first calibration target in table 2 is based on the evidence in figure 1. That figure reproduces data constructed in Ferreira (2012). Each quarterly observation in the figure is the cross-sectional standard deviation of the quarterly rate of return on equity for financial firms in the CRSP data base. The sample mean of those observations is 0.2, after rounding. The analog in our model of the volatility measure in figure 1 is s^b in (10). We calibrate the model so that in steady state $s^b = 0.20$. The cyclical properties of the volatility data, as well as HP-filtered GDP data in figure 1 are discussed in a later section.

Our second calibration target in table 2 is the interest rate spread paid by financial firms. We associate the interest rate spread in the data with $R_g^d - R$ in our model. Loosely, we have in mind that R_g^d is the interest rate on the face of the loan contract. The 60 annual

Table 1. Baseline Model Parameter Values

Meaning	*Name*	*Value*
Panel A: financial parameters		
Return parameter, bad entrepreneur	b	-0.09
Return parameter, good entrepreneur	g	0.00
Constant, effort function	$\bar{a}$	0.83
Slope, effort function	$\bar{b}$	0.30
Lump-sumtransfer fromhouseholds to bankers	$\tilde{T}$	0.38
Fraction of banker net worth that stays with bankers	γ	0.85
Panel B: Parameters that do not affect steady state		
Steady state inflation (APR)	$400(\pi - 1)$	2.40
Taylor rule weight on inflation	α_{π}	1.50
Taylor rule weight on output growth	$\alpha_{\Delta y}$	0.50
Smoothing parameter in Taylor rule	ρ_p	0.80
Curvature on investment adjustment costs	S''	5.00
Calvo sticky price parameter	ξ_p	0.75
Calvo sticky wage parameter	ξ_w	0.75
Panel C: Nonfinancial parameters		
Steady state gdp growth (APR)	μ_{z^*}	1.65
Steady state rate of decline in investment good price (APR)	Υ	1.69
Capital depreciation rate	δ	0.03
Production fixed cost	Φ	0.89
Capital share	α	0.40
Steady state markup, intermediate good producers	λ_f	1.20
Habit parameter	b_u	0.74
Household discount rate	$100(\beta^{-4} - 1)$	0.52
Steady state markup, workers	λ_w	1.05
Frisch labor supply elasticity	$1/\sigma_L$	1.00
Weight on labor disutility	Ψ_L	1.00
Steady state scaled government spending	$\tilde{g}$	0.89

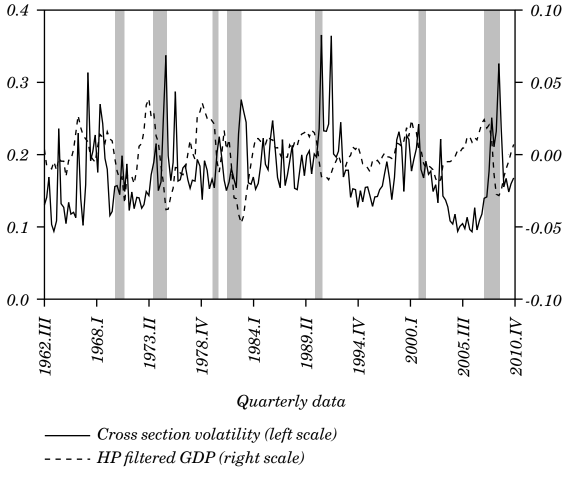
Source: Authors' elaboration.

Table 2: Steady State Calibration Targets for Baseline Model

Variable meaning	*Variable name*	*Magnitude*
Cross-sectional standard deviation of quarterly non-financial firmequity returns	s^b	0.20
Financial firminterest rate spreads (APR)	$400(R_g^d - R)$	0.60
Financial firmleverage	L	20.00
Allocative efficiency of the banking system	$p(e)e^g + (1-p(e))e^b$	1
Profits of intermediate good producers (controled by fixed cost, Φ)		0
Government consumption relative to GDP (controlled by $\tilde{g}$)		0.20
Growth rate of per capita GDP (APR)	$400(\mu_z^* - 1)$	1.65
Rate of decline in real price of capital (APR)	$400(\Upsilon - 1)$	1.69

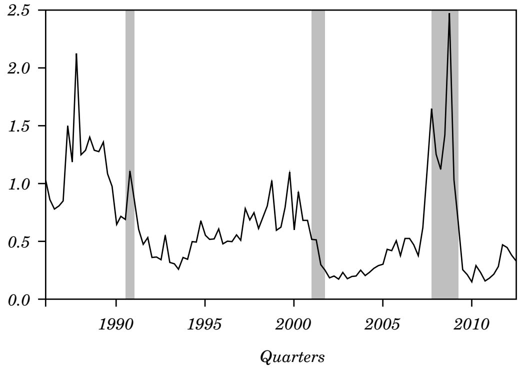
Source: Authors' elaboration.

Figure 1. Cross-section Standard Deviation Financial Firm Quarterly Return on Equity, HP-filtered U.S. Real GDP



Source: Authors' calculations with data from Federal Reserve Board of Governors.

Figure 2. 3 Month U.S. Libor versus 3 Month T-bill (APR)



Source: Federal Reserve Board of Governors.

basis point interest rate spread in table 2 is the sample average of the data on spreads in figure 2. That figure displays quarterly data on the spread on 3-month loans, measured by the London Interbank Offer Rate, over the rate on 3-month U.S. government securities. The data are reported in annual percent terms.

The third calibration target is leverage L, which we set to 20. We based this on sample leverage data reported in figure 3 of CGFS (2009). According to the results reported there, the leverage of large U.S. investment banks averaged around 25 since 1995 and the leverage of U.S. commercial banks averaged around 14 over the period.[16] Our value $L = 20$ is a rough average of the two.

For the remaining calibration targets we use the average growth of U.S. per capita GDP and the average decline in U.S. durable goods prices. We set the allocative efficiency of the financial system in steady state to unity. We suspect that this is in the nature of normalization. Finally, we set the fixed cost in the production function so that profits of the intermediate good firms in steady state are zero. We do not allow entry or exit of these firms, and the implausibility of this assumption is perhaps minimized with the zero steady state profit assumption.

16. The data of large U.S. investment banks are based on information about Bear Stearns, Goldman Sachs, Lehman Brothers, Merrill Lynch and Morgan Stanley.

The parameters pertaining to the financial sector that remain to be determined are $\bar{b}$ and γ. The parameter, $\bar{b}$, is important in our analysis. If $\bar{b}$ is sufficiently low, then the unobserved and observed equilibria are similar, and the essential mechanism emphasized in this paper is absent. With low $\bar{b}$, our baseline model inherits the property of the observable effort equilibrium, that binding leverage reduces social welfare. If $\bar{b}$ is too high, then the incentive to exert effort is substantial and there ceases to exist an interior equilibrium with $p(e) < 1$ in the baseline model. We balance these two extremes by setting $\bar{b} = 0.3$. With $\bar{b} = 0.2$, social welfare falls when leverage is restricted by a very modest amount, to 19.999. The parameter γ resembles a similar object in Bernanke, Gertler and Gilchrist (1999), which assigns a value of 0.98 to it. We found that with such a large value of γ, the dynamic response of variables to a monetary policy shock is very different from the results based on vector auto regressions (VARs) reported in CEE. In particular, a jump in the monetary policy shock in (24) drives inflation and output up, rather than down. We are still exploring the economic reasons for this result. However, we noticed that with $\gamma = 0.85$, the impulse responses to a monetary policy shock appear more nearly in line with the results reported in CEE. This is why we chose the value $\gamma = 0.85$. We are investigating what the implications of micro data may be for the value of this parameter.

The parameters in panel B were assigned values that are standard in the literature. The steady state inflation rate corresponds roughly to the actual U.S. experience in recent decades. The Calvo sticky price and wage parameters imply that prices and wages, on average, remain unchanged for about a year. Similarly, the parameter values in panel C are also fairly standard.

3.2 The Steady State Effects of Leverage

We consider the impact on welfare and other variables of imposing a binding leverage restriction. The results are reported in table 3. The first column of numbers displays the steady state properties of our baseline model, the unobservable effort model without any leverage restrictions. In that model, the assets of the financial system are 20 times their net worth. The second column of numbers shows what happens to the steady state of the model when all parameters are held at their values in table 1, but a binding leverage restriction of 17 is imposed. The last two columns of numbers report the same

Table 3. Steady State Properties of the Model

		Unobserved effort		*Observed effort*	
		Leverage restriction		*Leverage restriction*	
Variable meaning	*Variable name*	*Non-binding*	*Binding*	*Non-binding*	*Binding*
Spread	$400(R_g^d - R)$	0.600	0.211	NA	NA
Multiplier on cash constraint	ν	0.060	0.040	0.000	0.000
Scaled consumption	c	1.840	1.880	2.010	1.950
Scaled GDP	y	4.430	4.370	4.680	4.430
Labor	h	1.180	1.160	1.150	1.140
Scaled capital stock	k	51.520	51.400	59.750	53.860
Capital output ratio	$k/(c + i + g)$	11.630	11.750	12.780	12.150
Bank assets	$N + d$	51.520	51.310	59.550	53.680
Bank net worth	N	2.580	3.020	2.580	3.160
Bank deposits	d	48.940	48.290	56.980	50.520
Bank leverage	$(N+d)/N$	20.000	17.000	23.120	17.000

Table 3. (continued)

Variable meaning	Variable name	Unobserved effort		Observed effort	
		Leverage restriction		Leverage restriction	
		Non-binding	*Binding*	*Non-binding*	*Binding*
Bank return on equity (APR)	$400\left(\frac{[p(e_t)R^g_{t+1}+(1-p(e_t))R^b_{t+1}](N_t+d_t)-R_t d_t}{N_t}-1\right)$	4.590	14.960	4.590	17.630
Equity portion of bank return (APR)	$400(p(e_t)R^g_{t+1}+(1-p(e_t))R^b_{t+1}-1)$	4.590	5.200	4.590	5.360
Deposit portion of bank return (APR)	$400[p(e_t)R^g_{t+1}+(1-p(e_t))R^b_{t+1}-R_t]\frac{d_t}{N_t}$	0.000	9.760	0.000	12.270
Benchmark return on capital (APR)	$400(R^k-1)$	4.590	4.470	3.230	4.000
Bank efficiency	$p(e)e^g+(1-p(e))e^b$	1.000	1.002	1.003	1.003
Fraction of firms with good balance sheets	$p(e)$	0.962	0.982	1.000	1.000
Benefit of leverage (in c units)	100χ	NA	1.190	NA	-2.700
Benefit of making effort observable (in c units)	100χ	NA	NA	6.110	2.030

Source: Authors' calculations.
Note: (i) NA, not applicable, indicates that the number is not defined. (ii) All calculations based on a single set of parameter values, reported in table 1.

results as in the first two columns, but they apply to the version of our model in which effort is observable. We first consider the results for the unobserved effort version of the model.

When leverage restrictions are imposed, table 3 indicates that bank borrowing d declines. A consequence of this is that the interest rate spread on banks falls. To gain intuition into this result, we can see, from the fact that the multiplier, ν, on the cash constraint (3) is positive, that the cash constraint is binding (for ν, see (9)). This means that the creditors of banks with poorly performing assets must share in the losses, i.e., R_g^d is low. However, given the zero profit condition of mutual funds (1), it follows that R_g^d must be high. That is, $R_b^d > R$ and $R_g^d > R$. We can see from (3) that, given R^b and bank net worth, creditors of ex post bad banks suffer fewer losses the smaller are their deposits. This is why the value of R_b^d that solves (3) with equality increases with lower deposits. This in turn implies, via the mutual funds' zero profit condition that R_g^d falls towards R as d falls. Thus, deposit rates fluctuate less with the performance of bank portfolios with smaller d. This explains why the interest rate spread falls from 60 basis points in the baseline model to 21 basis points with the imposition of the leverage restriction. A closely related result is that ν falls with the introduction of the binding leverage constraint.

The reduction in the interest rate spread faced by banks helps to improve the efficiency of the economy by giving banks an incentive to increase e (see (8)). But these effects alone only go part way in explaining the full impact of imposing a leverage restriction on this economy. There is also an important general equilibrium, a dynamic effect of the leverage restriction that operates via its impact on banker net worth.

To understand this general equilibrium effect, we observe that a leverage restriction, in effect, allows banks to collude and behave like monopsonists. Deposits are a key input for banks and unregulated competition drives the profits that banks earn on deposits to zero. We can see this from the d equation in (9). That equation shows that in an unregulated banking system, the profits earned by issuing deposits are zero in expectation. This zero profit condition crucially depends on banks being able to expand deposits in case they earn positive profits on them. When a binding leverage restriction is imposed, this competitive mechanism is short-circuited. The d equation in (9) is replaced by (17), where $\Lambda \geq 0$ is the multiplier on the leverage constraint in the banker problem. When this multiplier is positive the bankers make positive profits on deposits. To explain this further, it is useful to focus on a particular decomposition of the rate of return on equity for banks. This rate of return is:

$$\frac{\begin{array}{l}\left[p\left(e_t\right)R^g_{t+1}+\left(1-p\left(e_t\right)\right)R^b_{t+1}\right]N_t\\ +\left[p\left(e_t\right)\left(R^g_{t+1}-R^d_{g,t+1}\right)+\left(1-p\left(e_t\right)\right)\left(R^b_{t+1}-R^d_{b,t+1}\right)\right]d_t\end{array}}{N_t}-1$$

$$= \overbrace{p\left(e_t\right)R^g_{t+1}+\left(1-p\left(e_t\right)\right)R^b_{t+1}-1}^{\text{equity portion of bank rate of return on bank equity}}$$

$$\overbrace{+\left[p\left(e_t\right)\left(R^g_{t+1}-R^d_{g,t+1}\right)+\left(1-p\left(e_t\right)\right)\left(R^b_{t+1}-R^d_{b,t+1}\right)\right]\frac{d_t}{N_t}}^{\text{deposit contribution to rate of return on bank equity}}$$

These three objects are displayed in table 3, after substituting out for $R^d_{g,t+1}$ and $R^d_{b,t+1}$ using the mutual fund zero profit condition. The d equation in (9) implies that, in steady state, the object in square brackets in the deposit contribution to banks' return on equity is zero.[17] So, the fact that d_t/N_t is very large when leverage is 20 has no implication for bank profits. However, with the imposition of the leverage restriction, the object in square brackets becomes positive and then the large size of d_t/N_t is very important. Indeed, it jumps from 0 to 9.76 (APR) when the leverage restriction is imposed. This is the primary reason why banks' rate of return on equity jumps from only 4.59 percent per year in the absence of regulations to a very large 14.96 percent per year when the leverage restriction is imposed. A small additional factor behind this jump is that the equity portion of bankers' rate of return on equity jumps a little too. That reflects the improvement in the efficiency of the banking system as e rises with the imposition of the leverage regulation. To see this, recall from (26) that the gross return on bank assets is given by:

$$p(e)R^g+(1-p(e))-R^b \tag{29}$$

$$=\left[p(e)e^g+(1-p(e))\,e^b\right]R^k.$$

17. Here, we also use the mutual fund, zero-profit condition.

From this we see that the gross return on bank assets can rise, even if R^k falls a little, if the allocative efficiency of the banking system improves enough.[18]

With the high rate of profit it is not surprising that in the new steady state associated with a leverage restriction, bank net worth is higher. Indeed, it is a substantial 17 percent higher. This effect on bank net worth mitigates one of the negative consequences of the leverage restriction. We can see this from (8), which shows that banker effort is not just decreasing with an increased spread between R_b^d and R_g^d, but it is also a function of the total quantity of assets under management. Thus, the bank profits occasioned by the imposition of leverage restrictions raise banker net worth and mitigate the negative impact on banker efficiency of a fall in deposits.

As a way of summarizing the results in table 3 for the unobserved effort model of this section, we examine the impact of leverage on welfare. We suppose that the social welfare function is given by:

$$u = \log\left(c - \frac{b}{\mu_{z^*}}c\right) - \frac{\psi_L}{1+\sigma_L}h^{1+\sigma_L} - \frac{1}{2}e^2,$$

where c represents C_t/z_t^* in steady state. Let u^l and u^{nl} denote the value of this function in the equilibrium with leverage imposed and not imposed, respectively. Let $u^{nl}(\chi)$ denote utility in the equilibrium without leverage in which consumption c^{nl} is replaced by $(1+\chi)c^{nl}$. We measure the utility improvement from imposing leverage by the value of χ that solves $u^{nl}(\chi) = u^l$. That is,

$$\chi = e^{ul-unl} - 1.$$

In the table we report 100χ. Note that the welfare improvement from imposing leverage is a very substantial 1.19 percent. We suspect that, if anything, this understates the welfare improvement somewhat. According to the table, the quantity of capital falls a small amount with the imposition of the leverage restriction while the efficiency of the banking system improves. This suggests that during the transition between steady states (which is ignored in our welfare

18. The rate of return R^k on capital falls somewhat because the capital to labor ratio rises, and this reduces the rental rate of capital. This is the only input into R^k that changes with the imposition of leverage.

calculations), investment must be relatively low and consumption correspondingly high.

We now discuss the last two columns in table 3. The column headed "non-binding" describes properties of the equilibrium of our model when effort is observable and the model parameters take on the values in table 1. The column headed "binding" indicates the equilibrium when leverage is restricted to 17. We do not report interest rate spreads for the observable effort model because, as indicated above, spreads are not uniquely determined in that model. Comparing the results in the last two columns with the results in the first two columns allows us to highlight the central role in our analysis played by the assumption that effort is not observable. The welfare results in the table provide two ways to summarize the results.

First, note that imposing a leverage restriction on the model when effort is observed implies a very substantial 2.70 percent drop in welfare.[19] Evidently, leverage restrictions are counterproductive when effort is observable. Second, the results indicate that the lack of observability of effort implies a substantial reduction in welfare. In the absence of a leverage restriction, the welfare gain from making effort observable is 6.11 percent.[20] When a binding leverage limit of 17 is in place, then the welfare gain from making effort observable is also a substantial 2.03 percent.[21]

We now discuss why it is that the observable effort equilibrium is so much better than the equilibrium in which effort is not observable. We then sum up by pointing out the benefits of the leverage restriction on the unobserved effort economy explaining what it is about the leverage restriction that improves welfare.

Making effort observable results in higher consumption and output, and lower employment. These additions to utility are partially offset by the utility cost of extra effort by bankers. This extra effort by bankers in the observable effort equilibrium is the key to understanding why consumption and capital are higher, and

19. The simultaneous drop in the capital stock and the absence of any change in the efficiency of the banking system suggests that when the transition is taken into account, the drop in welfare may be smaller.

20. It is not clear how taking into account the transition between steady states would affect this welfare calculation. In the steady state with observable effort, the quantity of capital is higher but the efficiency of the banking system is also greater. The impact of the transition on welfare depends on the extent to which the higher amount of capital reflects increased efficiency and/or a reduction in consumption during the transition.

21. The observations about the impact of the transition on welfare calculations made in the previous footnote apply here as well.

labor lower, in that equilibrium. To see this, note that the steady state version of (6), combined with (29), imply:

$$R = [p(e)\, e^g + (1 - p(e))\, e^b]\, R^k.$$

When e rises with observability of effort, the object in square brackets (the allocative efficiency of the banking system) increases and, absent a change in R^k, would cause a rise in R. Imagine that that rise in R did occur, stimulating more deposits. That would lead to more capital, thus driving R^k down. In the new steady state, R is the same as it was before effort was made observable. Thus, across steady states R^k must fall by the same amount that the efficiency of the banking system rises. The fall in R^k implies a rise in the capital to labor ratio k/h. According to table 3, this rise is accomplished in part by an increase in k and in part by a decrease in h. The higher steady state capital is sustained by higher intermediation $N + d$ and this primarily reflects a higher level of deposits.[22] Imposing the leverage restriction on the unobserved effort economy moves consumption, employment and effort in the same direction that making effort observable does. This is why imposing the leverage restriction raises welfare.

3.3 Dynamic Properties of the Model

In this section we consider the dynamic effects of a monetary policy shock and four financial shocks.

3.3.1 Monetary policy shock

Figure 3 displays the responses in our baseline model to a 25 basis point shock to monetary policy. First, consider the standard macroeconomic variables. The shock has a persistent, hump-shaped and long-lived effect on output, consumption and investment. The maximal decline of 0.35 and 0.55 percentage points, respectively, in GDP and investment occurs after about two years. In the case of consumption, the maximal decline occurs three years after the shock and the maximal decline is a little over 0.35 percent. Inflation drops a modest 8 annualized basis points. Unlike the pattern reported in CEE, the response in inflation does not display a hump-shape. However,

22. In the case with no leverage restriction, the rise in $N + d$ is entirely due to a rise in d.

Figure 3. Dynamic Response of Baseline Model to Monetary Policy Shock

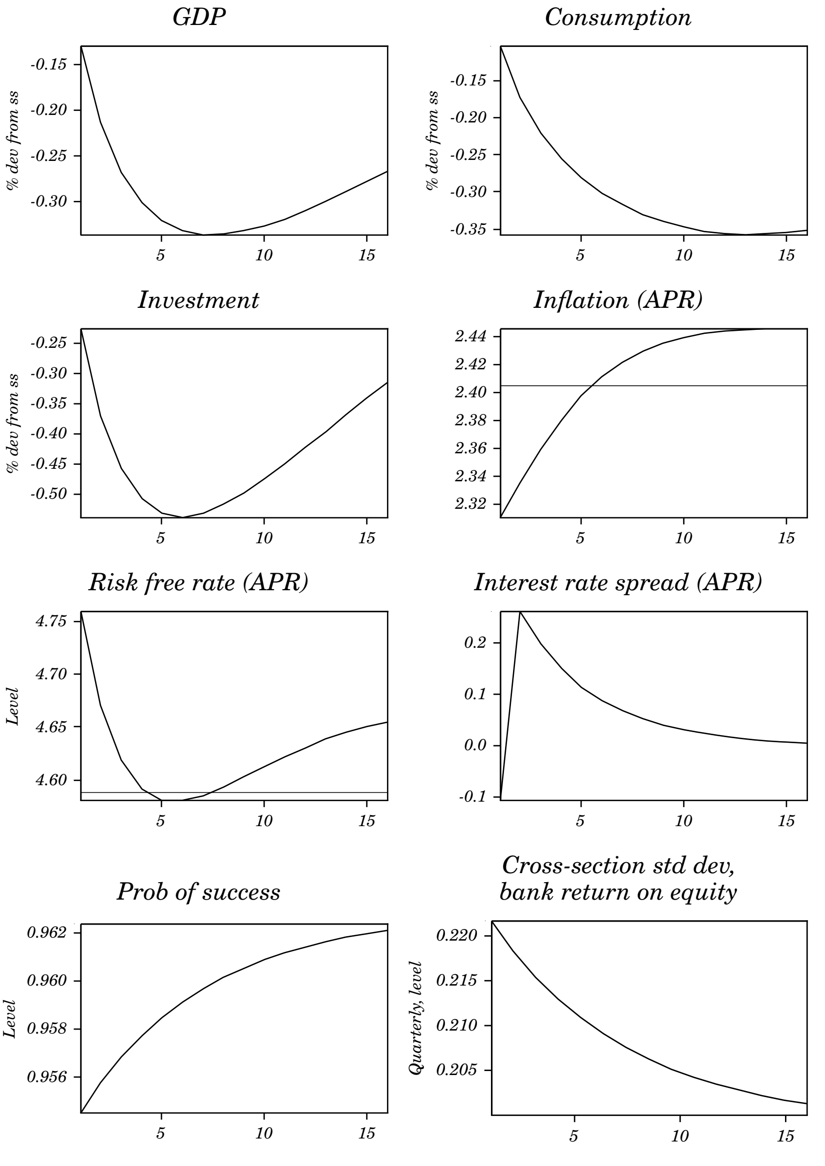
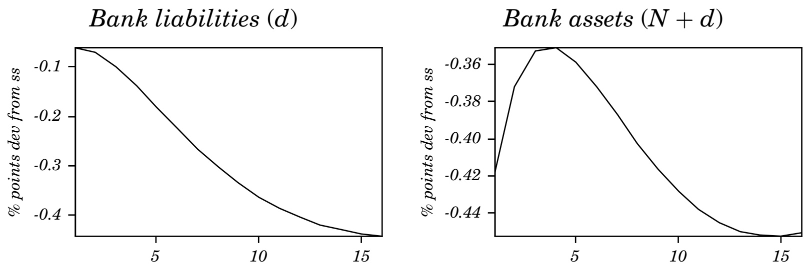


Figure 3. (continued)



Source: Authors' elaboration.

direct comparison between the results in figure 3 and VAR-based estimates of the effects of monetary policy shocks reported in CEE and other places is not possible. The latter estimates often assume that aggregate measures of economic activity and prices and wages are predetermined within the quarter to a monetary policy shock. In our model, this identifying assumption is not satisfied. One way to see this is to note that the actual rise in the interest rate is only 15 basis points in the period of the shock. The fact that the interest rate does not rise the full 25 basis points of the policy shock reflects the immediate negative impact on the interest rate of the fall in output and inflation. Still, it seems like a generally positive feature of the model that the implied impulse responses correspond, in a rough qualitative sense, to the implications of VAR studies for aggregate variables and inflation.

Now, consider the impact on financial variables. The reduction in output and investment reduces R^k by two channels: it reduces the rental rate of capital and the value of capital $P_{k'}$. Both of these have the effect of reducing bank net worth. The reduction in bank net worth leads to a tightening of the cash constraint (3). The result is that the interest rate spread on banks increases and banker effort declines. That is, $p(e)$ falls 70 basis points. This in turn is manifest in a rise in the cross-sectional dispersion of bank equity returns. Interestingly, cross-sectional dispersion in the rate of return on financial firm equity is countercyclical in the data (figure 1). Finally, bank assets $N + d$ and bank liabilities d both decline.

The relative size of the decline in $N + d$ and d is of some interest. To pursue this, it is useful to focus on a particular decomposition of the percent change in bank leverage. Let Δx denote $(x - x^s)/\, x^s$,

Figure 4. Dynamic Response of Baseline Model to Υ Shock

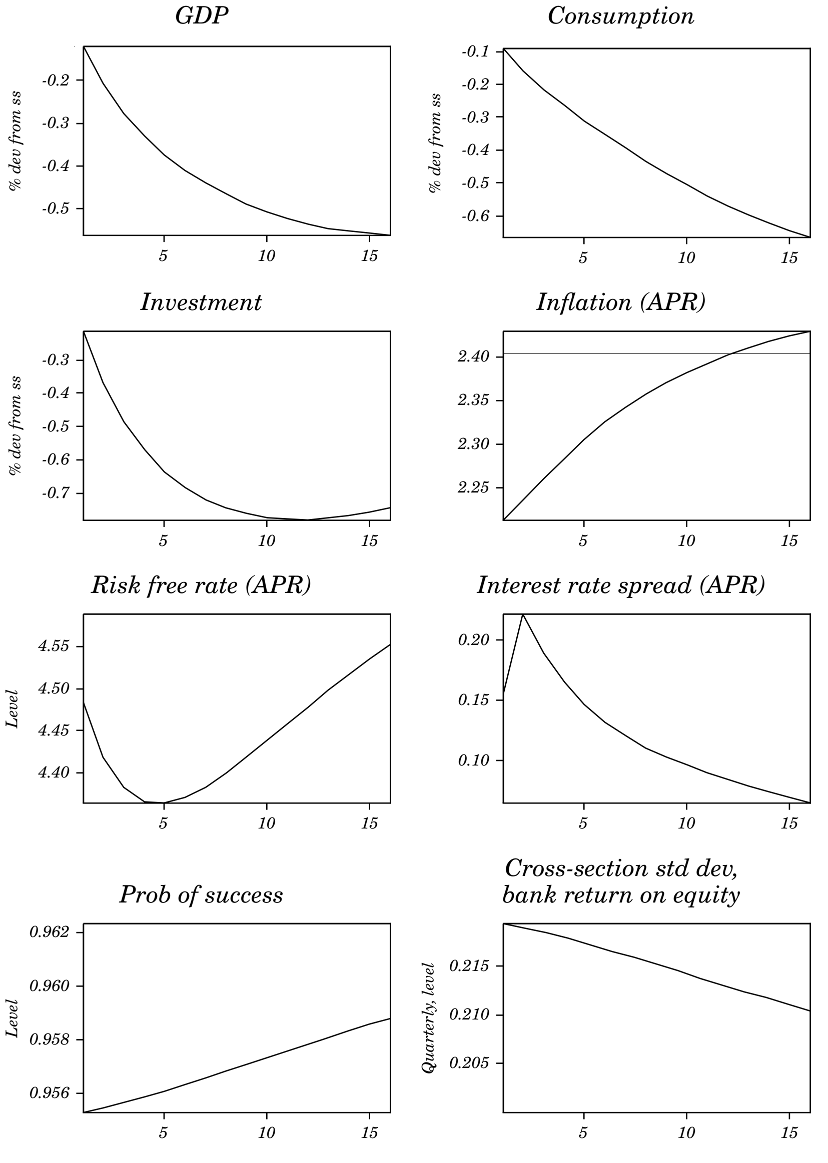
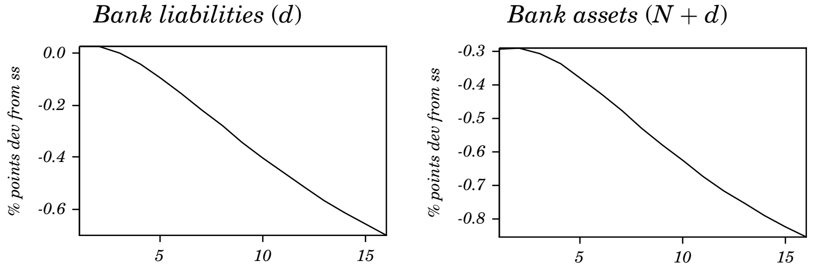


Figure 4. (continued)



Source: Authors' elaboration.

where x^s is a reference value (perhaps its lagged value) of a variable x. Then, letting L denote bank leverage $(N + d)/N$ we have[23]

$$\Delta L = (L - 1)[\Delta d - \Delta\,(N + d)].$$

Using this expression we can infer from figure 3 that our model implies a rise in leverage in the wake of a monetary-policy induced contraction. Recent literature suggests this implication is counterfactual (see Adrian, Cola and Shin, 2012). We suspect that a version of the model could be constructed in which credit responds more and net worth less, so that leverage is pro-cyclical.

3.3.2 Financial shocks

The dynamic responses of the model variables to our three financial shocks are displayed in figures 4, 5 and 6. A notable feature of these figures is how similar they are, at least qualitatively. In each case, consumption, investment, output, inflation and the risk-free rate all fall in response to the shock. The interest rate spread rises and the cross-sectional dispersion in bank equity returns jumps as $p(e)$ falls. Finally, bank assets and liabilities both fall. However, the former fall by a greater percent, so that leverage is countercyclical in each case. It is perhaps not surprising that the risk shock has the greatest quantitative impact on $p(e)$.

23. Note that $\Delta(N + d) = N/(N + d)\ \Delta N + d/(N + d)\Delta d$, so that $\Delta N = (N + d)/\Delta(N + d) - d/N\Delta d$. Also, $\Delta L = \Delta(N + d) - \Delta N$.
The formula in the text follows by substituting out for ΔN from the first expression.

Figure 5. Dynamic Response of Baseline Model to Risk Shock

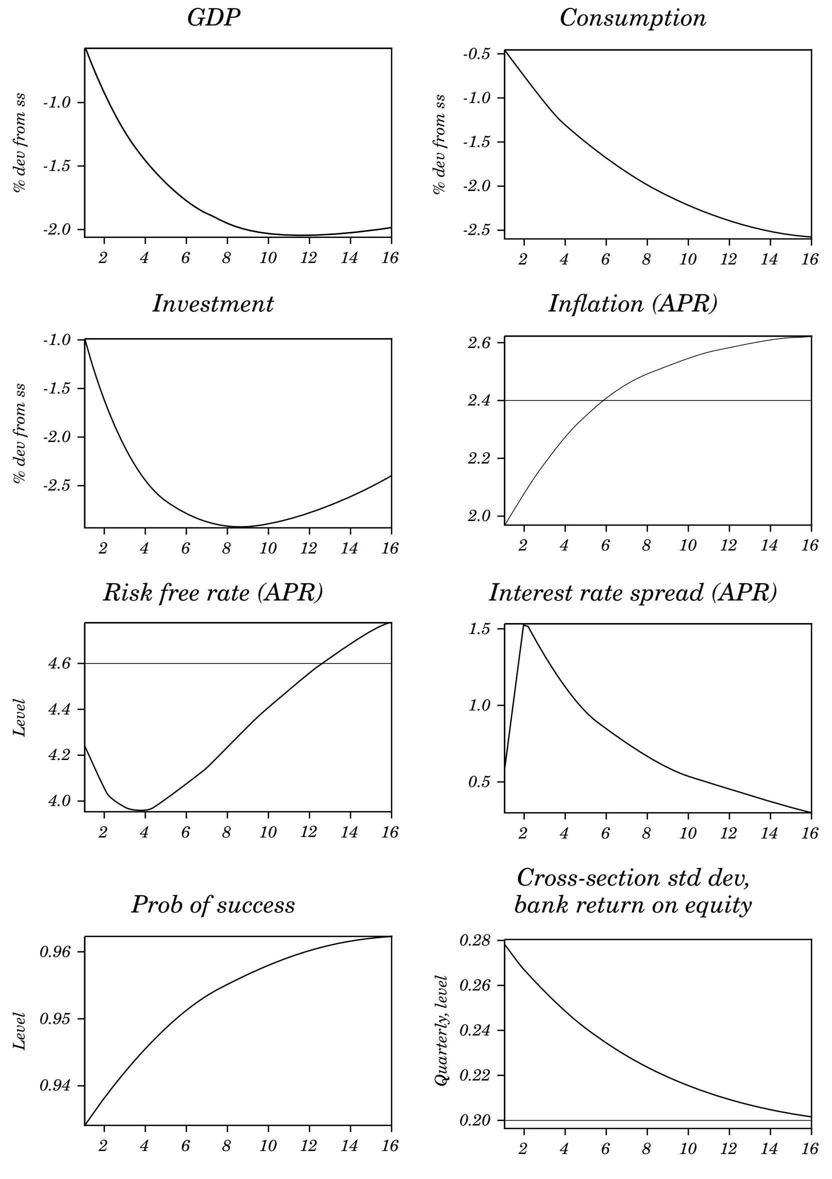
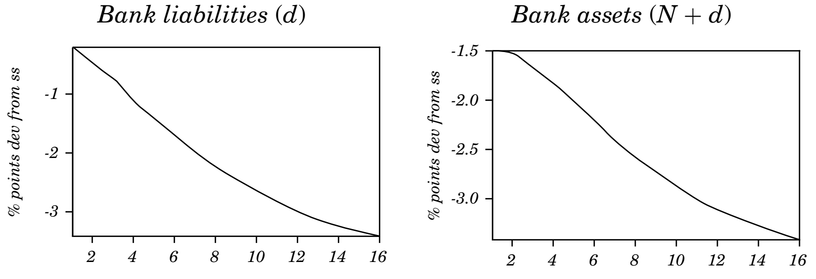


Figure 5. (continued)



Source: Authors' elaboration.

Figure 6. Dynamic Response of Baseline Model to *T* Shock

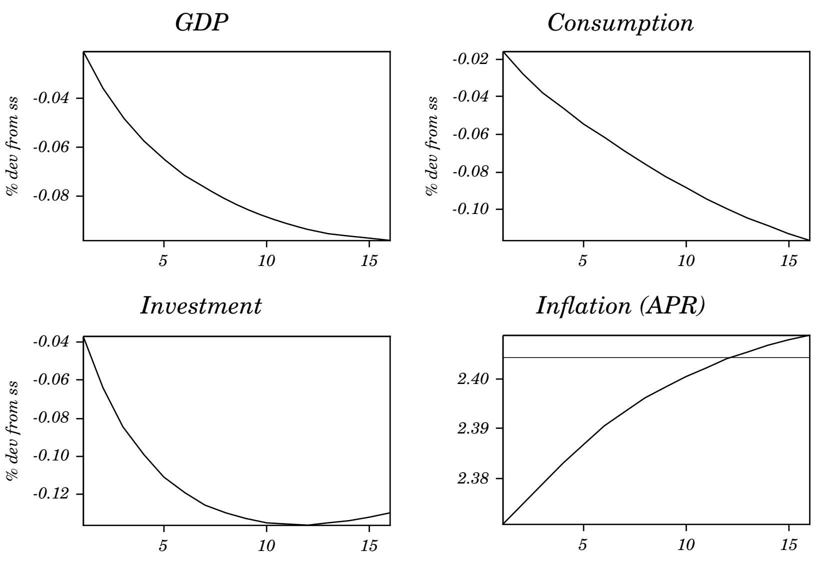
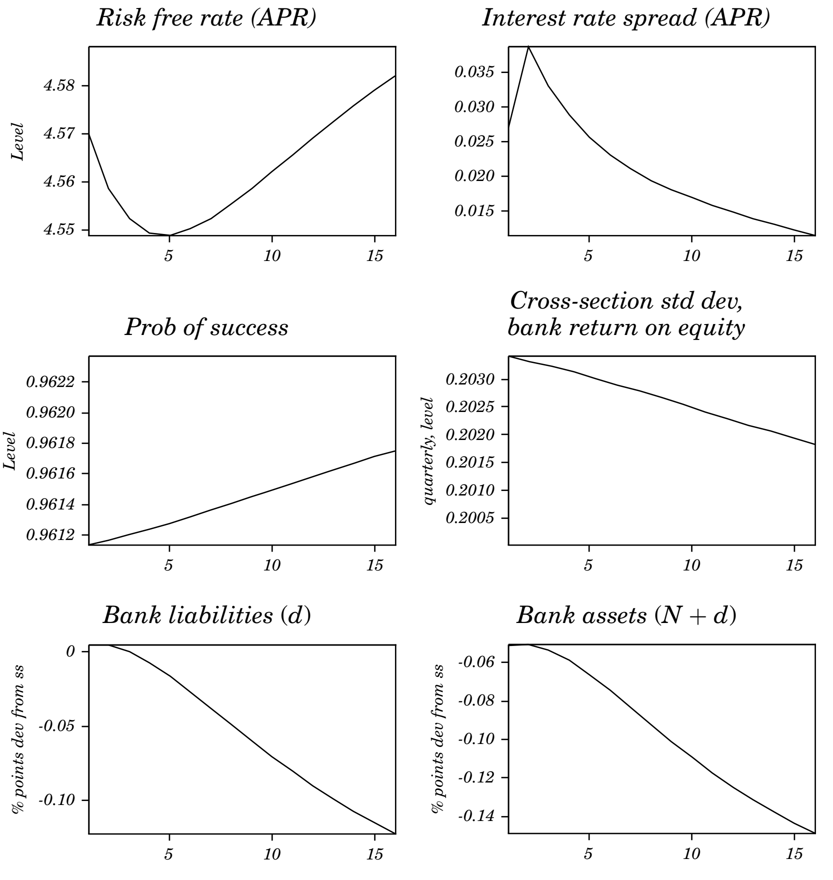


Figure 6. (continued)



Source: Authors' elaboration.

4. Conclusion

Bank leverage has received considerable attention in recent years. Several questions have been raised about leverage:

— Should bank leverage be restricted, and how should those restrictions be varied over the business cycle?

— How should monetary policy react to bank leverage, if at all?

This paper describes an environment that can in principle be used to shed light on these questions. We have presented some preliminary results by studying the implications for leverage in steady state. We showed that steady state welfare improves substantially with a binding welfare restriction. There are several ways to understand the economics of this result. We pursue one way in this paper. Bigio (2012) takes an alternative approach, in which he relates the improvement in welfare to the operation of a pecuniary externality. Either way, leverage restrictions help to correct a problem in the private economy. For this reason, we think the model environment is an interesting one for studying the questions listed above.

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Leverage Restrictions in a Business Cycle Model: A Comment

Saki Bigio
Columbia Business School

The paper by Christiano and Ikeda in this volume is one of the first efforts to quantify the welfare gains of leverage constraints in a macroeconomic model with a banking sector. Unlike other models, their answer is that they can be even more desirable when banks hold little equity, and intermediation is depressed. The paper stresses a static force that makes leverage constraints desirable from a second best perspective. This static consideration is the outcome of two frictions: The first is hidden effort on the side of bankers when choosing projects to fund. The second is the presence of incomplete contracts (in the form of limited liability), which prevents depositors from setting contracts that eliminate the hidden effort problem. As a consequence of the lack of optimal contracts, times when banks have little equity will be times when optimal contracts cannot be signed and effort is inefficient.

A restriction on leverage will act as a positive pecuniary externality: it will raise expected profits of banks and alleviate the hidden effort problem. In addition, a leverage constraint limits the extent of potential losses for banks. This improves the moral hazard problem by allowing better contracts. This policy constitutes a Pareto improvement that operates in times when banks are equity poor. To my knowledge, this is one of the few models that provide a rationale for imposing leverage constraints during times of low bank

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equity. This is a scenario that roughly fits the current international regulatory landscape.

This discussion provides the following: In a first section, I offer a static model that illustrates the main force in the model. I deliberately strip off Christiano and Ikeda's model to make the point transparent. I then take a step forward in setting up a planner's problem. This planner's problem highlights why leverage constraints help in the model. I then discuss the dynamic consideration for leverage constraints that I think the authors have overlooked. Finally, I comment on the importance of "being prudential about prudential macroeconomic policy."

1. Main Force

1.1 Environment

To illustrate the main static force in the *CI* model, consider a one-period model. The demographics are composed of two types of players, each populating a unit continuum. Let's call them households and bankers. Households hold a total endowment C of consumption commodities. Every household has the same individual endowment, which we denote by c. Bankers hold a corresponding endowment of N (with n standing for individual endowments). For interpretation, we refer to the bankers' endowment as their net-worth. Both types are risk-neutral and would like to eat as much as possible.

1.2 Technology

Households have access to storage without depreciation. In addition, they have a cost to transfer deposits to bankers $\varphi(d)$. Here, φ satisfies $\varphi' > 0$, $\varphi'' > 0$, $\varphi(0) = 0$. This assumption is important. Although it may seem odd to have a convex technology to transform goods into deposits, this technology yields an upward sloping supply for deposits as a function of expected interest rates that would appear in a dynamic setup with intertemporal substitution. It is simply a shortcut to obtain that curve without involving dynamics. An elastic supply schedule operates at the heart of the pecuniary externality present in the model.

Bankers have access to a linear technology transforming the endowment into consumption goods. However, the technology is risky and characterized by returns in good and bad states: $\bar{R}^G > \bar{R}^{B\prime} > 1$. Bankers can affect the probability from obtaining the high returns by exerting effort. Naturally, the effort or the probability of success has a cost function $C(p) \equiv p^2$.

1.3 Markets

It is convenient to study the model under three possible institutional environments in order to understand what the necessary ingredients of the model are.

(I) Complete Markets: There exists an $\bar{R}$—contingent market for deposits. Thus, we denote the return on deposits by (R_d^G, R_d^B) in good and bad states, and R_d the realized return. Moreover, effort is determined before the realization of returns and there is full commitment on the side of the bankers.

(II) Hidden Effort: Under this market arrangement, there also exists an $\bar{R}$—contingent debt market, but in this case, effort is not contractible. This is an example of hidden, or non-contractible, effort.

(III) Hidden Effort and Limited Liability Constraints: This is the same institutional arrangement as in *(II)* except that now bank losses cannot exceed N.

1.4 Households' Problem

The households choose between deposits d and storage to maximize the end-of-period consumption. Their objective is

$$W^H(c) = \underset{0 \le d \le c}{m}(c - \varphi(d)) + E[R_d d].$$

The solution to this problem is

$$E[R_d] = \varphi'(d).$$

so arranging terms delivers

$$E[R_d] = \varphi'(d)$$

where $E[R_d]$ is the expected level of returns given d. Since every household is identical, then we can write this expression in terms of the aggregate amount of supply of deposits D^S:

$$E[R_d] \equiv \varphi'(D^S). \tag{1}$$

Let's now begin defining the bank's problem for the market arrangement (I).

1.5 Bank's Problem in Market I

We setup the banker's problem as choosing

$$W^B(n) = \underset{p\in[0,1],(R_d^G,\, R_d^B),d}{m}(d+n)(p\bar{R}^G + (1-p)\bar{R}^B) - d(pR_d^G + (1-p)R_d^B) - \frac{1}{2}p^2$$

subject to

$$pR_d^G + (1-p)R_d^B \geq E[R_d]. \tag{2}$$

There are two things to observe from this problem. First, banks are choosing an effort level that is part of the public information. This follows from the assumption that, under this market arrangement, effort is observable. Second, they choose a contract (R_d^G, R_d^B) pair and a level of deposit demand to maximize profits subject to constraint (2). In constraint (2) it can be interpreted that in order to be able to attract deposits, banks must at least offer an expected return equivalent to the expected market rate. We denote the sum of all deposits that banks demand from households by D^d. We are ready to define an equilibrium.

1.6 Equilibrium in Market I

In an equilibrium, under market arrangement, there are policy functions for households and bankers and an expected market return $E[R_d]$ such that it satisfies:

1. Household's optimally choose d given $E[R_d]$.
2. Banks choose (p, R_d^G, R_d^B, d) optimally given $E[R_d]$.
3. The deposit market clears $D^d = D^S$.
4. $E[R_d]$ is rational and satisfies $pR_d^G + (1-p)R_d^B$ where p, R_d^G, R_d^B are the solutions to the optimal contract.

Analyzing the problem is simplified by defining $S = \bar{R}^G - \bar{R}^B$ and $s = R_d^G - R_d^B$. Here, it is worth noting that for any p chosen, it is always the case that the choice of (p, R_d^G, R_d^B) will satisfy $pR_d^G + (1-p)R_d^B \quad E[R_d]$.[1] Thus, using the principle of optimality,

1. Suppose this is not the case, then there is another contract with lower $(R_d^G,$ $R_d^B)$ such that, at the same level of deposits and p, the contract improves over that candidate solution.

the banker's problem can be written by replacing this equivalence in the objective

$$W^B(n) = \underset{p\in[0,1],d}{m}(d+n)(pS+\bar{R}^B) - dE[R_d] - \frac{1}{2}p^2.$$

An important observation is that the objective is not a function of (R_d^G, R_d^B). Any equilibrium must satisfy

$$(pS+\bar{R}^B) = E[R_d] = \varphi'(D^*) \tag{3}$$

where D^* is the optimal level of deposits or investment. If the condition doesn't hold with equality, d is 0 or ∞. In equilibrium this possibility is ruled out. Moreover, the optimality of effort yields

$$(N+D^*)S \geq * p(N+D^*)S < 1. \tag{4}$$

This set of equations yields a single solution, which is obtained through the following program

$$((N+D^*)S^2+\bar{R}^B) = \varphi'(D^*)(N+D^*)S < 1p = (N+D^*)\ S$$

or

$$(S+\bar{R}^B) = \varphi'(D^*)(N+D^*)S \geq 1p = 1.$$

We can summarize the system as

$$p = min\{(N+D^*)S,1\} \text{ and } (min\{(N+D^*)S,1\}S+\bar{R}^B) = \varphi'(D^*).$$

This is an equation with a single solution $D^*(N)$, $D^*(N)$ increasing and concave in N. In this risk-neutral environment, naturally, (R_d^G, R_d^B) is indeterminate. In the particular case where $\varphi = 1/2\ D^2$, we have

$$D^*(N) = m\left\{N\frac{S^2}{(1-S^2)} + \frac{\bar{R}^B}{(1-S^2)}, S+\bar{R}^B\right\}.$$

and

$$p^{*}(N) = m\left\{\frac{NS}{(1-S^2)} + \frac{\bar{R}^B S}{(1-S^2)}, 1\right\}.$$

The welfare theorems apply in this environment. However, it is useful to define a planner's problem subject to the same resource constraint.

$$W^B(C,N) = \underset{D,p}{m}(C, -\varphi(D)) + (N+D)\,(pS + \bar{R}^B) - \frac{1}{2}p^2.$$

It should be obvious that the first order conditions of this problem coincide with (3) and (4), which verify the first welfare theorem. Let's summarize the findings thus far.

Lesson 1: With complete markets and contractible effort, the competitive equilibrium is efficient and is independent of the contract (R_d^G, R_d^B).

There is another observation. Notice that when effort is contractible, limited liability plays no role. The limited liability constraint can be written as

$$(D+N)\bar{R}^B - DR_d^B \geq 0, (D+N)\bar{R}^G - DR_d^G \geq 0. \tag{5}$$

An unconstrained optimum will specify a level of $p^*$and D^* as a function of N. In turn, the value of $E[R_d]$ is pinned down by $\varphi(D^*)$. Thus, in order to implement the first best and imposing the LLC constraint, we need to find a pair R_d^{B*}, R_d^{G*} that jointly satisfies

$$(D^*+N)\bar{R}^B - D^*R_d^{B*} \geq 0 \text{ and } (D^*+N)\bar{R}^G - D^*R_d^{G*} \geq 0.$$

and

$$p^*(R_d^{G*} - R_d^{B*}) + R_d^{B*} = \varphi'(D^*).$$

Can that pair be found? The answer is yes, always. We guess and verify that their exists a pair (x, y) such that (R_d^{B*}, R_d^{G*}) always satisfies the above. To prove, let's conjecture that one such (x, y)

contract is one in which the LLC constraint binds in the bad state. That is: $(D^* + N)\bar{R}^B - D^* x = 0$ or $(1 + \tilde{n})\bar{R}^B = x$ for $\tilde{n} = N/D^*$. Now, it had better be the case that $p^*(y - x) + x = \varphi'(D^*)$. So rearranging terms yields

$$y = \frac{\varphi'(D^*)}{p^*} - \frac{(1 - p^*)}{p^*} x.$$

We can plug this identity into the LLC for the good state. We obtain

$$(1 + \tilde{n})\bar{R}^G > \frac{\varphi'(D^*)}{p^*} - \frac{(1 - p^*)}{p^*} (1 + \tilde{n})\bar{R}^B$$

and rearranging terms implies

$$(1 + \tilde{n})(p^* \bar{R}^G + (1 - p^*)\bar{R}^B) > \varphi'(D^*).$$

But recall that the FOC at the optimum implies $(p^* \bar{R}^G + (1 - p^*)\bar{R}^B) = \varphi'(D^*)$, so the LLC constraint for the good state is equivalent to

$$(1 + \tilde{n})\varphi'(D^*) > \varphi'(D^*)$$

which holds truth for all $N > 0$. We have formally shown the second lesson.

Lesson 2: If effort is contractible, then competitive equilibrium is efficient even if we impose a limited liability constraint on the contract space of (R_d^G, R_d^B). That is, there is a competitive equilibrium that implements the first best allocation.

1.7 Equilibrium in Market II

Let's discard limited liability again but include hidden effort. The presence of hidden effort alters things. When non-verifiable effort is present, we must take into account the incentives of the bankers when employing effort. The reason being that a contract will not be able to implement a prespecified amount of effort if the incentives of the banker aren't taken into consideration. Suppose households and bankers have already agreed on a contract, then, no matter what the prespecified level of effort is, the banker will always choose effort such that it solves

$$W^B(n) = \underset{p\in[0,1]}{m}(d+n)(p\bar{R}^G + (1-p)\bar{R}^B) - d(pR_d^G + (1-p)R_d^B) - \frac{1}{2}p^2.$$

The FOC for this problem is given by

$$(d+n)S - ds = \varphi'(D^*). \tag{6}$$

The equation (6) is the incentive compatibility condition required by this problem.

The revelation principle will require that we specify the Banker's problem including equation (6). Thus, under the institutional environment of hidden effort, we setup the banker's problem as choosing

$$W^B(n) = \underset{p\in[0,1],(R_d^G,\, R_d^B),d}{m}(d+n)(p\bar{R}^G + (1-p)\bar{R}^B) - d(ps + R_d^B) - \frac{1}{2}p^2$$

subject to

$$ps + R_d^B \geq E[R_d]$$

and

$$(d+n)S - ds = \varphi'(D^*).$$

The equilibrium is defined as earlier. Observe that R_d^B is not in the incentive compatibility constraint of the problem, but only the wedge s. So we can reach the same conclusion as before that $ps + R_d^B = E[R_d]$ and that the problem is

$$W^B(n) = \underset{p\in[0,1],(R_d^G,\, R_d^B),d}{m}(d+n)(p\bar{R}^G + (1-p)\bar{R}^B) - dE[R_d] - \frac{1}{2}p^2$$

subject to

$$(d+n)S - ds = \varphi'(D^*).$$

Now, it is easy to show that there exists an optimal contract with $R_d^G = R_d^B = \varphi'(D^*)$ that implements the first best. It may no longer be the only equilibrium—we would need to check this—but at least we can guarantee that hidden effort does not alter whether or not first best allocation is part of an equilibrium set with hidden effort. The intuition is very simple. When $s > 0$ on the margin, the banker is better off exerting less effort than at the optimal level. The reason is that, although a higher probability of success increases total surplus $(d+n)S$, the banker is paying for all the effort, whereby, he has to share the benefits with the household. The only contracts that implement the first best effort are those in which the banker extracts all the benefits of his additional effort.

Recall that under Market I, the efficient allocation was maximizing total aggregate surplus. If bankers choose a contract where $s \neq 0$ they will violate the first order condition for effort. However, this will affect the total surplus for a given level of deposits. If for a given level of deposits, total surplus is lower, either the return to households must fall, or the banker's surplus is lower. There is always room for an improvement of welfare setting $s = 0$. The first best satisfies incentive compatibility at the optimum and makes everyone better off. Thus, we arrive to the following.

Lesson 3: Hidden effort does not introduce any additional inefficiencies as $R_d^G = R_d^B = \varphi'(D^*)$ *implements the first best allocation.*

1.8 Equilibrium in Market III

So far, we have shown that hidden effort and limited liability play no role, independently. We now argue that they not only introduce inefficiencies, but due to a pecuniary externality, will deliver constrained inefficiencies.

The banker's problem is now constrained by the limited liability constraint (LLC)

$$W^B(n) = \underset{p\in[0,1],(R_d^G,R_d^B),d}{m}(d+n)(p\bar{R}^G + (1-p)\bar{R}^B) - d\varphi'(D^*) - \frac{1}{2}p^2$$

subject to

$$(d+n)S - ds = \varphi'(D^*),$$

$$(d+n)\bar{R}^{B*} - dR_d^{B*} \geq 0$$

and $(d+n)\bar{R}^G - dR_d^{G*} \geq 0$

Recall now that the first best can only be achieved if $s=0$, or in other words, if debt is risk free: $R_d^{B*}=R_d^{G*}=\varphi'(D^*)$. Can this contract always be implemented with limited liability? Not any more. To see this, observe that if limited liability constraints bind with risk-free debt, it will be in the low state, where resources are scarce. In the examples I present here, their is a lowest level of that satisfies the LLC in the bad state

$$(1+N^o/D^*(N^o))\bar{R}^B=\varphi'(D^*(N^o)).$$

Thus, for $N<N^o$ it is impossible to satisfy the LLC constraint in the bad state with the first best allocations. The same is true in the more general setup of Christiano and Ikeda. In general, it is the case that the return on deposits in the bad state has to be lower than in the good state. This creates a wedge on the return on deposits in good and bad states s. This positive wedge lowers the incentives of the banker to put effort and lower the return on deposits and loans.

Lesson 4: With hidden effort and limited liability, there is a sufficiently low level of bank net worth such that the first best allocation cannot be implemented. Effort is suboptimal in these cases.

The work of Cristiano and Ikeda highlights the benefits of a restriction on leverage. In essence, with the LLC in place, and hidden effort, we have the market's solution as the solution to the following problem

$$\max_{p\in[0,1],(R_d^G,R_d^B),d}(d+N)(p\bar{R}^G+(1-p)\bar{R}^B)-d\varphi'(D)-\frac{1}{2}p^2$$

IR: $ps+R_d^B\geq E[R_d]$

IC: $(d+N)S-ds=\varphi'(D^c)$

LLC: $(d+N)\bar{R}^B-dR_d^B\geq 0$, $(d+N)\bar{R}^G-dR_d^G\geq 0$

where D^c is taken as given and equals d.

The constrained planner's problem is different because this problem takes into account the scale of the bank, which has effects on the incentives constraints.

$$\max_{p\in[0,1],(R_d^G,R_d^B),d}(d+N)(p\bar{R}^G+(1-p)\bar{R}^B)-d\varphi'(\mathrm{d})-\frac{1}{2}p^2$$

IR: $ps+R_d^B\geq E[R_d]$

IC: $(d+N)S-ds=\varphi'(D^c)$

LLC: $(d+N)\bar{R}^B-DR_d^B\geq 0$, $(d+N)\bar{R}^G-dR_d^G\geq 0$

This is the case of a *pecuniary externality*. In this case, the planner is aware that by restricting the amount of investment, the bank can borrow cheaper. There are two effects. The first is that if banks can borrow cheaper they can offer better contracts. This aspect improves welfare because of the IC constraint and that improves efficiency as more effort can be provided. There is a free lunch. To obtain resources to consume, banks can either obtain costly funding from depositors from a function $\varphi'(D^c)$ or they can exert high effort with deposits. Under the two frictions, in general the market outcome is constrained efficient because at the planner's solution competitive bankers will try to attract more deposits. In equilibrium, market forces will increase the required return to depositors that will degrade incentives to exert effort.

The second effect is that lower leverage itself makes the bank more solvent in the bad state. However, this is not the source of the inefficiency as the banker's problem does take this effect into account. We are ready to summarize the last lesson of the static model.

Lesson 5: It may be desirable to implement leverage constraints if banks have low equity. Leverage constraints will improve a pecuniary externality. This externality enhances the hidden effort problem. Thus, with LLC and hidden effort, the market allocation is constrained inefficiently.

2. Dynamic Considerations

The single-period model discussed misses the dynamic consideration that may make leverage constraints desirable. The version (that I read) of Christiano Ikeda in this volume focuses on only one consideration. The authors noted that problems arise only in states where equity is low. In a competitive environment, as argued earlier, the linearity of returns on bank investment, given a level of p, makes expected returns go to zero. This is not the case when the LLC constraint binds because the model delivers a desirable *monopsony effect* from leverage constraints. With this effect, we expect equity to recover faster.

In my view, Christiano and Ikeda missed a precautionary motive of leverage constraints. The static problem above highlighted that low equity leads to inefficiencies. In a dynamic setup, leverage constraints may also be desirable in good times. That is, even if effort is efficient, it may be desirable to impose leverage constraints: although these constraints may potentially lead to inefficiencies in good times, these inefficiencies may be desirable. The reason is that a planner may wish to trade-off inefficiencies in good times for less inefficiencies in bad times. Leverage constraints are a way to control the size of potential losses of equity. Putting it differently, the planner may wish to smooth market imperfections. I believe this has been the main point of models that suggest countercyclical equity buffers such as Bianchi (2011) or Bigio (2012). We now turn to the comment.

Lesson 6: In a dynamic model, leverage constraints may induce more inefficiencies in "good times" to reduce even more inefficiencies in "bad times." Leverage constraints in "bad times" may reduce competition in financial markets, which may lead to a quicker recovery of bank equity. These forces are the dynamic considerations in the design of leverage constraints.

3. Prudential Macro-Prudential Policy

Although Christiano and Ikeda's paper is full of insights, we should take its lessons with caution. The aftermath of the Great Recession has seen a surge in financial regulation. The capital constraints imposed by Basel-III and banking regulation in Europe have been of particular importance. Although gradual, these constraints are currently binding the actions of banks and are heavily criticized by the financial press.

Christiano and Ikeda is one of the first papers that provide a full-fledged micro-founded model of financial intermediation that prescribes countercyclical capital requirements. In this comment, I argue that microfoundations are not a sufficient condition for policy recommendation. I argue that this model may well fit the data, but there are other microfounded models that can possibly fit the same data, but whose policy recommendations are quite the opposite. These are times where it may pay off to be prudential about macroprudential policy.

To support my view, let's contrast the present model with a model in which the success probability is not a choice by the bank, but rather an increasing deterministic function p of D, the aggregate level of deposits. A model like this can be associated with positive externalities from bank credit. Actually, another of Christiano and Ikeda's papers, Christiano and Ikeda (2012) presents several examples of models that fit this description. Another model that has this property is Bigio (2012).[2]

Assume that there is also limited liability and the rest of the model is identical. Recall that the relative amount of bank equity to the assets of the economy is the only state variable in the model (see also Brunnermeir, He & Krishnamurthy, etc).

Table 1. Sign of Correlation of Observable with Bankers' Net-Worth for both the Christiano-Ikeda Model and the Behavioral Model

$Corr(x,N)$	$C\ I$	*Behavioral*
$E(\Delta Y_t)$	+	+
$V(\Delta Y_t)$	–	–
R	+	+
P_t	+	+

Source: Author's elaboration.

Table 1 describes the correlations delivered by the C&I model and by our behavioral model. These correlations could be used to estimate the parameters of the model in a policy recommendation paper.

Four facts:

1. In both models, the economy's growth rate should be increasing in equity. In the C&I model, the root of the problem is that low net-worth makes limited liability binding, and distorts the optimal contract. In the behavioral model, or in Bigio 2012, low net-worth would force the amount of deposits to fall because of limited liability. Our behavioral assumption immediately implies that the probability of success in good projects should fall.

2. I'm particularly familiar with this model.

2. In models with capital accumulation, the above should map into less growth.
3. If p is bounded by 1/2, for same reason as fact 2, we should expect more volatile output.
4. Depositors are rational. They will expect and earn lower returns when the scale of the banks balance sheet falls.

Although both models have mechanisms that deliver similar testable implications, their policy recommendations are very different. This is like saying that although a model can be immune to the Lucas critique in that they can be used to analyze policy, its policy recommendations may be undesirable. To see why in the context of our example, let's note some facts about leverage constraints. Four facts about leverage constraints follow:

1. Both models, deliver opposite implications for leverage constraints, whereas the Christiano and Ikeda model shows it improves success probabilities, the model with a mechanical rule implies the opposite by construction.
2. In models with capital accumulation, the above should map into different implications for growth.
3. If p is bounded by 1/2, the output volatility will move in different directions.
4. Less deposits means lower interest rates in both models.

I summarize the effects of leverage constraints via table 2.

Table 2. Effects of Leverage Constraints in Times of Low Equity in the Christiano-Ikeda Model and the Behavioral Model

Effects of leverage constraints on	*C I*	*Behavioral*
$E(\Delta Y_t)$	+	–
$V(\Delta Y_t)$	–	+
R	–	–
P_t	+	–

Source: Author's elaboration.

Clearly, both models deliver different policy implications. To identify either model, an econometric methodology would require observing *effort*. Since effort is unobservable by assumption, the way to distinguish either model would be through a natural experiment. Exploring this idea goes beyond this discussion, but I believe understanding the right frictions banks face is a macroeconomic priority. Summing up we arrive at the following.

Lesson 7. Two equally well-microfounded models may prescribe different policy implications. We ought to be prudential about macro-prudential policy.

4. Summarizing Ideas

Christiano and Ikeda's paper belongs to a growing literature placing financial intermediation at the center of a macroeconomic model. There are very few macroeconomic models that explore leverage constraints. The mechanism in the paper operates by having a limited liability constraint that activates a moral-hazard problem when limited liability can not be met. This type of work is very important, especially in light of an even stricter financial regulation that banks in Europe and the U.S. are facing: BASEL-III, Dodd-Frank etc. It is no surprise that popular writings such as The Economist or The Wall Street Journal continuously place this topic among their headlines. This model supports the capital requirements that are in place nowadays. However, I have argued that other models, with identical testable implications, can deliver opposite recommendations. Regulators should be prudential about macro-prudential policies. We do not want to live in a world where regulators do in times of skinny cows, what they should have done when cows were fat.

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Macro-Prudential Policy and the Conduct of Monetary Policy

Denis Beau
Banque de France

Christophe Cahn
Banque de France

Laurent Clerc
Banque de France

Benoît Mojon
Banque de France

The "Great Contraction" in global economic activity triggered by the financial crisis, and the extraordinary fiscal and monetary measures that public authorities had to undertake in order to put the economy back on track by putting public finances under heavy strains and leading to extremely low short-term interest rates, have shown the enormous costs resulting from an unstable financial system.

Such costs have triggered wide-ranging reviews of financial-stability policies. An important outcome of such a review is the strengthening of policies and instruments focused on macro-financial stability, the so-called "macro-prudential policies."

The deployment of such policies may however raise important coordination issues with other stability-oriented policies, ranging from micro-prudential to monetary policies. Such coordination issues

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stem from the interdependencies between these policies, in terms of both objectives and transmission mechanisms.

The aim of this paper is to explore the coordination issues specifically raised by the cyclical effects of macro-prudential and monetary policies.[1] Under this perspective, we address the following two questions: First, do the likely interactions between macro-prudential policies and monetary policy create a risk of conflicts in the pursuit of financial stability and price stability? Second, how large is this risk?

The paper is organized as follows. In section 1, we discuss the possible interactions between macro-prudential and monetary policies; whereas, in section 2, we present results from simulations conducted with a DSGE model estimated using time series of euro area macroeconomic variables over the period 1985-2010. These simulations allow us to assess the circumstances under which macro-prudential policies may have compounding, neutral or conflicting outcomes that interfere with the pursuit of price stability by monetary policy.

1. The Interactions between Macro-Prudential and Monetary Policies and the Risk of Conflicting Impact on Financial and Price Stability

1.1 The New Role of Macro-Prudential Policies in Financial-Stability Oriented Regulatory Frameworks

The financial crisis has shown that neither market discipline nor regulation and supervision of the financial system's main components (i.e. institutions, markets and infrastructures) can prevent systemic risk, i.e. the risk that disruptions to financial services' activities may have serious negative consequences on the stability of the financial system as a whole, and therefore on the real economy.

1. The objective of macro-prudential policies are both preventing the build-up of systemic risk, and mitigating its impact on the economy. There are two dimensions to this: First, improving the resilience of the financial system, by limiting the contagion effect due to "bank runs," asset fire sales and externalities phenomena, improving infrastructures and monitoring aggregate risk. Second, limiting the risk of spillovers of financial instability on the business cycle and the real economy. In this paper, we focus exclusively on this second dimension of macro-prudential policies, which are the most likely to interfere with monetary policy's goal to stabilize prices.

In order to better limit the likelihood and impact of systemic risk, a reform of the international regulatory framework is underway. Its objective is to better guarantee the stability of the financial system as a whole, not just of its components.[2] A key element of that reform, beyond strengthening the supervision of individual financial institutions, the oversight of key market infrastructures and the monitoring of the functioning of financial markets, is the strengthening of the role of so-called "macro-prudential" policies, namely policies that focus on the interactions between financial institutions, markets, infrastructure and the business cycle.[3]

In September 2010, the Basel Committee for Banking Supervision (BCBS) proposed an important step in the reform of the international regulatory framework. The G20 leaders endorsed such proposal at their Seoul summit in November 2010. Beyond significantly strengthening micro-prudential requirements in terms of capital, liquidity and leverage, the BCBS agreed on the introduction of a so-called "macro-prudential overlay,"[4] which has two dimensions.

First, it seeks to reduce the banking system's tendency to amplify the ups and downs of the business cycle through the excessive credit supply and excessive credit cutbacks, which typically arise in periods of financial exuberance and financial stress, respectively. Tools to be used to that effect notably include a capital conservation, which will prevent banks from making inappropriate distribution when their capital declines, and a countercyclical capital buffer, which will compel banks to increase their capital base during periods of excessive credit growth.

Second, it seeks to limit the transmission of shocks across the financial system. Tools to be used to that effect are still being debated, but they will most likely combine capital surcharge, bail-in debt and contingent capital for systemically important financial institutions (SIFIs).

2. See H. Hannoun: "Towards a global financial stability framework." 45th SEACEN Governors' Conference, 26-27 February 2010.

3. See CGFS "Macro-prudential instruments and frameworks: a stocktaking of issues and experiences." May 2010.

4. See N. Wellink "A new regulatory landscape," *16th International Conference of Banking Supervisors,* 22 September 2010.

1.2 Coordination within the New Institutional Arrangements

Box 1 below presents the main features of the new institutional arrangements recently adopted in Europe, the U.S., and the U.K.. While the three setups are somewhat different in nature, it must be noted that each of them has been designed so as to allow an effective coordination and information sharing amongst the central banks and the authority in charge of the macro-prudential policy.

Box 1. Institutional arrangements in the U.S., the U.K., and the E.U.

The responses to the crisis in terms of macro-prudential regulation have been quite heterogeneous across different jurisdictions. On one hand, the Financial Regulation Bill (also referred to as the Dodd-Frank Act) which was approved by the U.S. Senate in July 2010, has created a new Financial Stability Oversight Council (FSOC), headed by the Treasury Secretary and independent from the Fed. On the other hand, the U.K. Treasury presented, in July 2010, a proposal for reforming the tripartite model, which led to the inception of a new Financial Policy Committee within the Bank of England with primary statutory responsibility for maintaining financial stability. In Europe, following the recommendations of the de Larosière report, the European Commission has created a European Systemic Risk Board (ESRB), which came into force on December 16, 2010 and which, like its U.S. counterpart, is independent from the European Central Bank. By contrast to its U.S. counterpart, however, the ESRB is not provided with the full control of macro-prudential tools.

In the U.S., the Dodd-Frank Act and the Consumer Protection Act adopted in July 2010 are probably the most extensive pieces of financial services regulation since the Great Depression. The Dodd-Frank Act creates a new interagency council, the Financial Stability Oversight Council (FSOC), but also establishes a new system for the liquidation of certain financial companies; it provides for a new framework to regulate derivatives; it establishes new corporate governance requirements; and it regulates credit rating agencies and securitization. The FSOC is in charge of identifying, monitoring and addressing systemic risks posed by large and complex financial firms, and of making recommendations to regulators. It is also be tasked with monitoring domestic and international regulatory proposals, facilitating information sharing among financial services regulators, designating non-bank financial companies as systemically important, and providing recommendations to the Federal Reserve Board on prudential standards. It is able to provide direction to, and request data and analyses from, the Office of Financial Research (OFR). Being within the treasury department, this office contributes to improving the quality of financial data available to policy-makers and providing analytical support to the FSOC. It should also develop a reference database easily accessible to the public, in order to maximize data efficiency and security, by coordinating with regulators, both domestically and internationally. Finally, it should standardize financial reporting requirements.

In performing its tasks, the FSOC is therefore completely independent from the Fed. Interestingly, in addition to its current oversight responsibilities, and in order to mitigate risks to the financial system from large, interconnected financial institutions, the Fed is directed to establish prudential standards of its own or at the FSOC's recommendations. That is, the Fed is entrusted with autonomous macro-prudential tools on top of its dual monetary policy mandate.

In the U.K., recognizing serious failures in their tripartite regulatory system, authorities took a major step in order to change their regulatory framework, transferring operational responsibility for prudential regulation from the FSA to a new subsidiary of the Bank of England. In addition, a new Financial Policy Committee has been created within the Bank of England with the responsibility for maintaining financial stability. This committee works internationally with similar systemically focused authorities and with the ESRB to coordinate macro-prudential policies. The aim of this reform is to bring together responsibility for macro- and micro-prudential regulation within a single institution, i.e. the central bank.

To some extent, the European way is halfway between the U.S. and the U.K. approaches. Like in the U.S., the ESRB is an interagency council, independent from the ECB and only focused on macro-prudential policy. On the other hand, the inception of the ERSB is drawing heavily from the knowledge and the experience of the Eurosystem. Additionally, the ECB provides the ESRB with analytical, statistical, administrative and logistical support. National central banks and supervisors also provide technical advice, which constitute an important input into the work of the ESRB.

A major difference with the U.S. and the U.K. is, however, the lack of effective and autonomous regulatory tools. In effect, the ESRB will only have the possibility of issuing warnings and recommendations. The institutional arrangement, which has brought central bank governors and heads of supervision together since January 2011, should ensure both effective coordination and information sharing. The ESRB is tasked with identifying and measuring systemic risk. It has been mandated to develop a "risk dashboard," prioritize these risks, conduct top-down stress tests when appropriate, and finally propose policy responses through warnings and recommendations. These however cannot designate individual financial institutions.

Its tools are based on the obligation to "comply or explain." Therefore, even though the ESRB does not have formal directive power and the comply-or-explain obligation is not legally binding, such recommendations should have considerable moral force. The effectiveness of these recommendations may be considerably strengthened if they are made public.

In the U.S., the Financial Stability Oversight Council (FSOC) is independent from the Fed and is chaired by the U.S. Treasury. The Fed, however, participates jointly with other regulators in the FSOC and supports the Council's mission to prevent and address risks to financial stability. Such an involvement makes sure that the threats and the efforts to mitigate systemic financial risk effectively inform the conduct of monetary policy. It should however be noted that the Fed is still directed to establish prudential standards of its own and that it is entrusted with autonomous macro-prudential tools on top of its dual monetary policy mandate.

In Europe, the European Systemic Risk Board is distinct and separate from the ECB. It neither changes the monetary policy mandate, nor the functioning of the ECB, nor that of any national central bank in the E.U. However, the ECB plays a pivotal role in the new framework. The presence of the governors of all E.U. central banks in the Board of the ESRB, and the appointment of the ECB's president as the Chair of the ESRB, assign a pivotal role to the authorities in charge of monetary policy in the support of the ESRB. The joint participation of central banks both in the ECB's governing council and the ESRB Board should greatly facilitate coordination and the exchange of information between the two institutions.

Finally, in the U.K., the new Financial Stability Committee has been created within the Bank of England. It is separate from the Monetary Policy Committee and has an overall membership of 11, including internal members from the Bank of England. The remaining five members are from outside the bank, including a Treasury representative. This new committee is chaired by the governor and includes the deputy governors in charge of monetary policy and financial stability, and the newly created deputy governor of prudential regulation. Here, once again, the framework insures that the monetary policy decisions will effectively be fully aware of the macro-prudential policy design and implementation. Coordination is facilitated by having the governor of the bank chairing both the financial and the monetary policy committees. The reform acknowledges that a significant challenge for the bank will precisely be to manage this interaction between two statutory objectives and it has already made some proposals to do so. Under this respect, an important aspect is the sequencing of the meetings in order to make sure both committees will be able to fully take into account the most recent decisions taken by the others.

An important aspect of the coordination process relies of the information flows and sharing between the responsible institutions or committees. The U.S. authorities indeed established a specific institution (the OFR, see box 1 above) to cope with this issue. Information sharing between the monetary and macro-prudential authorities is in that context of paramount importance. Considerations of data availability place central banks in an ideal position as key information providers in the field of macro-prudential policies due to the enormous amount of data they already collect for the conduct of monetary policy.

Remaining challenges

The dilution of responsibilities amongst authorities and the associated risk of "territorial" disputes can be addressed, or at least limited, by a clear assignment of objectives and tools. As a matter of fact, the simulations presented in section 3 clearly suggest that the conduct of monetary policy should keep a primary objective of maintaining price stability. Hence, the macro-prudential policy should not rely on monetary policy to preserve financial stability.

Ideally, the design of the macro-prudential policy objectives should preserve the independence of monetary policy making, facilitate coordination between the two policies, limit conflicts of objectives and clarify how these can be resolved when they occur.

First, the new macro-prudential objectives should be fully compatible with the monetary policy mandate in the following sense. It should neither jeopardize the primary objective of price stability for monetary policy nor put the central bank's independence in their pursuit for price stability at risk.[5] That inflation expectations remained firmly anchored throughout the most severe financial crisis in 80 years has proven to be a considerable asset in the management of crisis. This asset, which builds on the clear mandate of monetary policy, the operational independence of central banks and their track record, should not be put at risk. In addition, the interferences with the conduct and the implementation of monetary policy should be limited to the maximum possible extent.

Second, clarity about the objectives of macro-prudential policies should be provided ex ante. The new regulatory frameworks tend to favor institutional setups involving several institutions or layers. This should imply close coordination between entities in charge of micro- and macro-prudential regulations on one hand, and between macro-prudential policies and other macroeconomic policies—

5. We refer here to the situation of Europe. In the case of the U.S., the Fed's monetary policy has a dual mandate of price stability and full employment.

monetary and fiscal policies in particular—on the other. Therefore, clear objectives would minimize the potential for macro-prudential policies to undermine the responsibility for the objectives relevant to micro-prudential supervision, and fiscal and monetary policies. The extent and the nature of the collaboration amongst the various agencies involved in macro-prudential regulation in the financial crisis management phase are primarily shaped by how the different responsibilities for supervision and regulation, bank resolution, the provision of public guarantee and solvency support are allocated.

Finally, in circumstances where monetary policy and macro-prudential policy objectives may be temporarily in conflict, accountability requires that such a conflict be publicly acknowledged. Policy bodies should be transparent to the extent of how policy decisions factor in trade-off between objectives. The common objective should be to strike the right balance between the short-term costs of financial stability and long-term costs of price instability, for example, as explained in Carney (2009) as the de-anchoring of inflation expectations.

In practice however, it should be stressed that an accountability framework of macro-prudential authorities will be more difficult to design than the one for monetary policy authorities. To begin with, as of today, we have neither a quantitative, nor (some may even say) a qualitative definition of financial stability, nor can we rely on an operational definition of systemic risk. This is in sharp contrast with the widely agreed definition and measurement of price stability on the basis of consumer price indices.

Recent research has focused on developing measures of systemic risk and means of allocating such risk to financial institutions (see for instance Engle and Brownlees, 2010). However, the construction of financial stability indices (see Hollo, Kremer and Lo Duca, 2010) is still in its infancy. Moreover, the goal of this research is more to provide new indicators than operational or quantitative targets to be assigned to macro-prudential authorities. The parallel with the monetary policy framework, as it has been designed over the last two decades, although tempting, is still very remote as far as macro-prudential policy is concerned.

1.3 The Interdependencies between Macro-Prudential and Monetary Policies

Macro-prudential and monetary policies pursue two different objectives, namely financial stability and price stability. Following the standard Tinbergen principle, two separate (sets of) instruments allow authorities to implement the two policies. Turning to the allocation of instruments to objectives, the Poole (1970) principle of comparative efficiency provides the natural analytical benchmark. There is a broad consensus that monetary policy tools (e.g. central bank money supply conditions) are the natural ones for pursuing price stability. Additional tools, such as time-varying, countercyclical capital requirements should be used to implement macro-prudential policies that will help to preserve financial stability. This is consistent with the "principle of effective market classification" made popular by R. Mundell (1962) according to which, "Policies should be paired with the objectives on which they have the most influence."

In principle, such an allocation of policy instruments to the two objectives would limit the need of policy coordination. In practice however, having two separate sets of instruments may not necessarily prevent situations in which they interact, and may therefore have compounding or conflicting effects on the objectives they pursue. Moreover, the literature also points out that fully optimal policy would call for coordination when spillovers are large enough.

In this paper we take the view that the implementation of macro-prudential policies will at the very least impact upon, and therefore alter, the transmission mechanism of monetary policy. The main reason for this is that macro-prudential policies will (partly) work through the very same transmission channels as monetary policy, the most likely being the bank lending and the balance sheet channels (see table 1 below for an overview) and—exactly as monetary policy—are intended to modify private agents' behavior.

The likelihood of an interaction between macro-prudential and monetary policies originates from the focus of macro-prudential policies on monetary and financial institutions.[6] These institutions turn out to be central banks' counterparts in their provision of liquidity to the economy.

6. The scope of macro-prudential policies should in principle be broad, as regulations currently under preparation shall make the new regulatory agencies responsible for the macro-prudential oversight of all types of financial intermediaries, including the shadow banking system, markets, products and infrastructures. However, collecting comprehensive information and assessing the financial risk on all these dimensions may prove challenging. By focusing on the regulated sector, but monitoring the links between the regulated and the unregulated parts of the financial system, through contingent credit lines, franchises, out-of-balance sheet movements or agreements etc., the macro-prudential authority should have an effective lever on the whole financial system.

Table 1. Macro-prudential Instruments and Monetary Policy Transmission Channels

Vulnerability	*Financial system component*		*Envisaged macro-prudential tool*	*Transmission channels*
Leverage	Bank / Deposit taker	Balance sheet	• Capital ratio • Risk weights • Provisioning • Profit distribution restrictions • Credit growth cap	Bank lending Broad credit Balance sheet
		Lending contract	• LTV cap • Debt service/income cap • Maturity cap	Bank lending
	Non-bank investor			
	Securities market		• Margin/haircut limits	Collateral
	Financial infrastructure			
Liquidity or market risk	Bank / Deposit taker	Balance sheet	• Liquidity/reserve requirements • FX lending restrictions • Currency mismatch limit • Open FX position limit	Bank lending Balance sheet
		Lending contract	• Valuation rules	Balance sheet Collateral
	Non-bank investor		• Local curr. or FX reserve requirements	Balance sheet
	Securities market		• Central banks balance sheet operations	Collateral Portfolio
	Financial infrastructure		• Exchange trading	
Inter-connectedness	Bank / Deposit taker	Balance sheet	• Capital surcharge for SIFIs	Bank lending
		Lending contract		
	Non-bank investor			
	Securities market			
	Financial infrastructure		• Central counterparty	Interest rate

Source: CGFS (2010) and Banque de France.

1.4 The Risks of Conflicting Interactions

Whether macro-prudential and monetary policies may have complementary, conflicting or independent outcomes on financial and price stability will depend on the type and diffusion of supply and demand imbalances across the financial system and the real economy (table 2).

A typical example of a conflicting impact would be a situation in which an asset bubble has been identified, while there are strong risks to price stability on the downside. In other words, supply and demand are misaligned in both the financial system and the real economy, but in opposite directions. In that case, macro-prudential policy should aim at restricting credit and liquidity growth, but this could lead to an undesired contraction in aggregate activity, and to increased downside risks to price stability. The macro-prudential policy would then contribute positively to meet the financial stability objective, but would have an adverse impact on the price stability objective, calling for a policy response, possibly a loosening of the monetary policy stance.

Such a loosening of the monetary policy stance, however, may in turn have an adverse impact on the financial stability objective. Lower interest rates could indeed contribute to the build-up of financial imbalances via the so-called "risk-taking" channel.[7] Simply put, very low interest rates may create incentives for banks to take on more risk through the interplay of various channels including asset substitution, search for yield, pro-cyclical leverage and risk shifting[8] when banks operate under asymmetric information and limited liability.

Recent research has provided empirical evidence in favor of the existence of such a channel. It has been documented,[9] for example, how market-based measures of banks' risks (as perceived by financial market participants) tend to react positively to changes in interest rates so that a lower interest rate leads investors to perceive banks as comparatively less risky. By the same token, several paper, have shown that credit standards are correlated with the level of interest rates: lower interest rates, in particular, imply lower credit standards

7. See Rajan (2005) and Borio and Zhu (2008).
8. See De Nicolo *et al.* (2010).
9. See Altunbas, Gambacorta and Marques (2010).

including to customers who are perceived as representing a higher credit risk. Research carried out at the Banque de France[10] has shown that when the regulatory environment is not transparent, a decrease in the level of the real interest rate increases banks' risk-taking behavior, partly because it may facilitate the under-pricing of risks, which is typical when asset prices rise.

An alternative channel through which low rates may contribute to the building up of financial imbalances originates from central banks' ultimate focus on goods and services' prices rather than on asset prices. During the pre-subprime crisis period, characterized by big supply shocks originating from the integration of large developing countries into the global economy, the resulting disinflationary pressures induced central banks to keep nominal interest rates at historically low levels, which, with the benefit of hindsight, may have contributed to excessive credit growth, with the resulting creation of asset price bubbles.[11]

Overall, Mundell's separate-assignment principle for formulating monetary and macro-prudential policies should therefore not be understood as necessarily implying that coordination is not needed. On the contrary, it should lead to the conclusion that monetary policy decisions need to take into account the macroeconomic effects of macro-prudential policies and vice versa.[12] In section 3 we resort to estimated DSGE models to illustrate this point.

Table 2. Likely Instances of Conflicts between Monetary and Macro-Prudential Policies

	Inflation above target	*Inflation close to target*	*Inflation below target*
Financial exuberance (boom)	Complementary	Independent	Conflicting
No imbalance	Independent	Independent	Independent
Financial deflation (bust)	Conflicting	Independent	Complementary

Source: Authors' elaboration.

10. See Dubecq, Mojon and Ragot (2010).
11. See Taylor (2009) and Obstfeld and Rogoff (2009).
12. See Yellen J. L. (2010): "Macro-prudential Supervision and Monetary Policy in the Post-crisis World." Remarks at the Annual Meeting of the National Association for Business Economics, October, 11.

2. Lessons from Model-Based Simulations

In this section we use model-based simulations to identify the circumstances under which macro-prudential and monetary policies may have compounding, neutral or even conflicting outcomes on financial and price stability. We investigate the most efficient policy mix under such circumstances.

2.1 The Approach Followed and the Characteristics of the Models Used

Economists typically use micro-founded models, where behavioral assumptions are invariant with respect to the policy regime, to assess the relative merits of alternative economic policies. In macroeconomics, these models are the most widely used analytical tools in order to describe the effects of alternative monetary policies on the business cycle and inflation. In this context, the decisions of consumers and firms can be described as deriving from intra-temporal and inter-temporal maximization of their utility and profits given their preferences and the state of technology.

Usual assumptions are that households supply labor and allocate their income into consumption and investment within a period and over time, while firms combine labor and capital into output. In addition, it is typically assumed that all prices and wages cannot be reset every period (prices and wages are sticky) because of nominal rigidities. Such rigidities open the way to the non-neutrality of monetary policy. The most attractive feature of such models is that their behavioral patterns are independent of government policies. They can therefore be used in order to compare alternative monetary policies, or their interplay with macro-prudential policies.

These models, however, have several drawbacks (see appendix C for a comprehensive review). Their dynamic properties, and therefore the relative performance of alternative policies, depend on parameters, the estimates of which remain largely uncertain. More to the point of this paper, only recently have these models imbedded a description of the financial sector (see appendix A for a survey of this literature).

This is usually done in the following way. Credit is modeled as a determinant of either physical capital accumulation or housing investment because of the existence of some form of asymmetric information. Hence, borrowers can issue credit only up to the value of their collateral (see Bernanke, Gertler and Gilchrist, 1999 or Iacoviello, 2005).[13] The availability and the cost of credit can influence aggregate demand, output gap and inflation. One can therefore use such models to analyze how the cyclical component of macro-prudential policies, which are expected to mainly consist of leaning against credit developments, impact upon business-cycle dynamics, and therefore price stability.

As of today, only very few papers[14] have proposed a formal assessment of the effects of macro-prudential policies on price stability. In a recent contribution, N'Diaye (2009) shows that raising capital requirements during periods of economic boom can dampen the financial accelerator mechanism. Hence, macro-prudential policies may facilitate the stabilization of inflation, and hence, the task of the monetary policy authority. This conclusion, however, may not hold true under all types of economic circumstances. If the economy is predominantly driven by shocks that move inflation and credit in opposite directions, then policies that aim at stabilizing credit may in turn destabilize inflation.

We describe such mechanisms in models that have been estimated over the period 1985-2010 for the euro area (see appendix B for a description of the model). These estimates provide a first assessment of the circumstances under which the pursuit of price and financial stability may be conflicting. We focus in particular on the response of inflation to the typical shocks that have driven the euro area business cycle over the last 25 years, as captured by our estimates.

2.2 Modeling Monetary and Macro-Prudential Policies

We then consider whether alternative policy regimes influence dynamics under these "typical economic circumstances." We focus our analysis on four archetypical policy regimes:

13. Recent contribution investigate more extensively the role of the financial structure, including a focus on bank capital (Dib, 2010; Meh and Moran, 2010; Angelini, Neri and Panetta, 2010, and references therein. See also Curdia and Woodford; de Fiore and Tristani; Karadi and Gertler; Gertler, Kiyotaki, and Queralto (2010); Brunnermeier *et al.* (2012) and references therein.

14. Most contributions are recent if not very recent. See Kannan, Rabanal, and Scott (2009), N'Diaye (2009), Angeloni and Faia (2010), Gerali *et al.* (2009), Angelini, Neri and Panetta (2010), Gertler, Kiyotaki ,and Queralto (2010), Cecchetti and Kohler (2010), and Antipa, Mengus and Mojon (2010). See also Kashyap and Stein (2010), Fahr, Rostagno, Smets, and Tristani (2010).

A “plain vanilla” Taylor rule: this is the benchmark case where the monetary policy instrument, i.e. the short-term interest rate, follows a standard Taylor rule and is assigned the sole objective of price stability. According to this rule, the short-term nominal interest rate increases in reaction to both the inflation and the output gap.

“Lean against the financial wind” or “augmented” Taylor rule: under this regime, monetary policy leans against financial winds, i.e. the Taylor rule is augmented with an argument whereby the short-term nominal interest rate increases with credit growth.

Independent macro-prudential policy: the two authorities conduct their policies separately and independently (i.e. non-cooperatively), focusing on their respective objective.

Finally, we consider a fourth policy regime in which the central bank factors in credit developments in its interest rate decision, that is, it follows an “augmented” Taylor rule, while an independent macro-prudential authority leans separately against the wind.

We assume that the purpose of macro-prudential policy consists mainly in “leaning against the financial winds.”[15] [16] Therefore, a macro-prudential rule involved in these third and fourth regimes specifies how a macro-prudential instrument leans against nominal credit growth. In our model, this takes the form of policy makers’ ability to influence the loan-to-value ratio that enters the collateral constraint of impatient households and entrepreneurs. From a macroeconomic perspective, this is equivalent to limiting the amplitude of the deviation of aggregate credit from its steady-state value. It is indeed likely that the forthcoming macro-prudential policy could take the form of “leaning against credit,” or implicitly lead to such an effect.[17] Such an outcome might result from the recourse to several instruments currently under discussion for macro-prudential policies. For instance, regulations requiring that banks set aside more capital as asset prices rise would raise the interest rate margin that banks have to charge on loans over their funding

15. See footnote 1.

16. Gertler, Kiyotaki and Queralto (2010) focus instead on the contrasting effects of subsidizing the issuance of external equity *ex ante*, which increases the resilience of the banking system in the event of the crisis, and the time varying threat of no public intervention in times of crisis, which increases risk-taking by the banking system as in Farhi and Tirole (2010).

17. Alessi and Detken (2009) show that persistent deviations of the credit/GDP ratio from its trend (which is akin to our steady state level of credit) are a robust leading indicator of a costly bust in the financial and real cycles. See also Borgy, Clerc and Renne (2011) for a comprehensive analysis of early warning indicators of financial, crises-led recessions.

costs. Other instruments may contribute to this purpose, including dynamic provisioning, pro-cyclical capital or liquidity requirements, and taxation of credit or of maturity transformation.[18] We abstract from the discussion of the most appropriate instruments to lean against credit, altogether, in order to focus instead on the macroeconomic effects of such stabilization policies.

Turning to the specific coefficients of the policy rules, we proceed first with a simplest initial calibration of Taylor rule for the benchmark regime, with coefficients of 1.5 on inflation and 0.5 on the output gap,[19] with an autoregressive coefficient of 0.9. The augmented Taylor rule uses an ad hoc coefficient of 0.7 on the log level of nominal credit. This magnitude is meant to have an effect of credit on the variance of the interest rate in between the variance due to inflation and that due to the output gap. In terms of the macro-prudential policy that affects directly the loan to value ratio in the model, we set $\tau = 0.5$ in

$$\theta_t = \bar{\theta} z_t^{\theta} \left(\frac{b_t}{\bar{b}} \right)^{-\tau}$$

2.3 A Typology of Shocks and Their Effects on Price Stability

We now turn to comparing the dynamics of inflation across regimes. There exists a broad consensus that policies aimed at price and financial stability ought to be mutually reinforcing following shocks that move aggregate demand, including credit supply shocks. On the other hand, the effects on inflation of these two objectives may

18. A presentation of these options is available in the CGFS report. See also Jeanne and Korinek (2010) on the pros and cons of a Pigouvian tax on credit.

19. The larger the weights on output variability in the loss function, the more the monetary policy maker cares about output variability. In the case of the Federal Reserve, which has a double objective of full employment and price stability, we could for instance expect a higher weight than for the Eurosystem, whose mandate is primarily to focus on price stability. In the latter case we could in principle assume that only inflation variability matters to the central bank. However, as argued by Svensson (1999), even the monetary policy of a central bank that seeks to stabilize inflation can be modeled via a Taylor rule, which makes the policy rate react not only to the current (or expected) inflation rate, but also to the current (or expected) output gap, simply because the output gap is a determinant of future inflation. We do not want to take these exercises too literally because they crucially depend on model's parameters that, in general, are not precisely estimated. Our purpose is instead mainly illustrative.

be conflicting following shocks to productivity.[20] Indeed, a persistent increase in productivity can stimulate demand for houses because economic agents anticipate an increase in their future income and, provided some inertia from real wages, reduce both unit labor costs and inflation. To some extent, this corresponds to the situation of many OECD countries in the run up to the sub-prime crisis. Credit growth was very dynamic, growing much faster than GDP while inflation remained low and stable. Arguably, if inflation is indeed a monetary phenomenon, macro-prudential policies that would have slowed credit and money growth could have had the side effect of pushing inflation rates below the inflation objectives of monetary authorities, if not to negative values. Such policies could have put a threat on the anchoring of inflation expectations close to the level of the inflation objective of central banks.[21]

We use the estimated model in order to illustrate situations in which monetary and macro-prudential policies may either neutralize or reinforce each other. The behavioral parameters and the stochastic structure (i.e. the relative importance of shocks) are estimated over the period 1985-2010. We then compare the dynamics of economic variables across the four policy regimes listed above.

Alternative policies within one type of regime differ in terms of the strength with which the policymaker reacts to inflation, the output gap, or credit. These weights can be linked to the preferences of the authorities (see the textbooks of Woodford, 2003; Galí, 2008; and Walsh, 2010). We come back to this point later, but the main trust of the qualitative results we present here is not affected by the preferences implicitly consistent with these policy rule coefficients.

In view of the potential conflict between the objectives of price and financial stability under some circumstances, the next important question is to assess how important such shocks can be in the business cycle. This is however the object of an endless academic literature that goes beyond the scope of this paper.

A first pass on this question is to report how important such shocks were, according to our model estimates. The variance decomposition of inflation, output gap, short-term interest rate, credit and housing prices are reported in table 3.

20. This point is also illustrated in Kannan, Rabanal and Scott (2009) and Angeloni and Faia (2010).

21. On the trade-off between financial stabilization and the cost to the credibility of the inflation objective, see the illuminating discussion of Carney (2009).

Table 3. Variance Decomposition of the Main Euro Area Aggregates

	Housing pref	*Productivity*	*Credit supply*	*Cost push*	*Monetary policy*
Credit	5.37	23.37	49.89	7.29	5.72
House price	34.15	44.84	0.17	10.06	2.75
Interest rate	3.74	19.85	0.12	57.41	14.79
Output	1.3	56.19	0.18	31.04	7.96
Inflation	0.58	38.72	0.1	54.06	3.64

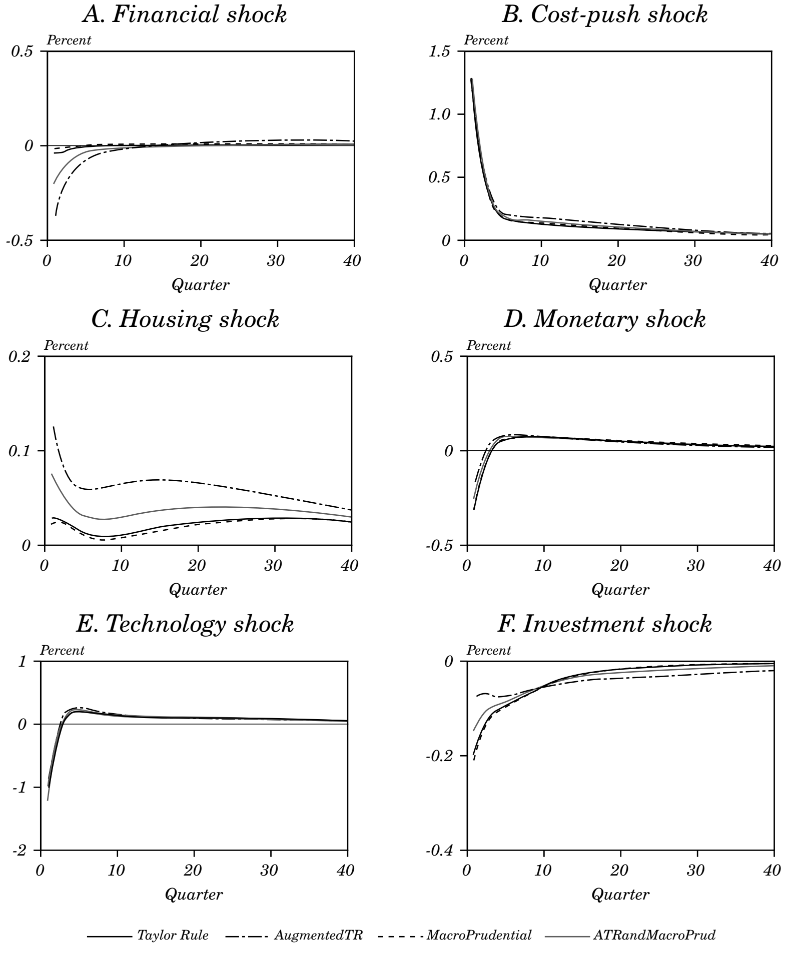
Source: Authors' calculations.
Percent of total variance, only most important shocks are reported.

These variance decompositions point to those shocks that are the most important ones. The variances of inflation are shocks to mark-up and productivity and to a much lesser extent, monetary policy. Hence, an authority that cares about stabilizing inflation should care mostly about the potential perturbation due to the pursuit of macro-prudential policy following such shocks. However, this variance decomposition may not be entirely robust and we compare the dynamics of inflation for all identified shocks in the model.

In any event, the most relevant point of our analysis is to describe whether the four policy regimes imply differences in inflation dynamics. Hence, we report the response of inflation to all the estimated shocks of the model in figure 1. First, the responses of inflation to technology, cost-push and monetary policy shocks are almost identical across the four policy regimes, and these three shocks account for 90 % of the variance of inflation.

The dynamics of inflation differ for other shocks. In particular, the augmented Taylor rule can be destabilizing for inflation if compared to the benchmark plain vanilla Taylor rule regime. This is the case following either the housing preference shock or the financial shock. As can be seen in figure 2, which reports the effects of a financial shock, the augmented Taylor rule implies an abrupt increase in the real interest rate, which turns out destabilizing for output and inflation. In contrast, the combination of a standard Taylor rule and a target macro-prudential rule (in the policy regime 3) turns out both more stabilizing for credit (figures 3 and 4) and non-destabilizing for inflation.

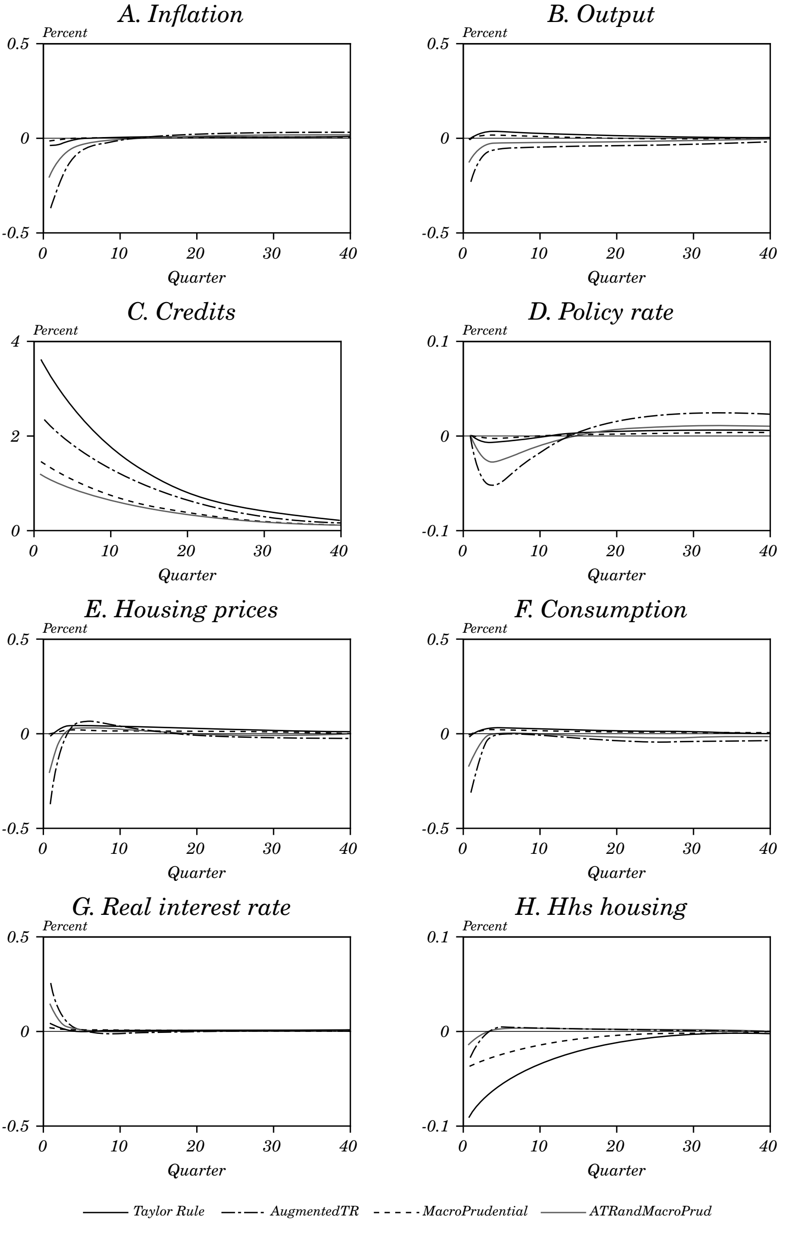
Figure 1. Inflation Dynamics across Policy Regimes
Inflation



Source: Authors' elaboration.

Figure 2. Effects of a Financial Shock (Credit Supply) across Policy Regimes

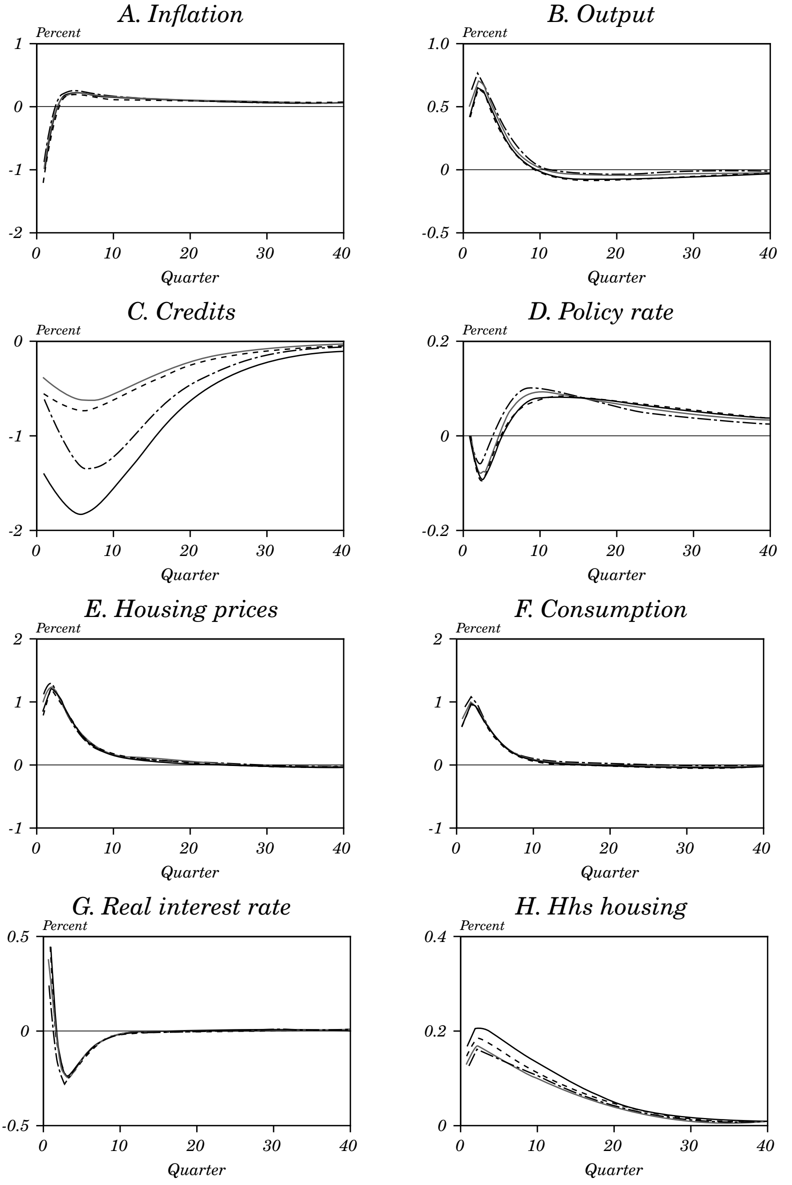
Financial shock



Source: Authors' elaboration.

Figure 3. Effects of a Productivity Shock across Policy Regimes

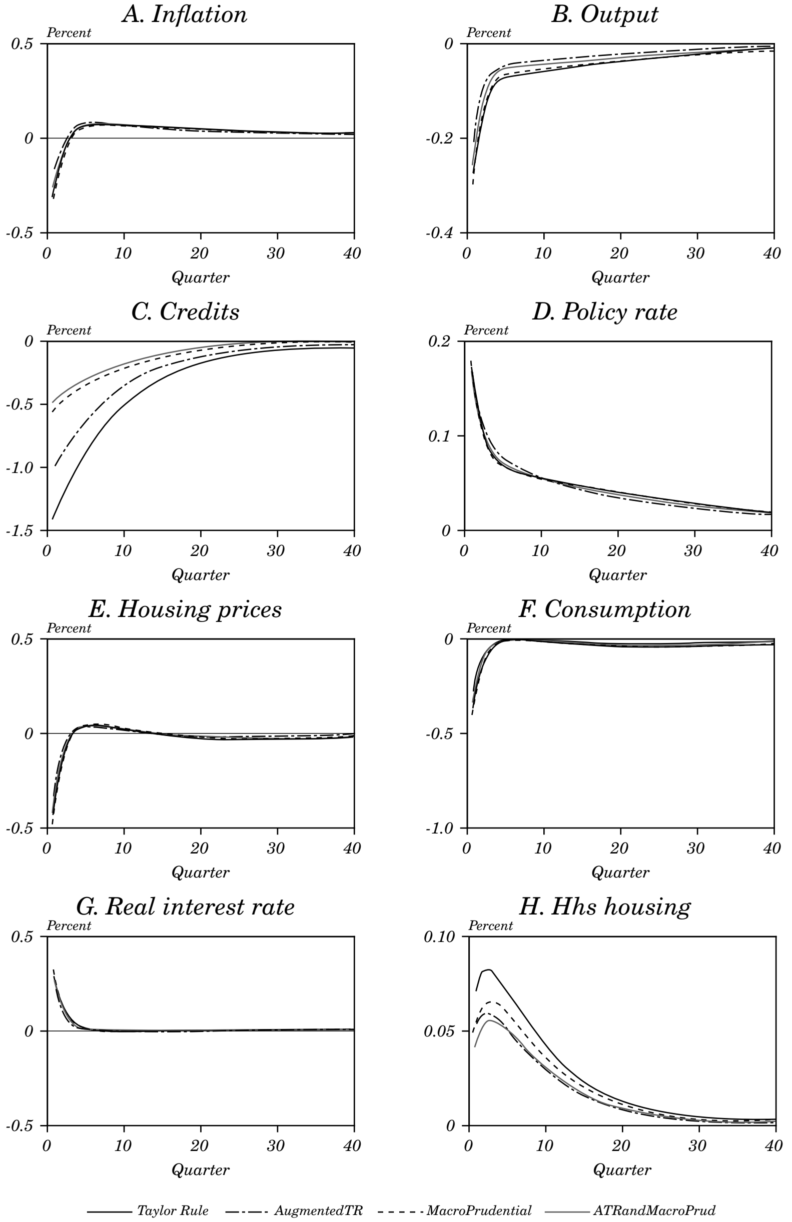
Tecnology shock



Source: Authors' elaboration.

Figure 4. Effects of a Monetary Policy Shock across Policy Regimes

Monetary shock



Source: Authors' elaboration.

2.4 Limiting the Amplitude of Boom-Bust Cycles

We now turn to the model to analyze whether macro-prudential policies would limit the amplitude of boom-bust cycles. The experiment we conduct this time takes the form of a deterministic simulation of the model for two levels of steady state loan-to-value (LTV) ratios. First, we design a sequence of financial shocks to obtain a plausible boom-bust cycle of credit, meant to replicate the recent Spanish financial cycle, which in this case the steady state LTV ratio is 0.7. Our benchmark credit cycle is the deviation of Spanish bank credit to the private sector, from its HP trend, between 2006 and 2012.

Second, we input the exact same sequence of shocks to a version of the model where the steady state LTV ratio is 0.35.

The results, reported in figure 5, show a much more muted credit cycle in the model with half the LTV ratio (see the impulse response in red), as could be expected. The trajectory of output deviation from trend is also much more limited for a smaller LTV ratio. However, the experiment also shows that the response of output to the financial shock seems implausibly high in view of the Spanish experience. The impulse responses of inflation, the interest rate and house prices (not reported for the sake of space) show much less instability in the model with smaller LTV ratio.

3. Conclusion

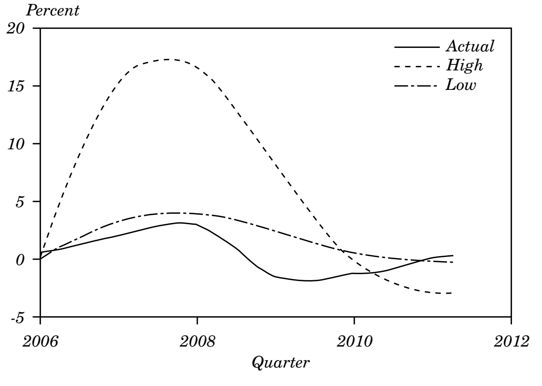
In this paper, we analyze how macro-prudential policy interactions may affect the conduct and performance of monetary policy. First we discuss the set-up of institutions in charge of macro-prudential policy in the U.S. and in Europe and the potential conflict that this new policy may have with monetary policy.

We then assess whether macro-prudential and monetary policies may have compounding, neutral or conflicting effects on financial and price stability. According to an econometric approach relying on a DSGE model estimated for both in the euro area, we show that episodes of conflict should, on average, be rather limited over the business cycle. These conflicts depend on the nature of the shocks impacting on the economy. Over the period under review (1985-2009), both the credit and the housing preference shocks, which are the most relevant for macro-prudential policies, on average, only

Figure 5. Counterfactual on Macro-Prudential Policies

A. Credits-trend deviation

B. Output-trend deviation



Source: Authors' elaboration.

marginally accounted for inflation dynamics. And for the shocks that have explained most of the fluctuation in inflation, whether monetary policy leans against financial winds or not, and whether we have an additional macro-prudential policy instrument active or not, hardly makes any difference for the dynamics of inflation.

Assuming that such a finding is robust across different sample periods and countries, this means that the implementation of macro-prudential policy should not be overly harmful to monetary policy.

Quite the contrary, it may even facilitate the latter by offsetting the transmission of financial disturbances to the real economy. This assumes however that the macro-prudential authority is able to counter the propagation of destabilizing asset price and credit supply shocks to the real economy by leaning against credit.

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APPENDIX A

Literature Review: Financial Frictions and Canonical Macro-Models

Canonical macroeconomic models mostly incorporate the assumption of frictionless financial markets. Based on the Modigliani-Miller (1958) theorem, these models imply that the composition of agents' balance sheets has no effect on their optimal spending decision. Thus, canonical macro models have difficulties accounting for the feedback between financial conditions and the real economy in times of financial distress.

One of the first contributions to have challenged the Modigliani-Miller theorem is the seminal article by Bernanke, Gertler and Gilchrist (1999), henceforth BGG. In this framework, borrowers face an external finance premium, which reflects the different costs of internally and externally raised funds. The finance premium inversely depends on borrowers' net worth, which is pro-cyclical due to the pro-cyclicality of profits and asset prices. This entails that the external finance premium is countercyclical, enhancing the swings in borrowing and hence investment and aggregate demand. The external finance premium therefore propagates shocks to the real economy and amplifies business cycle fluctuations.

Gilchrist, Ortiz and Zakrajsek (2009) incorporate a proxy of the external finance premium in a DSGE model estimated on U.S. data over the period 1973-2008. The authors find an operative financial accelerator, i.e. increases in the external finance premium cause important and protracted contractions in investment and output. De Graeve (2008) provides for an estimate of the external finance premium, which is on an average of 130 basis points over the post-WWII period.[22]

Another type of framework focusing on borrowers' balance sheets goes back to the work of Kiyotaki and Moore (1997). In this set-up, lenders cannot force borrowers to reimburse their debt. Thus, durable assets such as land and machinery play a dual role

22. When taking the data to the model, the author finds that for some shocks (such as investment supply shocks) the finance premium is not countercyclical. This may give rise to a financial decelerator mechanism corroborated also by the results of Iacoviello (2005) and Christiano, Motto and Rostagno (2007), see further below for more details.

being used as factors of production and collateral for loans at the same time. Borrowers' credit lines are consequently affected by the collateralized assets' prices and collateral constraints govern borrowers' investment and spending decisions, which in turn affect asset prices then again. The dynamic interaction between credit limits and asset prices function as a transmission mechanism by which the effects of financial shocks persist, is amplified and spills over to other sectors.

Liu, Wang and Zha (2009) estimate a DSGE model with U.S. data and show that the amplification mechanism in Kiyotaki and Moore (1997) is empirically important. This study finds positive co-movements between housing prices and business investment. A shock to housing demand—affecting the marginal rate of substitution between housing and consumption—generates important macroeconomic fluctuations, accounting for 36-46% and 22-38% of the fluctuations in investment and output, respectively.

One implication of the above-described models is that borrowing constraints are always binding, in which case default never occurs in equilibrium. In contrast, in Carlstrom and Fuerst's (1997) analysis,[23] agency costs are endogenous over the business cycle and default emerges as an equilibrium phenomenon. Consequently, there is room for regulatory policies. Based on this framework, Faia and Monacelli (2007)[24] address the question of whether monetary policy should react to asset prices, answering it affirmatively. More precisely, in their setting, asset price movements are caused by financial distortions since the price of capital is determined in a lending market characterized by moral hazard, i.e. the asset price is subject to a tax. In the case of a positive productivity shock, this wedge evolves pro-cyclically, thereby restraining investment. For an increase in asset price, monetary policy should therefore react by lowering the nominal interest rate. This result may seem controversial; however, it also hinges on the metric that is used to evaluate the performance of different policy rules. While policy rules are usually assessed considering the volatility of inflation and output, here the selection is based on strict welfare criteria.

23. Based on the costly state verification model by Townsend (1979).

24. The authors succeed in generating a countercyclical behavior of the external finance premium by assuming that the mean distribution of investment outcomes across lenders depends on the state of aggregate productivity: the pro-cyclicality of the external finance premium in Carlstrom and Fuerst (1997) initial analysis being a very counterintuitive result.

In a recent paper, Iacoviello (2005) combines a financial accelerator mechanism à la BGG with collateral constraints tied to real estate values in the spirit of Kiyotaki and Moore (1997). A third rigidity is added to this framework, debt contracts are denominated in nominal terms. This allows considering the distributional consequences of nominal rigidities as in Fisher (1933). The Fisher debt deflation channel amplifies effects of shocks that drive output and the price level in the same direction, such as positive demand shocks,[25] and dampens the impact of shocks that drive output and the price level in opposite directions. Finally, Iacoviello finds that responding to asset prices does not improve output and inflation stabilization.

The above-mentioned studies consider the demand side of financial frictions, i.e. borrowers' balance sheets. Arguably, supply side factors may have a substantial impact on the business cycle; that is to say that a bank's balance sheet might affect the transmission of shocks. Christiano, Motto and Rostagno (2007) incorporate a banking sector into a DSGE model containing also a debt-deflation channel. As in Iacoviello, the authors find that financial accelerator/decelerator mechanisms depend on the nature of shocks. Moreover, quantitatively, financial frictions according to BGG. are an important driving force of business cycle fluctuations, both in the euro area and the U.S. When it comes to the transmission and amplification of shocks, these frictions play a substantially bigger role than the incorporated banking sector. Finally, in this set-up, output volatility is stabilized when broad monetary aggregates are taken into account; reacting to the stock market is stabilizing for the U.S. economy but not so for the euro area.

Meh and Moran (2010) construct a dynamic general equilibrium model in which the balance sheet of banks affects the propagation of shocks.[26] Key to the propagation of shocks in this model is the banks' capital adequacy ratio. Although it arises from market discipline, the simulations give insights on its cyclical properties: whether capital adequacy ratios ought to be pro-cyclical or if it will depend on the

25. For a positive demand shock, consumer and asset prices increase. This reduces the real value of outstanding debt, positively affecting borrowers' net worth. Simultaneously, the rise in asset prices augments the borrowing capacity of the debtors, allowing them to spend and invest more. As borrowers have a higher propensity to spend than lenders, the net effect on demand is positive, and acts as an amplification mechanism for the initial shock.

26. At the heart of the propagation mechanism lays a double moral hazard problem seen in Holstrom and Tirole (1997).

nature of shocks. Following technology and monetary policy shocks, capital adequacy ratios vary negatively with the cycle, possibly exacerbating the business cycle. When disturbances originate within the banking sector (i.e. sudden drops in bank capital) capital adequacy ratios are pro-cyclical: capital adequacy ratios loosen just as output weakens. Finally, independent of the shock's nature, economies whose banking sectors remain well capitalized experience smaller reductions in bank lending, and hence less severe downturns. Bank capital thus increases an economy's ability to absorb shocks and, in doing so, affects the conduct of monetary policy.

Finally, De Walque, Pierrard and Rouabah (2008) model on interbank market, populated by heterogeneous banks. In their framework, agents, including banks, can default on their financial obligations. Here, endogenous default rates generate a countercyclical risk premium acting as a financial accelerator. Their framework is particularly interesting because monetary policy takes the form of liquidity injections into the interbank market. The authors find that a central bank's liquidity injections lead to less financial instability (measured by the ratio of repayment of funds borrowed on the interbank market). However, in terms of output volatility, liquidity injections have an ambiguous effect.

Only few models explicitly account for macro-prudential policies in a broader sense. One of them is Kannan, Rabanal and Scott (2009). The authors examine the potential role of monetary policy in mitigating the effects of asset price booms. Results imply that stronger monetary reactions to signs of overheating, or a credit or asset price bubble, could help counter accelerator mechanisms that push up credit growth and asset prices (in line with what Cecchetti, Genberg, Lipsky and Wadhwani, 2000 argue). However, this is only the case when shocks are of a financial character. For technology shocks, a standard Taylor rule still does best in terms of reducing volatility in output and inflation.

Gerali, Neri, Sessa, and Signoretti (2009) provide for the only up to date DSGE model incorporating a banking sector, estimated on euro area data. Here, banks enjoy some degree of market power (in both the loan and the deposit markets) and accumulate capital subject to a capital adequacy requirement. Due to the interest rate setting behaviour of banks the model accounts for an intermediation spread. This spread alters the pass-through of changes in the policy rate to bank rates, usually at work in standard models with endogenous borrowing constraints but without financial intermediation.[27] Overall, the authors find that banking induces some attenuation on output, mainly reflecting the presence of sticky interest rates. Banking nonetheless enhances the persistence in real variables in response to technology shocks. Finally, the authors assess the contribution of financial shocks to the crisis experienced since 2007 and find that almost all the contraction of real GDP was due to factors that either pushed up the cost of credit or reduced the amount of credit available to the private sector.

Angelini *et al.* (2010) introduce interactions and sequencing between monetary and macro-prudential policies, the latter seeking to stabilize the loans/GDP ratio and GDP growth. The paper's preliminary results so far do not hint an important quantifiable aspect of strategic interactions between monetary and macro-prudential policy makers. However, interactions seem to play a role for the cyclicality of the macro-prudential rules tested in the analysis.

Finally, Angeloni and Faia (2009) provide for another framework allowing the study of interactions between bank regulation and monetary policies in fragile banking systems (i.e. when bank runs are possible). Given this framework, households' welfare is optimized by a combination of countercyclical capital ratios and a monetary policy response to asset prices.

27. The overall effect of intermediation is affected by the stickiness of interest rates (banks translate changes in interest rates only partially) inducing some attenuation. On the other hand, the credit market power and the ensuing mark-up between lending rates and policy rates amplifies changes in the policy rate for borrowers, while the markdown between the policy rate and the deposit rate attenuate effects for lenders.

Appendix B

The Euro Area Model Used for Simulations

In section 2 of this paper, we rely on a modified version of the models estimated by Antipa, Mengus and Mojon (2010), in which we consider impatient entrepreneurs and patient (or Ricardian) households only. The model is a DSGE seen in Iaccoviello (2005) with residential investment, house prices and housing loans. It should be stressed that, in the model, housing prices influence the investment cycle as in Liu *et al.* (2009).

The Private Sector

Only housing shocks intervene in agents' utility functions. In our specification, patient households are subject to the marginal utility of housing that in turn affects housing demand. Contrary to Iacoviello (2005) where changes to the marginal substitution between housing and consumption affect both patient and impatient households, here we are interested in the interactions between a demand shock on one hand and a biting, borrowing constraint in a framework of nominal debt indexation on the other hand.

Formally, housing preference shocks intervene on φ_t in the constrained households' utility function:

$$E_0 \sum_{t=0}^{\infty} \left(\beta^R\right)^t \left(\log\left(C_t\right) + \varphi_t \log\left(L_t^h\right) - \frac{1}{1+\eta}\left(N_t\right)^{1+\eta} \right)$$

where C_t, L_t^h and N_t are consumption, housing and hours worked respectively.

The ordering in time preferences is the following: entrepreneurs are more impatient than patient households ($\beta^E = 0.975$; $\beta^R = 0.9943$, see Gerali *et al.*, 2009). We take $\eta = 1$.

The other distinctive feature of this model is the borrowing constraints for entrepreneurs. Entrepreneurs maximize their utility subject, not only to a standard inter-temporal budget constraint, but also to a borrowing constraint that will be binding at equilibrium. This borrowing constraint is given by:

$$R_t B_t^E \leq \theta_t E_t(q_{t+1} L_t^E)$$

where $E_t(q_{t+1})$is the expected house price in $t + 1$ and L_t^E is the entrepreneur's holdings in housing wealth, and $\theta_t = \bar{\theta} z_t^{\theta}$ the loan-to-value ratio with z_t^{θ} an AR(1) shock ($\bar{\theta} = 0.35$ as in Iacoviello, 2005). Borrowing is thus limited to the net present discounted value of housing wealth. A positive financial shock, z_t^{θ}, can therefore be understood as a relaxation of entrepreneurs loan to value ratio (caused by an increase in competition in the banking sector or financial innovation for instance). These constraints are binding equalities at equilibrium.

The model was estimated for the euro area based on quarterly observations from 1997:IV to 2011:II. The observables used for the estimation are GDP, consumption, residential investment, inflation, the money market rate, housing loans and the house prices. Observations are used in first difference of logged variables, except for housing prices time series, which is used in fourth difference to get rid of seasonal variations. Only the parameters relative to the shocks (standard deviation and persistence coefficients) and the monetary policy reaction function are estimated through bayesienne procedure. The remaining parameters are calibrated according to previous studies. The estimated parameters are reported at the end of the present appendix. Dynare codes used for the estimation and simulations are available upon request from the authors.

Government Policies

Following a standard approach, we evaluate the potency of MP policies by simulating the effects of various shocks in the model across three of the four archetypical policy regimes listed in section 2.1:

1. The Plain Vanilla Taylor Rule

This reaction function of the central bank reflects the adjustment of level of short-term interest rates in response to lagged deviations of inflation, and output, from their respective steady state values. The relationship can be expressed as

$$r_t = (1 - \gamma_R)[\gamma_\pi \hat{\pi}_{t-1}^C + \gamma_y \hat{y}_{t-1}] + \gamma_R r_{t-1} + z_t^r$$

where γ_R denotes the inertia of interest rates and γ_π, γ_y are the coefficients assigned to the reactions to the inflationary and output gaps, respectively. z_t^r denotes an AR(1) monetary shock.

2. Lean Against the Wind Taylor Rule

In this second policy regime, the central bank also raises interest rates in reaction to the growth rate of credit. The monetary policy rule can then be expressed as

$$r_t = (1 - \gamma_R)[\gamma_\pi \hat{\pi}^C_{t-1} + \gamma_y \hat{y}_{t-1} + \gamma_b \hat{b}_{t-1}] + \gamma_R r_{t-1} + z^r_t$$

where $\hat{b}_{t-1}$ denotes the lagged deviation of real credit with respect to its steady state value (γ_b being the corresponding weight within the policy rule).

3. Independent Macro-Prudential Policy

In this third regime, we have both the same monetary policy rule as in regime 1, i.e.

$$r_t = (1 - \gamma_R)[\gamma_\pi \hat{\pi}^C_{t-1} + \gamma_y \hat{y}_{t-1}] + \gamma_R r_{t-1} + z^r_t$$

and the lean against credit rule. The latter rule impacts upon agents' borrowing constraints by affecting their respective loan-to-value ratios. The equation for the time-varying loan-to-value ratio, and hence the credit rule, is:

$$\theta_t = \bar{\theta} z^\theta_t \left(\frac{b_t}{\bar{b}}\right)^{-\tau}$$

where z^θ_t is an AR(1) shock to the loan-to-value ratio, and has to be understood as a credit supply shock. b_t is the entrepreneurs' debt level ($\bar{b}$ its steady-state level). Finally, τ governs the strength of the policy-makers reaction to excessive credit growth.

This is a combination of the plain vanilla Taylor rule and an independent policy instrument, which reacts to the growth rate of nominal credit thus constraining agents' loan-to-value ratio and hence the amount of overall credit.

Table B1. Parameter Estimates

Symbol	*Description*	*Prior*[a]	*Posterior mode*[b]
Shocks' persistence parameter			
ρ_{φ}	Housing shock	Beta (0.8,0.05)	0.9390 (0.0165)
ρ_g	External/Gov. shock	Beta (0.8,0.1)	0.7911 (0.0433)
ρ_t	Technology shock	Beta (0.8,0.1)	0.6821 (0.0293)
ρ_{θ}	Loan-to-value ratio shock	Beta (0.8,0.1)	0.9322 (0.0229)
ρ_p	Cost-push shock	Beta (0.8,0.1)	0.8362 (0.0093)
ρ_i	Investment shock	Beta (0.8,0.1)	0.5380 (0.0558)
Standard deviation of shocks' innovation			
σ_h	Housing shock	Inverse Gamma (0.01,0.02)	0.0861 (0.0250)
σ_g	External/Gov. shock	Inverse Gamma (0.01,0.02)	0.0124 (0.0012)
σ_t	Technology shock	Inverse Gamma (0.01,0.02)	0.0196 (0.0021)
σ_{θ}	Loan-to-value ratio shock	Inverse Gamma (0.01,0.02)	0.0239 (0.0024)
σ_p	Cost-push shock	Inverse Gamma (0.01,0.02)	0.0040 (0.0005)
σ_i	Investment shock	Inverse Gamma (0.01,0.02)	0.0548 (0.0068)
σ_r	Monetary shock	Inverse Gamma (0.01,0.02)	0.0018 (0.0002)
Taylor rule			
$\gamma_{\pi} - 1$	Coefficient on inflation	Inverse Gamma (0.5,0.5)	0.1278 (0.0186)
γ_y	Coefficient on output	Normal (0.5,0.1)	0.6156 (0.0756)
γ_R	Smoothing parameter	Beta (0.8,0.05)	0.9159 (0.0133)

Source: Authors' elaboration.
a. Priors: shape (prior mean, prior standard deviation).
b. Gaussian approximation of posterior standard deviation at the mode is given in parentheses.

APPENDIX C

Limitations of the Model and of the Simulation Exercises Performed with it

The exercise developed in this section allows us to gain insights on the interaction between monetary and macro-prudential policies. However, several limits in the analysis should be acknowledged. It is nevertheless also fair to emphasize that, although they might call for further significant developments, these limits are mainly entrenched in any modeling exercise. Consequently, most of them would also apply to a wider range of modeling exercises.

1. Uncertainty about the model (is this DSGE model a fair representation of the actual economy?)

Building a model involves choosing a set of simplifying assumptions. An important one is that the economy is isolated from the rest of the world. However, domestic financial stability and domestic inflation rates are affected by what happens in the rest of the world and in big foreign economies. A drawback of considering the economy as a single entity is that the issues of both the international coordination of those two policies and the quantification of their importance cannot be addressed.

Another important issue is the modeling of the financial imperfections and of their impact on the business cycle. As evident from table 2.1 and from the simulations reported in figures 3.1a to 3.9, credit developments have only a limited effect on the dynamics of real and nominal variables. This could be because the financial cycle is longer lasting and more asymmetric than the real business cycle, and the models are estimated over samples during which monetary policy has managed to dampen inflation fluctuations.

More generally, the model only focuses on a specific form of credit rationing. There is no role for a fall in the demand for credit and for an increase in the savings rate, which have been observed for some agents during the crisis. Moreover, liquidity hoarding by banks is a sign of effective self-insurance on the part of some financial institutions, which is not present in the model. A new literature studies uncertainty shocks and precautionary savings (Bloom, 2009) in order to explain a fall in activity when uncertainty increases, which can create negative externalities. This model abstracts from all of that and, once again, focuses on only one margin.

Credit constraints capture the difficulties for entrepreneurs to get financed. Admittedly, they capture market freeze during financial turmoil, which may be linked to market liquidity. Dealing with this effect in such a reduced-form way allows to simply estimate the effect at stake, but the market failure for funding and market liquidity are different, and so is the optimal policy answer. Interactions between funding and market liquidity are studied by a recent literature (see for example Brunnermeier and Pedersen, 2009), which however does not provide quantitative insight yet.

2. Uncertainty about the policy function objective

The postulated policy objectives and the associated reaction functions are intuitive and tractable. However, they are not derived from primitive parameters describing the preferences of the agents the public authority aims at maximizing. In particular, it might be the case that the relative weight given to each of the target variables in the rule (or in the loss function) differs from the optimal one that these primitive parameters would imply.

3. Uncertainty about the estimated coefficients: econometric structure (time-varying parameters, heteroskedasticity, etc.)

Simulating the economy under different policies is based on estimated parameter values. These estimates are thus prone to estimation uncertainty, which could also be included in the simulations. More generally, tackling the uncertainty concerning the parameters' values could call for considering that the structure of the model is itself uncertain, and include this as a feature of the estimation procedure. For instance, one may allow for time-variation in either the parameters describing the transmission mechanism of the structural shocks to the macroeconomic aggregates, or the ones characterizing the variance of the structural shocks.

4. Policy dependence of the estimated parameters (the so-called Lucas critique)

Along the same lines, using estimated coefficients to conduct policy simulations is prone to the so-called Lucas critique. The estimation strategy postulates a given structure of the economy. This structure involves, among other elements, the parameters characterizing the policy reaction function. In particular, private sector's agents take their decisions conditional on this policy rule (and these specific parameters). Therefore, a shift in the policy rule may affect the structure of the economy and require re-estimating the model under the new structure. However, for this to be implementable, we would need data under a regime where macro-prudential policy already existed.

5. Uncertainty about the data: revisions (i.e. Orphanides)

The simulations are based on final releases of macroeconomic aggregates. By contrast, public authorities take decisions in real time and therefore rely on real-time data that are subsequently updated, and sometimes differ substantially from final figures. This is especially relevant when the economy experiences big disruptions whose consequences are difficult to interpret in real time, and thus take time to be learned. It may therefore be interesting to see how the conclusions of the exercise would differ if the policy reacted to these real-time data.

6. Uncertainty about the central bank's (or other authority's) ability to implement the policy

In the model, we assume in particular that the authorities can lean against credit.

a. Information (about the agents and the economy) needed to implement (optimal) policy (i.e. Orphanides and Williams)

The uncertainty behind the parameter estimates alluded above is more than just a matter of econometrics methodology. It is reasonable to assume that public authorities may have an informational advantage, compared to the private sector in monitoring and processing statistical information, and therefore have a more precise view of the evolution of the macroeconomic outlook. They nevertheless still remain uncertain about the exact structure of the economy. By comparison the proposed simulation exercise postulates that the authorities have an accurate perception of this structure. An extension would be to analyze a situation where the objective function of the central bank (or other authority) incorporates their own uncertainty about this complex structure. This would influence their optimal decisions (and therefore the optimal reaction function). For instance they might want to minimize the loss under the less favorable scenario induced by their approximation instead of the scenario where the economy behaves as described by the "point estimates" of the models parameter.

b. Political economy

The model considers a macro-prudential authority, which is well settled and independent from national governments. It therefore abstracts from the process of setting-up this new regulatory body. However, national or industrial vested interest may stall this process. This would pave the way for time-inconsistency problems due to non-credible commitments to restrict credit growth when the macroeconomic outlook calls for it.

Monetary Policy And Macro-Prudential Regulation: The Risk-Sharing Paradigm

Atif Mian
Princeton University

Economic history is replete with episodes of financial crises creating havoc for the real economy. These episodes typically have three important ingredients. First, there are large financial flows to finance a bubbling asset class such as sovereigns or housing with "safe" debt. Second, there is a sharp downward movement in the price of the asset that was being financed with debt. Third, there is no apparent "real shock" that one can point a figure at for the large drop in asset prices. In particular, there is no major production-side disruption such as the failure of a technology, political coup or breakout of large-scale disease. Yet the financial shocks translate into a deep and long economic recession. Why?

In this paper I argue that the fundamental reason for financial recessions is a failure of risk sharing. The workhorse macro model is based on a representative agent economy. Such models implicitly assume that households in the real world are able to shield themselves against large asset price movements. This is patently false in the data. As a result, aggregate demand and output will fall unless the economy is massively and quickly able to reallocate real consumption across households.

While financial shocks in the presence of high leverage necessitate the need to reallocate consumption across households, the real economy cannot move at the pace and frequency that a levered financial market

My discussion in this article is based on my joint work with Amir Sufi. I am also thankful to Virgiliu Midrigan for his comments and suggestions. The views and conclusions presented in this paper are exclusively those of the author and do not necessarily reflect the position of the Central Bank of Chile or its Board members.

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demands. For example, relative prices cannot fluctuate as quickly as needed by the new financial reality; nominal wages can be stubbornly sticky; labor cannot be hired quickly by new sectors; and nominal interest rates cannot go negative. The slow pace of adjustment on the real side implies that the overall economy fails to reverse the real consequences of the risk sharing failure. Consequently, the economy goes into a decline.

This note discusses the evidence on the failure of risk sharing in the U.S. economy, and the role of policy in mitigating the effects of this failure. I discuss why traditional macro policy fails to limit financial excess *ex-ante*, and why it is naturally limited in its scope to deal with the consequences of financial excesses *ex-post*. Consequently, I argue that we need to design our financial system within a "risk-sharing paradigm" and provide some speculative suggestions in this regard.

My views in this paper are based on empirical work I have done with Amir Sufi and co-authors on the 2007-2008 U.S. financial crisis. My more prescriptive suggestions in this paper were mentioned in my written testimony to the U.S. Senate in October of 2011.

1. The Failure to Share Risk

An implicit but important assumption of typical representative agent macro models is that households are able to share idiosyncratic financial risks. In other words, the cross-sectional distribution of asset price shocks may be ignored.

This is an important assumption for two reasons. First, the bursting of debt-financed bubbles generates extreme cross-sectional variation in financial shocks that cannot be quantitatively ignored. Sections 1.1. and 1.2. illustrate this point using the build-up and then collapse of the U.S. housing market as an example.

Second, the inability of some households to protect themselves against extreme financial shocks translates into a sharp cut in their consumer demand. These cuts amplify the initial shock by triggering job layoffs on the production side. Aggregate demand fails to equal potential output supply due to standard and well-understood frictions including wage rigidity, debt deflation and the zero lower bound. I discuss evidence for these channels in section 1.3.

1.1 Debt and Bubbles

The original sin for finance-driven recessions is often some debt-financed bubble. In the context of the recent U.S. financial crisis, I show that the collapse in U.S. house prices was preceded by (a) an expansion in the supply of credit to the U.S. and (b) an increase in house prices that was de-coupled from traditional housing fundamentals.

The increase in household leverage from 2001 to 2007 was stunning by historical comparison—household debt doubled from $7 trillion to $14 trillion. The household debt to income ratio increased by more during these six years than the previous 45 years combined! In fact, the household debt to income ratio in 2007 was higher than at any point since 1929; the previous high in 1929 did not end well either.

Why did U.S. households borrow so much and in such a short span of time? The standard economic explanation for household borrowing is the permanent income hypothesis: households borrow against higher expected income in an effort to smooth consumption. Does the permanent income hypothesis explain the rapid rise in U.S. household debt?

In Mian and Sufi (2009), we argue that the answer is no. For example, contrary to the permanent income hypothesis predictions, households with the largest increase in debt had the largest decline in income. In particular, mortgage credit growth and income growth were negatively correlated at the zip code level from 2002 to 2005, despite being positively correlated in every other time period back to 1990. Mortgage credit flowed into areas with declining incomes at a faster pace.

Instead, the increase in leverage can be explained by a relaxation in lending standards, or an expansion in securitization-driven mortgage credit supply. For example, the fraction of home purchase mortgages that were securitized by non-GSE institutions rose from 3% to almost 20% from 2002 to 2005, before collapsing completely by 2008. The non-GSE securitizations primarily targeted zip codes that had a large share of subprime borrowers. In these zip codes, mortgage denial rates dropped dramatically and debt to income ratios skyrocketed.

One consequence of the rapid increase in supply of mortgage credit was its impact on house prices. As credit became more easily available to households that were historically rationed out of the credit market, house prices began to rise. Moreover, the increase in house prices was not uniform across the U.S.; house price appreciated faster in areas that had difficult-to-build terrain, i.e. where housing supply was inelastic. While this mechanism does not explain all of the cross-sectional variation in house price growth across the U.S., it does explain a major proportion of it.[1]

The increase in house prices had a large impact on further encouraging the accumulation of debt by households. In Mian and Sufi (2011a), we focus on the feedback effect from house prices to household borrowing by analyzing individual level borrowing data on U.S. households that already owned their homes in 1997 before mortgage credit expanded. We find that existing homeowners borrowed 25 to 30 cents against the rising value of their home equity from 2002 to 2006.

The home equity-based borrowing channel is strongest for low credit quality borrowers, borrowers with high credit card utilization rate, and younger borrowers. Moreover, home-equity borrowing was not used to purchase new properties or to pay down expensive credit card balances, implying that the new debt was likely used for real outlays such as home improvement and consumption. Overall, we estimate that the home-equity based borrowing channel can explain 50% of the overall increase in debt among homeowners from 2002 to 2006.

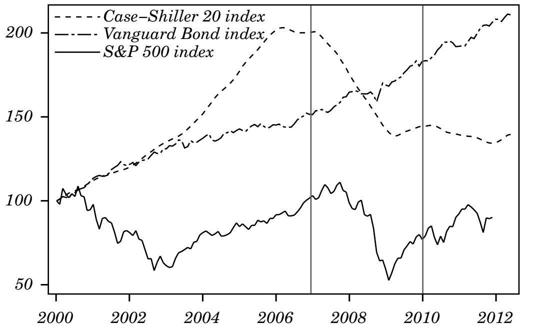
In short, the massive increase in household leverage in the U.S. in the early 2000's was not driven by permanent income shocks but rather an expansion in the supply of credit to the U.S., which was, in turn, likely driven by the search for "safe debt" by Asian markets in the aftermath of the emerging market financial crises of the late 1990s. The increase in mortgage credit supply fueled a remarkable increase in house prices that was de-coupled from its traditional housing fundamentals such as household income. U.S. homeowners—particularly those with weaker credit scores—borrowed aggressively against the rising value of their houses. Consequently, the increase of 7 trillion dollars in household debt was concentrated among low credit score homeowners in inelastic housing supply areas that experienced high house price appreciation.

1.2 The Cross-Sectional Distribution Of Net Wealth Shocks

Figure 1 shows the evolution of aggregate stock, bond and housing indices in the U.S. during recent years. While both stock and housing markets collapsed at the onset of the financial crisis, the recovery in

1. In particular, cities in Arizona and Nevada are important outliers. See Mian and Sufi (2009, 2011a) for more details.

Figure 1. Return of Stocks, Bonds and U.S. Housing



Source: FRED, St. Louis Federal Reserve.

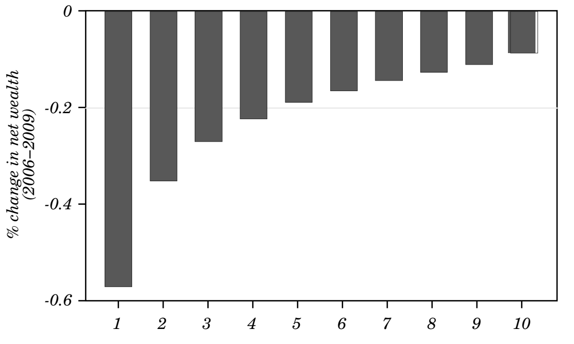
the stock market was relatively robust. The collapse in the housing market was more permanent, and hence more damaging for anyone else exposed to this particular risk. What were the net cross-sectional consequences of the movement in asset prices shown in figure 1?

Mian, Rao and Sufi (2012) answer this question by constructing household balance sheets at the zip code level. The financial shock to net wealth at the household level depends on (a) the exposure of a household to each of the three asset classes, and (b) the amount of debt on the household's balance sheet. We use household borrowing data from Equifax, house price data from Core Logic, and stock and bond holding data imputed from tax returns—all at the zip code level—to construct change in zip code level housing net wealth from 2006 to 2009.

The result in figure 2 is striking. Households that experienced the largest decline in house prices also happened to have high levels of leverage and often did not have any financial cushion through stocks and bond holdings. This resulted in a sharp redistribution of net wealth across the U.S. from 2006 to 2009.

The bottom decile of U.S. zip codes, in terms of net wealth shock, lost close to 60% of their total wealth in 2006. The top decile, on the other hand, only suffered a loss of around 10%. This heterogeneity in net wealth destruction and its geographical concentration had important consequences for the real economy in terms of consumption and employment.

Figure 2. Distribution of net Wealth Shocks at the Zip Code Level[a]



Source: Equifax.
a. Wealth is defined as the value of stocks, bonds and houses less liabilities for households at the zip code level.

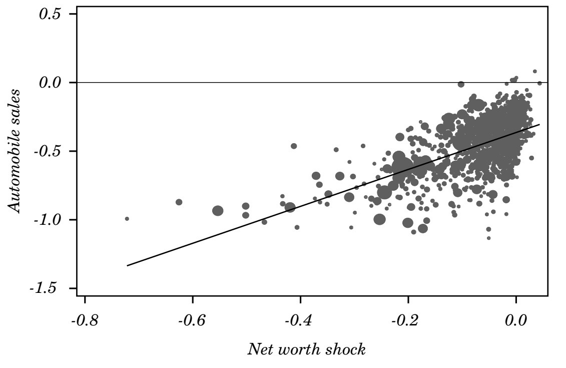
1.3 Net Wealth Shock and Real Outcomes

Figure 3 uses data from Mian, Rao and Sufi (2012) to show how consumption responded to the sharp decline in net wealth in some counties. It plots change in consumption—proxied by number of new automobiles sold—against the net wealth shock experienced by households in a county. There is a very robust pattern with households cutting back on their purchases of new automobiles a lot more if they are hit by a stronger net wealth shock. While figure 3 only shows results for automobile purchases, Mian, Rao and Sufi (2012) show that the same results hold true for broader measures of consumption as well.

The key point to take away from figure 3 is that households are unable to share financial risk. Full risk-sharing implies that idiosyncratic movements in house prices should have no impact on real consumption. Aggregate consumption might go up or down in response to various shocks, but cross-sectionally there should be no relationship between consumption change and financial shocks. The evidence in figure 3 strongly rejects the full insurance implication of typical representative agent models.

The fact that households with high exposure to housing shock and leverage cut back on their consumption, has drastic ripple effects

Figure 3. Change in Automobile Sales and Household Net Worth Changes[a]



Source: R.L. Polk.
a. Sample:2006-2009. The unit of observation is a county, and counties are weighted by their population size.

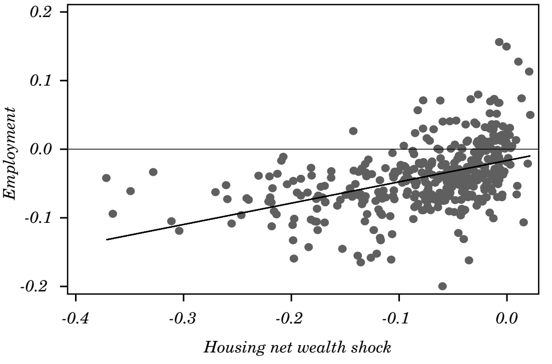
throughout the economy via employment losses. The reason is that goods consumed in one part of the country are produced throughout the U.S. and abroad. For example, if Californians sharply reduce auto purchases because of excessive leverage and house price decline, the drop in auto purchases will likely reduce employment in Michigan and Ohio where auto parts are manufactured. At the same time, the non-tradable employment would only be impacted in areas where the initial consumption decline is located.

Thus, employment losses that are driven by a reduction in consumption due to net wealth shocks have a very specific prediction: the fall in tradable employment will be uniformly spread throughout the U.S., while the fall in non-tradable employment will be localized in precisely those counties that experienced the strongest decline in consumption. Mian and Sufi (2012) test this specific prediction using county level data on tradable and non-tradable employment.

Figure 4 presents the key result. There is a strong correlation between non-tradable job losses and net wealth shock experienced by a county, while the drop in tradable employment is uniform across the counties. The magnitude of the overall drop in employment due to the initial consumption decline can be estimated using the slope of the non-tradable employment change and net wealth shock

Figure 4. Change in Employment and Household net Wealth Shock, County Level

A. Non-tradable



B. Tradable

Source: Equifax.

relationship, and assuming that a similar relationship exists for the tradable sector (except when that cannot be detected cross-sectionally for reasons stated earlier). The quantitative calculation reveals a decline of almost 4 million jobs or 65% of total jobs lost due to the demand shock (see Mian and Sufi, 2012 for details).

2. The Effectiveness of Monetary And Prudential Policies

In the event of a recession, monetary policy attempts to boost real activity by lowering nominal interest rates directly (both short term and long term via policy guidance and/or quantitative easing) and real interest rates indirectly through expected inflation. A large and impressive body of New Keynesian literature explains how monetary policy can be effective in a world with nominal rigidities. However, these models abstract away from the net wealth distributional issue discussed above.

In this section, I discuss whether or not monetary policy and related financial prudential regulations are effective when the source of real disturbances is a failure to share risk—as was the case in the 2007-2008 U.S. financial crisis. Policy can help in one of two ways. It can try to prevent the financial crisis in the first place by constraining debt (leverage) and bubbles. Alternatively, policy can react in the aftermath of a financial shock by muting any threatening real consequences.

2.1 Can Policy Makers Prevent Financial Shocks?

As discussed earlier, debt and asset bubbles are two key factors behind most financial crises. Consequently, a number of policy discussions are based on either preventing high levels of leverage through capital regulation, or coming up with ways to minimize the likelihood of asset bubbles.

Consider capital regulation that mandates a minimum capitalization ratio for financial intermediaries. Does such a requirement help prevent financial recessions? The recent U.S. experience illustrates why the answer is no. First, any attempt to impose a capital regulation creates a divide between the regulated and the unregulated (i.e. "shadow") banking systems. Since leverage is appealing for financial intermediaries, especially those interested in taking large risks, regulation increases the incentives to take intermediation towards the shadow part of the banking system. This is indeed what happened in the U.S.

Second, and more importantly, capital regulation presumes that the regulator has the ability to measure capital and risk appropriately, and also has the will to impose capital requirements when necessary. However, the ability of regulators to effectively manage capital requirements is questionable at best. Consider the practically negligible amount of capital that bank regulators allow banks to hold against the many "AAA" mortgage backed securities on the banks' balance sheets. It is apparent that the regulators have no special ability to measure the inherent risks embedded in financial assets. Regulators in Europe were equally caught off guard given the extremely low capital they allowed banks to hold against European periphery sovereign bonds.

The failure of capital requirements to discipline banks in the most recent financial crisis can be gauged from the fact that while there was significant variation in the risk-adjusted capital ratio used by bank regulators before the crisis, the capital ratio had as significant variation in the risk-adjusted capital ratio used by bank regulators before the crisis; the capital ratio had zero predictive power in explaining which banks were more likely to end up in trouble (Haldane, 2012). In fact, a simple unadjusted leverage ratio had better (i.e. positive) power for predicting which banks are more likely to end up in trouble. While regulators have shown no evidence of any ability to measure risk, their ability to impose tough capital requirements when needed is also questionable.

However, the third reason for the inadequacy of capital requirements and, in the context of the 2007-08 U.S. financial crisis, the most important, is the fact that the core problem in the most recent recession was leverage in U.S. household balance sheets. As explained in detail in section 1, it was leverage in U.S. household balance sheets coupled with the housing shock that led to the large cross-sectional shock to net wealth. Even if all the banks were perfectly well capitalized, household net wealth would have been seriously impaired in the aftermath of the housing collapse. In terms of the risk-sharing failure identified in section 1, the traditional focus on capital requirements in the banking sector does not offer much help.

2.2 Can Policy Clean Up Ex-post?

If prudential regulations are unable to limit the likelihood of financial crises ex-ante, can monetary policy ex-post help in minimizing the real consequences of crises? The evidence in section 1 shows that in order for monetary policy to be effective in limiting the real costs of financial crises, it must explicitly support households that have been most adversely impacted by the net wealth shock. I now discuss evidence in the aftermath of the U.S. financial crisis on the effectiveness of monetary policy.

2.2.1 Credit supply

An easing of monetary policy at the onset of a financial crisis may limit the damage done by the crisis by facilitating credit creation. Was this dimension of monetary policy helpful? The analysis in section I suggests that it is unlikely to be the case since the core problem was one of weak consumer demand due to impaired household balance sheets. There is significant evidence to suggest that monetary policy's role in increasing credit supply was unhelpful in the midst of the recent financial crisis.

First, despite the Fed lowering interest rates to zero, as well as quantitative easing, banks were unable to increase credit. Consequently, excess reserves held by the banking sector went from zero in 2009 to one and a half trillion dollars in 2011-2012. Banks had all the liquidity in the world and still could not find able borrowers.

Second, corporate firms were flush with cash and yet unwilling to make further investments. Kahle and Stulz (2012) show that there was no meaningful difference between bank-dependent and non bank-dependent firms in the rates of investment during the post-crisis period. In fact, bank-dependent firms were equally likely to hoard cash. The hesitancy of firms to invest, despite large cash holdings, suggests that credit supply was not the primary problem.

Finally, a large-scale survey by NFIB of firm managers shows that only about 5% of managers complained about financing problems. On the other hand, almost a third complained about poor sales or lack of demand in the midst of the recession. Both the bank and firm level evidence is consistent with the idea that weakness in consumer demand is the primary driver of recession.

2.2.2 Household credit

If the core problem is at household level, then perhaps monetary policy can help by making it easier for liquidity and credit constrained households to borrow. Is monetary policy effective in doing so in the midst of a crisis?

One of the ways through which monetary policy might favor indebted households is by lowering the carrying cost of their existing debts. In this way, lowering interest rates might act like a direct transfer in favor of debtors at the expense of creditors. This can be a useful policy given the results in section 1. Is monetary easing effective in transferring financial resources to the most indebted households?

Mian, Rao and Sufi (2012) show that the very factors that necessitate the need for a transfer from creditors to debtors also make it difficult for monetary policy to be effective. In particular, for monetary policy to be effective, one needs to lower the nominal debt burden of highly indebted homeowners. However, the same homeowners are most likely to be "under water" and hence, poor candidates for refinancing of existing mortgages.

We show that this is indeed the case. The sharp fall in mortgage interest rates as a result of monetary easing disproportionately helps prime borrowers who have significant equity in their homes. Refinancing rates are lowest for subprime borrowers with high loan to value ratios. Unfortunately, these are exactly the homeowners that are most in need of refinancing help. Thus, monetary policy is unable to work on the margins where it is most needed in the midst of a debt-overhang environment.

2.2.3 Default and bankruptcy

One direct way to help households cope with severe financial shocks is to allow them to default and clear their debt burdens. While this is clearly a mechanism that operates in the U.S., there are three main reasons why defaults are not sufficient to prevent the real costs associated with financial shocks.

First, defaults impose direct costs that add to the real burden of a financial crisis. In the case of housing debt, default leads to seizure of property and foreclosures. When the initial shock is wide in scope, as the 2007-2008 U.S. housing shock was, large-scale foreclosures are costly. Mian, Sufi and Trebbi (2011) show that foreclosures have strong negative externalities by significantly reducing the value of homes in the neighborhood of a foreclosed home. The house price effect of foreclosures also leads to a negative feedback effect on local consumption and investment.

Second, declaring default is costly from the individual perspective as well since it eliminates access to the credit markets, makes the homeowner lose his home, and may have additional emotional cost. In fact, a quarter of U.S. homeowners continue to pay back their mortgage loans despite being "under-water" on their properties. This fact suggests that the psychological and economic costs of declaring default are large enough to prevent millions of homeowners from using default to discharge their debts.

Third, the negative real effect of financial shocks start showing up well before a household is "under-water" and hence, a candidate for default. For example, a homeowner who loses most but not all of his equity in the home cannot use default to cushion the financial shock. At the same time, the financial shock will force this homeowner to cut back on his consumption, leading to the adverse real consequences mentioned earlier.

3. Policy Choices within the Risk Sharing Paradigm

Section 1 showed that the source of real shocks on the consumption and employment side is the sharp change in net wealth experienced by highly indebted households. The inability of these households to insure themselves against such financial shocks ex-ante results in a high real cost for the overall economy as exemplified by the total loss in employment due to the reduction in consumer demand.

Section 2 discussed why monetary policy is not very effective in providing financial support to the households most severely hit by the net wealth shock. To put it differently, monetary policy fails to provide adequate insurance to these households. While I have focused on the limits of monetary policy in a financial recession, I do not intend to imply that monetary policy is completely useless. Clearly given the problems associated with household net wealth shocks, a loosening of monetary policy goes in the right direction. Philippon and Midrigan (2011) also argue that the easing of monetary policy helped improve the real economy. However, the focus of this paper is on the limits faced by monetary policy in practice, and what else can be done to improve the situation.

A more direct mechanism for improving the balance sheet position of those most adversely impacted by the housing crisis would be mortgage principal write downs. This would be the most direct manner in which transfers between credit and debtors can be made. While the government did try to initiate such schemes through programs such as HAMP, these programs have been largely ineffective.

The reason is that it is not in the lenders' private interest to write down debt that continues to be serviced on time. However, as the analysis above highlights, the collective consequences of such "individually rational" actions are quite unpleasant. If a large number of financially distressed homeowners cut back on consumption in order to protect their homes and continue paying their mortgages, the aggregate demand and employment consequences hurt everyone.

Unfortunately, the current deleveraging cycle in the U.S. is painfully slow. Despite more than three years since the start of this cycle, the amount of debt paid off or written down remains stubbornly small. Out of the 7 trillion dollars accumulated over 2001-2007, only about one trillion has been paid down or written off. U.S. household balance sheets remain highly levered by historical standards. The most recent monthly auto sales data also continue to show significant weakness in consumer demand among high leverage counties.

While the focus of my discussion has been the recent U.S. economic downturn, the relationship between high household leverage and long economic slumps is not limited to our current experience. In his seminal paper, Irving Fisher (1933) described the role that high household indebtedness and the process of deleveraging played in perpetuating the Great Depression. More recent empirical work by scholars such as Mishkin (1978), Olney (1999), and Eichengreen and Mitchener (2003) further supports this view of the Great Depression. Evidence from Japanese and European recessions (e.g. King 1994) also highlights problems associated with leverage.

Our collective experience from historical recessions, as well as the most recent global slump, points to a fundamental weakness in the modern financial system, its inability to distribute downside risk equitably and efficiently across the population. The tendency to rely too much on debt-financed economic activity implies that in the event of a negative economy-wide shock, most of the financial pain is pushed on a particular segment of the population (i.e. the borrowing class). As the recent U.S. experience reminds us, pushing most of the downside risk on one segment of the population is seriously damaging for the overall economy.

Going forward, in order to avoid deep economic slumps resulting from an over-leveraged household sector, we need to put contingencies in place that will automatically write down the value of outstanding debt if the overall economic environment is sufficiently negative. I refer to such contracts as "ex-ante flexible financial contracts." Surely there are complicated legal issues pertaining to mortgage debt restructuring. Similarly, any orderly mechanism of debt restructuring should minimize unwanted disruptions in the banking and financial system. These are difficult and complex problems but not impossible to address, and require collective regulatory and legislative action.

There is a lot to think through here before implementing a particular policy. However, it is feasible to re-design debt covenants by introducing contingencies for economic downturns. For example, mortgage principal can be automatically written down if the local house price index falls beyond a certain threshold. Since such contingencies are written on aggregate states of nature, they do not suffer from the standard moral hazard criticism. Lenders will obviously price in such contingencies before extending credit, but it is a price that benefits borrowers and the economy in the long run. If we had such contingencies present in the current mortgage contracts, we could have avoided the extreme economic pain due to the negative wealth shock—aggregate demand cycle.

Flexible debt contracts would not only make the crash less severe, but they would help prevent the bubble in the first place. The reliance on debt contracts gives investors a false sense of security. Because they have a senior claim on assets, they ignore issues such as fraud or poor lending practices that may artificially boost house prices. Historical examples abound in which lenders were lulled into complacency and, therefore, fueled a bubble with loose lending practices. Flexible debt contracts would force investors to explicitly consider the downside risks to lending and therefore make bubbles less likely.

It is important to recognize that government policy currently encourages the use of inflexible debt contracts through the mortgage and business interest tax deduction. All else being equal, government policy currently subsidizes the use of debt despite the overwhelming evidence that excessive debt levels are associated with severe subsequent recessions. At a minimum, governments need to move away from a system that encourages one specific financial instrument—straight debt—at the expense of others. The evidence presented in this note suggests that there are legitimate grounds for governments to do the opposite, i.e. subsidize more flexible financial contracts at the expense of traditional debt instrument.

There are obvious questions associated with such an idea. For example, why do such flexible mortgages not already exist? Is there a role of the government or the Federal Reserve to encourage their use? These are great questions, and there is a lot to investigate here. My primary goal on this note is to point out the direction in which I believe we need to go. A number of details need to be spelled out, but it is clear—given the evidence—that we need to have better designed financial instruments to deal with economy-wide fluctuations in asset prices and expectations. The hope is that we move in that general direction.

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Jobless Recoveries during Financial Crises: Is Inflation the Way Out?

Guillermo Calvo
Columbia University

Fabrizio Coricelli
Paris School of Economics

Pablo Ottonello
Columbia University

The slow rate of employment growth relative to that of output is a sticking point in the recovery from the financial crisis episode that started in 2008 in the U.S. and Europe (a phenomenon labeled "jobless recovery"). The issue is a particularly burning one in Europe where some observers claim that problem economies (like Greece, Italy, Ireland, Spain, and Portugal) would be better off abandoning the euro and gaining competitiveness through steep devaluation. This would be a momentous decision for Europe and the rest of the world because, among other things, it may set off an era of competitive devaluation and tariff war. Thus, these topics require prompt attention.

In Calvo, Coricelli, and Ottonello (2012), we show that jobless recoveries have been a salient feature of financial crises in advanced economies since World War II. Once output per capita recovers its trend, the increase in unemployment from output peak to recovery tends to be higher during financial crises than in other recession episodes. This is consistent with findings in previous empirical literature that have documented the effect of financial crises on

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unemployment (see, for example, Knotek and Terry, 2009; Reinhart and Reinhart, 2010; Bernal-Verdugo, Furceri, and Guillaume, 2012; and Chodorow-Reich, 2013). However, jobless recoveries are not, in general, observed in high-inflation episodes. In particular, in Calvo, Coricelli, and Ottonello (2012), we show that in Emerging Market (EM) financial crisis episodes in which the annual rate of inflation exceeds 30 percent, when output recovers its trend level, the rate of unemployment returns to its pre-crisis level, but real wages are 13 percent below their pre-crisis level—a phenomenon that we label "wageless recovery." Thus, inflation is no panacea for the labor market, and evidence supports the view that the labor market is highly vulnerable to financial crisis through high unemployment and/or low wages. Moreover, the fact that inflation helps to reduce the rate of unemployment suggests that the two sets of cases identified in our previous study are partly a result of *nominal wage rigidity* (see Schmitt-Grohé and Uribe, 2011; 2013b). If this is the case, currency devaluation, insofar as it generates inflation, may help to speed up the return to full employment in Europe (as argued in Friedman, 1953), but wage earners are likely to bear the brunt of the adjustment.

The objective of this paper is twofold: (1) to exhibit case studies for individual countries that illustrate econometric results in Calvo, Coricelli, and Ottonello (2012), and (2) to discuss policies related to jobless recovery in the current financial crisis in the U.S. and Europe: inflation, real currency depreciation, and credit-recovery policies.

First, case studies are developed for Sweden and Argentina. We look at two crisis episodes for each country. In the case of Sweden, we examine the 1990-1993 and the 2008-2009 recessions. Identifying the financial component of each crisis with a methodology similar to that developed in Calvo, Izquierdo, and Mejia (2008), we show that only the crisis of 1990-1993—one of the widely studied "Big Five" banking crises—experienced a *domestic credit sudden stop* (i.e. a sudden and large contraction in domestic bank credit flows). Although the 2008-2009 recession happened during a worldwide financial crisis, evidence suggests that recession came through a contraction in exports due to a fall in demand from the E.U. rather than a shock stemming from the financial market. Inflation was relatively low in both episodes (below 10 percent annual rate) and, thus, putting them side-by-side allows us to compare a financial with a non-financial crisis for the same economy under low inflation. Results illustrate the econometric evidence in Calvo, Coricelli, and Ottonello (2012): joblessness is substantially larger during the financial crisis (i.e., the 1990-93 episode).

For Argentina, we select the 1995 and the 1998-2002 crises. Both episodes can be classified as financial crises. However, the 1998-2002 episode exhibits a much higher rate of inflation than the threshold considered in our previous study (30 percent), while in the 1995 crisis, inflation remained well below the threshold. In line with Calvo, Coricelli, and Ottonello (2012), the 1995 episode displays a sharp and persistent increase in the rate of unemployment in contrast with the 1998-2002 episode in which unemployment recovers *pari passu* with output (despite the record-setting output contraction from peak to trough, comparable to that in the U.S. Great Depression). However, when output recovers its pre-crisis level, wages remain 16 percent below their pre-crisis level.

Second, we discuss three policy tools to speed up employment recovery during financial crises: inflation, real currency depreciation, and credit-recovery policies. Being relatively rare phenomena in advanced economies, the resulting dearth of data makes policies in financial crises difficult to characterize. An option is to use the experience of (not so rare) EM financial crisis events as a laboratory to discuss policy options. This is the methodology we follow in this paper. Thus, the discussion of policies will be based on an empirical analysis that extends the one in Calvo, Coricelli, and Ottonello (2012), focusing on 55 financial crisis episodes in EMs.

We begin by digging more deeply into the relationship between inflation and jobless recovery, also considering the possible role of real currency depreciation and resource reallocation (between tradables and non-tradables). This discussion is particularly relevant for countries that, being in the Eurozone, cannot follow a nominal currency depreciation policy to mitigate high unemployment rates (e.g. Greece, Italy, Ireland, Spain, and Portugal). We show some evidence suggesting that large inflationary spikes (not a higher inflation plateau) help employment recovery. Even in high-inflation episodes, inflation typically returns to its pre-crisis levels, which is consistent with a vertical Phillips curve. Another finding is that (independent of inflation) financial crises are associated with real currency depreciation (i.e., the rise in the real exchange rate) from output peak to recovery. This shows that the relative price of non-tradables fails to recover along with output even if the real wage does not fall, as is the case in low-inflation financial crisis episodes. This implies that, contrary to widespread views, nominal currency depreciation may eliminate joblessness only if it generates enough inflation to create a contraction in real wages; real currency depreciation or sector reallocation might not be sufficient to avoid jobless recovery if all sectors are subject to binding credit constraints that put labor at a disadvantage with respect to capital. Similarly, for countries with fixed exchange rates, "internal" or fiscal devaluations during financial crises are likely to work more through reductions in labor costs than changes in relative prices and sectoral reallocation obtained through taxes and subsidies affecting differentially tradable and non-tradable sectors.[1]

However, neither nominal nor real wage flexibility can avoid the adverse effects of financial crises on labor markets, as wage flexibility determines the distribution of the burden of the adjustment between employment and real wages, but does not relieve the burden from wage earners. Our findings highlight the difficulty in simultaneously preventing jobless and wageless recoveries, and suggest that the first line of action should be an attempt to relax credit constraints. We discuss both a theoretical framework and empirical evidence that help to make this case.

Finally, we argue that an effective way to prevent jobless recoveries in EMs may be to accumulate international reserves during booms, which can be used to provide credit to firms during financial crises.

1. Two Case Studies: Sweden and Argentina

1.1 Sweden: Financial Crises and Jobless Recovery

In the early 1990s, Sweden experienced one of the largest "Big Five" banking crises in the post-war history of developed economies. The Swedish banking crisis has been extensively studied (see, for example, Englund, 1999; Reinhart and Rogoff, 2008). Moreover, this episode has been frequently cited in literature to illustrate the effect of banking crises on unemployment (see, for example, Knotek and Terry, 2009; Talvi, Munyo, and Perez, 2012).

Our aim is to identify the effect of the financial component of the crisis on the labor market by comparing the outcomes of the Swedish banking crisis of the early 1990s with those of another recession episode in Sweden, similarly deep, but whose nature has not been financial: the recession that started in 2008 in the context of the European economic crisis.

1. Fahri, Gopinath, and Itskhoki (2012) and Schmitt-Grohé and Uribe (2011) show that fiscal instruments can replicate the real effects of nominal devaluations and discuss this route for European countries as a way to exit their recession ensuing from the recent global financial crisis.

Figure 1 (panel A) depicts the behavior of output per capita in the two recession episodes. Both episodes displayed a large and similar contraction of economic activity: during the banking crisis of the early 1990s, output per capita from peak to trough dropped by 7.7 percent, while in the crisis that started in 2008, output per capita contracted from peak to trough by 8.6 percent. The duration of both episodes is also comparable: 25 quarters from peak to output recovery point in the banking crisis of the early 1990s, and 19 quarters in the 2008 recession. Measured by the year-on-year change in producer price index, inflation in both episodes was relatively low: the maximum level of inflation during the crisis of 1991-1993 and the crisis of 2008-2009 was 8.6 percent and 6.9 percent, respectively.

While both crises are comparable in terms of economic activity and inflation, the financial aspect of these recession episodes is remarkably different. In the early 1990s, Sweden went through a severe real estate crisis. Real estate prices dropped by more than 50 percent in 1991-1992, affecting major banks heavily exposed to the real estate market. A systemic banking crisis followed. During the recession of 2008-2009, in turn, the picture looks significantly different. In spite of the sharp drop in output, the financial sector was resilient, and credit conditions remained relatively favorable for firms and households. Short-term interest rates were markedly reduced after 2008, and the spread between Swedish and German long-term interest rates remained stable and close to zero throughout the recession episode.

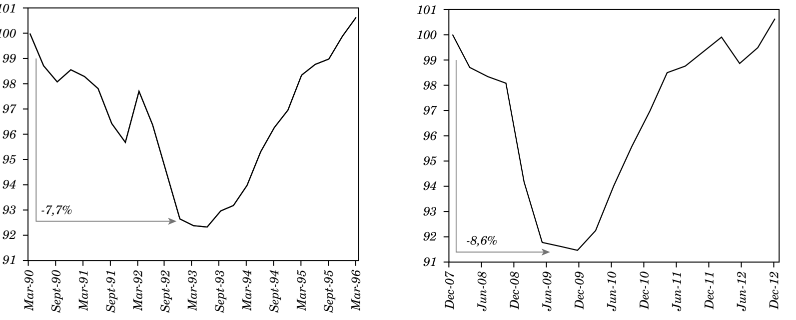
To more formally identify the financial nature of the two recession episodes, we determine whether, in each episode, the economy experienced a sudden and large contraction in domestic bank credit flows (i.e. a *Domestic Credit Sudden Stop*)[2] using an empirical methodology similar to that developed in Calvo, Izquierdo, and Mejia (2008), detailed in appendix A. Results are portrayed in figure 2 (panel A). We can see that, in the last 30 years, Sweden experienced two domestic sudden stops, both during the banking crisis of the early 1990s. During the 2008 recession episode, Sweden experienced a deceleration in bank credit growth but not a domestic sudden stop. This empirical evidence supports the view that, of the two recession episodes we are studying for Sweden, only the banking crisis of the early 1990s constitutes a financial crisis episode. Finally, figure 1 (panel B) displays the behavior of real credit stock to the private

2. The concept of a (External) Sudden Stop was originally developed to describe a sudden and large contraction in *external* credit flows (see Calvo, 1998).

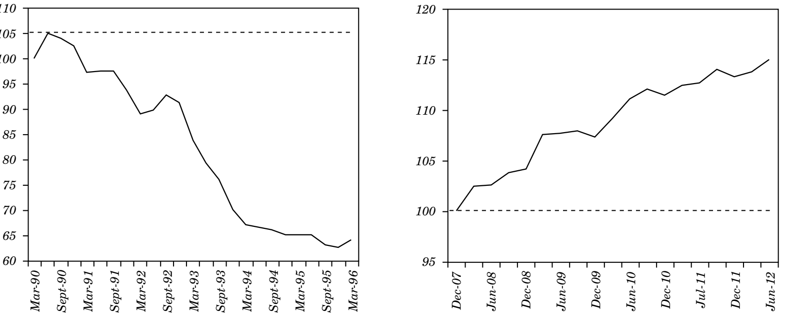
Figure 1. Sweden: Financial Crisis and Jobless Recovery

Crisis of 1991-1993 *Crisis of 2008-2009*

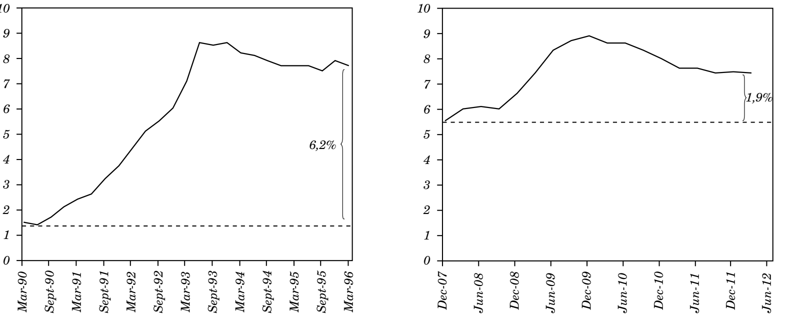
A. Output
(GDP per capita, in real terms)



B. Bank credit
(Bank credit to de private sector, per capita stock, in real terms)



C. Unemployment
(Rate, percent)



Source: Author's elaboration.
Data for GDP and unemployment rate was obtained from OECD; data for population was obtained from WDI; data for bank credit to the private sector and the CPI was obtained from the IMF. Real bank credit data was constructed using the CPI.

sector during both episodes. We can see that, during the banking crisis of the early 1990s, real bank credit stock contracted by 35 percent while it continued increasing throughout the 2008 episode.

The behavior of unemployment is depicted in figure 1 (panel C). It can be seen that the financial crisis of the early 1990s was associated with a much larger jobless recovery than the 2008 recession. In particular, during the financial crisis of the early 1990s, when output per capita recovers its pre-crisis level, unemployment is still 6 percentage points above its pre-crisis level, compared to only 1.9 percentage points during the 2008 recession. This illustrates the finding in Calvo, Coricelli, and Ottonello (2012) that financial crisis episodes are associated with a larger jobless recovery than non-financial recession episodes.

1.2 Argentina: High Inflation and Wageless Recovery

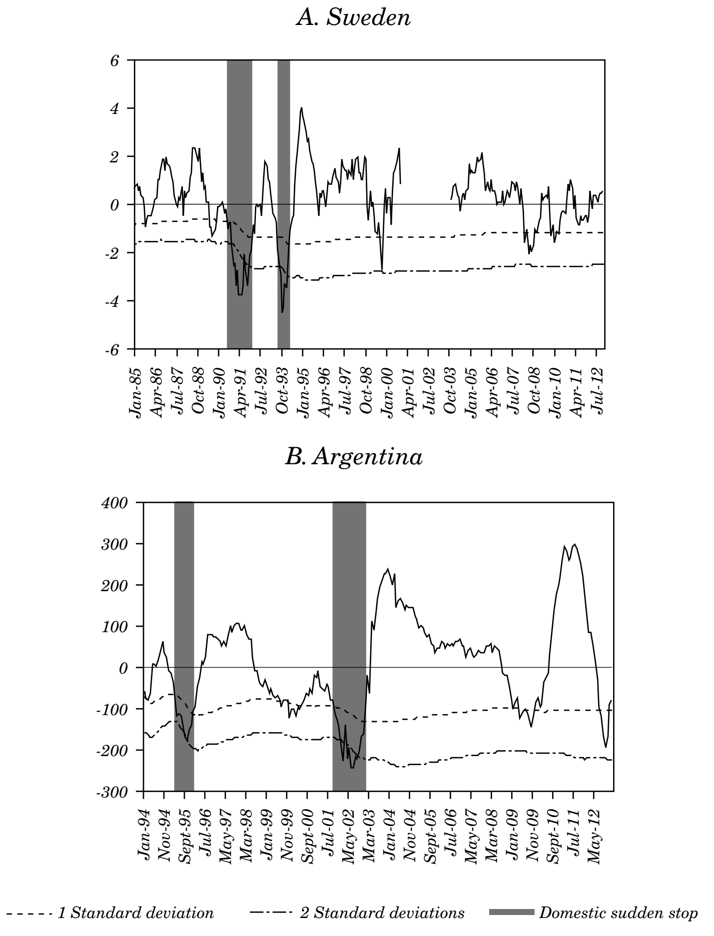
During the 1990s Argentina experienced two recession episodes. The first started in 1994 and was triggered by the "Tequila crisis"; the second started in 1998 and was initially associated with the East Asian and Russian crises. As shown in figure 2 (panel B), Argentina experienced a domestic sudden stop during both episodes (see appendix A for details). Thus, using this methodology, both recession episodes could be classified as financial crises. Other methodologies such as Calvo, Izquierdo, and Talvi (2006) and Reinhart and Rogoff (2009) reach the same conclusion.

The crisis of 1998-2002 was the most severe in terms of both financial and real outcomes. Between 1998 and 2002, output per capita fell 23.7 percent from peak to trough, a much larger fall than the 6.5 percent peak-to-trough output per capita contraction between 1994 and 1995 (figure 3, panel A). However, analyzing the behavior of unemployment, a striking fact emerges: while the 1994-1995 crisis shows a significant jobless recovery (when output per capita recovers its pre-crisis level, unemployment is still 4 percentage points above its pre-crisis level), the 1998-2002 crisis displays no trace of jobless recovery at all (when output per capita recovers its pre-crisis level, unemployment also recovers its pre-crisis level, as seen in figure 3, panel B).

A key difference between these episodes is inflation (figure 3, panel C).[3] During the crisis of 1994-1995 Argentina was in a currency peg, and the maximum level of inflation was 5.5 percent per annum.

3. We measure inflation in each quarter with the year-on-year change of the producer price index.

Figure 2. Domestic Sudden Stops in Sweden and Argentina
(Bank credit flows to the private sector, real year-on-year change)



Source: Author's elaboration.
Real bank credit data was constructed using the CPI. Data for bank credit to the private sector and the CPI was obtained from the IMF.

During the 1998-2002 crisis, Argentina abandoned the currency peg, and inflation reached 123 percent per annum.[4]

4. Schmitt-Grohé and Uribe (2011) also provide evidence for the role of devaluation on unemployment and real wages in the Argentinean 2001-2002 episode.

Inflation, however, cannot fully erase the trace of financial crises on the labor market. Figure 3 (panel D) shows the behavior of real wages. It can be seen that the crisis of 1998-2002 displays a significant “wageless” recovery: when output per capita recovers its pre-crisis level, real wages are still 16.4 percent below their pre-crisis level.

The case of Argentina illustrates the second lesson from our case studies: during financial crises, inflation seems to be able to eliminate jobless recoveries but at the expense of a substantially lower real wage, as shown in Calvo, Coricelli, and Ottonello (2012).

Figure 3. Argentina: Financial Crises, Inflation, Jobless and Wageless Recovery[a]

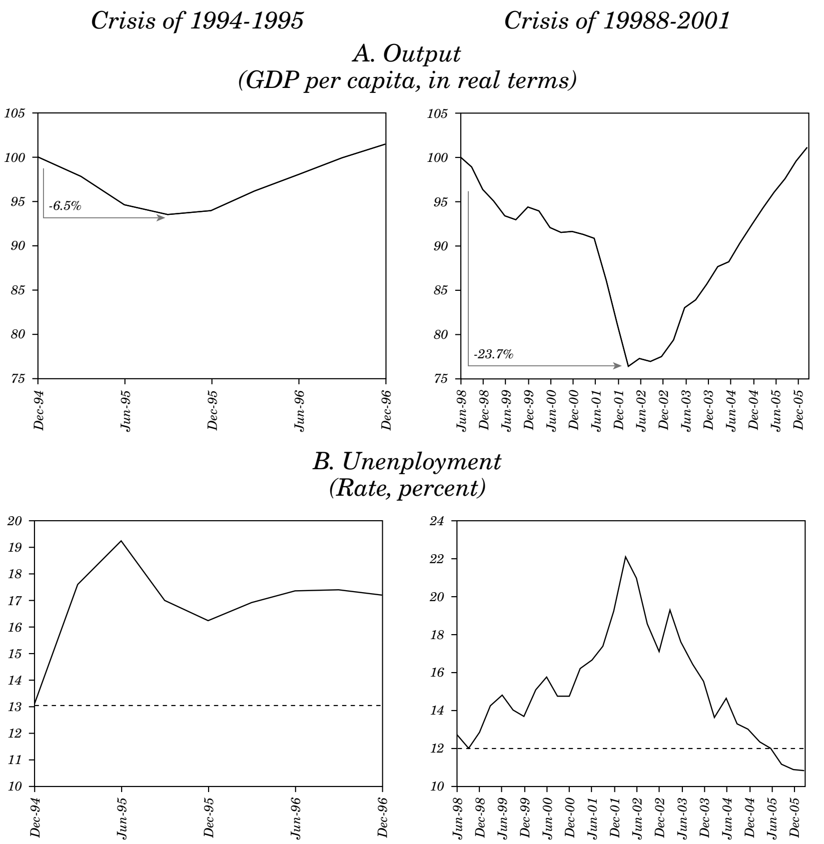
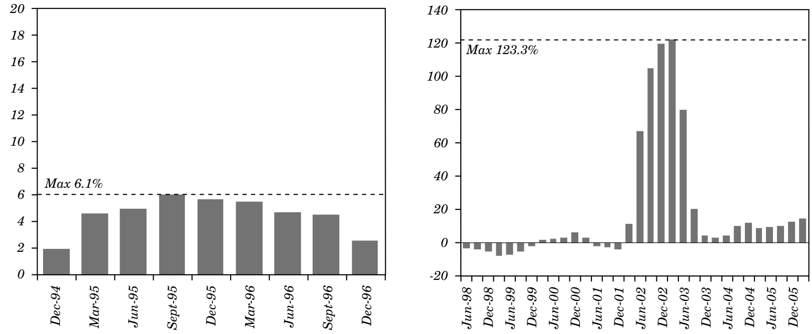


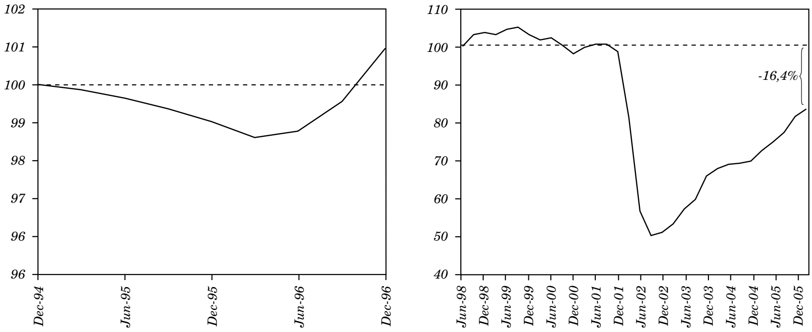
Figure 3. (continued)

Crisis of 1994-1995 *Crisis of 19988-2001*

C. Inflation
(PPI, percentage change)



D. Real wage
(Peak=100)



Source: Author's elaboration.
Data for GDP, PPI, and unemployment rate was obtained from INDEC (Instituto Nacional de Estadística y Censos, Argentina); data for nominal wages was obtained from ECLAC; data for population was obtained from WDI. In periods in which data for unemployment, wages, and population were not available at quarterly frequency, interpolation methods based on semi-annual or annual data were used to illustrate the quarterly behavior of the series.

2. Policy Discussion

This section discusses policies to mitigate jobless recoveries during financial crises. We conduct an empirical study to investigate the role of inflation, real currency depreciation, and credit policies on jobless recoveries during financial crises. We begin this section by describing the data that we use in the empirical analysis.

2.1 Data

2.1.1 Sample construction

The main objective of the empirical analysis is to test how inflation, real exchange rate, sector allocation, and credit are related to unemployment and wage recovery during financial crises. To this end, we build a sample of financial crises in EMs and define an output peak and a recovery point for each recession episode.

We use the sample of recession episodes since 1980 identified in Calvo, Izquierdo, and Talvi (2006) using annual data for financially integrated EMs.[5] In this sample, the occurrence of a recession episode is identified as a period of negative change in GDP.

As in Calvo, Coricelli, and Ottonello (2012), we define the output peak and recovery point using the cyclical component of output per capita for each recession episode.[6] In particular, given a recession episode, we define a pre-crisis peak as the period displaying the maximum cyclical component of output per capita in the window with a positive cyclical component of output per capita preceding the recession episode. The recovery point is defined as the period after the output trough in which output per capita recovers its trend level. The output trough is defined as the period between output peak and recovery point displaying the minimum level of cyclical component of output per capita. The cyclical component of output was computed using the HP filter. Data on output and population are obtained from OECD, WEO, and WDI datasets. With this methodology, we identify 71 recession episodes in EMs.

5. Countries included in the sample are Argentina, Brazil, Bulgaria, Chile, Colombia, Croatia, Czech Republic, Dominican Republic, Ecuador, El Salvador, Hungary, Indonesia, Ivory Coast, Lebanon, Malaysia, Mexico, Morocco, Nigeria, Panama, Peru, Philippines, Poland, Russia, South Africa, South Korea, Thailand, Tunisia, Turkey, Ukraine, Uruguay, and Venezuela. Since we are interested in analyzing unemployment recovery in market economies during the crisis, we excluded two types of episodes from this sample. First, those associated with the collapse of the Soviet Union (in particular, the recession episodes that started prior to 1991 in Bulgaria, Czech Republic, Croatia, Hungary, Poland, Russia and Ukraine). Second, episodes in which output per capita did not fully recover its trend level before the occurrence of another recession episode.

6. As discussed in Calvo, Coricelli, and Ottonello (2012), defining the recovery point of output per capita in terms of its trend level is relevant to ensure that differences among episodes are not driven by different recoveries to trend as argued in Ball, Leigh, and Loungani (2013). Dating recession episodes with the *level* of output per capita (i.e. defining the recovery point as the point in which output recovers its pre-crisis level), similar results are obtained.

From this set of recession episodes, we focus on financial crises. As in Calvo, Coricelli, and Ottonello (2012), we define a *financial crisis* as a recession episode in which a banking crisis event or a debt default or rescheduling event occurs in a window of one year before the output per capita peak, and one year after the output per capita recovery point. Data on banking crises, debt default and rescheduling events are obtained from Reinhart and Rogoff (2009). This methodology yields a sample of 55 episodes of financial crises in EMs, detailed in appendix B (table B.1).

2.1.2 Definition of variables

All variables are defined using annual data. We measure jobless and wageless recovery as in Calvo, Coricelli, and Ottonello (2012) and compute, for each episode, the change in the unemployment rate and the log change in real wages between output peak and output recovery points (denoted $\Delta_{PR}u$ and $\Delta_{PR}w$, respectively). The data on unemployment and wages are obtained from WEO, ILO, ECLA, Trading Economics datasets, and national sources. Nominal wages are deflated by the producer price index obtained from the IMF dataset and national sources.[7]

With these two variables we construct a proxy for the change of the real wage bill per capita, denoted by $\Delta_{PR}wl$. With $\Delta_{PR}l$ denoting the log change of employment rate, the change of the wage bill per capita is defined as $\Delta_{PR}wl = \Delta_{PR}w + \Delta_{PR}l$. [8]

We follow a similar strategy to measure real exchange rate depreciation and resource reallocation. For each episode, we compute the log change of the real exchange rate, the log change in the share of tradables in production, and the log change in the share of exports in production between output peak and output recovery point (denoted by $\Delta_{PR}rxr$, $\Delta_{PR}ty$ and $\Delta_{PR}xy$ respectively). The real exchange rate (*RXR*) is defined as the ratio of U.S. and domestic prices, both expressed in domestic currency (i.e. $RXR = (EP^*/P)$, where E denotes the nominal exchange rate, P^* denotes U.S. CPI, and P denotes domestic CPI). We define the tradable output as the sum of value added in agriculture and manufacturing, as is typically done

7. For countries in which producer price index is not available we use the wholesale price index or the consumer price index.

8. Due to data availability, we proxy the log change of employment rate using unemployment data, i.e.

$\Delta_{PR}l = log\ (1-u_R/1-u_P)$

in the literature. We compute the share of tradables in production as the ratio between tradable output and GDP, and the share of exports in production as the ratio between exports of goods and services and GDP, based on national account statistics. Both ratios are computed with data at constant prices. Data for the real exchange rate and the share of tradables and exports in production are obtained from WEO and WDI datasets.

For each episode, we compute the year-on-year inflation rate at the output peak (π_P), at the output trough (π_T) and at the output recovery point (π_R); and the maximum level of inflation for the entire episode ($\pi_{\max}$). Following Calvo, Coricelli, and Ottonello (2012), we define a high (low) inflation episode as one in which the maximum level of inflation is above (below) the 30 percent annual rate. This threshold is the upper bound considered in Dornbusch and Fischer (1993) to define moderate inflations, and the cutoff above which Calvo and Reinhart (2002) define high inflations. With this classification, we construct a dummy variable that takes the value of 1 if the episode displays high inflation and zero otherwise (denoted $high\_\pi_{\max,i}$). It is also useful to distinguish episodes of hyperinflation. We consider a hyperinflation episode as one in which the annual inflation rate is above 200 percent. This classification leads us to identify eight hyperinflation episodes in line with those studied in the literature (see for example, Hanke and Krus, 2013; Sargent, Williams, and Zha, 2009).[9] We compute inflation using the producer price index (wholesale price index or the consumer price index when not available) obtained from the IMF dataset and national sources.

We construct a variable to measure credit recovery during a recession episode (denoted by $\Delta_{PR} credit$). Based on the findings in Calvo, Izquierdo, and Talvi (2006), we use the change in the cyclical component of real credit per capita from output peak to full recovery point ($\Delta_{PR} credit\_c$).[10] The cyclical component of credit was computed using the HP filter. Data on credit was obtained from IFS dataset and from national sources.

9. In particular the hyperinflation episodes are Argentina 1980, 1984, and 1987; Bulgaria 1995; Brazil 1980, 1987 and 1991; and Peru 1987 (dates refer to output peak of the episode).

10. In the recession episodes in which a financial crisis episode occurs prior to or at the output peak, we consider the maximum level in the cyclical component of real credit per capita between the beginning of the financial crisis and the output peak instead of the cyclical component of real credit per capita at the output peak. Otherwise, when a financial crisis starts before the recession episode, considering the level of credit at the output peak is considering a level of credit already affected by the financial crisis episode.

Finally, the empirical analysis includes two sets of controls. The first are labor market controls (denoted by $labor\_mkt_P$, computed at the output peak. As emphasized in the labor market literature, labor market institutions are likely to affect the response of unemployment to shocks, including the recovery of unemployment following recession episodes (see Blanchard, 2006; Bertola, Blau, and Kahn, 2007; Furceri and Mourougane, 2009; Bernal-Verdugo, Furceri, and Guillaume, 2012). In particular, we use two variables: an indicator of labor market legislation ($lamrig_P$) from the recent dataset on labor market regulations constructed by Campos and Nugent (2012); and the natural rate of unemployment ($natural\_u_P$), computed as the average rate of unemployment in the whole sample period. Second, we control for the secular growth experienced throughout the recession episode, denoted by gd. With g denoting the annual secular growth rate of a given country and d the duration of a recession episode, the secular growth experienced throughout the recession episode is defined as $gd = g \times d$. The secular growth rate for a given country is computed as the average per capita growth rate between 1980 and 2007. The duration of the recession episode is defined as the number of years from output peak to recovery point. Controlling for this variable is relevant since countries can have different long-run growth rates, and recession episodes might differ in their duration, which can affect jobless and wageless recoveries. For instance, in a neoclassical growth model, higher technological progress would lead to a higher growth of real wages.

2.2 Inflation and Labor Market Recovery from Financial Crises

Empirical evidence in Calvo, Coricelli, and Ottonello (2012) suggests that high inflation (defined as annual inflation above 30 percent) may help to lower the rate of unemployment in the context of financial crises. This is illustrated in our sample of EM financial crises in figure 4 (panels A and B): low-inflation episodes display jobless recovery, with real wages similar to pre-crisis levels; high-inflation episodes display no jobless recovery, but a significant wageless recovery.

To formally test this stylized fact, we estimate a model relating jobless and wageless recoveries to high inflation, controlling for labor market characteristics and secular growth:

$$\Delta_{PR} z_i = \alpha + \beta\, high\_\pi_{\max,i} + X'_i \gamma_i + \epsilon_i, \tag{1}$$

where $\Delta_{PR}z_i$ denotes the jobless recovery measure ($\Delta_{PR}u_i$) or wageless recovery measure ($\Delta_{PR}w_i$) in financial crisis episode i, X_i is a vector of controls including labor market controls ($labor\_mkt_{P,i}$) and secular growth (gd_i), and $\in_i$ is a random error term (variables are defined in section 2.1). The coefficient of interest is β the difference in jobless recovery or wageless recovery displayed by high-inflation episodes relative to low-inflation episodes.

Results from OLS estimates are presented in table A1 and confirm the findings in Calvo, Coricelli, and Ottonello (2012): high-inflation episodes tend to display less unemployment and lower real wages at output recovery point than low-inflation episodes. Estimated coefficients are statistically significant at the five or ten percent level, and economically relevant: high-inflation episodes tend to display 2 percent less increase in the unemployment rate from output peak to recovery than low-inflation episodes; and from output peak to recovery point real wages in high-inflation episodes tend to decrease 15 percent more than low-inflation episodes. Appendix C (table C.2) shows that these results are robust to the inclusion of additional recession and country controls.

The threshold we have considered so far to define a high-inflation episode (above 30 percent) is similar to that used in previous literature (Dornbusch and Fischer, 1993; Calvo and Reinhart, 2002). To study this threshold more formally, we conduct threshold estimation, following Hansen (2000), to identify a level of inflation from which financial crisis episodes have a different degree of jobless recovery. Results confirm the presence of a threshold around 30 percent (point estimate of 31.7 percent). The estimation procedure and results are detailed in appendix D.

Having established a link between high inflation and unemployment recovery, we now use the sample of EM financial crises to study the dynamic pattern displayed by inflation, which is especially relevant from a policy perspective. As shown in figure 4 (panel C) in the typical financial crisis episode, inflation spikes up between output peak and trough, and returns to its pre-crisis level once output recovers its trend level, not resulting in permanently higher inflation. Since inflation returns to its pre-crisis level even in high-inflation episodes (excluding hyperinflation episodes, section 2.1), seems to suggest that a *transitory* hike in the rate of inflation can have an effect on unemployment recovery.

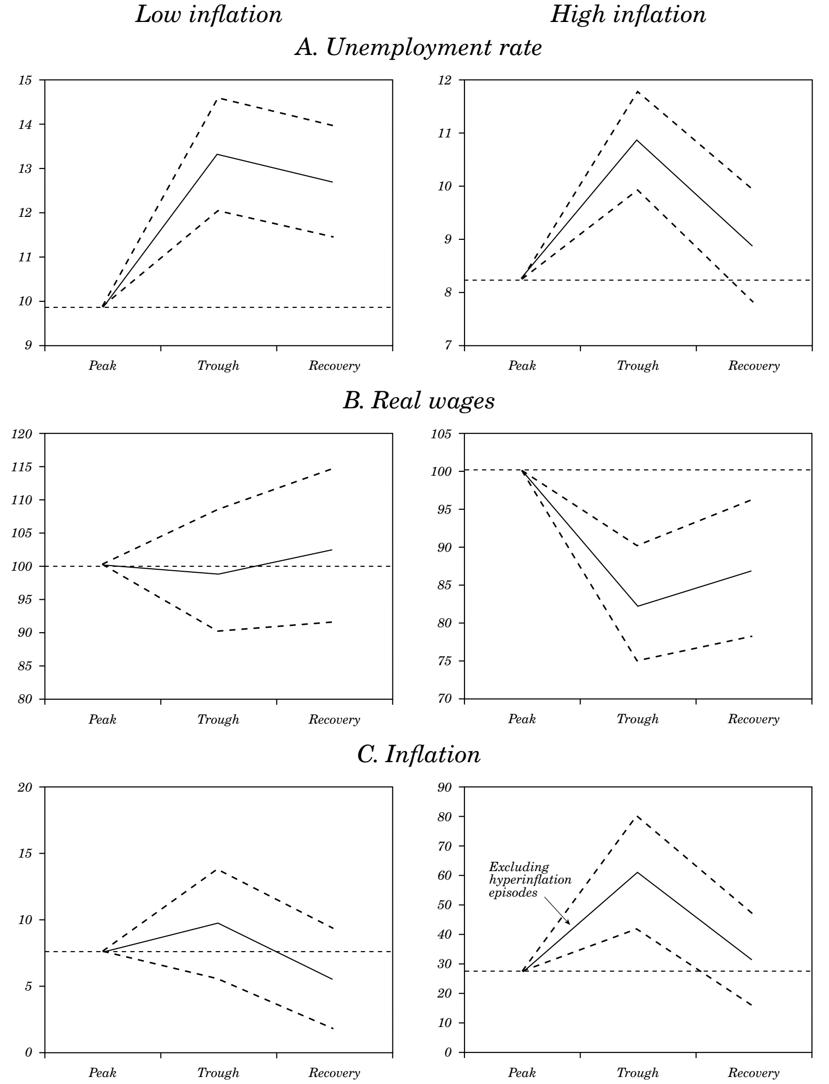
To provide further evidence on this issue we estimate model (1) —relating high inflation to jobless and wageless recovery—but instead of classifying high-inflation episodes based on the maximum level of inflation experienced during the episode, we classify high-inflation episodes based on inflation experienced at the output peak and at the output recovery point. In particular, we construct a dummy variable that takes the value of 1 if the episode displays high inflation (above 30 percent) at the output peak, and zero otherwise (denoted $high\_\pi_{P,i}$); and a dummy variable that takes the value of 1 if the episode displays high inflation (above 30 percent) at the output trough, and zero otherwise (denoted $high\_\pi_{R,i}$).

Results from OLS estimates are presented in table A.2. Neither high inflation at the output peak nor high inflation at the recovery point displays a statistically significant relationship with jobless or wageless recovery, suggesting that having high inflation when the financial crisis episode starts, or maintaining high inflation levels once output has recovered its trend, might not be necessary to fight jobless recovery. Thus, what seems to be needed to speed up employment during the recovery of financial crises is more a relative price adjustment (a fall in the real wage) than a permanent increase in the inflation rate.

To sum up, the good news for central banks is, first, that having inflation levels at the output peak or recovery points does not seem to impinge on jobless recoveries; and, second, that in the typical high-inflation episode, inflation does return to its pre-crisis low-inflation level (figure 4, panel C). The bad news is that the level of inflation that seems to be needed to mitigate a jobless recovery is not trivial (above 30 percent), and is above what most central banks would be willing to accept.

Since the threshold identified (30 percent) is relatively high, a relevant question for policy design is whether or not there is any *linear* type of relationship that can also be established empirically between the inflation experienced in the episode (level or change) and unemployment recovery. If this is the case, countries could choose only a moderate increase in inflation and still expect to have an effect on jobless recovery. Appendix E shows that there does not seem to be strong evidence supporting the statistical significance of a relationship of this type. Evidence suggests that, on one hand, a small increase in inflation might not be of any help to fight jobless recoveries. On the other hand, a very large increase in inflation appears to be overkill, which is consistent with the existence of a long-run vertical Phillips curve around the pre-crisis rate of unemployment. Thus, the relationship between jobless recovery and inflation is far from simple. Part of this complexity is probably associated with wage setting. We leave this issue for future research.

Figure 4. Inflation and Labor Market Recovery from Financial Crises in EMs



Source: Author's elaboration.

Slashed lines depict 95 percent confidence intervals for the change in unemployment and inflation, and for the log change in real wages (sample and variables defined in section 2.1). Peak, trough, and recovery point are defined using the cyclical component of output per capita, as defined in section 2.1. Low-inflation (high-inflation) episodes are episodes in which the maximum level of annual inflation rate is below (above) 30 percent. Hyperinflation episodes are eight episodes of the sample that display a maximum level of annual inflation greater than 200 percent (Argentina, 1980, 1984, and 1987; Bulgaria, 1995; Brazil, 1980, 1987 and 1991; Peru, 1987 (see section 2.1)).

2.3 Real Exchange Rates, Inflation and Labor Market Recovery from Financial Crises

During financial crises, it is common for EMs to achieve high levels of inflation by depreciating the nominal currency, as illustrated by the case of Argentina in section 1. From a policy perspective, a key issue to study is whether the relationship between high inflation and jobless recovery is driven by currency depreciation. In other words, to what extent does the transmission mechanism from inflation to higher employment rely on real currency depreciation and resource reallocation from non-tradable to tradable sectors?

To shed light on this question, we begin by analyzing the behavior of the real exchange rate and sector reallocation in our sample of EM financial crises, comparing low-inflation episodes and high-inflation episodes (for definition of sample variables see section 2.1). Figure 5 (panel A) shows that from *output peak to trough,* high-inflation episodes display larger real currency depreciation and sector reallocation than low-inflation episodes. This is easy to understand given the fact that, during an inflationary spike, the nominal exchange rate typically adjusts faster than goods prices due to price stickiness.

However, if real depreciation were the main factor behind the negative relationship between inflation and unemployment, one would expect that high-inflation episodes display higher real currency depreciation and resource reallocation, from *output peak to recovery*, than low-inflation episodes. As depicted in figure 5, this is shown not to be the case: both low-inflation episodes and high-inflation episodes display similar levels of real currency depreciation from output peak to recovery point; consistent with this, from output peak to recovery, both high-inflation episodes and low-inflation episodes display a similar change in the share of exports in production and the share of tradables in production.

To formally test these hypotheses, we estimate a model relating changes in the real exchange rate and resource reallocation to high inflation, controlling for labor market characteristics and secular growth:

$$\Delta_{P_T} q_i = \alpha + \beta\, high\_\pi_{\max,i} + X'_i \gamma_i + \in_i, \tag{2}$$

where $\Delta_{P_T} q_i$ denotes the log change in the real exchange rate ($\Delta_{P_T} rxr_i$) or the measures of resource reallocation ($\Delta_{P_T} rxr_i$ or $\Delta_{P_T} xy_i$)

in financial crisis episode i, τ denotes output trough ($\tau = T$) or output recovery point ($\tau = R$), X_i is a vector of controls including labor market controls ($labor\_mkt_{P,i}$) and secular growth ($gd_{\ i}$), and $\in_i$ is a random error term (variables are defined in section 2.1). This model is similar to the one in equation (1) but uses real exchange rate depreciation and resource reallocation instead of labor market outcomes as dependent variables.

Results from OLS estimates are presented in tables 3A and 3B and confirm the above conclusions from the graphical analysis. Columns 1-3 of table 3A show that from output peak to trough, the increase in the real exchange rate is larger in high-inflation episodes than in low-inflation episodes. However, if one considers the whole crisis interval, from output peak to recovery, there is no statistically significant difference between the real exchange rate depreciation of high-inflation episodes and low-inflation episodes, as shown in columns 4-6 of table 3A. As shown in table 3B, similar conclusions are obtained for sector reallocation: sector reallocation is not larger in high-inflation episodes than in low-inflation episodes. Appendix C (table C.3) shows that high inflation is not related to changes in the real exchange rate, or sector allocation, from output peak to recovery once additional recession and country controls are included.

Having established that from output peak to recovery point there is no significant relationship between real exchange rate changes and inflation, we investigate whether, independent from inflation, real currency depreciation and sector reallocation from output peak to recovery point might have any relationship with jobless recovery. To study this question, we directly estimate the relationship between jobless recovery, real exchange rate, and resource reallocation from output peak to recovery point, controlling for labor market characteristics and secular growth:

$$\Delta_{PR}u_i = \alpha + \beta\, \Delta_{PR}q_i + X'_i\gamma_i + \in_i, \tag{3}$$

where the subscript i refers to each financial crisis episode, $\Delta_{PR}q_i$ denotes $\Delta_{PR}rxr_i$, $\Delta_{PR}ty_i$ or $\Delta_{PR}xy_i$ and $\in_i$ is a random error term (variables are defined in section 2.1).

Results are presented in tables 4A and 4B. OLS estimates indicate that there is no statistically significant association between peak-to-recovery change in unemployment and real exchange rate changes or sector allocation. Appendix C (table C.4) shows that these finding are robust to the inclusion of additional recession and country controls.

We conclude that during financial crises, real currency depreciation and sector reallocation from output peak to recovery seem to be independent of whether the recovery is jobless or wageless. Accordingly, real exchange rate depreciation and sector reallocation might not be sufficient to mitigate jobless recoveries if they take place without the adjustment in real wages. As we will discuss in section 2.4, a key reason why financial crises impact the labor market may be the presence of credit constraints that differentially affect employment from other factors of production, determining a lower equilibrium real wage rate. If credit constraints were present in both tradable and non-tradable sectors, a sector reallocation would not necessarily avoid a jobless recovery.[11]

Furthermore, evidence suggests that a full recovery of employment might be achieved without a significant change in the real exchange rate and resource reallocation, given the economy manages to achieve an adjustment in the real wage. In our sample, an extreme but illustrative example of this situation can be found in some hyperinflation episodes.

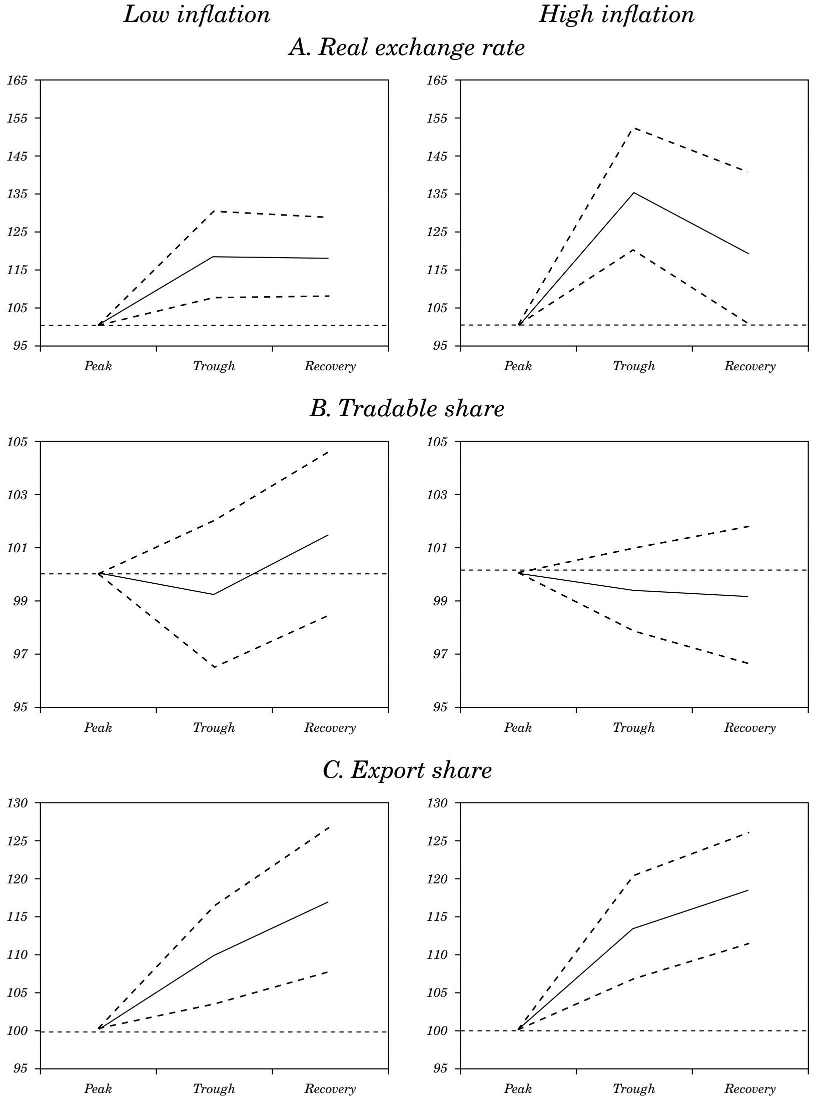
These results suggest two policy implications for countries with fixed exchange rates, such as those in the Eurozone. Firstly, fiscal devaluations, based on reduction of labor costs, might work better than those based on changes in relative prices between tradable and non-tradable goods and sectoral reallocation (provoked by, e.g., import tariff and export subsidy).

Secondly, if the Eurozone as a whole increases inflation and as a result, there is an adjustment in real wages in peripheral economies (e.g. Greece, Ireland, Portugal and Spain), there could be positive effects on unemployment even if this does not necessarily imply a real currency depreciation for the peripheral economies relative to the core economies (Germany in particular).[12]

11. Tornell and Westermann (2003) argue that credit constraints are more stringent in the non-tradable sector, and this is one reason for the dynamics of the real exchange rate and sectoral reallocation associated with twin crises (currency and banking crises). They also find that real exchange rate changes and sectoral reallocation are independent of the exchange rate regime. However, they do not discuss implications of credit constraints for the adjustment of labor markets.

12. For an analysis of adjustment in real wages as a result of inflation in the Eurozone, see Schmitt-Grohé and Uribe (2013a).

Figure 5. Inflation, Real Exchange Rates and Sector Allocation during Financial Crises in EMs



Source: Author's elaboration.
Slashed lines depict 95 percent confidence intervals for log changes in the real exchange rate, tradable share (tradable-to-GDP ratio) and exports share (exports-to-GDP ratio), sample and variables defined in section 2.1. Low-inflation (high-inflation) episodes are episodes in which the maximum level of annual inflation rate is below (above) 30 percent. Peak, trough, and recovery point are defined using the cyclical component of output per capita, as defined in section 2.1.

2.4 Beyond Inflation: Relaxing Credit Constraints

This section focuses on policies that go to the heart of the workings of financial crises and, if adequately managed, could help the recovery of both employment and real wages, namely, relaxing credit constraints. We begin by presenting a theoretical framework that explains the mechanism by which financial crises can induce a jobless recovery.

2.4.1 A Simple theoretical framework

Financial crises typically impact collateral values (e.g. fall in housing prices), tightening the availability of credit for firms. But not all firms' projects require the same collateral per unit cost. Collateral requirements are lower for projects and firms possessing easily recognizable collateral (e.g., tangible assets) or "intrinsic collateral" (Calvo, 2011). As a large component of such intrinsic collateral is given by physical capital, a relaxation of credit conditions might support more capital-intensive activities. This hypothesis is related to the literature on inalienability of human capital (Hart and Moore, 1994) and to the literature on asset tangibility. Pledgeable assets support more borrowing because such assets mitigate contractibility problems: tangibility increases the value that can be captured by creditors in default states (Almeida and Campello, 2007; Tirole, 2005).

In Calvo, Coricelli, and Ottonello (2012) we develop a simple theoretical framework to formalize this hypothesis. In particular, the model considers the case of a firm that produces homogeneous output by means of capital (K) and labor (L), using a production technology given by $AF(K, L)$, where A stands for neutral technical progress, and function F is linear homogenous, and twice-continuously differentiable. Factors of production have to be hired a period in advance, for which credit is required. Therefore, assuming that capital is fully depreciated at the end of the period, and the relevant rate of interest is zero (assumptions that can be relaxed without affecting the central results), profits are given by the following expression,

$$AF(K, L) - (K + WL), \tag{4}$$

where W stands for the wage rate plus search and other costs associated with labor hiring (measured in terms of output).

The central element of the model is the assumption that credit is subject to a constraint that takes the following form:

$$K + WL \leq Z + (1 - \theta) \tag{5}$$

where $Z > 0$ is a parameter measuring extrinsic collateral constraint (see below), and the parameter $\theta \in [0\ ,1)$.

The left-hand side of expression (5) corresponds to credit needs which, for simplicity, are assumed equal to factor cost. The right-hand side stands for total collateral, which equals the sum of the "extrinsic collateral", Z, (amount of collateral that the firm can post in addition to the factors of production, an exogenous parameter), and the intrinsic collateral, $(1 - \theta)K$. For instance, if K is its own collateral (i.e., $\theta = 0$), then the credit constraint boils down to $WL \leq Z$ and labor would be the only input subject to a credit constraint. Moreover, the wage bill is proportional to the credit constraint.

This constraint captures the asymmetry that might exist between capital and labor in providing collateral. If loans are not repaid, for instance, the creditors can still recover some part of K. In contrast, funds spent on hiring labor cannot be recovered from the workers. In Calvo, Coricelli, and Ottonello (2012), we provide empirical evidence showing that, in advanced economies, the contraction of collateral values (measured with stock market and housing prices) tends to be associated with jobless recovery.

One can show that if firms are subject to a credit constraint of this form, then, after a contraction in the binding extrinsic collateral (Z), profit-maximizing technology becomes more capital-intensive as technology grows. This implies jobless recovery, if the real wage is constant; or a fall in the equilibrium real wage at the point of output recovery, if wages are flexible (Calvo, Coricelli, and Ottonello, 2012).

2.4.2. Credit and jobless recovery during financial crises

From the theoretical framework discussed above, it follows that policies aimed to relax credit constraints should help to mitigate the labor market consequences of financial crises (jobless or wageless recovery).

We explore this hypothesis empirically for our sample of financial crises in EMs. In particular, conditional on a financial crisis event, we analyze whether credit recovery is related to the recovery of the wage bill, wl.[13] Since, depending on the levels of inflation, financial crises can impact the labor market in the form of jobless or wageless recovery, the wage bill is a plausible summary measure of conditions in the labor market. We estimate the following model:

$$\Delta_{PR} wl_i = \alpha + \beta_1 \Delta_{PR} credit_i + \beta_2 high\_\pi_{\max,i} + X'_i \gamma + \epsilon_i, \tag{6}$$

where, as before, X_i is a vector of controls including labor market controls ($labor\_mkt_{P,i}$) and secular growth (gd_i), and ϵ_i is a random error term (variables are defined in section 2.1). In this model, we also control for the presence of high inflation (which was identified in section 2.2 as having a negative relationship with jobless recovery). The coefficient of interest is β_1, interpreted as the effect of credit recovery on the recovery of the wage bill during financial crisis episodes.

A major concern associated with the OLS estimates of model (6) is the possibility that the recovery of bank credit is endogenous to labor market recovery, as, for example, unemployed workers might have restricted access to the credit market. To address this issue, we use an instrumental variable (IV) estimation strategy to identify the exogenous effect of credit recovery on the labor market recovery. We use the instrument employed in Calvo, Coricelli, and Ottonello (2012), namely the cyclical component of real per capita credit at the output peak ($credit_P$).[14] This instrument is a variable that captures credit market outcomes *prior* to the recession episode, as is typically done in the literature to predict financial crises (see, for example, Gourinchas, Valdes, and Landerretche, 2001; Schularick and Taylor, 2009; Mendoza and Terrones, 2012). Table 5A shows that the first stage coefficients are negative and statistically significant at the one percent level, showing that credit booms prior to the recession episodes are associated with a higher contraction of credit from output peak to recovery point.

Results are presented in table 5B. The OLS estimates, reported in columns 1, 3, and 5, indicate that there is a positive association

13. Calvo, Coricelli, and Ottonello (2012) analyze the relationship between credit recovery, and jobless and wageless recoveries for all recession episodes to understand the difference between financial crises and other recession episodes. Here the objective is the analysis of credit policies during financial crises, and for that reason we restrict the analysis only to these episodes.

14. The cyclical component of credit is computed using the HP filter. Recall that the output peak occurs prior to the crisis.

between credit recovery and wage bill recovery, statistically significant at the five percent level. Columns 2, 4, and 6 of table 5 show that the IV estimates are also positive and significant at the five percent level, suggesting that the exogenous component of credit plays a role in the labor market recovery. Appendix C (table C.5) shows that these findings are robust to the inclusion of additional recession controls and country controls.

This empirical evidence is complementary to the view that credit policies can be an effective instrument to mitigate the effect of financial crises on real economic activity (see, for example, Gertler and Kiyotaki, 2010).[15] In particular, this evidence suggests that credit policies can improve employment and wages simultaneously at the recovery of financial crises.

3. Final Words

In this paper we discuss the role of inflation, real currency depreciation, and credit-recovery policies in helping unemployment recovery during financial crises, based on an empirical analysis of a sample of EM financial crisis episodes.

Higher unemployment, once output has recovered its trend, seems to stem from the interaction between credit constraints that differentially affect labor, and nominal wage rigidities. Our evidence indicates that high inflation can help to overcome nominal wage rigidities—in high-inflation episodes, unemployment recovers its pre-crisis level once output has recovered its trend—but not the labor market consequences of credit constraints—in these episodes real wages are significantly below their pre-crisis level once output recovers its trend. At the same time, real exchange rate depreciation seems to be able to help unemployment only insofar as it generates inflation at levels far above current convention.

Only direct credit policies that tackle the root of the problem seem to be able to help unemployment and wages simultaneously. Even if our evidence points to the relevance of policies that relax credit constraints, achieving this objective is an important open issue for future research. However, common sense suggests the following conjectures.

15. Gertler and Kiyotaki (2010) analyze credit policies employed by the Federal Reserve during the financial crisis that started in 2008: i) expansion of discount window operations ii) lending directly in high grade credit markets.

In advanced economies, quantitative easing operations, especially if they involve the purchase of "toxic" assets, can have an effect on increasing firms' collateral and relaxing credit constraints that affect employment recovery.

In EMs, credit policies can be harder to implement because the government tends to be part of the problem. For this reason, a relevant instrument to mitigate jobless recovery might be the accumulation of international reserves, *prior* to financial crises. International reserve accumulation might not only reduce the probability of experiencing a *credit* event (Calvo, Izquierdo, and Loo-Kung, 2012), but might also facilitate credit policies during financial crises. Brazil offers a good example of this type of policy. It consists of using international reserves for extending credit lines to the export sector.[16]

Finally this discussion stresses the potential role of multilaterals in providing liquidity during financial crises in EMs. The new credit lines created by the IMF during the recent crisis (flexible credit lines and the precautionary and liquid lines) go in that direction, although the overall magnitude of the resources that can be quickly mobilized remains an issue. Partnership and coordination between multilaterals and the private sector can also be effective. For some emerging European countries, the so-called "Vienna initiative"—whereby the main foreign lenders committed to maintain the pre-crisis stock of credit in those countries that agreed to subscribe an IMF/EU program—helped to avoid a sudden withdrawal of foreign investors. However, in principle, the "Vienna initiative" did not fully shelter receiving countries from a sudden stop in credit flows.

16. See, for example, Martins and Salles (2010), Barbosa (2010), and Aisen and Franken (2010).

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Appendix A
Tables

Table A1. Inflation and Labor Market Recovery from Financial Crises in EMs

Dependent variable	$\Delta_{PR}u$			$\Delta_{PR}w$		
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
$high\_\pi_{\max}$	-0.021** (0.008)	-0.024*** (0.009)	-0.023** (0.009)	-0.165* (0.084)	-0.157* (0.078)	-0.165* (0.087)
$natural\_u_P$	0.088 (0.086)		0.121 (0.095)	0.752 (0.963)		0.758 (1.017)
$lamrig_P$		0.002 (0.008)	0.007 (0.009)		-0.005 (0.079)	0.002 (0.087)
gd	-0.037 (0.042)	-0.052 (0.040)	-0.026 (0.044)	0.873** (0.402)	0.768** (0.367)	0.876** (0.429)
No. observations	45	45	45	41	45	41

Source: Author's calculations.
Standard errors in parentheses.
* indicates significance at 10 percent level; ** at 5 percent level; *** at 1 percent level.
Sample and variables definition are detailed in section 3.1.

Table A2. Inflation and Labor Market Recovery from Financial Crises in EMs

Dependent variable	$\Delta_{PR}u$						$\Delta_{PR}w$					
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(12)*
$high\_\pi_P$	-0.010 (0.009)	-0.012 (0.009)	-0.010 (0.009)				0.036 (0.090)	0.020 (0.085)	0.038 (0.091)			
$high\_\pi_R$				-0.009 (0.010)	-0.012 (0.010)	-0.010 (0.010)				-0.063 (0.104)	-0.085 (0.096)	-0.061 (0.105)
$natural\_u_P$	0.128 (0.089)		0.139 (0.101)	0.121 (0.091)		0.135 (0.103)	1.161 (1.012)		1.056 (1.071)	0.894 (1.039)		0.811 (1.095)
$lamrig_P$		-0.004 (0.008)	0.002 (0.009)		-0.003 (0.008)	0.003 (0.009)		-0.058 (0.080)	-0.030 (0.090)		-0.040 (0.080)	-0.024 (0.090)
gd	-0.022 (0.043)	-0.047 (0.042)	-0.018 (0.047)	-0.033 (0.047)	-0.060 (0.044)	-0.028 (0.050)	1.038** (0.418)	0.754* (0.384)	0.987** (0.449)	0.917** (0.444)	0.683* (0.389)	0.878* (0.472)
No. obs.	45	45	45	45	45	45	41	45	41	41	45	41

Source: Author's calculations.
Standard errors in parentheses.
* indicates significance at 10 percent level; ** at 5 percent level; *** at 1 percent level.
Sample and variables definition are detailed in section 3.1.

Table A3a. Inflation and Real Exchange Rate during Financial Crises in EMs

Dependent variable	$\Delta_{PT}rxr$			$\Delta_{PR}rxr$		
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
$high\_\pi_{\max}$	0.111 (0.093)	0.143* (0.084)	0.135 (0.095)	-0.058 (0.114)	0.052 (0.107)	-0.020 (0.114)
$natural\_u_P$	-0.476 (0.945)		-1.044 (1.038)	-0.005 (1.155)		-0.873 (1.254)
$lamrig_P$		-0.050 (0.082)	-0.121 (0.095)		-0.154 (0.105)	-0.185 (0.114)
gd	0.216 (0.460)	0.357 (0.381)	0.014 (0.483)	0.088 (0.562)	0.315 (0.487)	-0.221 (0.583)
No. observations	45	55	45	45	55	45

Source: Author's calculations.
Standard errors in parentheses.
* indicates significance at 10 percent level; ** at 5 percent level; *** at 1 percent level.
Sample and variables definition are detailed in section 3.1.

Table A3b. Inflation and Sector Allocation during Financial Crises in EMs

Dependent variable	$\Delta_{PT}ty$			$\Delta_{PR}ty$			$\Delta_{PT}ty$			$\Delta_{PR}ty$		
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(12)*
$high\_\pi_{\max}$	0.003 (0.016)	-0.006 (0.017)	0.000 (0.016)	-0.019 (0.022)	-0.029 (0.021)	-0.019 (0.023)	-0.008 (0.050)	0.019 (0.045)	-0.004 (0.052)	-0.048 (0.050)	-0.007 (0.050)	-0.038 (0.051)
$natural\_u_P$	-0.002 (0.159)		0.117 (0.178)	-0.355 (0.225)		-0.338 (0.259)	-0.989* (0.508)		-1.083* (0.568)	-1.537*** (0.507)		-1.766*** (0.562)
$lamrig_P$		0.022 (0.017)	0.023 (0.016)		0.015 (0.021)	0.003 (0.024)		0.023 (0.045)	-0.020 (0.052)		0.023 (0.049)	-0.049 (0.051)
gd	0.126 (0.090)	0.072 (0.081)	0.185* (0.098)	0.112 (0.127)	0.136 (0.101)	0.120 (0.142)	-0.044 (0.247)	0.224 (0.200)	-0.077 (0.264)	0.327 (0.247)	0.660*** (0.219)	0.246 (0.262)
No. obs.	40	48	40	40	48	40	45	53	45	45	53	45

Source: Author's calculations.
Standard errors in parentheses.
* indicates significance at 10 percent level; ** at 5 percent level; *** at 1 percent level.
Sample and variables definition are detailed in section 3.1.

Table A4a. Real Exchange Rate and Jobless Recovery During Financial Crises in EMs

Dependent variable	$\Delta_{PR}u$					
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
$\Delta_{PT}rxr$	-0.003 (0.015)	-0.006 (0.015)	-0.002 (0.015)			
$\Delta_{PR}rxr$				0.005 (0.012)	0.004 (0.013)	0.006 (0.013)
$natural\_u_P$	0.140 (0.090)		0.151 (0.104)	0.142 (0.089)		0.159 (0.102)
$lamrig_P$		-0.005 (0.008)	0.002 (0.009)		-0.004 (0.008)	0.003 (0.009)
gd	-0.017 (0.044)	-0.044 (0.043)	-0.013 (0.048)	-0.018 (0.044)	-0.045 (0.043)	-0.011 (0.048)
No. observations	45	45	45	45	45	45

Source: Author's elaboration.
Standard errors in parentheses.
* indicates significance at 10 percent level; ** at 5 percent level; *** at 1 percent level.
Sample and variables definition are detailed in section 3.1.

Table A4b. Sector Allocation and Jobless Recovery During Financial Crises in EMs

Dependent variable	$\Delta_{PR}u$											
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(12)*
$\Delta_{PT}ty$	0.019 (0.103)	0.013 (0.108)	-0.009 (0.106)									
$\Delta_{PR}ty$				-0.027 (0.072)	-0.050 (0.072)	-0.027 (0.072)						
$\Delta_{PT}xy$							-0.009 (0.028)	-0.019 (0.028)	-0.008 (0.029)			
$\Delta_{PR}xy$										0.017 (0.028)	-0.001 (0.026)	0.019 (0.029)
$natural\_u_P$	0.132 (0.094)		0.194* (0.109)	0.123 (0.096)		0.185 (0.111)	0.134 (0.093)		0.145 (0.106)	0.167* (0.097)		0.187 (0.113)
$lamrig_P$		0.002 (0.009)	0.011 (0.010)		0.003 (0.009)	0.011 (0.010)		-0.004 (0.008)	0.002 (0.009)		-0.004 (0.008)	0.003 (0.009)
gd	0.003 (0.054)	-0.024 (0.053)	0.037 (0.062)	0.009 (0.053)	-0.011 (0.053)	0.040 (0.060)	-0.017 (0.044)	-0.042 (0.043)	-0.013 (0.048)	-0.023 (0.045)	-0.045 (0.046)	-0.018 (0.048)
No. obs.	40	40	40	40	40	40	45	45	45	45	45	45

Source: Author's elaboration.
Standard errors in parentheses.
* indicates significance at 10 percent level; ** at 5 percent level; *** at 1 percent level.
Sample and variables definition are detailed in section 3.1.

Table A5a. Credit Cycle at the Peak and Credit Recovery (First Stage)

	$\Delta_{PR}credit$		
Dependent variable	*(1)*	*(2)*	*(3)*
$credit_P$	-1.285*** (0.143)	-1.105*** (0.124)	-1.256*** (0.150)
$high\_\pi_{\max}$	-0.086 (0.063)	-0.107* (0.055)	-0.096 (0.066)
$natural\_u_P$	-0.900 (0.636)		-0.706 (0.707)
$lamrig_P$		0.122** (0.053)	0.044 (0.067)
gd	-0.134 (0.310)	0.180 (0.247)	-0.066 (0.329)
No. observations	45	55	45

Source: Author's elaboration.
Standard errors in parentheses.
* indicates significance at 10 percent level; ** at 5 percent level; *** at 1 percent level.
Sample and variables definition are detailed in section 3.1.

Table A5b. Credit Recovery and Labor Market Recovery during Financial Crises in EMs

Dependent variable	$\Delta_{PR}wl$					
Estimation method	*OLS* *(1)*	*IV* *(2)*	*OLS* *(3)*	*IV* *(4)*	*OLS* *(5)*	*IV* *(6)*
$\Delta_{PR}credit$	0.403** (0.159)	0.456** (0.197)	0.428** (0.162)	0.507** (0.205)	0.421** (0.165)	0.483** (0.206)
$high\_\pi_{\max}$	-0.096 (0.084)	-0.089 (0.085)	-0.087 (0.086)	-0.075 (0.089)	-0.084 (0.087)	-0.075 (0.090)
$natural\_u_P$	0.668 (0.920)	0.662 (0.921)			0.509 (0.975)	0.479 (0.979)
$lamrig_P$			-0.060 (0.081)	-0.068 (0.082)	-0.046 (0.086)	-0.053 (0.087)
gd	1.042** (0.386)	1.057** (0.389)	0.891** (0.376)	0.906** (0.378)	0.973** (0.411)	0.979** (0.412)
No. observations	39	39	39	39	39	39

Source: Author's elaboration.
Standard errors in parentheses.
* indicates significance at 10 percent level; ** at 5 percent level; *** at 1 percent level.
Sample and variables definition are detailed in section 3.1.

Appendix B
Methodology for Domestic Sudden Stops

Following Calvo, Izquierdo, and Mejia (2008) a *Domestic Sudden Stop* is defined as a phase that meets the following conditions:

— It contains at least one observation where the year-on-year fall in real bank credit flows lie at least two standard deviations below its sample mean (this addresses the "unexpected" requirement of a sudden stop).

— The sudden stop phase starts the first time the annual change in real bank credit flows fall one standard deviation below the mean and ends once the annual change in capital flows exceed one standard deviation below its sample mean (this captures the persistence of the sudden stop).

Calvo, Izquierdo, and Mejia (2008) use this methodology to define *External Sudden Stops*, using (external) capital flows instead of bank credit flows. Data on bank credit flows includes claims on the private sector by depositary institutions. CPI deflates credit data. Data source: IFS.

Appendix C
List of Financial Crisis Episodes

Table C.1 lists the 55 financial crisis episodes included in the empirical analysis. As detailed in section 2.1, low-inflation (high-inflation) episodes are episodes in which the maximum level of annual inflation rate is below (above) 30 percent.

Table C1. Sample of Financial Crisis Episodes

Low inflation		*High inflation*	
Country	*Peak*	*Country*	*Peak*
Algeria	1985	Algeria	1989
Algeria	1992	Argentina	1980
Argentina	1994	Argentina	1987
Brazil	1997	Argentina	1998
Colombia	1995	Brazil	1980
Côte d'Ivoire	1982	Brazil	1987
Côte d'Ivoire	1986	Brazil	1991
Côte d'Ivoire	1991	Bulgaria	1995
Côte d'Ivoire	1998	Chile	1981
Côte d'Ivoire	2001	Dominican Republic	2000
Korea	1996	Ecuador	1981
Malaysia	1984	Ecuador	1998
Malaysia	1997	El Salvador	1980
Morocco	1980	Indonesia	1997
Morocco	1982	Lebanon	1988
Morocco	1986	Mexico	1981
Panama	1982	Mexico	1994
Panama	1986	Nigeria	1980
Peru	1997	Peru	1981
Phillipines	1997	Phillipines	1983
South Africa	1981	Russia	1997
South Africa	1984	Turkey	1993
South Africa	1989	Turkey	1997
Thailand	1996	Turkey	2000
		Uruguay	1981
		Uruguay	1998
		Venezuela	1980
		Venezuela	1988
		Venezuela	1992
		Venezuela	1995
		Venezuela	2001

Appendix D
Robustness

In this section, we explore how robust our results are to the inclusion of additional controls that could be associated with the dependent variables in the above estimated equations. We explore controls related to the characteristics of the recession episode, and linked to country-specific characteristics. The following list describes each of these controls:

— Depth of the recession episode ($\Delta_{PT}y$). Defined as the log change in GDP per capita from output peak to trough. Jobless recoveries could result from deeper recession episodes if, for example, larger output contractions lead to higher increases in unemployment and there is hysteresis in unemployment. Data source: WEO and WDI.

— Country's historical inflation ($hist\_\pi$): Defined as the country's historical median (1980-2007) rate of inflation. We compute inflation using the producer price index (wholesale price index or the consumer price index when not available). Data source: IMF and national sources.

— Country's *openness*, defined as the country's historical average (1980-2007) of the share of tradables in GDP. The tradables sector includes agriculture and manufacturing. An economy that is more open could, for instance, require smaller real currency depreciation for a given shock (Calvo, Izquierdo, and Mejia, 2008). Data source: WDI.

— Country's financial development (*fin_development*). Defined as the country's historical median (1980-2007) of domestic credit provided by the banking sector in terms of GDP. Data source: WDI.

— Country size (*small_country*, *medium_country*, and *large_country*). Defined as three dummy variables measuring the size of the population of a given country: *small_country* takes the value of one when the country's population is below 20 million and zero otherwise; *medium_country* takes the value of one when the country's population is between 20 and 80 million and zero otherwise; *large_country* takes the value of one when the country's population is above 80 million and zero otherwise. Definition of thresholds and data source, Uribe (2012).

Results are presented in tables D.1-D.4. Table D.1 shows that the result—high-inflation episodes tend to display less unemployment and lower real wages at the output recovery point than low-inflation episodes (table A.1, section 2.2)—is robust to the inclusion of the additional recession and country controls. Only when we control for financial development or country size does the relationship between real wages and high inflation lose its statistical significance, although the estimated coefficient remains negative and has a similar size to that of the other regressions.

Table D.2 shows that, in line with section 2.3, high inflation is not related to changes in the real exchange rate or sector allocation from output peak to recovery once additional recession controls and country controls are included.

Table D.3 shows that the finding of no statistically significant association between jobless recovery and peak-to-recovery change in real exchange rate/sector allocation (section 2.3) is robust to the inclusion of the additional controls of this section.

Finally, table D.4 shows that the finding of a positive and statistically significant relationship between credit recovery and wage bill recovery (section 2.4) is robust to the inclusion of the additional controls of this section. In particular, both OLS and IV estimates are positive and statistically significant for all specifications.

Table D.1. Inflation and Labor Market Recovery from Financial Crises in EMs

Dependent variable	$\Delta_{PR}u$					$\Delta_{PR}w$				
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*
$high\_\pi_{\max}$	-0.020** (0.009)	-0.022** (0.009)	-0.023** (0.008)	-0.031*** (0.010)	-0.022** (0.009)	-0.160* (0.094)	-0.158* (0.089)	-0.167* (0.087)	-0.134 (0.105)	-0.133 (0.092)
$\Delta_{PT}y$	0.061 (0.059)					0.083 (0.603)				
$high\_\pi$		-0.010 (0.017)					-0.078 (0.167)			
$openness$			0.121 (0.072)					-0.779 (0.730)		
$fin\_development$				-0.000 (0.000)					0.001 (0.002)	
$small\_country$					-0.016 (0.013)					-0.149 (0.131)
$medium\_country$					-0.012 (0.011)					-0.012 (0.110)
$natural\_u_P$	0.118 (0.095)	0.109 (0.098)	0.251** (0.121)	0.120 (0.093)	0.164 (0.103)	0.760 (1.031)	0.661 (1.049)	0.021 (1.228)	0.670 (1.041)	1.371 (1.138)
$lamrig_P$	0.005 (0.009)	0.008 (0.009)	0.015 (0.010)	0.003 (0.009)	0.005 (0.009)	-0.001 (0.091)	0.014 (0.092)	-0.056 (0.103)	0.018 (0.094)	0.004 (0.091)
gd	-0.025 (0.044)	-0.031 (0.046)	-0.023 (0.043)	-0.018 (0.044)	-0.019 (0.048)	0.878* (0.436)	0.834* (0.443)	0.846* (0.429)	0.857* (0.435)	1.083** (0.462)
No. observations	45	45	45	45	45	41	41	41	41	41

Source: Author's elaboration.
Standard errors in parentheses.
* indicates significance at 10 percent level; ** at 5 percent level; *** at 1 percent level.
Sample and variables definition are detailed in section 3.1.

Table D.2. Inflation, Real Exchange Rate and Sector Allocation during Financial Crises in EMs

Dependent variable	$\Delta_{PR}rxr$					$\Delta_{PR}ty$					$\Delta_{PR}xy$				
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(12)*	*(13)*	*(14)*	*(15)*
$high\_\pi_{\max}$	-0.087 (0.119)	-0.004 (0.116)	-0.022 (0.114)	-0.081 (0.132)	-0.022 (0.122)	-0.028 (0.024)	-0.018 (0.023)	-0.015 (0.023)	-0.008 (0.027)	-0.012 (0.024)	-0.030 (0.055)	-0.050 (0.051)	-0.040 (0.049)	-0.009 (0.059)	-0.020 (0.053)
$\Delta_{PT}y$	-1.269 (0.766)					-0.175 (0.159)					0.163 (0.354)				
$high\_\pi$		-0.213 (0.223)					-0.030 (0.053)					0.150 (0.098)			
$openness$			-1.093 (0.973)					-0.310 (0.194)					-0.874** (0.421)		
$fin\_development$				-0.002 (0.002)					0.000 (0.000)					0.001 (0.001)	
$small\_country$					0.042 (0.176)					-0.030 (0.038)					-0.121 (0.076)
$medium\_country$					0.029 (0.151)					0.003 (0.031)					-0.035 (0.065)
$natural\_u_P$	-0.819 (1.228)	-1.119 (1.281)	-2.050 (1.631)	-0.876 (1.256)	-0.990 (1.379)	-0.348 (0.258)	-0.361 (0.264)	-0.618* (0.308)	-0.348 (0.261)	-0.234 (0.290)	-1.773*** (0.568)	-1.593*** (0.565)	-2.707*** (0.705)	-1.764*** (0.562)	-1.414** (0.597)
$lamrig_P$	-0.154 (0.113)	-0.156 (0.118)	-0.260* (0.132)	-0.212* (0.118)	-0.181 (0.121)	0.004 (0.024)	0.007 (0.025)	-0.014 (0.026)	0.009 (0.025)	0.010 (0.025)	-0.053 (0.053)	-0.069 (0.052)	-0.109* (0.057)	-0.036 (0.053)	-0.048 (0.052)
gd	-0.235 (0.571)	-0.334 (0.596)	-0.249 (0.582)	-0.161 (0.588)	-0.244 (0.644)	0.104 (0.142)	0.110 (0.145)	0.163 (0.142)	0.103 (0.145)	0.190 (0.157)	0.247 (0.264)	0.325 (0.263)	0.224 (0.252)	0.216 (0.263)	0.388 (0.279)
No. observations	45	45	45	45	45	40	40	40	40	40	45	45	45	45	45

Source: Author's elaboration.
Standard errors in parentheses.
* indicates significance at 10 percent level; ** at 5 percent level; *** at 1 percent level.
Sample and variables definition are detailed in section 3.1.

Table D.3. Jobless Recovery, Real Exchange Rate and Sector Allocation during Financial Crises in EMs

Dependent variable	$\Delta_{PR}u$														
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(12)*	*(13)*	*(14)*	*(15)*
$\Delta_{PR}rxr$	0.012 (0.013)	0.004 (0.013)	0.010 (0.013)	0.006 (0.013)	0.007 (0.013)										
$\Delta_{PR}ty$						-0.008 (0.069)	-0.029 (0.073)	-0.006 (0.074)	-0.028 (0.074)	-0.061 (0.065)					
$\Delta_{PR}xy$											0.014 (0.028)	0.026 (0.029)	0.037 (0.029)	0.021 (0.030)	0.009 (0.030)
$\Delta_{PT}y$	0.116* (0.060)					0.135** (0.061)					0.100* (0.059)				
$hist\_\pi$		-0.015 (0.018)					-0.004 (0.023)					-0.020 (0.018)			
$openness$			0.134 (0.079)					0.092 (0.088)					0.155* (0.081)		
$fin\_development$				-0.000 (0.000)					0.000 (0.000)					-0.000 (0.000)	
$small\_country$					-0.020 (0.014)					-0.049*** (0.014)					-0.019 (0.014)
$medium\_country$					-0.008 (0.012)					-0.025** (0.012)					-0.008 (0.012)
$natural\_u_P$	0.150 (0.099)	0.138 (0.106)	0.306** (0.133)	0.159 (0.104)	0.214* (0.109)	0.182* (0.105)	0.181 (0.114)	0.277* (0.141)	0.184 (0.114)	0.321*** (0.106)	0.166 (0.111)	0.173 (0.113)	0.383** (0.150)	0.191 (0.115)	0.219* (0.116)
$lamrig_P$	0.003 (0.009)	0.005 (0.010)	0.013 (0.011)	0.003 (0.010)	0.003 (0.010)	0.012 (0.010)	0.012 (0.011)	0.016 (0.011)	0.012 (0.011)	0.016 (0.009)	0.002 (0.009)	0.007 (0.010)	0.015 (0.011)	0.003 (0.010)	0.003 (0.010)
gd	-0.013 (0.046)	-0.021 (0.049)	-0.007 (0.047)	-0.011 (0.049)	0.007 (0.050)	0.039 (0.057)	0.038 (0.061)	0.025 (0.062)	0.039 (0.063)	0.102* (0.058)	-0.018 (0.047)	-0.031 (0.049)	-0.019 (0.046)	-0.016 (0.049)	0.002 (0.052)
No. observations	45	45	45	45	45	40	40	40	40	40	45	45	45	45	45

Source: Author's elaboration.
Standard errors in parentheses.
* indicates significance at 10 percent level; ** at 5 percent level; *** at 1 percent level.
Sample and variables definition are detailed in section 3.1.

Table D.4. Credit Recovery and Labor Market Recovery during Financial Crises in EMs

Dependent variable	$\Delta_{PR}wl$									
Estimation method	*OLS*	*IV*	*OLS*	*IV*	*OLS*	*IV*	*OLS*	*IV*	*OLS*	*IV*
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*
$\Delta_{PR}credit$	0.427** (0.169)	0.485** (0.210)	0.516*** (0.175)	0.624** (0.229)	0.423** (0.158)	0.535** (0.197)	0.416** (0.170)	0.475** (0.214)	0.401** (0.181)	0.470* (0.233)
$high\_\pi_{\max}$	-0.090 (0.092)	-0.083 (0.094)	-0.043 (0.091)	-0.022 (0.095)	-0.099 (0.084)	-0.082 (0.087)	-0.075 (0.102)	-0.070 (0.103)	-0.079 (0.092)	-0.072 (0.093)
$\Delta_{PT}y$	-0.139 (0.607)	-0.170 (0.612)								
$hist\_\pi$			-0.245 (0.170)	-0.285 (0.180)						
$openness$					-1.420* (0.735)	-1.423* (0.741)				
$fin\_development$							0.000 (0.002)	0.000 (0.002)		
$small\_country$									-0.027 (0.141)	-0.016 (0.143)
$medium\_country$									0.011 (0.114)	0.007 (0.114)
$natural\_u_P$	0.495 (0.991)	0.465 (0.995)	0.122 (0.997)	0.014 (1.013)	-0.745 (1.139)	-0.801 (1.150)	0.484 (1.001)	0.467 (1.003)	0.650 (1.157)	0.562 (1.175)
$lamrig_P$	-0.043 (0.088)	-0.049 (0.089)	-0.023 (0.086)	-0.030 (0.087)	-0.141 (0.096)	-0.153 (0.098)	-0.041 (0.094)	-0.049 (0.096)	-0.039 (0.095)	-0.049 (0.097)
gd	0.967** (0.418)	0.972** (0.419)	0.835* (0.416)	0.822* (0.419)	0.962** (0.395)	0.974** (0.398)	0.966** (0.419)	0.975** (0.420)	1.033** (0.463)	1.014** (0.465)
No. observations	39	39	39	39	39	39	39	39	39	39

Source: Author's elaboration.
Notes: standard errors in parentheses.
* indicates significance at 10 percent level; ** at 5 percent level; *** at 1 percent level.
Sample and variables definition are detailed in section 3.1.

Appendix E

Threshold Effects in the Inflation-Unemployment Relationship[17]

We follow Hansen (2000) in order to assess whether there is indeed robust evidence of a non-linear relationship between inflation and unemployment during financial crises in EMs. In particular, we wish to verify the presence of two different regimes for unemployment behavior distinguished by their level of inflation during the crisis episodes, as assumed in model (1) in the main text of the paper. Our conjecture is that low-inflation episodes are associated with more jobless recovery than high-inflation episodes.

The general form for the estimated model for a single threshold is as follows.[18]

$$\begin{aligned} \Delta_{PR}u_i &= \alpha_1 + X'_i\gamma_1 + \in_i \quad \text{for} \quad \pi_{\max,i} \leq q, \\ \Delta_{PR}u_i &= \alpha_2 + X'_i\gamma_2 + \in_i \quad \text{for} \quad \pi_{\max,i} > q. \end{aligned} \tag{E1}$$

where q is the threshold, $\Delta_{PR}u_i$ denotes the jobless recovery measure in financial crisis episode i, X_i is a vector of controls including labor market controls ($labor\_mkt_{P,i}$) and secular growth (gd_i), $\in_i$ is a random error term (variables are defined in section 2.1). The threshold variable is defined with respect to the maximum rate of inflation experienced during the episode ($\pi_{\max,i}$).

The equation estimated in model (1) of the main text is a single equation version of the above model, in which the threshold q is used to create a dummy, with value 1 for the high-inflation regime and 0 for the low-inflation regime.

Hansen's approach allows us to consider either all parameters as regime-dependent or just a subset of them. In the model estimated in

17. We thank Zorobabel Bicaba and Farshad Ravasan for excellent research assistance.

18. The specification in (E.1) is consistent with the one in model (1), studied in section 3.1, in which the level of inflation does not enter as a regressor. An alternative specification of the model for a single threshold would be to include the inflation variable that defines the threshold as a regressor:

$$\begin{aligned} \Delta_{PR}u_i &= \alpha_1 + \beta_1\pi_{\max,i} + X'_i\gamma_1 + \in_i \quad \text{for} \quad \pi_{\max,i} \leq q, \\ \Delta_{PR}u_i &= \alpha_2 + \beta_2\pi_{\max,i} + X'_i\gamma_2 + \in_i \quad \text{for} \quad \pi_{\max,i} > q. \end{aligned} \tag{E2}$$

A relationship of this type is studied in appendix E, where we relate continuous measures of inflation to unemployment recovery. The estimated threshold under this alternative specification is similar to that estimated under (A.1).

the main text, we consider as regime-dependent only the intercept, which is the variable subject to the shift caused by the threshold-related dummy. This amounts to assuming that $\gamma_1 = \gamma_2$. The least squares point estimate for the threshold is derived from the minimum of the graph of the normalized likelihood ratio sequence as a function of the threshold in inflation depicted in figure E.1 (Hansen, 2000). Said estimated value is 0.317. There are 17 episodes with $\pi_{\max,i} \leq 0{,}317$ and 26 episodes with $\pi_{\max,i} > 0{,}317$. The confidence interval around said point estimate is rather large, at 90 percent the interval is from 0.19 to 1.74 (table A.6). Roughly speaking, this interval can be seen in the graph from the intersections of the LR with the lowest critical line (associate to 90 percent confidence). The wide confidence interval indicates a difficulty in pinning down the exact location of the relevant threshold and, possibly, suggests the presence of additional thresholds. Due to the small size of our sample, we cannot perform robust tests for the presence of an additional threshold. The estimated threshold is robust to different sets of controls, including the case in which $\pi_{\max,i}$ enters the set of regressors. Table E.1 reports the results of the OLS regression for the split sample for model (1). The intercept switches in sign in the two

Table E.1. Regression on Split Sample

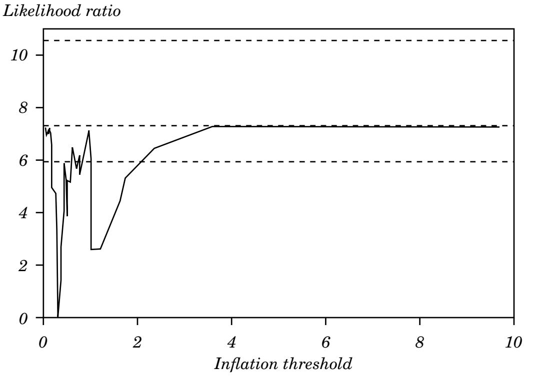
	$\Delta_{PR}u(\pi \leq 0{,}317)$	$\Delta_{PR}u(\pi > 0{,}317)$
Dependent variable	*1*	*2*
Regime independent variables		
$natural\_u_P$	0.105 (0.099)	0.105 (0.099)
$lamrig_P$	0.005 (0.009)	0.005 (0.009)
gd	-0.019 (0.04)	-0.019 (0.04)
Regime dependent variable		
Intercept	0.012 (0.025)	-0.011 (0.025)
No. observations	17	26

Source: Author's elaboration.
Sample and variables definition are detailed in section 3.1.
Standard errors shown below the coefficient.

regimes, and the difference between high and low inflation implies a decline in the rate of unemployment of about 2 percent when we move from low to high inflation.

In summary, Hansen's approach indicates that there is evidence of a threshold on inflation, dividing the sample in two different regimes. As documented in the OLS regression that uses the estimated threshold to identify a switch in regime, evidence suggests that moving from below to above a threshold around 30 percent for inflation helps explain a switch from jobless to job-intensive recovery.

Figure E.1. Likelihood Ratio and Threshold Variable (Inflation)



Source: Author's calculations.
The three dashed lines starting from below indicate the confidence interval at 90 percent, 95 percent, and 99 percent.

Appendix F
A Linear Relationship between Inflation and Unemployment

The threshold identified in this paper, in terms of a level of inflation up to which financial crisis episodes do not display a jobless recovery, is relatively high (30 percent). A relevant question for policy design is whether there is any *linear* type of relationship that can also be established empirically between the inflation experienced in the episode (the level of inflation or the change in inflation) and unemployment recovery. If this is the case, countries could choose only a moderate increase in inflation and still expect to have an effect on jobless recoveries.

The pattern we identify in the data is illustrated in figure F.1, displaying our measure of jobless recovery for different ranges of inflation rate achieved during the episode and suggesting the non-linear type of relationship between inflation and unemployment recovery we have discussed in section 2.2. However, aside from this pattern, data does not suggest a (strictly) decreasing relationship between the level of inflation and jobless recovery.

To further explore this pattern, we estimate a linear model relating jobless recovery to different continuous measures of inflation experienced during the episode. In particular, we estimate the model

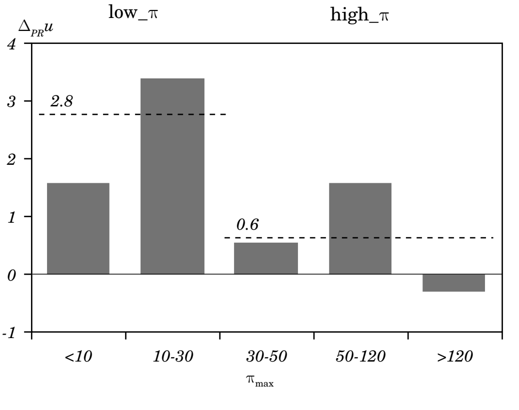
$$\Delta_{PR} u_i = \alpha + \beta \pi_i + X'_i \gamma + \in_i, \tag{F.1}$$

where π_i denotes a measure of the inflation experienced during the financial crisis episode i. The four measures of inflation experienced during the episode considered are the maximum level of inflation ($\pi_{\max}$), the level of inflation at the output trough (π_T), the difference between the maximum level of inflation and inflation at the output peak ($\Delta_{P\max}\pi$), and the change in inflation from peak to trough ($\Delta_{PT}\pi$) (variables are defined in section 2.1).

This model is similar to model (1), but the regressor—instead of being a dummy variable—is a continuous measure of the inflation experienced during the episode. Results are presented in table F.1. Columns 1-4 show that, for the whole sample, there is no statistically significant relationship between any of the continuous measures of inflation and unemployment. A possible explanation of this result could be that, as explained in section 2.1, eight episodes in our sample could be considered hyperinflations. However, columns 5 - 8 show that, if we include a dummy for hyperinflation episodes, the relationship between jobless recovery and inflation is still not statistically significant. Moreover, the negative estimated relationship is mostly driven by the difference between low-inflation episodes and high-inflation episodes: if we include a dummy variable for low-inflation episodes, it is not even clear that there is a negative relationship between inflation and unemployment recovery for low-inflation episodes (columns 9-12).[19]

The estimated results from this section show that there does not seem to be strong evidence supporting the statistical significance of a linear relationship between a continuous measure of inflation and unemployment recovery. Although the sample size is small, this suggests that, on one hand, a small increase in inflation might not be of any help to fight jobless recoveries; and on the other hand, a very large increase in inflation, beyond the identified threshold, might be an overkill to avoid jobless recovery.

Figure F.1. Inflation and Jobless Recovery (Percent)



Source: Author's calculations.
Sample and variables definition are detailed in section 2.1.

19. The results shown in table A.7 (columns 9-12) include a dummy variable for low-inflation episodes that experience a maximum annual rate of inflation below 30 percent, as in section 3.2. If we estimate this threshold using the method in Hansen (2000), as in appendix D, model (A.2), we obtain similar results: there does not seem to be evidence of a negative and significant relationship between inflation and unemployment recovery for low-inflation episodes.

Table F.1. Inflation and Labor Market Recovery from Financial Crises in EMs

	$\Delta_{PR}u$											
Dependent variable	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(12)*
$\pi_{\max}$	-0.000 (0.001)				0.000 (0.001)				0.000 (0.001)			
π_T		-0.001 (0.001)				0.001 (0.002)				0.001 (0.002)		
$\Delta_{P\max}\pi$			-0.000 (0.001)				0.000 (0.001)				0.000 (0.001)	
$\Delta_{PT}\pi$				-0.001 (0.002)				0.002 (0.002)				0.002 (0.002)
$\pi_{\max} \times (1-hyper)$					-0.014 (0.011)				-0.001 (0.014)			
$\pi_T \times (1-hyper)$						-0.015 (0.011)				-0.002 (0.015)		
$\Delta_{P\max}\pi \times (1-hyper)$							-0.010 (0.013)				0.013 (0.015)	
$\Delta_{PT}\pi \times (1-hyper)$								-0.014 (0.014)				0.000 (0.015)
$\pi_{\max} \times (1-high\_\pi_{\max})$									0.192** (0.090)			
$\pi_T \times (1-high\_\pi_{\max})$										0.193** (0.090)		
$\Delta_{P\max}\pi \times (1-high\_\pi_{\max})$											-0.006 (0.100)	
$\Delta_{PT}\pi \times (1-high\_\pi_{\max})$												-0.023 (0.085)

Table F.1. (continued)

	$\Delta_{PR}u$											
Dependent variable	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(12)*
$(1-hyper)$					0.027 (0.020)	0.030 (0.023)	0.023 (0.020)	0.027 (0.021)	0.013 (0.021)	0.017 (0.024)	0.003 (0.020)	0.016 (0.021)
$(1-high\_\pi_{\max})$									-0.003 (0.018)	-0.003 (0.018)	0.028** (0.013)	0.024** (0.011)
$natural\_u_P$	0.151 (0.102)	0.154 (0.101)	0.144 (0.105)	0.147 (0.105)	0.129 (0.103)	0.125 (0.103)	0.126 (0.109)	0.113 (0.109)	0.097 (0.096)	0.093 (0.096)	0.091 (0.095)	0.093 (0.107)
$lamrig_P$	0.003 (0.009)	0.003 (0.009)	0.002 (0.010)	0.002 (0.010)	0.006 (0.009)	0.006 (0.009)	0.004 (0.010)	0.004 (0.010)	0.010 (0.009)	0.010 (0.009)		0.006 (0.010)
gd	-0.015 (0.047)	-0.013 (0.047)	-0.012 (0.049)	-0.009 (0.049)	-0.022 (0.048)	-0.024 (0.048)	-0.013 (0.049)	-0.026 (0.051)	-0.021 (0.044)	-0.023 (0.044)	-0.024 (0.045)	-0.020 (0.050)
No. observations	45	45	44	44	45	45	44	44	45	45	44	44

Source: Author's calculations
Notes: standard errors in parentheses.
* indicates significance at 10 percent level; ** at 5 percent level; *** at 1 percent level.
Sample and variables definition are detailed in section 3.1.

International Aspects of the Zero Lower Bound Constraint

Michael B. Devereux
CEPR, NBER, and University of British Columbia

Large negative aggregate demand shocks can drive down an economy's equilibrium real interest rate, and if the central bank is committed to stabilizing inflation, monetary policy may be hampered by the zero lower bound on nominal interest rates –the economy may be in a "liquidity trap." The policy dilemma associated with the zero lower bound has been extensively debated in recent years. Based on the experience of Japan in the 1990's, writers like Krugman (1998), Eggertsson and Woodford (2003; 2005), Jung, Terinishi and Watanabe (2005), Svensson (2003), Auerbach and Obstfeld (2006), among others, explored how monetary policy announcements could be usefully employed even when the authorities have no more room for reducing short-term nominal interest rates. More recently, given the 2008-2009 global recession, a number of authors have explored the options for fiscal stimulus when the economy is stuck in a liquidity trap. Papers by Christiano, Eichenbaum and Rebelo (2009), Eggertsson (2010), Cogan et al. (2009), and Devereux (2010) have investigated the possibility of using government spending expansions and tax cuts when nominal interest rates are at their lower bound. In contrast to the Japanese experience, a key feature of recent history is that the zero lower bound constraint was more of a global phenomenon. Most focused on the problems facing either a closed economy or a small open economy in which policy-makers in the rest of the world were not faced with the analogous constraints. However, when many major countries are

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facing similar constraints on monetary policy, it is not clear how easy or useful it is to follow the conclusions of the previous literature.[1] How does a shock which pushes the economy down to the zero lower bound spread from one country to another? It is possible that the global interaction between countries in goods and assets markets may substantially alter the effects of a given set of policy responses within a liquidity trap? This paper examines the economics of the zero lower bound constraint in a two-country model, where one or both countries experience negative demand shocks that precipitate a liquidity trap. This paper also explores three issues raised by the previous discussion pertinent to the current policy debate. First, how is a liquidity trap propagated across countries? In particular, when taking a negative demand shock in one country, which pushes the unconstrained optimal nominal interest rate below zero, how does this constrain monetary policy in the neighboring country, and how does the answer to this depend on the openness of trade and international assets markets? Secondly, we examine the effectiveness of countercyclical fiscal policy within a liquidity trap. Recent literature has argued that fiscal policy becomes very effective when the monetary authority cannot adjust interest rates. Is there a global public-good aspect to a fiscal expansion? Does fiscal expansion in one country help to alleviate the fall in output in other countries? We explore how this argument holds up in a global framework with separate fiscal responses in an environment where either one or both countries is in a liquidity trap. Finally, we explore the nature of an optimal cooperative fiscal and monetary policy response to a liquidity trap, whether the liquidity trap holds for either one country, or globally.

A key aspect of our investigation is that we allow for variations in the degree to which countries are integrated in trade and financial markets. The model allows trade openness to vary from full trade integration to an environment completely closed to trade. In addition, we allow for a variation between complete asset market integration and financial autarky. Both elements are critical for answering the questions posed above. We find that when trade is fully open and asset markets are complete, then all liquidity traps are global; if the zero lower bound binds in one country, then it will bind generally. But with less than fully open trade, shocks are only transmitted incompletely,

1. Some recent exceptions are Fujiwara et al. (2009), Bodenstein, Erceg and Guerrieri (2009) and Jeanne (2009), and Cook and Devereux (2011, 2013). These papers are discussed further below.

and the country that is the source of the shock will be more likely to hit the zero lower bound. Even with fully open trade, incomplete asset markets also reduce the transmission of shocks, and with financial market autarky, we show that the zero lower bound cannot hold in both countries simultaneously.

A key result from the model is that the transmission of shocks in the zero lower bound is associated with perverse response of relative prices; the worst hit country tends to suffer terms of trade appreciation, rather than depreciation, thus exacerbating the effects of the shock.

We also find that fiscal expansion can be extremely effective in raising economic activity, but that it does so through reducing the terms of trade, and redirecting spending away from trading partners, thus reducing trading partners GDP. Thus, fiscal spending is a "beggar-thy-neighbor" policy in a liquidity trap. This result holds in both a complete and incomplete asset market environment.

Finally, we study an optimal cooperative policy response to the shock that generates the liquidity trap. The optimal response involves a joint policy of fiscal expansion and potential policy rate increases for the least hit country. This surprising result comes from the fact that policy rate increases can ameliorate the perverse response of relative prices to the liquidity-trap shock.

This paper is related to a number of others that have recently examined policy issues in a 'zero lower bound' situation in open economies. Fujiwara, Sudox and Teranishi (2009) examine the optimal monetary problem with commitment in a multi-country situation, but do not examine the determination of fiscal policy, or the transmission of demand shocks across countries. Fujiwara Nakajimaz, Sudo and Teranishi. (2010) extend this framework to look at various types of monetary policy cooperation in a global liquidity trap. Jeanne (2009) examines a "global liquidity trap" in a model of one-period-ahead pricing similar to that of Krugman (1998). Bodenstein, Erceg and Guerrieri (2009) use a fully specific two country DSGE model to examine the international transmission of shocks when one of the countries is in a liquidity trap, but do not focus on optimal monetary policy or fiscal policy choices. Cook and Devereux (2011) explore the effect of fiscal policy cooperation in a global liquidity trap. Cook and Devereux (2013) look at the jointly optimal fiscal and monetary policy problem in an international setting when one of the countries is constrained by the zero lower bound. Devereux and Yetman (2013) examine the role that effects of capital controls play in an environment where the zero-bound constraint is binding.

The rest of the paper is organized as follows. The next section develops the basic model. Section 3 examines the efficient global equilibrium under flexible prices and endogenous fiscal policy determination. Section 4 examines the solution under sticky prices, explores the impact of fiscal policies at the zero lower bound, and discusses the role of international policy spillovers. Section 5 examines the optimal policy-making problem in a global cooperative agreement. Some conclusions are then offered.

1. A Generic Two-Country New Keynesian Model

Take a model of two countries as an example, where in each country, households consume both private and public goods, and choose how much to work given wages and prices. The countries are referred to as "home" and "foreign." The countries are of equal size (with population normalized to unity). Consumption takes place across a range of differentiated goods. Asset markets are complete within countries, but between countries we construct a mechanism which allows for asset market completeness to vary between financial autarky and a full set of security markets. Firms produce private goods, while governments produce public goods and distribute them uniformly to households. Product prices are sticky. This means that demand shocks can have inefficient effects on output and inflation rates. Demand shocks are country specific shocks to household preferences for private goods in the present, relative to the future. When the central bank can freely adjust nominal interest rates, an appropriate monetary policy can completely undo the inefficient response to demand shocks. This would ensure that, in both countries, the adjustment to demand shocks is the same as would take place in a first-best economy. Then the government's optimal fiscal policy would produce the first-best division of output between public and private goods. However, if in one or both countries, the nominal interest rate that would sustain the first-best monetary policy is below zero, then monetary policy is limited by the zero lower bound. In this case, demand shocks do have real effects and generate inefficiencies, both in the response of the economy experiencing the shock, as well as neighboring countries. Most of the analysis of the paper will consist of exploring the nature of international shock transmission as the zero bound. We will also analyze the effects of fiscal policy shocks when the zero-bound constraint is binding.

1.1 Households

Let the utility of a representative home household evaluated from date 0, be defined as:

$$U_t = E_0 \sum_{t=0}^{\infty} \beta^t \left(U(C_t, \xi_t) - V\left(N_t\right) + J(G_t) \right) \tag{1}$$

where U, V, and J represent the utility of the composite home consumption bundle C_t, disutility of labor supply N_t, and utility of the public good G_t, respectively. U and J are differentiable and concave in C and G, while V is differentiable and convex in N. The variable ξ_t represents a preference term, which we label a "demand' shock." It is assumed that $U12 > 0$. An increase in ξ_t is equivalent to a rise in the household's time preference.

Consumption is defined as

$$C_t = \Phi C_{Ht}^{v/2} C_{Ft}^{1-v/2}, \nu \geq 1$$

Where $\Phi = (v/2)^{v/2}\,(1 - (v/2))^{v/2}$, C_H is the consumption of the home country composite good, and C_F is consumption of the foreign composite. The parameter $v \geq 1$ allows for home bias in preferences. Home bias is one of the critical determinants of the degree to which the zero-bound constraint is propagated across countries.

In addition, C_H and C_F are defined over the range of home and foreign differentiated goods with elasticity of substitution θ between goods, so that:

$$C_H = \left[\int_0^1 C_H(i)^{1-\frac{1}{\theta}} di \right]^{\frac{1}{1-\frac{1}{\theta}}},\ C_F = \left[\int_0^1 C_F(i)^{1-\frac{1}{\theta}} di \right]^{\frac{1}{1-\frac{1}{\theta}}},\ \theta > 1.$$

Price indices for home and foreign consumption may be written as:

$$P_H = \left[\int_0^1 P_H(i)^{1-\theta} di \right]^{\frac{1}{1-\theta}},\ P_F = \left[\int_0^1 P_F(i)^{1-\theta} di \right]^{\frac{1}{1-\theta}},$$

while the aggregate (CPI) price index for the home country is $P = P_H^{v/2} P_H^{1-v/2}$.

Demand for the individual differentiated goods and home and foreign composite goods can be derived from these functions in the usual way. Individual firms choose prices given a demand elasticity of θ.

We assume that home government spending falls exclusively on the home composite good, and analogously for the foreign composite good. Government consumption is taken as exogenous by households. The representative home household sells labor services to each of a continuum of home country firms, and receives a nominal wage W_t in return. The household's implicit labor supply is determined by the condition:

$$U_C(C_t,\xi_t)W_t = P_t N'(N_t). \tag{2}$$

We assume that there is a full set of state-contingent securities traded between home and foreign residents. However, we also assume that there is a state-contingent wedge in the security returns across countries that prevents the equalization of marginal utilities of asset returns between households in the two countries. Denote this wedge as Ω_t. Then we have the risk-sharing relationship given by:

$$U_C(C_t,\xi_t) = U_C(C_t^*,\xi_t^*)\frac{S_t P_t^*}{P_t}\Omega_t = U_C(C_t^*,\xi_t^*)T_t^{v-1}\Omega_t, \tag{3}$$

where S_t is the nominal exchange rate (home price of foreign currency), $P_t^* = P_H^{*v/2} P_H^{*1-v/2}$ is the foreign *CPI*, and $T = SP_F^*/P_H$ is the home country terms of trade. Implicit in this condition is the assumption that the law of one price holds in individual goods and home and foreign composite consumption goods (i.e. so that $P_F = SP_F^*$, etc).

Now we assume that the wedge in risk-sharing is governed by the functional relationship:

$$\Omega_t = \left(\frac{P_t C_t}{P_{Ht} Y_{Ht}}\right)^{\frac{\lambda}{1-\lambda}} \tag{4}$$

where Y_{Ht} represents home country GDP, an average of all home firms output. This form can be rationalized by the presence of lump-sum financed taxes that are conditioned on the ratio of consumption to domestic GDP. The specific usefulness of (4) is that it allows us to vary the effective degree of asset market completeness between that of un-restricted cross country risk-sharing (when $\lambda = 0$) to financial autarky (when $\lambda = 1$)[2].

We assume also that households hold domestic nominal government bonds, which pay an interest rate of R_t in all states of the world. Then the Euler equation for nominal bond pricing is given by:

$$\frac{U_C(C_t,\xi_t)}{P_t} = \beta R_{t+1} E_t \frac{U_C(C_{t+1},\xi_{t+1})}{P_{t+1}}. \tag{5}$$

Foreign household's actions can be exactly defined analogously. As we see from the definition of P_t^* given above, the foreign representative household has weight $v/2$, $(1 - v/2)$ on the foreign (home) composite good.

1.2 Firms

Firms use labor to produce individual differentiated goods. In the home country, firm i has the production function:

$$Y_t(i) = N_t(i),$$

The home firm's profits are defined by $\Pi_t(i) = P_{Ht}(i)Y_t(i) - W_t H_t(i)(1 - s_t)$, where s_t is a wage subsidy given to all home firms by the home government, financed with lump-sum taxation. This facilitates approximation of the model around an undistorted steady state.

We assume that each home firm resets its price according to Calvo pricing, where the probability of readjusting its price is $1 - \kappa$ in each period. The home firm sells its product to home and foreign consumers, and the home government, at a common price, facing a demand elasticity of θ. When the firm can adjust its price, it sets the new price, denoted $\tilde{P}_{Ht}(i)$, so as to maximize the present value of profits evaluated using the stochastic discount factor $m_{t+j} = (P_t / U_C(C_t,\varepsilon_t))(U_C(C_{t+j},\xi_{t+j})/P_{t+j})$. This leads to the optimal price setting condition as follows:

2. The form of this risk-sharing wedge is used in Devereux and Yetman (2013). The appeal of (4) is that it allows for intermediate degrees of asset market completeness without adding additional state variables into the model, as would be the case, for instance, if we limited asset trade across countries to that of non-state contingent bonds.

$$\tilde{P}_{Ht}(i) = \frac{\theta}{\theta - 1}(1 - s_t)\frac{E_t \sum_{j=0}^{\infty} m_{t+j}\kappa^j \frac{W_{t+j}}{A_{t+j}} Y_{t+j}(i)}{E_t \sum_{j=0}^{\infty} m_{t+j}\kappa^j Y_{t+j}(i)}. \tag{6}$$

All home firms that can adjust their price, choose the same price. In the aggregate, the price index for the home good then follows the process given by:

$$P_{Ht} = [(1 - \kappa)\tilde{P}_{Ht}^{1-\theta} + \kappa P_{Ht-1}^{1-\theta}]^{\frac{1}{1-\theta}}. \tag{7}$$

The behavior of foreign firms and the foreign good price index may be described analogously.

1.3 Fiscal Policy

We assume that governments have access to lump sum taxation. Each government then has the task of choosing both an optimal subsidy for its domestic monopoly producers and the level of public goods spending for its domestic constituents. In addition, we assume that the home government follows the state-contingent security tax policy governed by (4). The optimal profit subsidy is set as $s = 1/\theta$, which offsets the steady state monopoly distortion in price setting. With respect to the size of public spending, in the analysis below, we will focus on a jointly optimal cooperative monetary and fiscal policy set to maximize the sum of home and foreign utility. Government spending will be set as a trade-off between alternative objectives, and will depend on the constraints on monetary policy. If monetary policy is not limited by the zero bound, then government spending is optimally set from a pure public finance perspective. In a liquidity trap however, government spending policies will typically deviate from the optimal public finance rule and will be chosen to satisfy stabilization objectives.

1.4 Monetary Policy

We define monetary policy under three different possible regimes. In the first case, we assume that policy is governed by an arbitrary Taylor rule, which sets the short-term interest rate as a function of domestic inflation, as long as the interest rate is not constrained by the zero bound. If this constraint binds, then the interest rate is zero. In the case where monetary policy is governed by a Taylor rule, we assume the rule given by:

$$R_t^r = (1+\rho_t)(1+\tilde{\pi}_H)\left(\frac{P_{Ht}}{P_{Ht-1}}\frac{1}{1+\tilde{\pi}_H}\right)^{\gamma} \tag{8}$$

where ρ_t represents a desired path for the equilibrium real interest rate, and $\tilde{\pi}_H$ represents a desired path for the home goods inflation rate[3]. We assume that $\gamma > 1$. This rule does not allow for interest rate "smoothing." This simplification allows for simple analytical solutions to the model governed by the Taylor rule, and is not critical for the results.

In some cases, we also assume that monetary policy is set to target the natural interest rate (which is defined below), subject to the zero-bound constraint. Hence, we will assume in this case that the policy interest rate is set such that:

$$\ln(R_t) = \text{Max}(0, \tilde{r}_t) \tag{9}$$

Finally in section 5, we allow for an optimal targeting rule for monetary policy. Interestingly, in general, this will imply a different path of interest rates than that governed in (9). Again, however, this optimal rule must be constrained by the zero bound on nominal interest rates. In all cases, we assume that policy is determined under discretion, so we abstract from the possibility of effective forward guidance in monetary policy (and fiscal policy). In addition, we ignore the possibility of using asset purchases by the central bank to implement monetary policy.

Again, the monetary authority of the foreign country is characterized in an analogous manner.

1.5 Market Clearing

Each home country firm *i* faces demand for its good from home consumers, foreign consumers and its home government. We can define equilibrium in the market for good *i* as

3. It is more appropriate to define an interest rate rule over home goods inflation rather than the CPI inflation rate since in the absence of the zero lower bound, the policy-maker would wish to set the former inflation rate to zero.

$$Y_{Ht}(i) = \left(\frac{P_{Ht}(i)}{P_{Ht}}\right)^{-\theta} \left[\frac{v}{2}\frac{P_t}{P_{Ht}}C_t + (1-\frac{v}{2})\frac{S_t P_t^*}{P_{Ht}}C_t^* + G_t\right],$$

where G_t represents total home government spending on the aggregate home good. Now, aggregating across all home firms, market clearing in the home good is defined as

$$Y_{Ht} = \frac{v}{2}\frac{P_t}{P_{Ht}}C_t + (1-\frac{v}{2})\frac{S_t P_t^*}{P_{Ht}}C_t^* + G_t. \tag{10}$$

Here $Y_{Ht} = V_t^{-1}\int_0^1 Y_{Ht}(i)di$ is aggregate home country output, where we have defined $V_t = \int_0^1 (P_{Ht}(i)/P_{Ht})^{-\theta} di$. It follows that home country employment (employment for the representative home household) is given by $N_t = \int_0^1 N(i)di = A^{-1}Y_{Ht} = V_t$.

In the same manner, we may write the aggregate market clearing condition for the foreign good as

$$Y_{Ft} = \frac{v}{2}\frac{P_t^*}{P_{Ft}^*}C_t^* + \left(1-\frac{v}{2}\right)\frac{P_t}{S_t P_{Ft}^*}C_t^* + G_t^*, \tag{11}$$

and again, we may define foreign employment as $N_t^* = \int_0^1 N_t^*(i) di = A^{*-1}Y_{Ft}V_t^*$, where $V_t^* = \int_0^1 (P_{Ft}^*(i)/F_{Ft}^*)^{-\theta} di$.

An equilibrium in the world economy with positive nominal interest rates may be described by equation (3), and equations (2), (5), (6), (7) and (8) for the home and foreign economy, as well as (10) and (11). For given values of V_t and V_t^*, and given government spending policies, these equations determine an equilibrium sequence for the variables C_t, C_t^*, W_t, W_t^*, S_t, P_{Ht}, P_{Ft}^*, $\tilde{P}_{Ht}$, $\tilde{P}_{Ft}^*$, R_t, R_t^*, and N_t, N_t^*. In a first order approximation of the model, the distribution expressions V_t and V_t^* drop out, so up to a first order approximation, the behavior of all variables is fully determined by the outlined equations. When monetary policy in one or both countries is constrained by the zero lower bound, we have to define equilibrium in a constrained manner, as described below.

2. Equilibrium with Fully Flexible Prices

We first define the equilibrium of the model in a fully flexible price world equilibrium where $\kappa = 0$ in each country. In that case, $P_{Ht}(i) = P_{Ht}$, $P_{Ft}(i) = P_{Ft}$, and $V_t = V_t^* = 1$. In addition (given the presence of optimal subsidies) we have $P_{Ht} = A^{-1}W_t$ and $P_{Ft}^* = A^{-1}W_t^*$.

Letting a circumflex denote values in a flexible price world equilibrium, we may describe the equilibrium by the equations:

$$U_C(\tilde{C}_t,\xi_t)A = \tilde{T}_t^{1-\upsilon/2}V'(\tilde{N}_t), \quad U_C^*(\tilde{C}_t^*,\xi_t^*)A^* = \tilde{T}_t^{-(1-\upsilon/2)}V'(\tilde{N}_t^*) \tag{12}$$

$$U_C(\tilde{C}_t,\xi_t)\tilde{T}_t^{\upsilon-1}\left(\frac{\tilde{T}^{\upsilon/2-1}\tilde{N}}{\tilde{C}}\right)^{\frac{\lambda}{1-\lambda}} = U_C^*(\tilde{C}_t^*,\xi_t^*), \tag{13}$$

$$\tilde{N}_t = \frac{\upsilon}{2}\tilde{T}_t^{1-\upsilon/2}\tilde{C}_t + \left(1-\frac{\upsilon}{2}\right)\tilde{T}_t^{\upsilon/2}\tilde{C}_t^* + \tilde{G}_t, \tag{14}$$

$$\tilde{N}_t^* = \frac{\upsilon}{2}\tilde{T}_t^{-(1-\upsilon/2)}\tilde{C}_t^* + \left(1-\frac{\upsilon}{2}\right)\tilde{T}_t^{-\upsilon/2}\tilde{C}_t + \tilde{G}_t^* \tag{15}$$

This implicitly describes the efficient world equilibrium for consumption, output (or employment), and the terms of trade, conditional on values for home and foreign rates of government spending.

For the moment, we take government spending as exogenously given in both countries. We analyze equations (12) to (15) by taking a linear approximation around the globally efficient steady state. For a given variable X, define $\tilde{x} = \ln(\tilde{X}/\overline{X})$ to be the log difference of the global efficient value from the non-stochastic steady state, except for ε_t (to be defined below), and $\tilde{\pi}_{H+1}$ and $\tilde{r}_t$, which refer respectively to the level of the inflation rate and nominal interest rate. Since the model is symmetric, we have $\overline{T} = 1$ in a steady state. Then, we may express the linear approximation of (12) to (15) as:

$$\sigma\,\tilde{c}_t - \varepsilon_t + \phi\,\tilde{y}_t + \left(1-\frac{\upsilon}{2}\right)\tilde{\tau}_t = 0, \tag{16}$$

$$\sigma\, \tilde{c}_t^* - \varepsilon_t^* + \phi\, \tilde{y}_t^* - \left(1 - \frac{v}{2}\right)\tilde{\tau}_t = 0, \tag{17}$$

$$\tilde{y}_t = c_y\left(\frac{v}{2}\tilde{c}_t + \left(1 - \frac{v}{2}\right)\tilde{c}_t^*\right) + c_y v\left(1 - \frac{v}{2}\right)\tilde{\tau}_t + (1 - c_y)\tilde{g}_t, \tag{18}$$

$$\tilde{y}_t^* = c_y\left(\frac{v}{2}\tilde{c}_t^* + \left(1 - \frac{v}{2}\right)\tilde{c}_t\right) - c_y v\left(1 - \frac{v}{2}\right)\tilde{\tau}_t + (1 - c_y)\tilde{g}_t^*, \tag{19}$$

$$\begin{aligned}&(1-\lambda)\left(\sigma\tilde{c}_t - (\varepsilon_t - \varepsilon_t^*) - \sigma\tilde{c}_t^* - (v-1)\tilde{\tau}_t\right)\\ &+\lambda\left(c_y\tilde{c} + (1-c_y)\tilde{g} + (1 - v/2)\tilde{\tau} - \tilde{y}\right) = 0,\end{aligned} \tag{20}$$

Here we have defined $\sigma \equiv -\, U_{CC}\overline{C}/U_C$ as the inverse of the elasticity of intertemporal substitution in consumption, $\phi \equiv -\, (V''\overline{H}/V')$ as the elasticity of the marginal disutility of hours worked[4]. The ratio of private consumption to GDP is defined as c_y. Finally, $\varepsilon_t = (U_{C\xi}/U_C)\ln(\xi_t)$ is the measure of a positive demand shock in the home country, with an equivalent definition for the foreign country.

We may solve the system (16) to (20) to obtain the first order solutions for consumption, output and the terms of trade in response to demand shocks. For any variable x, define $x^W = (x + x^*)/2$ as the world *average*, and $x^R = (x + x^*)/2$ as the world *relative* in the variable. Since then $x = x^W + x^R$, we can write home and foreign consumption responses to demand shocks as:

$$\tilde{c}_t = \frac{1}{\phi c_y + \sigma}\varepsilon_t^W + \left[\begin{aligned}&(1-\omega)\left(\frac{1 + c_y\phi v(2-v)}{\sigma + \phi c_y D}\right)\\ &+\omega\left(\frac{(v-1)}{\sigma(1-v) + 2 - v + \phi c_y}\right)\end{aligned}\right]\varepsilon_t^R$$

4. In a subsequent section, we also make use of the parameter and $\sigma_g \equiv -\, (J''\overline{G}/J')$, which is the elasticity of the marginal utility of public goods. We will assume that $\sigma_g = \sigma$.

$$\tilde{c}_t^* = \frac{1}{\phi c_y + \sigma}\varepsilon_t^W - \left[\begin{array}{l}(1-\omega)\left(\dfrac{1+c_y\phi v(2-v)}{\sigma+\phi c_y D}\right) \\ +\omega\left(\dfrac{(v-1)}{\sigma(1-v)+2-v+\phi c_y}\right)\end{array}\right]\varepsilon_t^R$$

where $D \equiv \sigma v\,(2-v) + (1-v)^2$, and ω is a function of the risk-sharing weight λ, defined as:

$$\omega(\lambda) = \frac{\lambda c_y(2-v)(2-v+\sigma(v-1)+\phi c_y)}{2(1-\lambda)(\phi c_y D+\sigma)+\lambda c_y(2-v)(2-v+\sigma(v-1)+\phi c_y)}$$

Note that $\omega(0) = 0$, $\omega(1) = 1$, and $\omega'(\lambda) > 0$ for $0 \leq \lambda \leq 1$.

A demand shock raises the efficient flexible-price world consumption level, but the impact on individual country consumption depends on the source of the demand shock, the degree of home bias in preferences, and the openness of international capital markets. A world demand shock will raise the flexible price level of home and foreign consumption equally, but a relative home country demand shock leads consumption to move in opposite directions across countries, and the response will depend upon λ and v. For $\lambda = 0$, there is full risk-sharing, and asset markets will facilitate a rise in home country consumption for $\varepsilon^R > 0$ even for zero home bias in preferences ($v = 1$). But with no capital markets $\lambda = 1$, a rise in ε^R will raise home (and reduce) foreign flexible price consumption only when $v > 1$. The explanation for this latter effect is developed further below when examining the characteristics of the terms of trade under flexible prices.

The impact of demand shocks on flexible price output levels are likewise written as:

$$\tilde{y}_t = \frac{c_y}{c_y\phi+\sigma}\varepsilon_t^W + \left[(1-\omega)\left(\frac{c_y(v-1)}{\sigma+c_y\phi D}\right)+\omega\left(\frac{c_y}{\sigma(v-1)+2-v+c_y\phi}\right)\right]\varepsilon_t^R$$

$$\tilde{y}_t^* = \frac{c_y}{c_y\phi+\sigma}\varepsilon_t^W - \left[(1-\omega)\left(\frac{c_y(v-1)}{\sigma+c_y\phi D}\right)+\omega\left(\frac{c_y}{\sigma(v-1)+2-v+c_y\phi}\right)\right]\varepsilon_t^R$$

A world demand shock raises equilibrium output in both countries. When there is home bias in preferences, so that $v > 1$, a relative home demand shock tends to raise home output and reduce foreign output when financial markets are complete. Without capital markets, a relative demand shock increases relative home output even for $v = 1$, because without risk-sharing for preference shocks, the increase in relative home time preference directly increases home output through an increase in the supply of labor.

Demand shocks also affect the flexible price efficient response of the terms of trade. We can show that:

$$\frac{\tilde{\tau}_t}{2} = -\left[\frac{(1-\omega)\phi c_y(v-1)}{\sigma + c_y\phi D} - \frac{\omega}{2-v+c_y\phi+\sigma(v-1)}\right]\varepsilon_t^R$$

The response of the terms of trade to a relative demand shock depends on the degree of capital market integration. When $\lambda = 0$, there is full risk-sharing, and relative output and the terms of trade improve only when $v > 1$. But if $\lambda = 1$, with no capital markets, home relative output increases, and the terms of trade deteriorates. The different response of the terms of trade under the two alternative capital market structures comes from the different types of risk-sharing that occurs. With a full, unhindered set of security markets, cross country insurance allows for the occurrence of preference shocks, so that full risk-sharing does not generally equate consumption levels across countries. Rather, full risk-sharing, by equating the marginal utility of security payoffs across countries, leads to equal responses of labor supply in each country, according to (2). Then, home output will only rise if the rise in demand is tilted towards home goods (i.e. $v > 1$), which in itself tends to raise the terms of trade. In contrast, without capital markets, risk-sharing only takes place indirectly through terms of trade adjustment—relative home output increases due to the shift out in home labor supply, and this leads to an equilibrium fall in the relative home price—i.e. a terms of trade deterioration.

If monetary authorities could adjust nominal interest rates freely to respond to demand shocks, then the flexible-price efficient global equilibrium could be sustained. Following previous literature, we denote the interest rate that would sustain the flexible-price efficient outcome as the "natural interest rate." Denote $\tilde{r}_t$ as the (level of the) net nominal interest rate, and let $\bar{r}_t$ be its steady state value. Then, a log linear approximation of (5) leads to the expressions for the flexible-price equilibrium nominal interest rate in the home country as:

$$\tilde{r}_t = \bar{r} + \sigma E_t(\tilde{c}_{t+1} - \tilde{c}_t) - E_t(\varepsilon_{t+1} - \varepsilon_t) + E_t \tilde{\pi}_{Ht+1} + \left(1 - \frac{v}{2}\right) E_t(\tilde{\tau}_{t+1} - \tilde{\tau}_t) \quad (21)$$

Assume that an efficient monetary policy is to keep the domestic rate of inflation equal to zero. In addition, for now, assume that demand shocks follow an AR(1) process so that $\varepsilon_{t+1} = \mu\varepsilon_t + u_t$ and $\varepsilon^*_{t+1} = \mu\varepsilon^*_t + u^*_t$, where u^*_t and u_t are mean-zero and i.i.d., then the value of $\tilde{r}_t$ when the right hand side is driven by demand shocks alone can be derived as:

$$\tilde{r}_t = \bar{r} + \left(\frac{\phi c_y}{\phi c_y + \sigma} \varepsilon_t^W + \left(\frac{(1-\omega)\phi c_y (v-1)}{\sigma + \phi c_y D} + \frac{\omega \phi c_y}{2 - v + \phi c_y + \sigma(v-1)} \right) \varepsilon_t^R \right) (1-\mu) \quad (22)$$

In a similar manner, the foreign efficient nominal interest rate is:

$$\tilde{r}^*_t = \bar{r} + \left(\frac{\phi c_y}{\phi c_y + \sigma} \varepsilon_t^W - \left(\frac{(1-\omega)\phi c_y (v-1)}{\sigma + \phi c_y D} + \frac{\omega \phi c_y}{2 - v + \phi c_y + \sigma(v-1)} \right) \varepsilon_t^R \right) (1-\mu) \quad (23)$$

Natural interest rates respond to both aggregate and relative demand shocks. An aggregate demand shock raises global marginal utility and raises natural interest rates. A relative demand shock affects natural interest rates in separate ways in the two countries, but this depends upon the degree of capital market openness as well as the degree of home bias in preferences. If securities markets are full (i.e. $\lambda = 0$, so that $\omega = 0$), then a relative demand shock causes a rise (fall) in the home (foreign) natural interest rate, only if $v > 1$. With identical preferences across countries, and full security markets, the natural interest rate is independent of purely relative demand shocks. On the other hand, in the case of no capital markets (i.e. $\lambda = 1$ so that $\omega = 1$), a relative demand shock always raises (lowers) home (foreign) natural real interest rates, independent of whether v exceeds unity.

This discussion has direct bearing on the degree to which the zero-bound constraint will bind across countries in response to time preference shocks (negative demand shocks) emanating from one country. In general, these shocks will have both aggregate and relative components. But if there are full security markets and identical preferences, we see that natural interest rates are always equated across countries. Then, in a monetary policy regime in which authorities in each country attempt to target the natural interest rate, the occurrence of the zero-bound constraint will be perfectly synchronous across countries—all liquidity traps are global. But when there is home bias, or equivalently, when trade is not perfectly open across countries, this is no longer the case. In addition, even with fully open trade, capital market restrictions can also segment countries' natural interest rates so that the zero-bound constraint is not perfectly synchronized across countries when $\lambda > 0$.

Figure 1 illustrates the relationship between (22) and (23) consequent upon a negative shock to ε (the home preference term) as a function of v. In this case, the two expressions (22) and (23) become:[5]

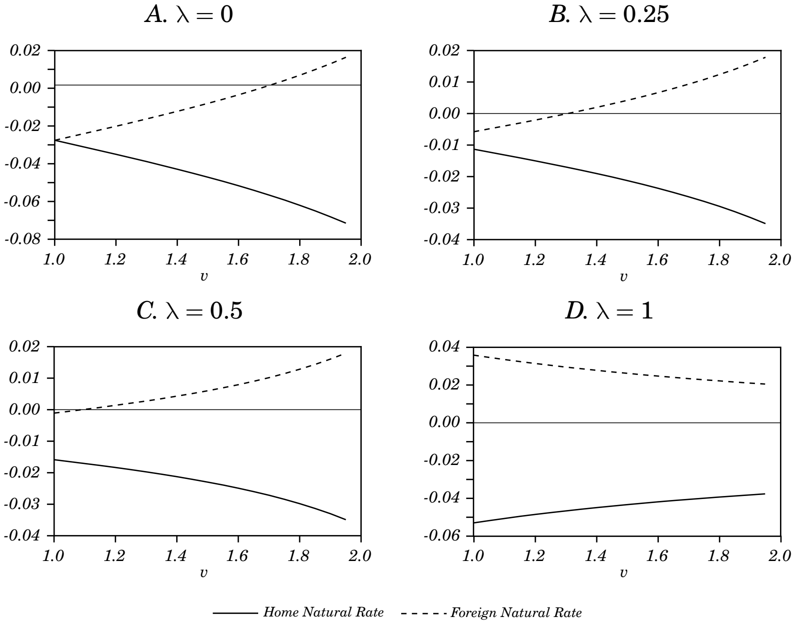
$$\tilde{r}_t = \bar{r} + \phi c_y \left(\frac{1}{\phi c_y + \sigma} + \left(\begin{array}{l} \dfrac{(1-\omega)(v-1)}{\sigma + \phi c_y D} \\ + \dfrac{\omega}{2 - v + \phi c_y + \sigma(v-1)} \end{array} \right) \right) (1-\mu)\frac{\varepsilon_t}{2} \tag{24}$$

and,

$$\tilde{r}_t^* = \bar{r} + \phi c_y \left(\frac{1}{\phi c_y + \sigma} - \left(\begin{array}{l} \dfrac{(1-\omega)(v-1)}{\sigma + \phi c_y D} \\ + \dfrac{\omega}{2 - v + \phi c_y + \sigma(v-1)} \end{array} \right) \right) (1-\mu)\frac{\varepsilon_t}{2}. \tag{25}$$

5. In this figure and the subsequent figures below, we use the following standard calibration of parameters and shocks; $\sigma = 2$, $\phi = 1$, $\beta = 0.99$, $k = 0.05$, $c_y = 0.8$, $\mu = 0.6$, $\bar{r} = 0.02$, and we assume that the shocks ε_t^W and ε_t^R are such that the desired interest rate would be -0.05 in the absence of the zero bound.

Figure 1. Natural Interest Rates



Source: Authors' elaboration.

The first panel of the figure shows the case of $\lambda = 0$, so that security markets are complete. The value of v ranges between 1 and 2. The calibration is such that for $\lambda = 0$ and $v = 1$, both countries fall into a liquidity trap. As v rises above 1, the fall in the home natural real interest rate is greater, while the foreign natural real interest rate falls by less. As v approaches 2, the home natural real interest rate falls by its maximal amount, and there is no affect at all on the foreign natural real interest rate. Two clear implications come from the figure: First, we see that the combination of integrated financial markets and international trade in goods cushions the full impact of savings shocks on the home natural real interest rate[6]. Second,

6. Note that the countries are of equal size. Extending the model to allow for differential size (and home bias in preferences) among countries would be straightforward, but would add notational complexity. In the case of size differences, smaller countries would be more vulnerable to global preference shocks creating a liquidity trap, but more insulated against domestic shocks.

the more open both economies are, the more likely that the liquidity trap will be experienced globally.

The second, third and fourth panels of figure 1 illustrate the relationship between v and natural interest rates as capital markets become more and more restricted. As λ increases, there is a wedge between natural interest rates, even if there is completely open trade ($v = 1$). In the limit, when $\lambda = 1$, as seen in expressions (24) and (25), the natural interest rates are negatively correlated. In this case, a negative home demand shock reduces the home natural rate by more in the open economy (when $v = 1$) than it would in the closed economy ($v = 2$), and the foreign natural interest rate increases above its initial steady state. Figure 1d illustrates an interesting implication of the consequence of capital market restrictions in the face of demand shocks. When $\lambda = 1$, we have financial autarky, so direct financial risk-sharing is eliminated. But the response of the terms of trade indicates that the indirect mechanism for risk sharing, through a terms of trade deterioration, is also prevented. This is because the terms of trade of the country experiencing the shock actually appreciates, as discussed above.

3. Demand Shocks with Sticky Prices and the Zero-bound Constraint

We now turn to the substantial analysis of the paper, exploring the impact of demand shocks in the case where prices are sticky, and the zero-bound constraint may bind. When prices are sticky, we may derive a log-linear approximation of the model in terms of inflation and output gaps in a manner similar to Clarida, Galí and Gertler (2002) and Engel (2010). Taking a linear approximation of (2), (6) and (7) around the zero inflation steady state, we derive the standard forward-looking inflation equation, in terms of "gaps," or deviations from the flexible-price efficient level of each variable. For any variable x, we define $\hat{x} = (X/\tilde{X})\ln$ as the log deviation from the flexible-price efficient level (as before, inflation and nominal interest rates are expressed in levels).

This model has the property of a full dichotomy of the system of equations into world averages and world relative variables. We can write the New Keynesian model for world averages in terms of the world average inflation rate, and world average output gap.

The average system is represented as:

$$\pi_t^W = \frac{k}{c_y}\left((\sigma + c_y\phi)\hat{y}_t^W - \sigma(1-c_y)\hat{g}_t^W\right) + \beta E_t \pi_{t+1}^W \tag{26}$$

$$\rho_t^W + \gamma\pi_t^W = E_t \frac{\sigma}{c_y}(\hat{y}_{t+1}^W - \hat{y}_t^W) + E_t \frac{(1-c_y)}{c_y}(\hat{g}_{t+1}^W - \hat{g}_t^W) + \tilde{r}_{t+1}^W \tag{27}$$

where $k = (1 - \beta\kappa)(1 - \kappa)/\kappa$, and $\tilde{r}_{t+1}^W$ is the world average natural interest rate. Then the relative system is given by:

$$\begin{aligned}\pi_t^R = {} & \frac{k}{c_y}\left(\phi c_y + (1-\omega_1)\sigma_D + \omega_1(2 - v + \sigma(v-1))\right)\hat{y}_t^R \\ & - \frac{k(1-c_y)}{c_y}\left((1-\omega_1)\sigma_D + \omega_1(2-v+\sigma(v-1))\right)\hat{g}_t^R + \beta E_t \pi_{t+1}^R\end{aligned} \tag{28}$$

$$\begin{aligned}\rho_t^R + \gamma\pi_t^R = {} & E_t \frac{1}{c_y}\left(\omega_1\sigma_D + (1-\omega_1)(2-v+\sigma(v-1))\right)(\hat{y}_{t+1}^R - \hat{y}_t^R) \\ & - E_t \frac{(1-c_y)}{c_y}\left(\omega_1\sigma_D + (1-\omega_1)(2-v+\sigma(v-1))\right)(\hat{g}_{t+1}^R - \hat{g}_t^R) + \tilde{r}_{t+1}^R\end{aligned} \tag{29}$$

where $\tilde{r}_{t+1}^R$ is the world relative natural interest rate, and we define expressions as follows:

$$\sigma_D \equiv \frac{\sigma}{D}, \text{and } \omega_1(\lambda) = \frac{2D(1-\lambda)}{2D(1-\lambda) + \lambda c_y(2-v)}.$$

Note that the system written in terms of 'world averages' is independent of the degree of trade integration, captured by the home bias parameter v, and of the degree of capital market integration, captured by the parameter λ. The system in terms of 'world relatives' does depend upon both v and λ.

From (26) to (29), we can solve for the values of π_t^W, $\hat{y}_t^W$, π_t^R, and $\hat{y}_t^R$. From these solutions, we can then recover the values of output, terms of trade, and consumption as a function of the movements in natural rates of interest $\tilde{r}_t$ and $\tilde{r}_t^*$ as well as the shocks to government spending gaps $\hat{g}_t$ and $\hat{g}_t^*$.

We note that, so long as it is feasible, a monetary policy rule which ensures that $\rho_t^W = \tilde{r}_{t+1}^W$ and $\rho_t^R = \tilde{r}_{t+1}^R$ can simultaneously ensure zero inflation and zero output gaps in both countries. This rule simply involves adjusting the individual national nominal interest rates to equal their respective natural interest rates in each country. However, if natural interest rates are pushed below zero, this is not feasible. In the analysis below, we focus on situations where the natural interest rates of one or both countries are temporarily below zero. In this case, we immediately cannot achieve zero inflation and zero output gaps for both countries simultaneously.

3.1 International Transmission of Shocks and the Zero Bound, with Full Capital Mobility

Our leading example will focus on the case of a negative demand shock emanating from the home country, so that $\varepsilon_t < 0$ and $\varepsilon_t^* = 0$. As shown above, this will reduce the natural interest rate in the home country, while its effect on the foreign natural interest rate depends upon both the degree of trade openness and the integration of world capital markets. We deal with each of these cases in turn, beginning with the case of fully open capital markets, and focusing on the influencing of varying trade openness on the international transmission of demand shocks at the zero bound, as well as the effectiveness of the fiscal policy response to such shocks. When $\lambda = 0$, it is immediate from (22) and (23), that natural interest rates move in the same direction in response to a demand shock. Furthermore, in the case of fully open trade $v = 1$, natural interest rates are identical, and both countries hit the zero lower bound simultaneously; there is either no liquidity trap, or a global liquidity trap. But more generally, when the shock is large enough, both countries can be in a liquidity trap even when $v > 1$.

While our focus is on the characteristics of the economy when monetary policy is constrained by the zero bound, it is first useful to review the properties of the model under a positive nominal interest rate when policy is governed by a Taylor rule according to (8). Although we have emphasized that in this case, an optimal monetary policy is to adjust nominal interest rates to equal natural interest rates, and thereby eliminating all welfare gaps, we first describe how such adjustment would take place when interest rates are arbitrarily adjusted according to a Taylor rule, and $\gamma > 1$, so that the Taylor principle applies. Since most of the literature in New Keynesian open economy models deals with this case, it serves as a useful contrast to the properties of the model in a liquidity trap.

3.1.1 Demand shocks and fiscal policy with a Taylor rule

Now specialize the Taylor rule (8) to the case where the target real interest rate $\bar{r}$ is constant (i.e. assuming that the monetary and fiscal authorities do not follow a policy of closing all gaps in the economy with positive nominal interest rates). We also assume that the target inflation rate $\tilde{\pi}_{Ht}$ is zero. Thus, in the linearized versions of (8) we set $r_t = \bar{r} + \gamma\pi_H$ and $\tilde{r}_t^* = \bar{r} + \gamma\pi_{Ft}^*$.

As noted above, we focus on a shock to the home country ε. From the above notation, this implies that $\varepsilon_t^W + \varepsilon_t^R = \varepsilon_t$ and $\varepsilon_t^W + \varepsilon_t^R = \varepsilon_t^* = 0$. As noted, we assume that the shock has persistence $0 < \mu < 1$. Then, we may derive the impact of these shocks on home and foreign output as follows:

$$\hat{y}^r_{t(\text{Taylor})} = \left[\frac{1}{(\sigma+\phi c_y)\Delta} + \frac{(v-1)D}{\Delta_1(\sigma+\phi c_y D)}\right]\frac{(1-\mu)(1-\beta\mu)\phi c_y^2\varepsilon_t}{2} \tag{30}$$

$$\hat{y}^{*r}_{t(\text{Taylor})} = \left[\frac{1}{(\sigma+\phi c_y)\Delta} - \frac{(v-1)D}{\Delta_1(\sigma+\phi c_y D)}\right]\frac{(1-\mu)(1-\beta\mu)\phi c_y^2\varepsilon_t}{2} \tag{31}$$

Here, $\Delta = \sigma(1-\mu)(1-\beta\mu) + k(\gamma_1 - \mu)(\sigma - \phi c_y) > 0$, and $\Delta_1 = \sigma(1-\mu)(1-\beta\mu) + k(\gamma_1 - \mu)(\sigma - \phi D c_y) > 0$.

From (30) and (31), a home country saving shock reduces output (in gap terms) in the home country. The response of the output gap in the foreign country depends on v, as seen below. For v relatively close to unity, the foreign output gap falls also. For $v > 1$, the response of the home output gap is always greater than that of the foreign output gap.

When $v > 1$, the savings shock must also generate some relative price movement across countries. We may compute the response of the terms of trade as follows:

$$\tau^r_{t(\text{Taylor})} = -\frac{\phi(v-1)c_y k\varepsilon_t(\gamma_1-\mu)}{\Delta_1}$$

In response to a savings shock, the home terms of trade depreciates since $\gamma > \mu$, given that monetary policy satisfies the Taylor principle. Intuitively, the shock leads to a decline in home inflation and a compensating interest-rate cut which facilitates an exchange-rate and terms-of-trade depreciation.

Again, to contrast with their effects in a global liquidity trap, we can examine the effects of fiscal spending shocks in the environment where the Taylor principle applies. Fiscal spending shocks always have differential effects across countries as spending is focused on the home good. Again, take the fiscal spending shock coming from the home country. In addition assume that shocks to the fiscal gap $\hat{g}_t$ are also AR(1) with persistence μ. Then we derive:

$$\hat{y}^{g}_{t(\text{Taylor})} = \frac{1}{2}(1-c_y)\frac{[\Delta_1+\Delta]\Theta}{\Delta\Delta_1}\hat{g}_t \tag{32}$$

$$\hat{y}^{*g}_{t(\text{Taylor})} = \frac{1}{2}(1-c_y)\frac{k\phi c_y(D-1)(\gamma-\mu)\Theta\hat{g}_t}{\Delta\Delta_1}$$

where $\Theta \equiv \sigma(1-\beta\mu)(1-\mu)+k(\gamma-\mu) > 0$. When nominal interest rates are positive, and the Taylor principle applies ($\gamma > 1$), then shocks to the fiscal spending gap will raise the home output gap. Here, and in what follows, we make the empirically relevant assumption that $\sigma > 1$, so that $D \geq 1$. In this case, home spending shocks also raise the foreign output gap so that the international transmission of fiscal policy is positive. But home output always rises more than foreign, since:

$$\hat{y}^{g}_{t(\text{Taylor})} - \hat{y}^{*g}_{t(\text{Taylor})} = (1-c_y)\frac{\Theta}{\Delta_1}\hat{g}_t > 0$$

The response of the terms of trade can be derived as follows:

$$\hat{\tau}^{g}_{t(\text{Taylor})} = -\frac{(1-c_y)k(\gamma-\mu)\phi\hat{g}_t}{\Delta_1} \tag{33}$$

Under a Taylor rule, a domestic fiscal expansion causes a terms-of-trade appreciation, causing a relative price movement, which drives expenditure away from the home good. The impact on home and foreign country consumption is given by:

$$\hat{c}^{g}_{t(\text{Taylor})} = -\frac{(1-c_y)k(\gamma-\mu)\phi\left[\Delta_1 + (v-1)\Delta\right]\hat{g}_t}{\Delta\Delta_1} \tag{34}$$

$$\hat{c}^{*g}_{t(\text{Taylor})} = -\frac{(1-c_y)k(\gamma-\mu)\phi\left[\Delta_1 - (v-1)\Delta\right]\hat{g}_t}{\Delta\Delta_1}$$

$$= -\frac{(1-c_y)k(\gamma-\mu)\phi(2-v)\left[\Theta + k\phi(\gamma-\mu)c_y(1+v(\sigma-1))\right]\hat{g}_t}{\Delta\Delta_1} \tag{35}$$

Consumption falls in both countries. When $v = 1$, home and foreign consumption fall equally in response to a fiscal gap expansion in either country. More generally, for $v > 1$, consumption falls by more in the home country.

A domestic government spending increase under a Taylor rule increases aggregate demand and domestic output. This raises domestic marginal cost, increasing inflation. The rise in inflation leads to a rise in the domestic nominal and real interest rate. This leads to an exchange-rate and terms-of-trade appreciation for the home country. The fall in aggregate consumption reduces demand for foreign output, but the foreign terms of trade depreciation increases demand for foreign output. For $\sigma > 1$, the second effect dominates, and foreign output increases.

How large is the fiscal multiplier? It is easy to show that both the own country and cross country fiscal multipliers must be less than unity. Define the fiscal spending multiplier as $dY/dG = [(Y/G)(\hat{y}/\hat{g})] = 1/[(1 - cy)(\hat{n}/\hat{g})]$. Since both consumption and the terms of trade fall following a fiscal spending shock, it must be the case that home output rises by less than $(1 - c_y)\hat{g}_t$, as is also evident from (32). Then the government spending multiplier in the economy governed by a Taylor rule is less than unity. Since foreign output rises by less than home, the fiscal spending multiplier for foreign output must also be less than unity.

Finally, note that since the terms of trade response tends to reduce the size of the fiscal multiplier, it should imply that trade openness reduces the effectiveness of fiscal policy in a traditional sense. This is indeed the case, under a Taylor rule. In particular, we can show that

$$\hat{y}^{g}_{t(\text{Taylor},\text{v}=2)} - \hat{y}^{g}_{t(\text{Taylor},\text{v}=1)} = \text{Sign}(\sigma-1)(\gamma-\mu) > 0$$

Thus, the multiplier in the closed economy ($v = 2$) is higher than that in the fully open economy ($v = 1$). This agrees with textbook intuition about "leakage" effects of fiscal spending shocks in the open economy. In this model, the reasoning is linked to the behavior of the terms of trade. With monetary policy governed by a Taylor rule, a fiscal expansion causes a terms-of-trade appreciation. This dampens the demand effects of fiscal expansion on domestic GDP and reduces the impact relative to that of a closed economy.

3.1.2 Savings shocks and fiscal policy in a liquidity trap

We now look at the same experiment, but assuming that the zero lower bound binds. Again, for the moment, we continue to focus on the case $\lambda = 0$ so that cross-country security trade is complete and unrestricted. As shown above, this is the case where the movement in natural interest rates is positively correlated across countries, for $v \leq 2$. To make a clear comparison to the previous case where the Taylor rule applied, we assume that at time *t* there is an unanticipated negative ε shock which pushes *both* the home and foreign country natural interest rates below zero. Then we assume further that this shock reverts back to 0 with probability $1-\mu$ in each period henceforth, and then remains at zero thereafter. Therefore, both countries are pushed into a liquidity trap immediately following the shock, and remain in the liquidity trap thereafter with probability μ.

We make the parallel assumption about the fiscal policy shocks. As long as the countries are in a liquidity trap, the fiscal gaps are non-zero. However, once the interest rate is above zero, all fiscal gaps revert back to zero. This allows for a direct comparison to the expressions for the impact of persistent savings and fiscal shocks in the economy operating under a Taylor rule.

Following these assumptions, the impact of a home country savings shock on domestic and foreign output can be derived as

$$\hat{y}^{r}_{t(\mathrm{ZLB})} = \left[\frac{1}{(\sigma+\phi c_y)\Delta_2} + \frac{(v-1)D}{\Delta_3(\sigma+\phi c_y D)}\right]\frac{(1-\mu)(1-\beta\mu)\phi c_y^2 \varepsilon_t}{2} \tag{36}$$

$$\hat{y}^{*r}_{t(\mathrm{ZLB})} = \left[\frac{1}{(\sigma+\phi c_y)\Delta_2} - \frac{(v-1)D}{\Delta_3(\sigma+\phi c_y D)}\right]\frac{(1-\mu)(1-\beta\mu)\phi c_y^2 \varepsilon_t}{2} \tag{37}$$

This notation is an extension of the previous definitions. In particular, $\Delta_2 = \sigma(1-\beta\mu)(1-\mu) - \mu k(\sigma + \phi c_y)$ and $\Delta_3 = \sigma(1-\beta\mu)(1-\mu) - \mu k(\sigma + \phi c_y D)$. In order that the equilibrium be determinate, it is necessary that $\Delta_3 > 0$, which implies that $\Delta_2 > 0$. The condition puts a limit on the degree of persistence of the savings shock that can be accommodated under this analysis. We make this assumption in what follows.[7] Comparing (30) and (36), we can establish that

$$\hat{y}^r_{t(\text{ZLB})} - \hat{y}^r_{t(\text{Taylor})} = \left[\frac{(1-\beta\mu)(1-\mu)\phi k c_y^2 \gamma}{\Delta\Delta_2}\right]\varepsilon_t$$

Since the expression inside the square brackets is positive, then for a negative savings shock, output falls more when the economy is constrained by the zero lower bound than when interest rates are able to adjust. This is a familiar result from Eggertsson and Woodford (2003) and Christiano et al. (2009). Under a Taylor rule, the fall in aggregate demand leads to a fall in inflation, and a compensating fall in the nominal and ex-post real interest rate in each country. When both countries are constrained by the zero bound, the fall in expected inflation leads to a rise in the real interest rate, leading to a further fall in aggregate demand. As long as $\Delta_3 > 0$ (so that $\Delta_2 > 0$), this process converges to a point where output falls such that the desired fall in savings is eliminated.

The international transmission of savings shocks in this case depends upon the degree of trade openness. When $v = 1$, the interest rate linkage across countries ensures that both countries experience the same shock, and thus the output gap moves identically across the two countries. But for a large v close to 2, it is possible that foreign output moves in the opposite direction to home output due to the response of the terms of trade.

How do the terms of trade respond the savings shock? In the previous section, under a Taylor rule, we showed that the terms of

7. When $\mu = 1$, the nominal interest rate is constant (up to a first order), and the equilibrium is indeterminate. With $\mu < 1$, the nominal interest rate will revert to the Taylor rule with probability $1-\mu$ in the future period. In this case, the condition $\Delta_3 > 0$ ensures that, in response to a negative savings shock, when the nominal interest rate does not respond in the current period, the fall in inflation, by raising the real interest rate, reduces aggregate demand by less than it reduces aggregate supply. In this case there is a unique equilibrium with lower output and lower inflation. If $\Delta_3 < 0$, this stability condition does not apply. The rise in the real interest rate reduces aggregate demand more than it reduces aggregate supply, and an equilibrium with lower output and inflation does not exist. For a discussion, see Eggertsson (2010).

trade depreciated after a negative home country savings shock, so long as $v > 1$. The terms of trade responded in a stabilizing direction. For the case of the zero lower bound, we can show that

$$\tau^{r}_{t(\mathrm{ZLB})} = \frac{\phi(v-1)c_y k\varepsilon_t\mu}{\Delta_3}$$

For a negative ε shock, the terms of trade appreciates. So relative prices move in a direction that exacerbates the fall in demand in the home country. This destabilizing effect of relative prices in a global liquidity trap is emphasized in Cook and Devereux (2013). It is tied to the fact that while nominal interest rates are constrained by the zero bound, there is still arbitrage in bond markets, so a fall in demand in the home country, by reducing inflation in the home country, will raise the home real interest rate, which precipitates a terms-of-trade appreciation.

The impact of shocks to the fiscal gaps on home and foreign output at the zero lower bound can be derived as

$$\hat{y}^{g}_{t(\mathrm{Taylor})} = \frac{1}{2}(1-c_y)\frac{[\Delta_3+\Delta_2]\Theta_1}{\Delta_2\Delta_3}\hat{g}_t \tag{38}$$

$$\hat{y}^{*g}_{t(\mathrm{Taylor})} = -\frac{1}{2}(1-c_y)\frac{k\phi c_y(D-1)\mu\Theta_1\hat{g}_t}{\Delta_2\Delta_3} \tag{39}$$

where $\Theta_1 = (1-\beta\mu)(1-\mu) - k\mu\sigma > 0$. We will compare the multiplier effects of domestic fiscal expansion in (38) with the equivalent under the Taylor rule below. Here, we note that the impact of the fiscal expansion on the foreign country is negative. That is, under a global liquidity trap, fiscal expansion has a beggar-thy-neighbor characteristic, reducing the output of foreign countries.

The derivation of the terms of trade and consumption in the liquidity trap can be expressed simply. The terms of trade responds as:

$$\hat{\tau}^{g}_{t(\mathrm{ZLB})} = \frac{(1-c_y)k\mu\phi\hat{g}_t}{\Delta_3} \tag{40}$$

In contrast to the case with a Taylor rule, a domestic fiscal expansion in a liquidity trap causes a terms of trade depreciation.

Finally, the effect of the fiscal shock on consumption is given by:

$$\hat{c}^{g}_{t(\mathrm{ZLB})} = \frac{(1-c_y)k\mu\phi\left[\Delta_3 + (v-1)\Delta_2\right]\hat{g}_t}{\Delta_2\Delta_3} \tag{41}$$

$$\hat{c}^{*g}_{t(\mathrm{ZLB})} = -\frac{(1-c_y)k\mu\phi\left[\Delta_3 - (v-1)\Delta_2\right]\hat{g}_t}{\Delta_2\Delta_3}$$

$$= -\frac{(1-c_y)k\mu\phi(2-v)\left[\Theta_1 - k\phi\mu_y(1+v(\sigma-1))\right]\hat{g}_t}{\Delta_2\Delta_3} \tag{42}$$

In the liquidity trap, for $v = 1$, a domestic country fiscal expansion leads both home and foreign consumption to rise. Without home bias, they rise by the same amount. But when $v > 1$, home consumption rises by more than foreign consumption and it is possible that foreign consumption falls.

At the zero lower bound, a home country fiscal expansion generates a terms of trade depreciation, which raises demand for the home good. Moreover, since it is easy to show that the preference-weighted growth in consumption of home goods rises, then it immediately follows that the own country fiscal spending multiplier must be greater than unity, since, in response to a rise in home government spending, home output must rise by more than $(1 - c_y)\hat{g}_t$.

Thus, we find that fiscal spending under a liquidity trap has a multiplier above one. But this comes at the expense of a negative cross country multiplier. Intuitively, the impact of an increase in the spending gap in a liquidity trap is to raise expected inflation in the home country relative to the foreign country. This reduces the home country real interest rate, and generates a terms-of-trade depreciation. The terms-of-trade depreciation increases demand for the home good, but reduces demand for the foreign good. Moreover, in this case, the latter effect offsets the impact of a rise in total aggregate consumption, so that foreign output must fall.[8]

In the discussion of the effects of fiscal spending under a Taylor rule, we found that openness reduced the size of the multiplier. How does this contrast to the case where the zero lower bound is binding

8. As we noted above, a similar result is found in Fujiwara and Ueda (2010), for the case $v = 1$ (in our notation).

in both countries? Taking the above fiscal multipliers, and again comparing the case of the fully open with the fully closed economy, we find:

$$\hat{y}^{g}_{t(\mathrm{ZLB},v=2)} - \hat{y}^{g}_{t(\mathrm{ZLB},v=1)} = -\mathrm{Sign}(\sigma - 1)\mu < 0$$

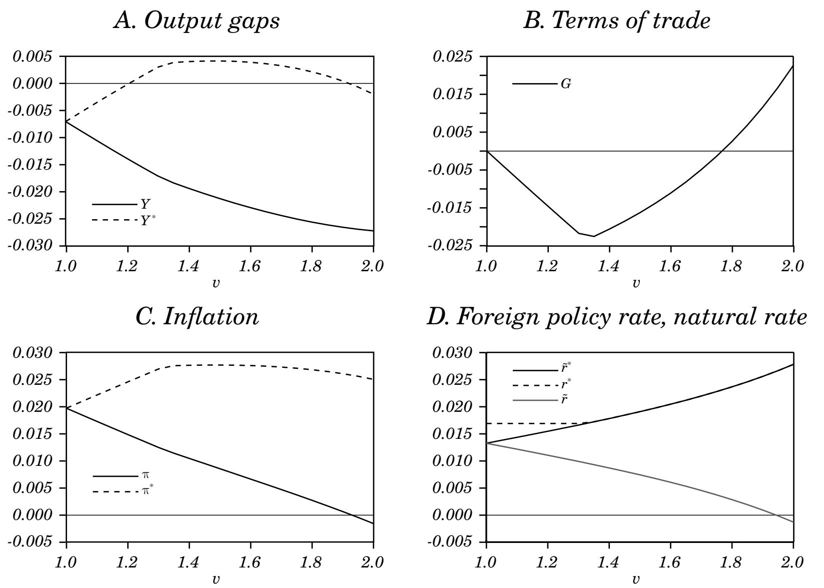
Thus, the fiscal multiplier is unambiguously larger in the open economy than in a closed economy! This is clearly consistent with our result that in the open economy, the fiscal spending shock generates a terms-of-trade deterioration, and crowds in spending from the rest of the world, while causing a fall in foreign output. As a result, paradoxically, for one country on its own, it requires a smaller fiscal expansion to offset a liquidity trap shock when the economy is more open than in a fully closed economy. Fiscal spending shocks in a liquidity trap involve a type of "reverse leakage."

3.1.3 Zero lower bound constraint in one country

So far, we have assumed that both countries are simultaneously constrained by the zero bound, and contrasted this case with one where monetary policy operates actively according to a Taylor rule. However, when less than fully open trade and asymmetric incidence of shocks exist, figure 1 shows that natural interest rates generally differ between countries. For a home country negative demand shock, there is a potentially large range of the v parameter where the foreign natural rate is above zero, and thus, if monetary policy follows the rule in (9), the foreign country will no longer be constrained by the zero bound. The question is, if the foreign country follows such a rule, how will a home country demand shock be transmitted through international goods and capital markets, and how will this in turn affect the response of the home country to the shock?

Figure 2 illustrates the relationship between the parameter v, the home and foreign natural interest rates, the home and foreign output gaps, and the terms of trade, when the foreign monetary authority follows the rule in (9). The figure is drawn such that for $v = 1$, the demand shock is large enough so that the natural interest rate (common across countries) is negative, and so both countries are in a liquidity trap. For $v \leq \bar{v}$, the results are identical to the analysis above, so that the home output gap falls more than the foreign output gap as the home terms of trade appreciates. But

Figure 2. ZLB in One Country

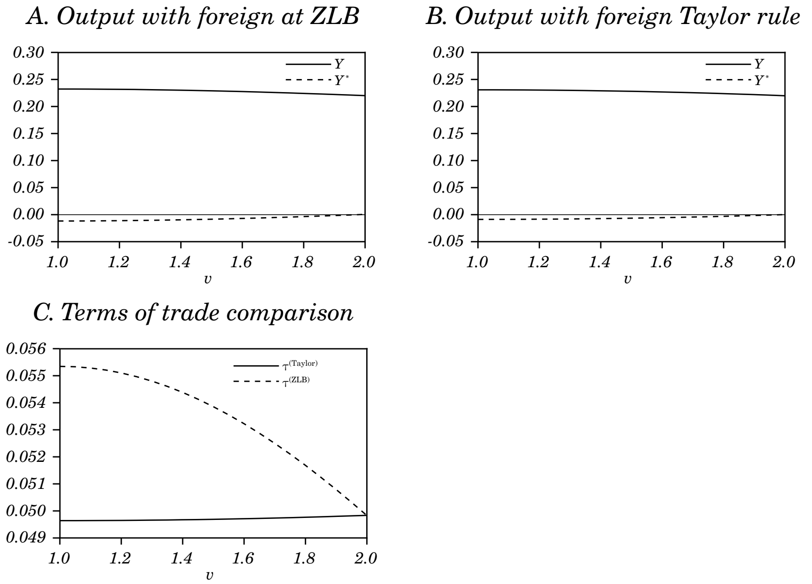


Source: Authors' elaboration.

for $v > \bar{v}$, the foreign country raises its policy rate since its natural interest rate is above zero. This monetary tightening has the effect of reversing the relationship between v and the terms of trade –the terms of trade now tend to depreciate (or strictly speaking, the appreciation is tempered) as v rises, and the foreign country raises its policy rate more and more. As a result, the fall in home country output is reduced. Note also, in this case, that foreign output rises in response to the home negative demand shock for high levels of v driven by the foreign terms of trade deterioration. So the foreign monetary tightening has the effect of reducing inflation and creating a positive output gap in the foreign country.

How do the results for the fiscal policy multiplier change when one country follows an activist monetary policy? For this comparison, we go back to the situation where countries follow a simple Taylor rule for monetary policy if the natural interest rate is positive—in contrast to the policy in (9). Again, we assume that the government spending gap reverts back to zero with probability $1 - \mu$ in each

Figure 3. Government Spending Shock



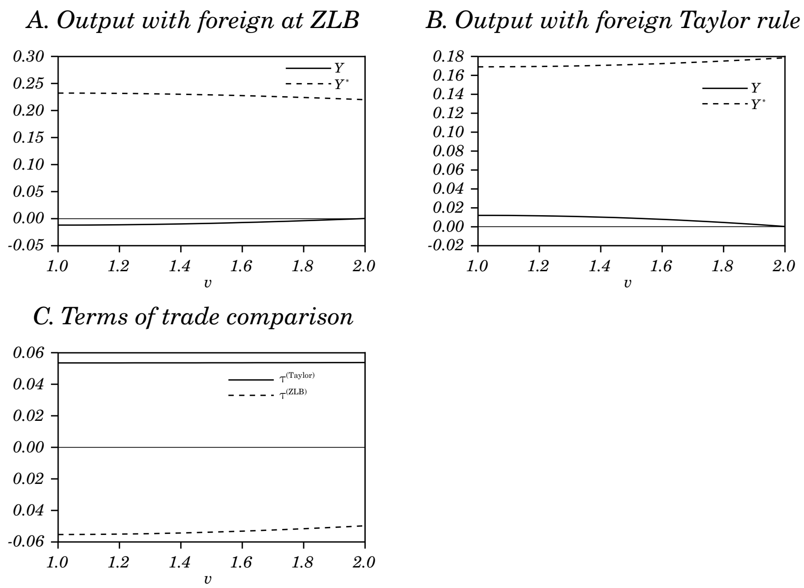
Source: Authors' elaboration.

period. Figure 3 compares the results for the effect of government spending on the home and foreign output gap, and the terms of trade, in the original case where both countries are constrained by the zero bound, and the case where the foreign country is unconstrained and follows a Taylor rule. The own multiplier in the home country is reduced by the endogenous interest rate response of the foreign economy.

Intuitively, this is because the foreign country tends to reduce interest rates, as cross-country fiscal multiplier is still negative (panel B of figure 3). This reduction in foreign interest rates lessens the response of the terms of trade (panel C of figure 3). It is possible to show that the home fiscal spending multiplier is still above unity, but it is clearly smaller than the case with a global liquidity trap.

Finally, figure 4 illustrates the effect of foreign government spending shocks when the foreign country follows an activist Taylor rule, but the home country is constrained by the zero bound on interest rates. Here we find that the spillover of foreign fiscal spending on the home output gap is positive—this is because the foreign spending

Figure 4. Government Spending in Foreign



Source: Authors' elaboration.

shock causes a terms-of-trade appreciation for the foreign economy when it follows a Taylor rule. Hence, we have a situation where spending expansion in the country constrained by the zero bound is highly expansionary with a multiplier above unity, but the spending expansion has a beggar-thy-neighbor impact. But spending shocks in the country unconstrained by the zero bound has a significantly smaller own multiplier, but a positive cross country impact.

3.2 Savings Shocks and the Liquidity Trap without Capital Mobility

A major element of the transmission mechanism for the demand shock in the previous section was the presence of fully open capital markets. Now we turn to the opposite case, where $\lambda = 1$, so that there is no capital mobility, and the transmission of shocks only takes place through goods market trade. In this case, as we saw from above, natural interest rates diverge between countries, even when $v = 1$. In fact, when $\lambda = 1$, natural interest rates move in opposite directions across countries in response to a demand shock emanating from one country alone. It should not therefore be surprising to see that demand shocks generate a negative correlation in output gaps across countries.

To see this, take the case again where neither country is constrained by the zero bound, and the Taylor rule for monetary policy is in effect. Also, to make the algebra more simple, take the $v = 1$ case. Then consequent on a demand shock in the home country, the movement in output gaps is given by

$$\hat{y}^{r}_{t(\mathrm{Taylor})} = \left[\frac{1}{(\sigma+\phi c_y)\Delta} + \frac{1}{(D_1+\phi c_y)(\Delta_4)}\right]\frac{(1-\mu)(1-\beta\mu)\phi c_y^2 \varepsilon_t}{2} \tag{43}$$

$$\hat{y}^{*r}_{t(\mathrm{Taylor})} = \left[\frac{1}{(\sigma+\phi c_y)\Delta} - \frac{1}{(D_1+\phi c_y)(\Delta_4)}\right]\frac{(1-\mu)(1-\beta\mu)\phi c_y^2 \varepsilon_t}{2} \tag{44}$$

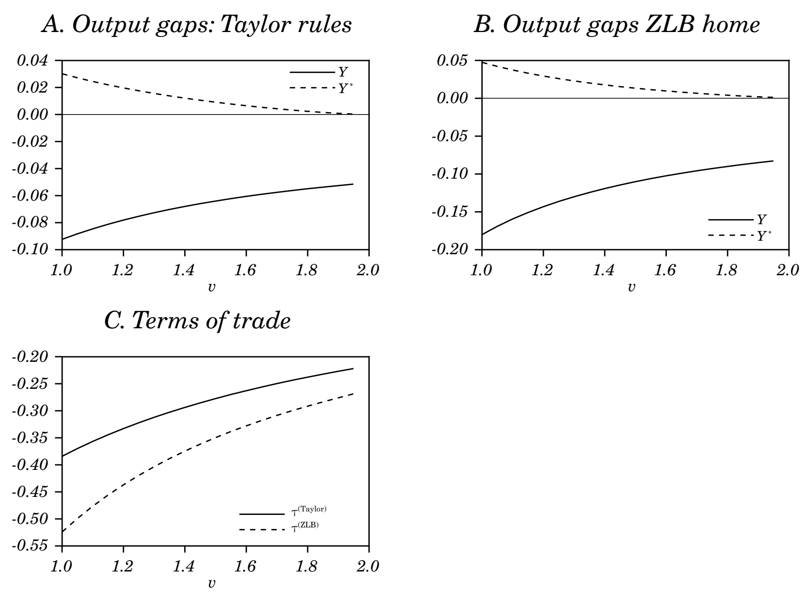
Where $D_1 \equiv 2 - v + \sigma(v-1)$ and $\Delta_4 \equiv D_1(1-\mu)(1-\beta\mu) + \kappa(\gamma_1 - \mu)(D_1 - \phi c_y)$.

When $\sigma > 1$, as is assumed, it is easy to show from (43) and (44) that $y_{t(Taylor)}$ is positive and $\hat{y}^{*}_{t(Taylor)}$ is negative. Thus, a demand shock causes a negative co-movement in output across countries when capital mobility is absent, even if preferences are identical. The key reason is that in the absence of capital mobility, the terms of trade responds in a different direction to a country specific demand shock. Recall that, with capital mobility and monetary policy governed by a Taylor rule, a positive home demand shock caused a rise in domestic inflation, a rise in the real interest rate and a terms-of-trade appreciation. But without capital mobility, the terms of trade is not governed by an interest parity condition across countries. Combining the goods market clearing conditions, and the home budget constraint in the absence of capital mobility, we may show that the terms of trade is determined by the simple condition:

$$\tau = \frac{(y_t - (1-c_y)g_t) - (y_t^* - (1-c_y)g_t^*)}{c_y}.$$

So the terms of trade is determined simply by the ratio of net output responses (net of government spending). A home demand shock that raises home output generates a terms-of-trade deterioration.

Figure 5. No Capital Mobility



Source: Authors' elaboration.

This redirects demand away from foreign goods, and leads to a fall in the foreign output gap.

Now focus on the case of a negative demand shock which leads to a binding zero-bound constraint (in the home country). Since (22) and (23) tell us that natural interest rates move in different directions across countries in this case, it must be that the foreign country is unconstrained by the zero bound. As before, we assume that the foreign country follows the rule in (9). Figure 5 illustrates the results for the movement of home and foreign output gaps as a function of v. Again, we find a negative co-movement across countries, and a terms-of-trade appreciation for the home country. The fall in output in the home country is greater than that when the Taylor rule is operative, for the same reason as before: a negative demand shock tends to persistently reduce inflation, raise real interest rates in the domestic country, and compound the effect of the initial shock. But in a qualitative sense, the international transmission with restricted capital mobility and the zero-bound constraint is similar to that when monetary policy is governed by a Taylor rule. In particular, the movement in relative prices is not reversed by the presence of the zero-bound constraint, as in the case of perfect capital mobility.

Finally, we turn to the evaluation of fiscal multipliers and cross country transmission of fiscal policy in the economy without capital mobility. Again, first, look at the effects of a home country fiscal expansion when both countries follow a Taylor rule. It may be shown the impact of a fiscal spending increase on home and foreign output is given by:

$$\hat{y}^{g}_{t(\text{Taylor})} = \frac{\sigma}{2}(1-c_y)\frac{\left[\Delta_4 + \Delta(2-\upsilon+\sigma(\upsilon-1))\right]\Theta}{\Delta\Delta_4}\hat{g}_t \tag{45}$$

$$\hat{y}^{*g}_{t(\text{Taylor})} = \frac{1}{2}(1-c_y)\frac{\kappa(2-\upsilon)\phi c_y(\sigma-1)(\gamma-\mu)\Theta\hat{g}_t}{\Delta\Delta_4}$$

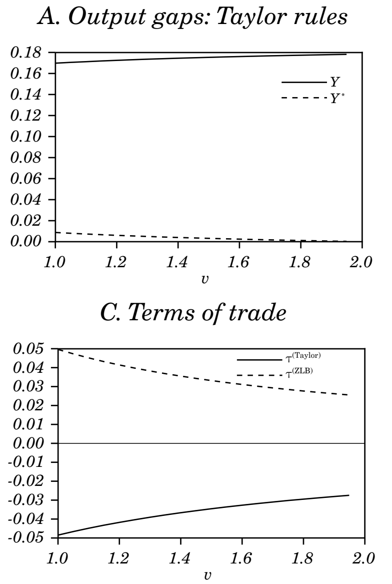
where $\Delta_4 \equiv (2-\upsilon+\sigma(\upsilon-1))\Theta + \kappa c_y \phi(\gamma-\mu)$. As in the case of perfect capital mobility, when monetary policy is operative, and governed by a Taylor rule, the home spending multiplier is positive, and the cross country spending multiplier is positive as well. The latter result is tied again to the terms of trade response. The impact of a home spending shock on the terms of trade is given by

$$\tau_{t(\text{Taylor})} = -\frac{(1-c_y)(\gamma-\mu)\phi\kappa}{\Delta_4}g_t \tag{46}$$

Hence, the home terms of trade appreciates in response to a government spending shock in the home country, as in the case of perfect capital mobility. Since the terms of trade is governed by condition (4.2), this also implies that net output $y_t - (1-c_y)g_t$ falls in response to a government spending shock, so the multiplier in this case is also less than unity.

How does this compare to the case where the home country is constrained by the zero bound? Recall that without capital mobility, both countries cannot be constrained by the zero bound at the same time. So for this case, we look at the response to a home country fiscal spending shock assuming that the foreign country monetary policy is constrained and follows a Taylor rule. Figure 6 illustrates this case, and for completeness, compares the case just examined (with both countries unconstrained) to the present case, where the home country is at the zero bound.

Figure 6. Government Spending, No Capital Mobility



Source: Authors' elaboration.

The results illustrate a notable parallel to the case with full capital mobility. While during normal monetary policy, a fiscal expansion leads to a terms of trade appreciation and a rise in domestic and foreign output, with the home country constrained by the zero bound; the spending shock leads to a terms of trade depreciation, a rise in home output, and a fall in foreign output. Hence, just as in the case of full capital mobility, fiscal spending has a beggar-thy-neighbor effect in a liquidity trap. It has this characteristic due to the reversed effect on relative prices at the zero bound. The fiscal spending shock generates a terms-of-trade depreciation, reducing demand in the foreign economy and reducing foreign output.

Figure 6 shows that, in the liquidity trap, the effect of openness to trade is also perverse without capital mobility. With operative monetary policy, openness reduces the impact of the spending shock on home country output. In contrast, increased openness tends to magnify the impact of the spending shock on output when the home country is constrained by the zero bound. Again, this is because increased openness magnifies the perverse relative price response, increasing demand for the home good and increasing the fiscal spending multiplier.

As before, we can also infer that, because net output $y_t - (1 - c_y)g_t$ is increased in response to the spending expansion, the fiscal spending multiplier is greater than unity in the liquidity trap, without capital mobility.

In the previous section, we argued that the perverse price responses to shocks in the liquidity trap were linked to the interest rate parity condition, which must hold in the environment of perfect capital mobility. Here, there is no such condition. As a result, we did not find a reversal of pricing responses to a demand shock. But in the case of the fiscal spending shock there is still a pricing response reversal. Here, it is tied to the fact that with open trade in goods, the terms of trade is pinned down by relative net outputs, and with a liquidity trap, a spending expansion can increase relative net home output—while outside this situation, the spending expansion causes a fall in relative home net output. Hence, a reversal of the terms of trade response is possible, even in the absence of full capital mobility.

4. Optimal Monetary and Fiscal Policy in a Liquidity Trap

In this section, we explore the determination of optimal policy in face of large preference shocks which push one or both countries against the zero lower bound in interest rates. We do so following the analysis of Jung et al. (2005) or Eggertsson and Woodford (2003), by looking at the optimal policy that minimizes a quadratic approximation to expected utility. In our environment, there are two countries, so the question of optimal policy naturally raises the question of whose welfare is maximized. We follow the recent open economy literature (e.g. Engel (2010), by assuming that policy is set in a cooperative fashion. The determination of optimal policy in a non-cooperative, Nash equilibrium is an important issue, but it raises technical complications which are beyond the scope of this survey[9]. In addition, we assume that policy is set under discretion so that monetary authorities cannot credibly commit to future paths of interest rates.

9. See Cook and Devereux (2013) for an example of a non-cooperative Nash equilibrium in a model where the zero-bound constraint binds.

4.1 Optimal Policy with Complete Capital Mobility

We first explore the determination of optimal monetary and fiscal policy under complete capital mobility, so that $\lambda = 0$. The period welfare function approximation for this case is shown in Cook and Devereux, (2011) to be

$$V_t = V_{(v=1),t} - \frac{1}{2}(\hat{y}_t - \hat{y}_t^*)^2 \Gamma_1 - \frac{1}{2}(\hat{g}_t - \hat{g}_t^*)^2 \Gamma_2 + ((\hat{y}_t - \hat{y}_t^*)(\hat{g}_t - \hat{g}_t^*)\Gamma_3 \quad (47)$$

Where:

$$V_{(v=1),t} = -(\hat{y}_t - \hat{y}_t^*)^2 \frac{(1+\phi c_y)}{2c_y^2} - (\hat{n}_t + \hat{n}_t^*)^2 \frac{(\sigma + \phi c_y)}{2c_y^2} \quad (48)$$

$$-(\hat{g}_t - \hat{g}_t^*)^2 \frac{(1-c_y)((1-c_y)+c_y\sigma)}{2c_y^2} - \frac{(1-c_y)}{2c_y^2}(\sigma(\hat{g}_t + \hat{g}_t^*)^2$$

$$-2((\hat{y}_t - \hat{y}_t^*)(\hat{g}_t - \hat{g}_t^*) + \sigma(\hat{y}_t + \hat{y}_t^*)(\hat{g}_t + \hat{g}_t^*)) - \frac{\theta}{k}\pi_{Ht}^2 - \frac{\theta}{k}\pi_{Ft}^2$$

Where

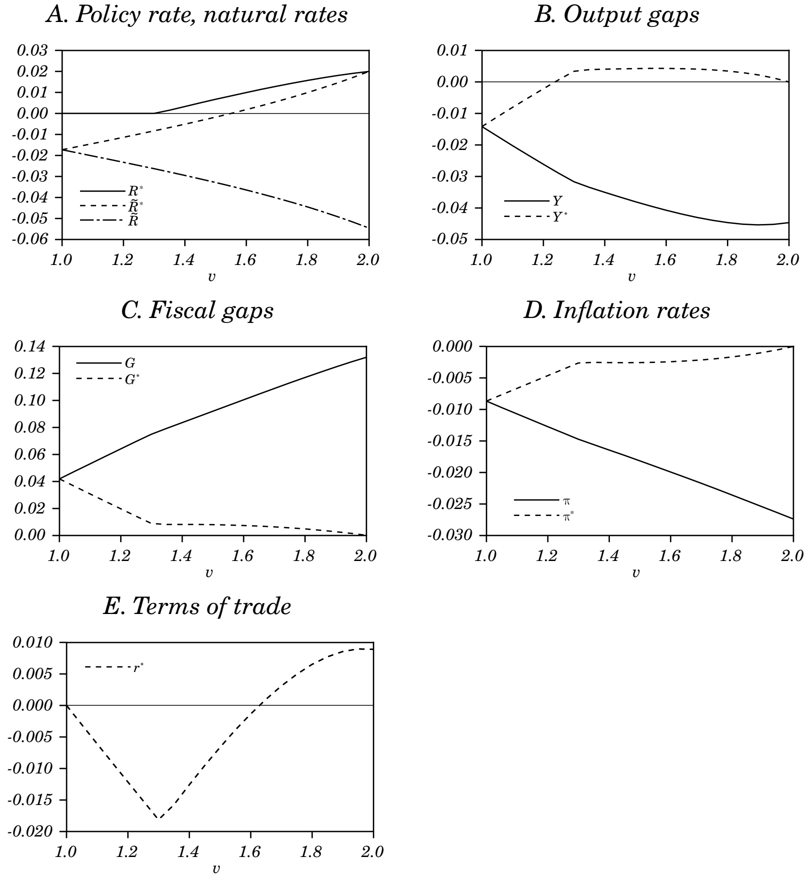
$$\Gamma_1 = \frac{(v-1)^2(\sigma-1)}{D}(1 + \frac{(1-c_y^2)}{c_y^2 D}),$$

$$\Gamma_2 = \frac{(1-c_y)^2(v-1)^2(\sigma-1)}{c_y^2 D^2}(1 + v(v-1)(\sigma-1)(2-v)c_y^2),$$

and $\Gamma_3 = \dfrac{(1-c_y)(v-1)^2(\sigma-1)}{c_y^2 D^2}(1 + v(v-1)(2-v)(\sigma-1)c_y^2).$

Since the nature of the shocks is such that the response of all macro variables is non-time varying, as long as the shock persists, we can characterize policy in terms of the response of interest rates and fiscal policy gaps following the shock, assuming that policy takes on the persistence characteristics of the shock—i.e. the optimal interest rate and fiscal spending gap response is constant, as long as the shock persists. Figure 7 describes the response of the foreign

Figure 7. Optimal Policy



Source: Authors' elaboration.

country interest rate, the fiscal spending gap, the output gaps, the terms of trade, and inflation rates in the two countries, which represents an optimal policy response to the shock. We assume that the shock emanates solely from the home country, and that the shock is such that the home country is always constrained by the zero bound. It is easy to show that for a large enough shock, the home country will always optimally set its policy interest rate to zero. The figure describes the response of home and foreign variables as a function of the home bias parameter v. Recall that in the case

$v = 1$, and with full capital mobility, the countries have identical natural interest rates so that the policy response must be identical across countries. Hence, with $v = 1$ and $\lambda = 0$, both countries must be constrained by the zero bound, under an optimal policy response. As before, the solutions for policy responses and all other variables are stationary.

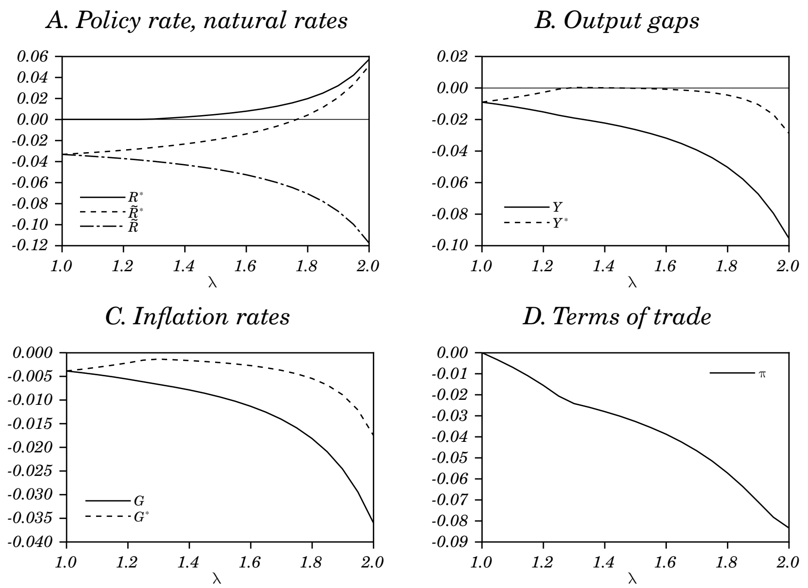
The top left panel of figure 7 illustrates the optimal foreign country policy interest rate as a function of v. For $v \leq \nu_L$, the foreign policy rate is constrained at zero. For $v > \nu_L$, the policy rate is positive, and interestingly, is above the foreign natural interest rate[10]. The top right panel describes the consequent values of home and foreign output. While for $v = 1$, home and foreign output are identical; the output responses diverge sharply as v rises above unity, since, as shown above, this involves a sharp terms of trade appreciation for the home country. As v rises above ν_L, the rise in the foreign policy rate reverses the appreciation of the terms of trade, and the rise in foreign output is restricted, as is the fall in home output. The figure also shows the optimal response of the fiscal spending gap. For no home bias, it is optimal for both home and foreign country fiscal spending gaps to rise. Then, as v rises, the foreign spending gap falls and the home spending gap rises even further. Hence, we see that the optimal policy response to a liquidity trap shock emanating from the home economy may involve a monetary policy tightening in the foreign economy, and a joint policy of fiscal policy expansion in both countries. The final panels of the figure show the response of the terms of trade and inflation rates. The terms of trade sharply appreciates initially in v, but as is clear from the figure, for $v > \nu_L$, the foreign country's monetary policy turns around the terms of trade appreciation. In addition, we find that it is optimal for the foreign country to experience a small deflation, even for $v > \nu_L$.

4.2 Optimal Policy with Limited Capital Mobility

We now turn to the case of $\lambda > 0$, where capital mobility is restricted as described above. Since the results for fiscal policy response are similar to that in the last subsection, we focus only on the optimal discretionary monetary policy response of the foreign

10. See Cook and Devereux (2013) for an explanation of this. It is noteworthy that these results show that, in general, the rule in (9) is not an optimal cooperative rule for monetary policy when one country is constrained by the zero bound.

Figure 8. Optimal Policy, No Capital Mobility



Source: Authors' elaboration.

government in the face of a shock to demand emanating from the home country. In addition, rather than focusing on the impact of the home bias coefficient v, we instead fix v and look at the optimal response to the shock for different values of λ. As before, we focus on a situation where the home country is always constrained by the zero bound, and we look at responses from the foreign country. From the results above, we know that for a higher and higher λ, the impact of the home country shock on natural interest rates and output gaps diverge between countries more and more, so we should anticipate that optimal policy responses would also diverge. This is what we find.

Figure 8 describes the optimal response of interest rates, output gaps, inflation rates, and terms of trade for the two countries as a function of λ. For ease of interpretation, we focus on the case where $v = 1$, so that in the case $\lambda = 1$, all realizations should be the same in each country. From the first panel of figure 8, we see that the optimal policy rate for the foreign country will be zero for $\lambda < \lambda_H$. After this point, the foreign country will raise its policy rate. The second panel of the figure shows that output gaps begin to diverge as λ increases, but the rise in the policy rate at $\lambda = \lambda_H$ limits this output gap. It does so by limiting the terms-of-trade appreciation of the home country, as illustrated in the fourth panel of figure 8.

These results indicate that limited capital mobility may have a large effect on the degree to which demand shocks generate "global liquidity traps," but also have an important implication for the optimal policy responses to such shocks.

5. Conclusions

This paper has explored the international transmission of shocks in an environment where the zero lower bound may be binding on one or more countries. We showed that the nature of transmission sensitively depends on the degree of trade openness and the degree of asset market completeness. When trade is fully open and asset markets are complete, then all liquidity traps are global; if the zero lower bound binds in one country then it will generally bind. But with less than fully open trade, shocks are only incompletely transmitted, and the country which is the source of the shock will be more likely to hit the zero lower bound. Even with fully open trade, incomplete assets markets also reduce the transmission of shocks, and with financial market autarky, we show that the zero lower bound cannot hold in both countries simultaneously.

The paper shows that the transmission of shocks in the zero lower bound is associated with perverse response of relative prices: the worst hit country tends to suffer terms-of-trade appreciation, rather than depreciation, thus exacerbating the effects of the shock. In a liquidity trap, fiscal expansion can be extremely effective in raising economic activity. But it does so through reducing the terms of trade, and redirecting spending away from trading partners, thus reducing trading partners GDP. Thus fiscal spending is a beggar-thy-neighbor policy in a liquidity trap. This result holds both in a complete and incomplete asset market environment.

Finally, we studied an optimal cooperative policy response to the shock which generates the liquidity trap. The optimal response involves a joint policy of fiscal expansion and potential policy rate increases for the least hit country. This surprising result comes from the fact that policy rate increases can ameliorate the perverse response of relative prices to the liquidity trap shock.

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Monetary Policy at the Zero Lower Bound: The Chilean Experience

Luis F. Céspedes
Universidad Adolfo Ibáñez

Javier García-Cicco
Central Bank of Chile
Universidad Católica Argentina

Diego Saravia
Central Bank of Chile

The global financial crisis that started in 2008 dramatically changed the analysis and implementation of monetary policy worldwide. Central banks were at the center of the stage during that time, implementing both conventional and unconventional policies. Not only were monetary policy rates drastically reduced, but also diverse policy measures were implemented: purchases of a wide range of financial assets, lending to financial institutions, intervening exchange rate markets and paying interest on reserves.[1] Given that these policies challenged the conventional view embedded in the predominant monetary policy model, within which central banks control only a short-term interest rate, it is most important to understand how these policies have worked, and to what extent they were successful.

We thank Carlos Salazar for research assistance and Matías Bernier and José Matus for helping us with the data and valuable discussions. We also thank Pablo García for his comments and suggestions. The views and conclusions presented in this paper are exclusively those of the authors and do not necessarily reflect the position of the Central Bank of Chile or its Board members.

1. See, for instance, Cespedes et al. (2011a) for a description of different policies implemented in central banks under an inflation-targeting framework.

Macroeconomic and Financial Stability: Challenges for Monetary Policy, edited by Sofía Bauducco, Lawrence Christiano and Claudio Raddatz. Santiago, Chile.

The purpose of this paper is to analyze the role that monetary policy actions played in the Chilean economy during the 2008-2010 period, particularly those implemented to deal with the zero-lower-bound situation. Responding to the global financial crisis, the Central Bank implemented a variety of policies; including, programs to provide domestic liquidity at the onset of the Lehman collapse, changes in the eligible collaterals used in operations with the Central Bank, a dramatic drop of 775 basis points in the policy rate reaching its lower bound at 50 basis points, and most notably the introduction of term liquidity facilities (the FLAP) as a way of committing to maintain the policy rate at the lower bound for an extended period of time. This last policy is the object of interest in this study.

In this paper, we describe the policy actions taken by the Central Bank and analyze the effects that they had on financial variables around the date when the FLAP was announced. We also study the effects of FLAP usage on banking lending activities. The focus on the FLAP is guaranteed, because it was the Central Bank's utmost effort to show its commitment to the provision of enough funds that would be available for a long enough period of time to let the economy cope with the financial crisis.

Accordingly, after describing the macroeconomic outlook for Chile in 2008, we pursue our analysis in two parts. In the first one, we analyze whether or not the market perceived the announcement that the policy interest rate would be maintained at its lowest level for a long period of time, which was the main goal behind the implementation of the FLAP, as credible. To do this, we study the way the announcements related to the FLAP program affected nominal and real interest rates, as well as other financial variables. In particular, we analyze the observed change in these variables around the date of the announcement, and contrast these observed values with impulse responses following monetary policy announcement (estimated using daily dates up to 2008). The results seem to indicate that the announcement had the effect of flattening the nominal yield curve, with the maximum effect being a decrease of between 30 and 50 basis points in medium term yields.

In the second part of the study we use panel regressions to understand how the use of the FLAP funds affected bank lending. For this, we construct a unique dataset consisting in a monthly panel combining banks' balance-sheet data and information about their FLAP usage. The results indicate that banks that borrowed from this facility increased commercial and consumer loans; the effect on mortgage credit was negligible.

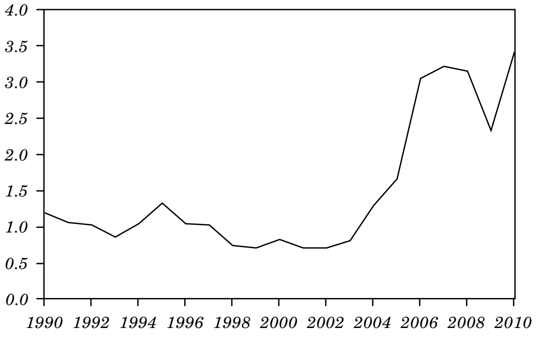
The rest of the paper is organized as follows: Section 1 presents a description of the events in Chile during 2008, as well as a description of the policies implemented. Section 2 discusses the conceptual framework that motivates our empirical work. In section 3, we analyze the effects of the FLAP announcement on interest rates and other financial assets. Section 4 presents the analysis based on bank level data. Finally, section 5 concludes.

1. Chile and the Global Financial Crisis

Chile's terms of trade started to increase significantly in the second half of the 2000s, led by especially high copper prices (figure 1). Despite suffering a negative shock due to higher energy prices, the economy was exhibiting a solid growth path. In the period 2005-2007, GDP grew at an annual average rate of 5.7 percent (figure 2). This strong GDP growth was the result of favorable international conditions and expansionary domestic macroeconomic policies.

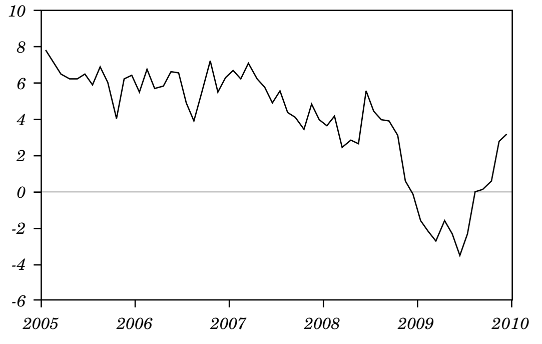
The significant increase in terms of trade did not produce a strong appreciation of the real exchange rate as would have been expected, based on previous terms of trade cycles. One explanation for this outcome was the implementation of a fiscal rule, which led to saving a significant fraction of the additional resources the government was collecting, due to the high price of copper.

Figure 1. Copper Prices
US$ per pound



Source: Central Bank of Chile.

Figure 2. Monthly Index of Economic Activity
Imacec, 12-month % change



Source: Central Bank of Chile.

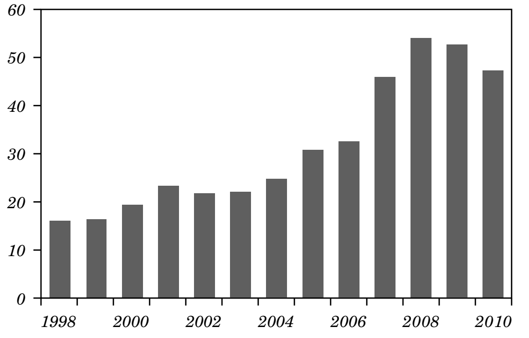
Figure 3. Nominal Exchange Rate
Ch$ per US$

Source: Central Bank of Chile.

But by the end of 2007, in the context of more expansionary monetary policy in the U.S., the nominal exchange rate began to appreciate significantly (figure 3). This led Central Bank to intervene in the foreign exchange market, starting the dollars purchase program in April 2008. Three months after the intervention was announced, the exchange rate had depreciated more than 12 percent.

During 2007 headline CPI inflation started to pick up due to increases in international food prices, and higher energy prices.

Figure 4. Energy Price- Central Grid Electricity Generation Cost
Average regulated price Ch$/Kwh



Source: National Bureau of Statistics.

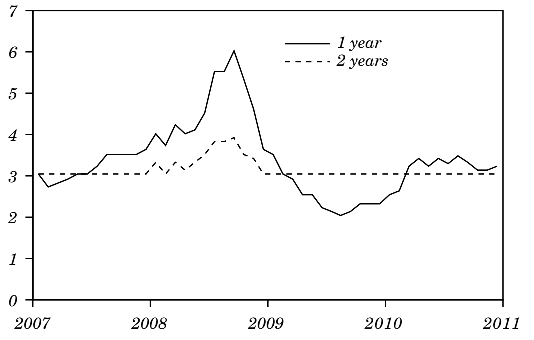
Nonetheless, core inflation measures remained below the inflation target of 3 percent at that time. Part of the higher energy prices were explained by the reduction in natural gas imports from Argentina, which caused electricity generation to shift towards more expensive sources. This, added to a reduction of rain, caused a significant increase in electricity prices (figure 4), which resulted in a lower rate of growth of output during the second half of 2007.

The combination of high oil prices and a more depreciated nominal exchange rate, since the intervention of the exchange rate market, started to generate pressures on tradable goods inflation. In this context, inflation expectations in the monetary policy horizon (2 years) started to deviate significantly from the inflation target (figure 5).

The Central Bank faced a difficult task: to increase the policy rate just enough to avoid second round effects, in order to control inflationary expectations and avoid an exchange rate appreciation. The monetary policy rate was raised by 100 basis points in the course of 2007. Between January and June 2008, the monetary policy rate was kept unchanged. In the same period, annual inflation rate went from 7.5 to 9.5%. The deterioration in inflation expectations, discussed before, led the Central Bank to increase its monetary policy rate rapidly. From June to September 2008, the Central Bank raised the interest rate from 6.25 to 8.25%.

The bankruptcy of Lehman Brothers in late September 2008 started an unprecedented period of monetary policy activism, not

Figure 5. Inflation Expectations, in 1 and 4 Years
12-month change



Source: Central Bank of Chile.

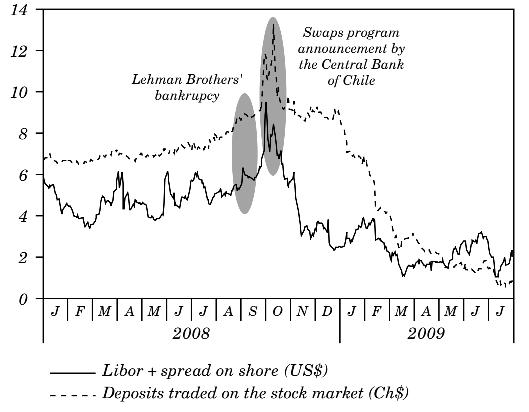
only in terms of the monetary stimulus itself, but also in terms of the different types of instruments implemented. In a first response after this event, the demand for liquidity intensified significantly, which led central banks around the world to either introduce or intensify existing liquidity provision measures.

In the case of Chile, the uncertainty regarding the effects of the U.S. financial crisis on the global economy triggered a significant increase in the demand for international and domestic liquidity. This situation translated into a significant increase in domestic interest rates. Deposit rates in domestic and foreign currency increased significantly (figure 6).

With a solid position in terms of international liquidity and a flexible exchange rate regime in full operation, the Central Bank of Chile announced a program of repos and swaps at the end of September 2008 with the objective of providing domestic and foreign liquidity to domestic financial intermediaries. This liquidity provision significantly reduced the deposit interest rates in domestic markets, which allowed the deposit interest rate in domestic currency to align itself with the monetary policy rate.

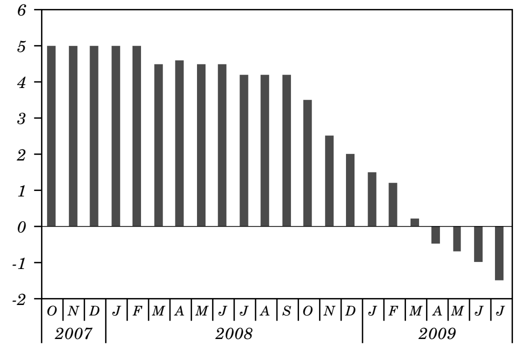
The severity of the financial crises generated a significant adjustment in macroeconomic expectations. Chile was not an exemption. In the case of economic activity, the less favorable external scenario during the first half of 2008 led to a relatively mild adjustment in GDP growth expectations for 2009. The situation was dramatically

Figure 6. Deposit Rates: Local US$ and Ch$ 90 Day Rates



Source: Central Bank of Chile.

Figure 7. GDP Growth Expectations
Annual percentage change

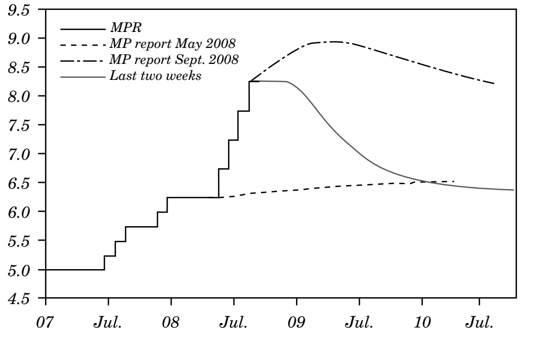


Source: Central Bank of Chile.

intensified in the last quarter of 2008 and throughout the first half of 2009. By December 2008, GDP growth expectation for 2009 was less than half the expected rate in September 2008 (figure 7).

It is interesting to notice that, despite falling from a level of 3.9 percent in September 2008 to 3.5 percent in October 2008, 24-month inflation expectations returned to the 3 percent inflation target in December 2008 (figure 5).

Figure 8. Expected Monetary Policy Rate on November 2008



Source: Central Bank of Chile.

Despite keeping interest rate unchanged during the last quarter of 2008, monetary policy shifted from a restricted stance towards a mode consistent with the external scenario faced by the Chilean economy. In effect, in the monetary policy meeting September 4th 2008, the Central Bank had indicated that additional increases in the monetary policy rate were considered in the most likely scenario. In contrast, after the monetary policy meeting on October 9th 2008, the Central Bank indicated that given the drastic change in the external scenario, a new, full evaluation of the factors that determine the path of the monetary policy interest rate (MPR) consistent with achieving the inflation objective was required.[2]

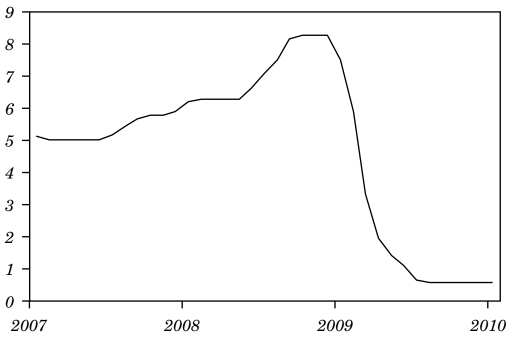
The re-evaluation of the macroeconomic scenario facing the Chilean economy was part of the material considered by the Board at the monetary policy meeting on November 13th 2008. In comparison with the macroeconomic scenario presented in September of that year, the Central Bank considered significantly lower terms of trade and lower trade partners GDP growth. Regarding the MPR path, the Central Bank considered, in this new scenario, a path similar to that derived from the different measures of private sector expectations. That path implied that the MPR would remain unchanged until the end of the year, and then it would experience a gradual reduction along 2009 to a level of around 6 percent (figure 8).

2. In normal times such evaluation occurred in May, September and January.

Figure 9. CPI Inflation
Percent

Source: Central Bank of Chile and National Bureau of Statistics.

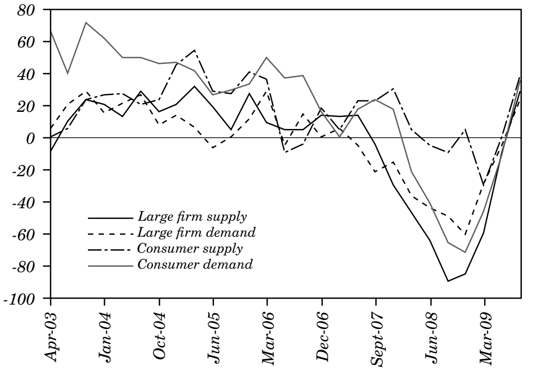
Figure 10. Monetary Policy Rate
Percent



Source: Central Bank of Chile.

By the end of 2008, it was clear that the contraction in the world's economic activity was well beyond the initial projections. At that point, the Central Bank of Chile started to implement a significant reduction in the monetary policy rate. Inflation, which had reached almost 10 percent in October 2008 due to high food and energy prices, experienced a rapid drop as commodity prices reverted from record highs in 2008 (figure 9). In the context of this fall in inflation, and a more negative external scenario than previously expected, the monetary policy rate was rapidly reduced (figure 10).

Figure 11. Bank Lending Conditions Survey
Net percent of survey responses[a]



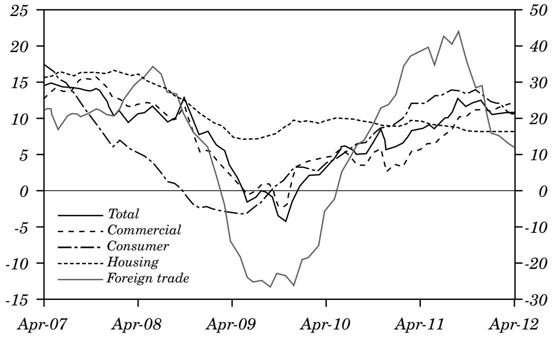
Source: Central Bank of Chile.
a. Negative values indicate a weaker perceotion of demand and less flexible supply conditions.

During all this period, financial conditions in the Chilean economy deteriorated markedly. The combination of high uncertainty, lower growth prospects (and commodity prices) and the deterioration in international financial conditions gave rise to very restrictive credit conditions (figure 11). Lending spreads increased significantly, and credit to firms became quite scarce. In this scenario, the possibility of disruptions in the monetary policy transmission channel could not be ruled out. In this context, the Central Bank announced a program that expanded the list of eligible collateral in its operations.

The deterioration of financial conditions resulted in a significant contraction in new loans. Commercial loans started to decrease rapidly in November 2008; the same was true for foreign trade credit and housing loans. Consumer loans had been falling since before September 2008, but its contraction was amplified since the bankruptcy of Lehman Brothers (figure 12).

As the economy was losing traction and inflation expectations continued falling (figure 5), the Central Bank reduced the policy rate to 75 basis points in June 2009 and added one additional statement in its monetary policy communiqué: "The Board considers that, in the most likely scenario, it will be necessary to maintain the monetary stimulus for a longer period than the one implicit in financial asset prices. This permits projected inflation to stand at 3% over the policy horizon." This statement reflected the intension of the Central Bank

Figure 12. Bank Loans
Real annual change, percent



Source: Central Bank of Chile.

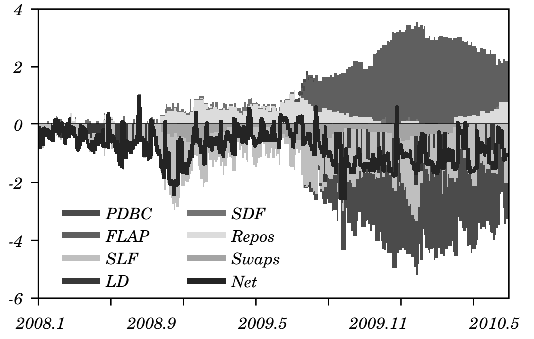
to signal a more expansionary path for the monetary policy rate than what was contemplated by private agents.

In the July meeting, the Board of the Central Bank of Chile decided to reduce the monetary policy interest rate by 25 basis points, to 0.50% annual (the words "minimum level" were added to indicate that no additional cuts in the monetary policy rate would be implemented), and to adopt complementary monetary policy measures to strengthen the effects of this decision. In the Central Bank's communiqué from the July 2009 monetary policy meeting, it was indicated that, "For projected inflation to reach 3% over the policy horizon within a context of a foreseen widening of the output gap and reduced imported cost pressures, it is necessary to increase the monetary stimulus. Therefore, the monetary policy rate will be held at this minimum level for a prolonged period of time."

Additionally, in order to reinforce this decision and align financial asset prices with the path of monetary policy, the Central Bank of Chile implemented complementary monetary policy measures:

— Established a term liquidity facility (*Facilidad de Liquidez a Plazo*, *FLAP*) for banking institutions, granting 90- and 180-day liquidity at the prevailing level of the monetary policy rate.
— Adjusted the program of Central Bank note issuance at maturities below one year, consistent with the aforementioned decision.
— Suspended, for the rest of 2009, the issuance of debt instruments maturing in one year or more, corresponding to two-year Central Bank peso-denominated bonds (BCP-2) and one-year Central Bank promissory notes (PDBC-360).

Figure 13. Monetary Operations of the Central Bank of Chile[a]
(Ch$ billions)



Source: Financial Stability Report 1st Semester 2010, Central Bank of Chile.
a. SLF: Standing liquidity facility; LD: Liquid deposits; SDF: Standing deposit facility, and FLAP: Short-term liquidity facility. PDBCs only consider the increase in the stock since the announcement of the FLAP. Source: Financial

Eligible collateral for the FLAP included Central Bank instruments, time deposits, and bank mortgage bills. The FLAP was widely used by local banks, peaking at Ch$3.284 trillion (close to US$6.5 billion) in mid-January 2010, or 40% of the banking system's capital and reserves. To neutralize the injection of resources associated with the FLAP, the Central Bank made significant PDBC issues, with a maximum of Ch$3.0 trillion (near US$6 billion) in February (figure 14).

In every monetary policy meeting since November 2009, the Central Bank extended the facility for loans up to six additional months. In the November meeting the FLAP was not further extended, implying that banks were able to borrow from the facility only until May 2010.

We conclude this section with some descriptive statistics on the FLAP usage. During the period in which the facility was available, 13 banks borrowed at least once from the facility, with nearly 60% of the total amount borrowed by two banks. The facility offered credit both in pesos and in UFs (indexation unit), with almost 60% of the total in UFs. Around 50% of the total was 180-day credit, while 30% had a 90-day maturity (the rest was mainly 30-day loans). Finally, July and November 2009 were the months in which the facility was more heavily used (almost 1 trillion pesos in July, and nearly 1.2 trillion in November).

2. Unconventional Monetary Policy: A Conceptual Framework

A justification for the implementation of unconventional monetary policy is that the usual monetary instrument, the control of the overnight interest rate in the interbank market, may have reached its lower bound, and the economy needs additional monetary stimulus. This was the scenario faced by the Central Bank of Chile in 2009.

The FLAP was implemented in order to reinforce the decision of the Central Bank of Chile to keep the interest rate in its lower bound for a prolonged period of time. Therefore, the first place it can be analyzed is within the credibility channel. In general terms, if a central bank can commit in advance to future settings of the policy rate that will be lower than they would have been otherwise; the zero lower bound would not be a constraint to provide additional stimulus if required. By generating inflation expectations, the central bank can reduce the real interest rate. Nevertheless, the key conjecture is that such promises may not be credible. Credibility has been emphasized as a crucial constraint in this situation, starting with Krugman (1998).

Eggertsson and Woodford (2003) have argued that shifts in the central bank's portfolio could be of some value in making the central bank's commitment to a particular kind of future policy credible to the private sector. Jeanne and Svensson (2007) argue that the commitment problem may be solved if the central bank cares enough about its capital position. In particular, by shifting the composition of its portfolio (increasing foreign exchange reserves), it generates a currency mismatch. If the central bank deviates from a promise of high inflation, the concomitant currency appreciation would, via the fall in the value of the central bank's foreign reserves, result in a capital loss. This would deter the central bank from reneging on a promise of high inflation, if the central bank is assumed to care about its capital. In a similar vein, Céspedes, Chang, and García-Cicco (2011) show that by shifting the maturity of its debt (selling short term bonds and holding long term bonds), a central bank can ensure the credibility of an inflationary policy.

The term liquidity facility (FLAP) for banking institutions can be easily related to this brand of literature. By providing up to 180-day loans at the prevailing level of the monetary policy rate to commercial banks, the Central Bank of Chile reinforced its commitment to keeping its monetary policy interest rate at the lower bound for a prolonged period of time. Had the Central Bank decided to increase its monetary policy interest rate in anticipation, it would have suffered capital losses. In this way, in the first part of our analysis, we empirically assess how the FLAP affected interest rates and other assets prices. Our goal is to establish how effective was the FLAP in changing market expectations regarding future monetary policy.

A second branch of the literature under which the FLAP can be placed corresponds to the recent works on financial frictions and financial intermediation. As discussed by Woodford (2010), if intermediaries face costs to originate and service loans, or to manage their portfolios, in a competitive equilibrium, the interest rate at which they are willing to lend will exceed their cost of funds by a spread that reflects the marginal cost of lending. This marginal cost may be increasing in the volume of lending by the intermediary if the production function for loans involve diminishing returns to increases in the variable factors, owing to the fixed nature of some factors (such as specialized expertise or facilities that cannot be expanded quickly). In this context, and in similar setups, the leverage of financial intermediaries may be limited by their capital.

In particular, recent literature has emphasized that the supply of loans by financial intermediaries may be constrained by the size of the losses that the intermediary would be subject to in bad states of the world, relative to its capital as in Adrian and Shin (2010), and by the value of their available collateral as in Garleanu and Pedersen (2009) and Ashcraft, Garleanu and Pedersen (2010). By relaxing the financial constraint that capital-constrained banks face, or by reducing the cost of financing of these banks, some unconventional policies may stimulate the economy. Related to this, Céspedes, Chang, and Velasco (2011) show that in the context of a model with financial intermediaries subject to financial constraint, direct lending by the central bank to these intermediaries relaxes the constraint that they face, and therefore has a positive effect on the supply of loans by the financial sector.

In this context, if the term "liquidity facility," implemented by the Central Bank of Chile, helped to relax the financial constraint of financial intermediaries, it may have affected the supply of loans of these institutions. This facility may be interpreted as a substitute for deposits or loans to banks at zero lower bound interest rates.

In line with this channel, in the second part of our empirical analysis we focus on the behavior of banks in response to the FLAP. We exploit a unique dataset that describes the use of the term liquidity facilities (FLAP) by each bank in the Chilean financial system.

3. The Effect of the FLAP Announcement on Asset Prices

In this section, we analyze the impact of policy announcements regarding the policy rate and the FLAP facility on both nominal and real interest yield, corresponding to instruments from the Central Bank of Chile, sovereign and corporate spreads, and the nominal exchange rate. As we argued before, one of the key transmission mechanisms for unconventional policies at the zero bound entails convincing the public that the Central Bank is going to implement expansionary polices for an extended period of time. Thus, we would expect these announcements to lower the long part of the nominal yield curve. In addition, comparing the response of nominal and real rates would allow us to gauge the effect of the announcement on inflation expectations and/or inflation premium. In addition, we want to explore if the FLAP announcement affected other relevant financial variables.

Event studies have been the common tool used in the literature to assess the effect of unconventional policy announcement in other countries. For instance, Cagnon et al. (2011) identify 23 events corresponding to announcements made by the Federal Reserve Board in the U.S. related to different asset-purchase programs implemented in 2008 and 2009. The case of the U.K.'s quantitative easing program is analyzed in Joyce et al. (2010). However, an event-based study is not feasible in our case because we do not have many events for the Chilean case.

Given this limitation, our approach exploits the fact that, at the same time the FLAP was announced, a reduction of 25 basis points in the policy rate was implemented. Suppose that we can characterize what is the usual reaction (in normal times) of financial variables to a 25 basis point cut in the policy rate. Then, if the market reaction was significantly different from the usual response to the announcement of drop in the policy rate, we could attribute the difference to another announcement in that same meeting (i.e. the FLAP). Therefore, our identification strategy relies on estimating the normal time response of the financial variables to changes in the policy rate, its associated uncertainty, and attributing any significant difference to the FLAP announcement. We do this by implementing the strategy proposed by Rigobon (2003), known as "identification through heteroskedasticity," which we discuss in detail below.

We use daily data on 12 variables. In terms of nominal yields, we use the monetary policy rate (MPR) and the yield on the Central Bank of Chile's nominal promissory notes and bonds (PDBC and BCP) of 1, 2, 3, 6, 12 and 24 months of maturity. In terms of real rates, we use the yield on indexed bonds (BCU) of 1 and 2 years of maturity. All these rates were transformed so that they represent the different time periods between them. In that way, we will have, for instance, the 1 month rate, the 1-month-in-1 month rate, the 1-month-in-2 month rate, etc.[3] We choose to set the data in this way because otherwise, for instance, the response of the 2 months rate will in part be due to the response of the 1 month rate, and we want to separate these two effects.

In terms of spreads, we use the JP Morgan EMBI spread from Chile, and the LVA measure of AAA corporate bond spread.[4] Finally, the nominal exchange rate (NER) is the rate in the interbank market. Our sample ranges from September 13th, 2002, to December 30th, 2008, which we consider the normal-time period,[5] adding to 1572 daily observations.[6]

In the remainder of this section we first describe the identification strategy implemented to characterize the usual response of different financial variables to monetary policy announcements, and then used them to identify the differential effect attributed to the FLAP announcement.

3. These were constructed using the expectations hypothesis.

4. This spread is constructed considering AAA indexed corporate bonds of more than 8 years to maturity, relative to indexed bond from the Central Bank with the same maturity.

5. The first decrease in the policy rate after the Lehman Brothers collapse was in January 2009. Results are robust with using data only up to August 2008, i.e. before the Lehman Brothers collapse.

6. The data on yields of instruments from the Central Bank are from Risk America, and the other variables are taken from Bloomberg.

3.1 Identification of Normal-Time Responses

To estimate the response of financial variables to monetary policy announcements using daily data, we follow a strategy known as "identification through heteroskedasticity." This approach was proposed by Rigobon (2003), and it has been applied to identify monetary policy shocks by, for instance, Rigobon and Sack (2004), and Wright (2011), using U.S. data. An application of the methodology with Chilean data is in Chaumont and García-Cicco (2013).[7] The basic idea behind this procedure is to exploit the increase in the volatility of financial variables observed on the dates of policy announcements.

Consider the vector Y_t collecting the n variables of interest, and assume its evolution can be represented by a vector auto-regression,

$$Y_t = B(L)Y_{t-1} + u_t,$$

where $B(L)$ is a matrix of lag coefficients and the reduced-form errors u_t are assumed to be i.i.d. with mean zero and variance-covariance matrix Ω. The reduced-form errors are linked with the structural errors through the relationship,

$$u_t = \sum_{j=1}^{n} R_j e_{j,t} \ ,$$

where R_j indicates how the structural error $e_{j,t}$ affects the reduced form errors. The goal is to identify R_M, i.e. the vector associated with the effect of monetary policy shocks.[8] The key identifying assumption is that the monetary policy shock has a variance σ_A^2 on announcement days and variance σ_{NA}^2 on all other dates, with $\sigma_A^2 \neq \sigma_{NA}^2$, while the variance of all other shocks does not change on those announcement dates.[9]

Let Ω_A and Ω_{NA} denote, respectively, the variance matrices of the reduced-form residuals on announcement and non-announcement

7. We refer to that paper for robustness checks of the results presented in this subsection.

8. Notice that the ordering of the shocks is irrelevant for this identification strategy.

9. The other structural shocks may display this kind of heteroskedasticity in different days. However, as we are only interested on identifying the monetary policy shocks, there is no need to specify the behavior of the other shocks.

dates. Given the assumed relationship between the reduced form and the structural error terms, we have

$$\Omega_A - \Omega_{NA} = R_M R_M' \sigma_A^2 - R_M R_M' \sigma_{NA}^2 = R_M R_M' (\sigma_A^2 - \sigma_{NA}^2).$$

This condition allows identifying R_M. Furthermore, assume without loss of generality that $(\sigma_A^2 - \sigma_{NA}^2) = 1$, as $(\sigma_A^2 - \sigma_{NA}^2)$ and R_M are not separately identified. Therefore, we can estimate R_M as the argument that solves the following minimum distance problem,

$$\min\left[vech(\hat{\Omega}_A - \hat{\Omega}_{NA}) - vech(R_M R_M')\right]'\left[\hat{V}_A - \hat{V}_{NA}\right]^{-1}$$

$$\left[vech(\hat{\Omega}_A - \hat{\Omega}_{NA}) - vech(R_M R_M')\right],$$

where $\hat{\Omega}_A$, $\hat{\Omega}_{NA}$ are constructed using the OLS reduced form errors, and $\hat{V}_A$, $\hat{V}_{NA}$ are the variances associated with the OLS estimators of $vech(\hat{\Omega}_A)$, $vech(\hat{\Omega}_{NA})$.[10] Once R_M is obtained, impulse responses can be computed with the usual techniques.[11]

Figure 14 displays the impulse responses,[12] normalizing the shock to represent a drop of 50 basis points of the monetary policy rate, for a 50-day horizon, using data up to December 30th, 2008. While the most important results in terms of our analysis in the next subsection are the obtained confidence bands, we provide here a brief discussion of the obtained responses.[13]

The identified shock produces a significant drop in the nominal rates up to a year of around 20 annualized basis points (a.b.p.). However, the nominal rate for 1 year in 1 year does not significantly move. The real rate also experiences a reduction: in the 1-year horizon, almost 30 a.b.p. in 50 days, while the minimum value for

10. The operator *vech()* represents the vectorization of the unique elements of a symmetric matrix.

11. In Chaumont and García-Cicco (2013) we present several tests for the hypothesis that Ω_A and Ω_{NA} are significantly different, which is the key moment condition that allows identification.

12. The reported 95% confidence bands (the gray areas) were constructed using the stationary bootstrap method proposed by Politis and Romano (1994) to resample blocks of residuals of expected length of 15 days. This is done to preserve some of the volatility clustering that is expected to be present in a daily dataset. Throughout the figures, all yields and spreads are expressed in annualized basis points, while the nominal exchange rate is expressed 100* log of pesos per dollar.

13. See Chaumont and García-Cicco (2013) for further discussion.

the 1-year in 1-year rate is around 15 a.b.p. This result implies a minor increase in inflation expectations (computed using the Fischer equation) up to two years, although the response of this implied expectation is not significant. In terms of spreads, the EMBI for Chile tends to decrease somehow after the announcement, while the corporate spread does no significantly move. Finally, the nominal exchange rate does not display a significant response either.

3.2 The Effects of the FLAP Announcement

Having described the usual response to monetary policy announcements, estimated using data up to 2008, we are interested in comparing these responses with the behavior of the variables after two announcement dates. The first one corresponds to the meeting on June 16^{th}, 2009. At that meeting, the policy rate was lowered from 125 to 75 basis points. While in previous meetings the Central Bank had aggressively decreased the policy rate (700 basis points from January to May 2009), and in previous press releases, even hinted that further reductions were to be expected; the June meeting was the first time that the Board communicated that "in the most likely scenario, it will be necessary to maintain the monetary stimulus for a longer period than the one implicit in financial asset prices." This can be regarded as a first attempt to communicate that the policy rate was to be maintained at low values for an extended period of time. Under perfect credibility, such announcement would have been enough to stimulate the economy.

The second date we considered was the July meeting (on the 9^{th}), when the policy rate was further decreased to 50 basis points and the FLAP was announced. It was also stated that "today's decision places the monetary policy rate in its minimum level" and that "the monetary policy rate will be held at this minimum level for a prolonged period of time."

Figure 15 displays, in solid black, the evolution of the variables 5 days before and 15 days after the June meeting (the zero corresponds to the day after the meeting).[14] We also report in dashed line the estimated response (and their 95% confidence bands in gray) that the estimated model (using data up to 2008) would have predicted given

14. It is important to highlight that in Chile monetary policy announcements are made after the markets close, and therefore they should have an impact in the day following the policy meeting.

Figure 14. Responses to the Monetary Policy Shocks in Normal Times

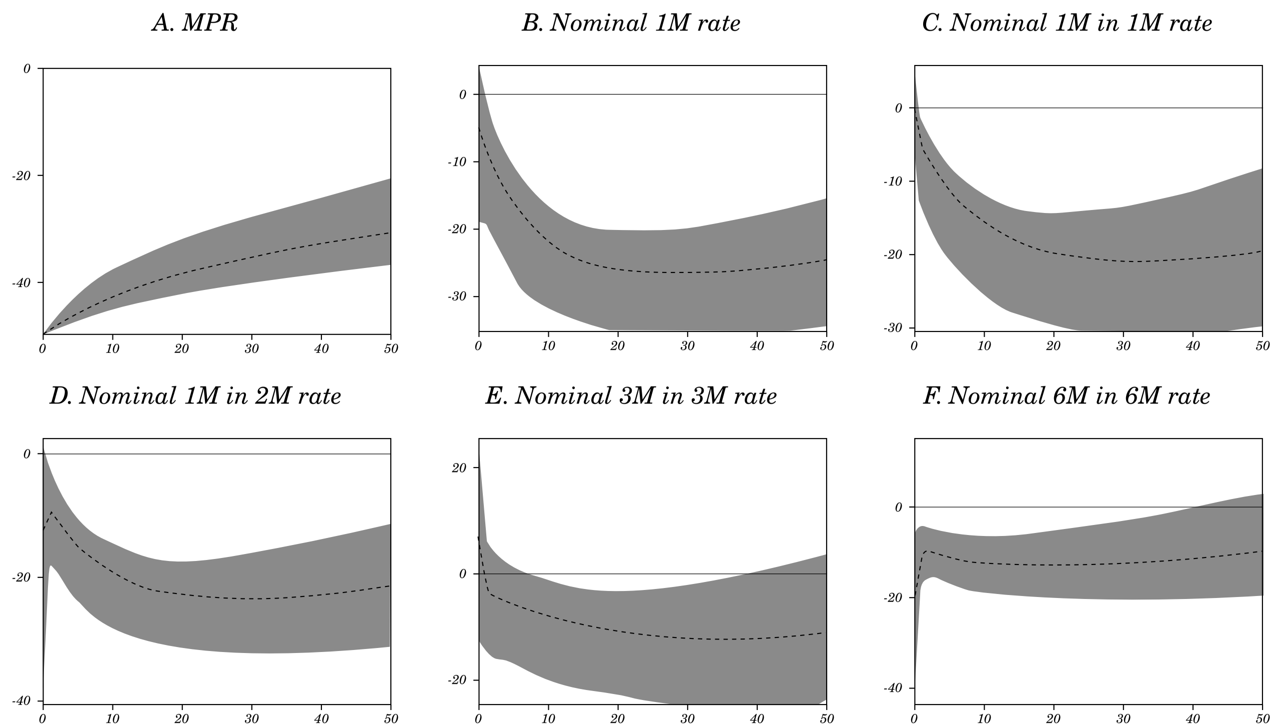
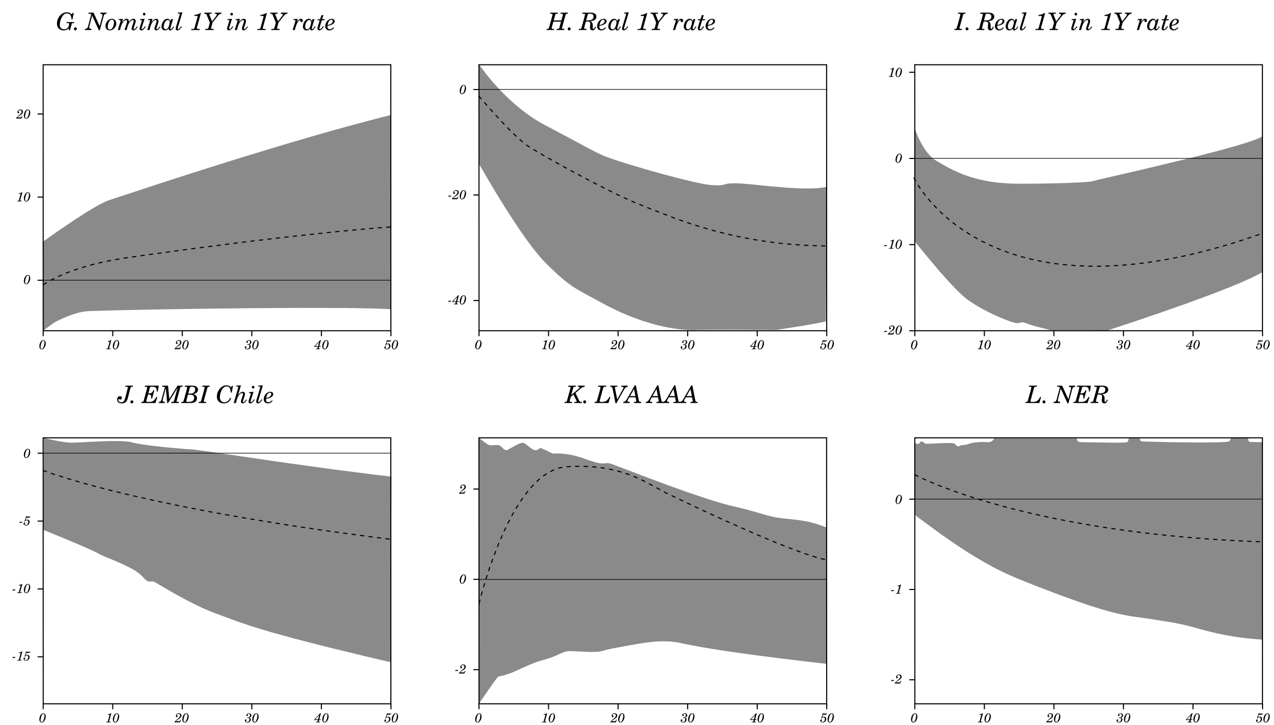


Figure 14. (continued)



Source: Authors' calculations.

Figure 15. Interest Rates and the Nominal Exchange Rate after the June Meeting

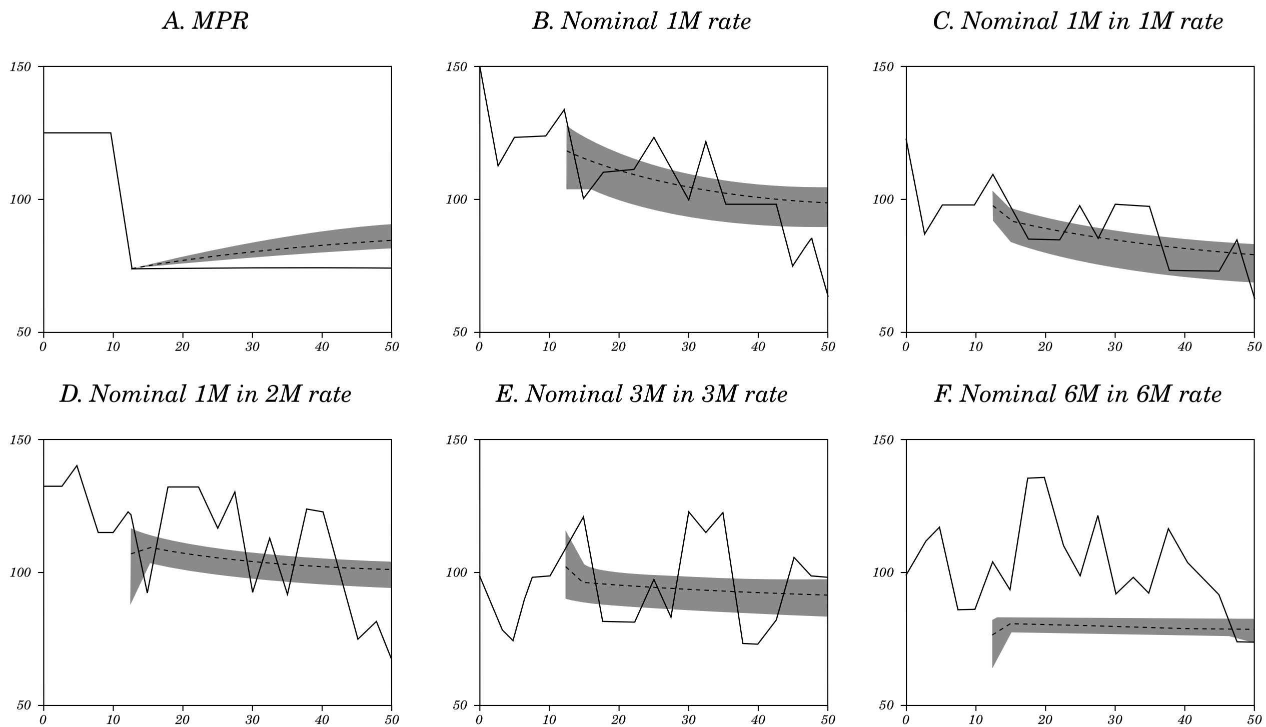
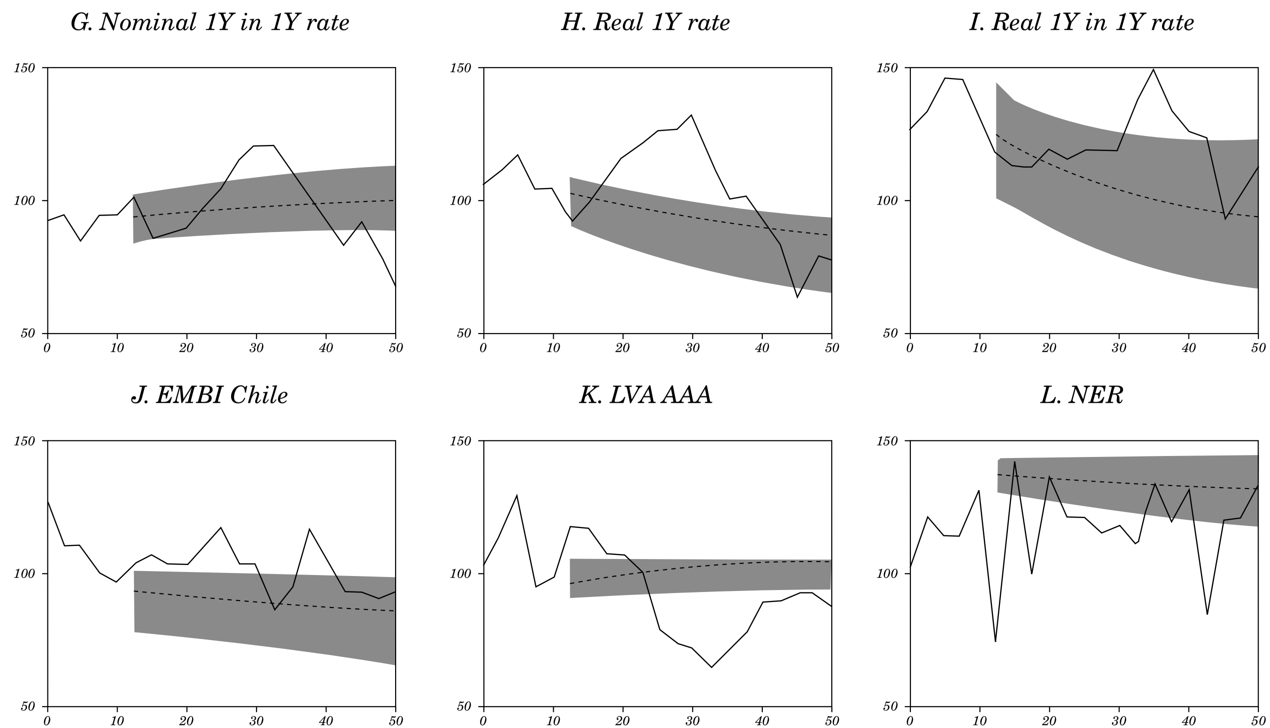


Figure 15. (continued)



Source: Authors' calculations.

the announced change in the monetary policy rate (50 basis points in this case). After that meeting the observed variables did not seem to move in any clear direction. This is particularly the case for nominal yields, whose evolution coincides with the estimated confidence bands for normal times. If anything, all the yields tended to move upwards after the June announcement, particularly those with maturities of 6 or more months. The spreads did not display a path significantly different from the usual response either. The nominal exchange rate was quite erratic around and after the meeting. Overall, it appears that at June meeting the Central Bank was not able to convey the message that the monetary stance was to remain expansive for a prolonged period.

The observed behavior was quite different after the July meeting, that included not only a reduction in the policy rate of 25 basis points, but also the announcement of the FLAP as a way to commit to keep the policy rate at the lower bound for an extended period of time. Figure 16 displays the evolution of the variables along with the estimated responses to a monetary policy shock for normal times, normalized to represent a drop of 25 basis points in the policy rate.

While the evolution of nominal yields up to a 3-month horizon was not significantly different from the usual response (if anything, they increased), in the 3 month in 3 month, and the 1 year in 1 year horizons, they decreased significantly. In particular, the former experienced a drop of almost 50 a.b.p., while for the latter, the reduction was around 30 a.b.p. The real rates fell as well, although not significantly different from the usual response.

Taken the behavior of real and nominal yields together, inflation expectations measured by the Fischer equation would indicate a drop in expected inflation, which in principle seems at odds with the conceptual framework discussed in the previous section (i.e. that an expansionary policy stance for a prolonged period of time should generate an increase in inflation expectations). A possible explanation for this observation is that computing inflation expectations using the Fischer equation, abstracts for the presence of inflation risk premium.[15] Thus, an alternative explanation for the decrease in the nominal yield is a reduction in that premium.

The evolution of the EMBI after the announcement did not

15. This premium is positive (i.e. the nominal rate is larger than the real minus expected inflation) whenever the correlation between the stochastic discount factor en future inflation is positive. See, for instance, Ang et al. (2008).

Figure 16. Interest Rates and the Nominal Exchange Rate after the July Meeting

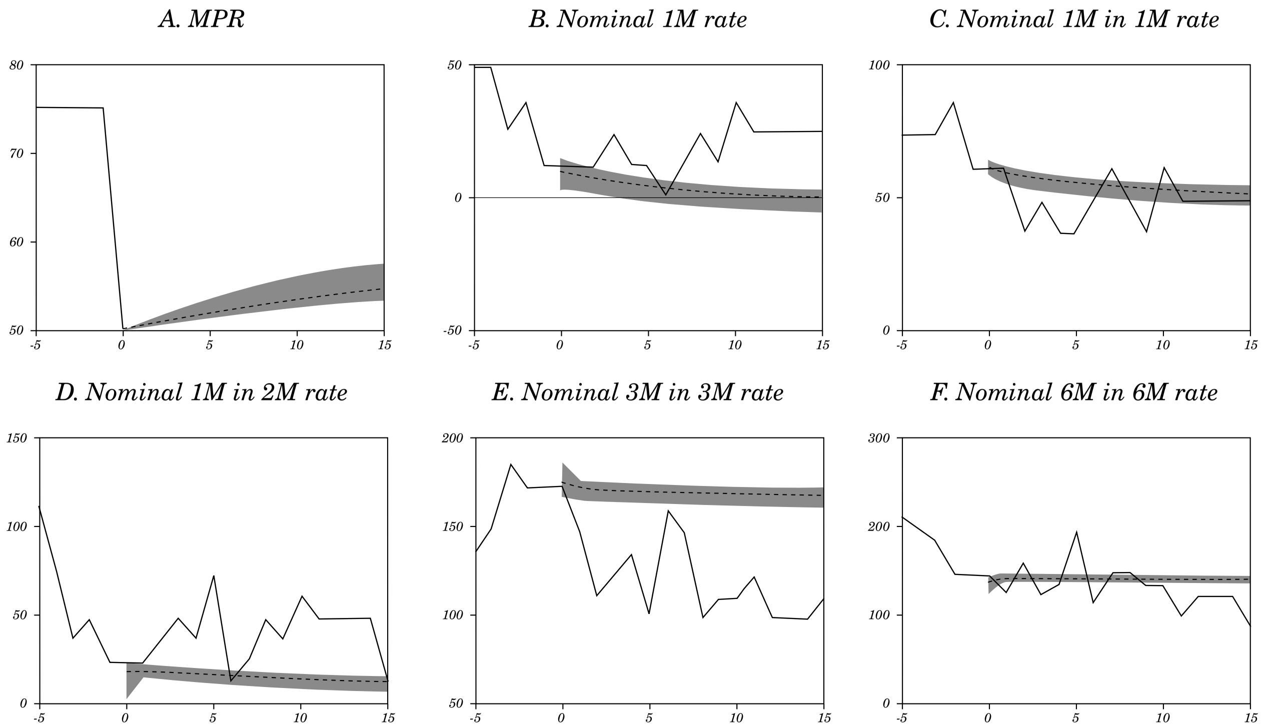
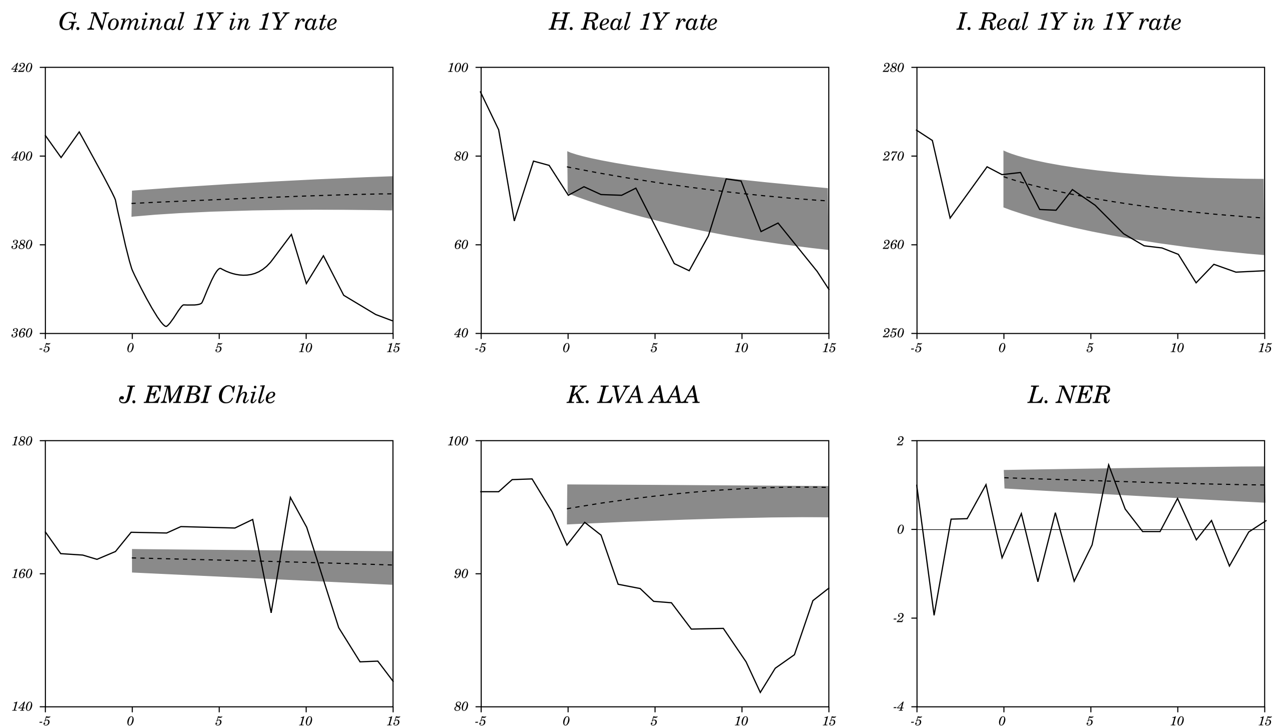


Figure 16. (continued)



Source: Authors' calculations.

significantly differ from the usual response after a 25 basis point cut in the policy rate. However, the corporate spread appears to have fallen significantly, by nearly 10 basis points. Finally, the nominal exchange rate significantly appreciated, which, although not consistent with the UIP prediction,[16] is in line with the perception at that time that future prospects for Chile were more favorable than those for the U.S.

To conclude this part of the analysis, it is important to compare these results with those papers previously mentioned that evaluate the effect of announcements regarding unconventional policies in other countries. While these studies also found that the announcement had a flattening impact on the yield curve, for these more developed countries the effect appears to be larger in the longer end of the curve (5 or 10 years). On the contrary, for Chile, the largest effect was in the 2-year horizon that as we mentioned, is the relevant policy horizon for Chile.

This difference could be an indication of the perceived severity of the recession that people expected at that time in different countries. While in developed countries like Europe or the U.S., (that were at the centers of the financial crisis) the recession was expected to be quite significant; for some other emerging countries like Chile, the impact of the crisis was perceived to be a more transitory phenomenon. Moreover, looking at the macroeconomic dynamics after 2009, Chile seems to have recovered from the crisis, experiencing GDP growth rates at pre-crisis levels and with inflation around the target, while the recovery in more developed economies appears to be quite slow.

4. The Effects of the FLAP on Bank Lending

In this section we study the lending behavior of Chilean banks during the FLAP period. The goal is to identify if the use of this liquidity facility had an effect on the loans issued by banks. We discuss first the data sources and variables used and then present the methodology and the result.

16. The UIP would have predicted that, taken the foreign rate as given, the flatter the domestic yield curve, the more depreciated the nominal exchange rate should be. Again, the presence of currency risk premium can generate deviations from the UIP prediction.

4.1 Data Sources and Variables

Our database includes monthly data on eleven banks, which represent 75% of the total assets in the Chilean banking system.[17] In terms of FLAP usage, they represent close to 90% of the total amount borrowed in this facility. The information regarding banks' financial situations comes from their monthly balance sheets, and the source is the *Superintendencia de Bancos e Instituciones Financieras* (*SBIF*). The data on FLAP usage is from the Central Bank of Chile. The sample spans across the whole FLAP period (eleven months, from July 2009 to May 2010).

To conduct the analysis, we use two variables related to the FLAP. The first one is a dummy variable indicating whether a particular bank used the program in a given month. The second one is a variable indicating the amount demanded in the facility by each bank during a given month.

From the balance sheets we extract information on banks' net worth: liquid and illiquid assets, liabilities, loans (commercial, consumer and mortgage) and provisions. In addition to these variables we also use an index of the Chilean economic activity (Imacec, published by the Central Bank of Chile) and the 12-month CPI inflation rate (from *Instituto Nacional de Estadísticas*, *INE*).

4.2 Methodology and Results

The goal is to assess whether or not the use of the FLAP facility affected the loans supplied by banks. To this end we estimate the following equation,

$$\frac{L^k_{i,t}}{A_{i,t}} = c + \beta FLAP^j_{i,t} + \delta X_{i,t} + \alpha Y_{i,t} + e_i + u_{i,t}.$$

Here $L^k_{i,t}$ denotes loans of type k (Total, Commercial, Consumer, or Mortgage) of bank i in month t, $A_{i,t}$ represents total assets, $X_{i,t}$

17. These are the banks for which we have observations for all the months and all the variables during the FLAP period. As a robustness check, we ran the regressions using four additional banks, for which, we only have observations for six months of the eleven in the FLAP period (i.e. an unbalanced panel). The sample adding these banks accounts for 91% of the total assets in the system. The point estimates that we obtained were not significantly different, although they were estimated with less precision.

is a vector of banks' specific variables in each month (in particular, we include net worth over liabilities, liquid assets over total assets, and provisions over total credit),[18] Y_t contains the activity indicator and inflation, e_i is an individual effects and u_{it} is the error term that varies both across banks and time. We use two alternative variables related to the use of the FLAP facilities ($FLAP^j_{i,t}$) a dummy that takes the value of one, if the bank borrowed from the facility in that month, and the amount borrowed from the facility as a percentage of total assets. The main goal is to estimate the parameter β for each alternative type of loan.

We estimate the equation using a fixed-effect model with instrumental variables. The fixed effect assumption allows for the possibility that the bank-specific, right-hand-side variables are correlated with individual unobserved effects (e_i).[19] Nonetheless, there is still a chance that the unobserved components in $u_{i,t}$ can be correlated with the regressors $FLAP^j_{i,t}$ and $X_{i,t}$ along the time dimension.[20] To avoid this problem we use as instrumental variables, two lags of the variables in $X_{i,t}$ and Y_t.[21] These are valid instruments under the assumption of weak exogeneity. In other words, we are assuming that shocks that affect individual variables at a given month are uncorrelated with the lagged values of these variables for the same individual.

Table 1 presents the results for each type of loan that we considered, when the variable $FLAP^j_{i,t}$ is the dummy for FLAP usage in that month. As we can see, the use of the FLAP had a significant effect on total, commercial and consumption loans. In particular, a bank that borrowed from the facility in a given month had a loans-to-total-assets ratio (relative to a bank that did not use the facility in that month) of almost 4 percentage points (p.p.) higher for total loans, 3 p.p. for commercial loans and less that 1 p.p. for consumer loans. The effect on mortgage loans was insignificant. The coefficients for the other regressors have the expected signs whenever they are significant.

18. These control variables are also used in the recent literature assessing the role of the different credit facilities implemented in the U.S. in response to the crisis (e.g. Talafierro, 2009; Veronesi and Zingales, 2010; and Li, 2011).

19. We also estimated a version with random effect as a robustness check, but there were no significant changes with this alternative method.

20. The correlation between $u_{i,t}$ and Y_t is ruled-out by assumption, for the latter are aggregate variables.

21. We also evaluated using one and three lags as instruments. However, the Stock-Yogo approach to weak instruments suggested using two lags.

Table 1. Credit Regressions with FLAP Dummy

Variables	*Total*	*Commercial*	*Consumption*	*Mortgage*
FLAP Dummy	0.038**	0.031**	0.007***	0.000
	(0.016)	(0.014)	(0.002)	(0.003)
Net Worth/Liabilities	0.056**	0.055**	-0.002	0.004
	(0.025)	(0.023)	(0.004)	(0.005)
Liquid Assets/Total Assets	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Provisions	-0.064*	-0.067**	0.003	-0.000
	(0.035)	(0.033)	(0.005)	(0.007)
Economic Activity	0.000	0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)
Inflation (12 months)	0.398**	0.361**	0.092***	-0.055
	(0.196)	(0.180)	(0.030)	(0.039)
Constant	0.257**	0.211**	0.045***	0.001
	(0.110)	(0.102)	(0.017)	(0.022)
Observations	121	121	121	121

Source: Authors' calculations.
Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table 2. Credit Regressions with FLAP Borrowing

Variables	*Total*	*Commercial*	*Consumption*	*Mortgage*
FLAP/Assets	1.576**	1.304*	0.279**	-0.007
	(0.717)	(0.671)	(0.111)	(0.161)
Net Worth/Liabilities	0.0607***	0.0587***	-0.002	0.003
	(0.0219)	(0.0205)	-0.004	-0.005
Liquid Assets/Assets	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Provisions/Liabilities	-0.064*	-0.066**	0.003	0.000
	(0.034)	(0.032)	(0.005)	(0.007)
Economic Activity	0.000	0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)
Inflation (12 months)	0.267*	0.256*	0.067***	-0.0570
	(0.156)	(0.146)	(0.024)	(0.0349)
Constant	0.231**	0.190**	0.041***	0.001
	(0.0983)	(0.0920)	(0.015)	(0.022)
Observations	121	121	121	121

Source: Authors' calculations.
Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

To put these results in context, it is useful to compare these estimated effects with the average values for the loans to assets ratios. During the FLAP period, the average (across months and banks) for total loans was 28%, for commercial 23%, for consumer 4%, and for mortgages was nearly 2%. Thus, the effect of using the FLAP represented around 13% of average total and commercial loans, and 17% of average consumer loans.

In table 2, we re-estimated the model but using the ratio of the amount borrowed in the FLAP program as a fraction of total assets as the explanatory variable. Because total assets normalize both the explained variable and the FLAP regressor, the coefficient on the FLAP variable can be interpreted as the increase in amount lent for each peso borrowed at the FLAP. The results indicate that each peso borrowed under the FLAP increased total loans at around 1.6 pesos, commercial loans at around 1.3 pesos, and consumer loans at almost 0.3 pesos. Mortgage credit, in line with the previous results, was not significantly changed. Given that commercial loans have generally shorter maturity than the other two types of loans, the evidence indicates that short-term borrowing (the FLAP) was used mainly to finance short-term lending.

Summarizing, the evidence suggests that there was an effect of the FLAP on loans, and in the desired direction. These effects were more important in commercial loans, and to a smaller degree, for consumption loans. The maturity of these two types of loans is shorter than for mortgages, which is reasonable given that the FLAP was a source of short-term funding for banks.

5. Conclusions

In this paper we have analyzed the effects of the unconventional monetary policy implemented by the Central Bank of Chile (a term liquidity facility) to deal with the zero-lower-bound situation originating from the recent global financial crisis and recession. The first part of the analysis was aimed to assess the main goal behind this policy; namely, to convey the message that the policy rate was going to remain at its lower bound for a prolonged period of time. The second part studied how banks used these additional available funds. In particular, we wanted to analyze if this source of liquidity was destined to increase the amount lent.

Overall, the results seem to indicate that the main goal was achieved, for the FLAP significantly flattened the nominal yield curve, particularly in the neighborhood of the relevant policy horizon for Chile (two years). In terms of the effects that the FLAP had on loans, banks that borrowed from the facility seem to have increased mainly commercial loans and, to a smaller degree, consumer loans as well. However, loans at longer horizons (mortgages) were not modified by the use of the facility.

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Credit Stabilization through Public Banks: The Case of BancoEstado

Luis Felipe Lagos
Instituto Libertad y Desarrollo, Chile

Matías Tapia
Pontificia Universidad Católica de Chile

A novel element in the policy mix that responded to the 2008-2009 financial crisis was the explicit role given to BancoEstado, a publicly-owned commercial bank, to alleviate the contraction in domestic credit provided by the banking sector. In order to aid its mission, BancoEstado was capitalized by 500 million dollars in 2009, ensuring that it would not be bounded by its loans to capital ratio.

While this, in a sense, is quasi fiscal policy (with the public sector channeling resources to potentially credit-constrained firms) and could thus be seen as similar to policies adopted in the U.S. at the same time, credit was not provided directly by the government, but through a bank that competes directly and successfully within the banking sector. While publicly owned, BancoEstado operates as a (constrained) profit-maximizing institution that tries to attain certain public policy objectives (like providing access to banking in remote areas) while still being competitive and profitable.

The use of a bank as an instrument has several advantages. Banks, in contrast to the government, enjoy economies of scale associated with their distribution networks and their previous

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investments in monitoring and information, and have informational advantages in dealing with potential clients. In that sense, a bank is probably more efficient than the government in creating credit rapidly and profitably, and in identifying firms and households that, while still viable as debtors, have become credit constrained in the private sector.

However, there might be an agency problem, in which banks' own objective function is at odds with the general purpose of the policy. Given a general mandate to provide credit, and the capital needed to do so without risking its financial stability, BancoEstado had the incentives to fulfill this mission in the most profitable way. That is, BancoEstado may have chosen to provide those loans that are the most profitable from a private perspective. The point, however, is that those types of credits, and the firms associated with them, might not be the ones that the public policy intended to help in the first place as a gap between private and public returns may exist. For example, BancoEstado might choose financial profitability and provide credit to firms that have high risk-adjusted rates of return, and who are not credit constrained in any significant way in the private market. Alternatively, BancoEstado might have seen its mission as an opportunity to grow as a bank, either in terms of market share or in reputation by establishing new credit relationships. Newly capitalized, and set to provide a significant amount of credit, BancoEstado may have chosen to target firms that were attractive as clients, given its own private incentives, even if they were not subject to any significant constraint in credit. Although the available data does not allow us to provide a definite conclusion regarding this issue, we will try to provide some evidence that may point in this direction.

Another significant channel through which BancoEstado may have had an impact of overall credit is through its effect on the actions of private banks. At a time in which most banks were constraining credit, BancoEstado expanded its credit creation aggressively. How did this affect other private banks? Did the credit provided by BancoEstado substitute private credit, or did it generate a competitive pressure which forced other banks to respond?

This paper studies the role played by this particular aspect of the policy mix during the 2008-2009 crisis, mainly focusing on the behavior of credit directly provided to firms. In order to do so, we use data from several databases collected by the Superintendence of Banks and Financial Institutions (SBIF) as well as data provided directly by BancoEstado.[1]

On a first order approach, we document the behavior of BancoEstado at an aggregate scale and describe the speed and relative significance of its response. We then focus on the composition of credit, looking in more detail at how the behavior of BancoEstado and the private banks differed among several sectors and credit sizes. Finally, we empirically test the effect of BancoEstado's actions on the behavior and valuation of the remaining banks in the market.

Our main empirical results are the following. In line with the program's main purpose, BancoEstado expanded its credit significantly, particularly in commercial loans. BancoEstado's actions on aggregate credit were clearly countercyclical, expanding credit when commercial banks were either contracting credit or creating new loans at a slower rate. BancoEstado's response was fast and affected aggregate credit, though its scope was limited by the bank's scale. BancoEstado's credit expanded more rapidly in segments with larger loans, suggesting that a significant share of the new credit ended up in large firms. There is no robust evidence of significant impact from BancoEstado's capitalization or its policy actions on private banks over the relevant period.

The paper is organized as follows. Section 1 provides an overall discussion of the crisis in the U.S., its implications in Chile, and the policy response of the monetary and fiscal authorities. Section 2 provides an overview on BancoEstado. Section 3 provides a descriptive analysis of the evolution of different types of credit provided by BancoEstado and the private sector. Section 4 provides a regression analysis. Section 5 concludes.

1. An Overview of the 2008-2009 Financial Crisis

1.1 The Aftermath of Lehman Brothers

The collapse of Lehman Brothers in September 2008 pushed financial markets over the edge, intensifying runs against banks and financial institutions at the same time that market liquidity

1. Unfortunately, potentially richer databases at the individual borrower level ended up being incomplete or rendered unusable by inconsistencies and mistakes. This made some empirical exercises, unfeasible.

virtually dried up. Uncertainty about the stability and solvency of financial institutions severely hit credit both domestically and internationally. The problems in the financial sector soon spread to the real economy with a contraction in trade, drops in output, and large increases in unemployment.

Starting in October 2008, the Federal Reserve and the European Central Bank responded with aggressive reductions in the monetary policy interest rate. However, two obstacles hampered the effects of this policy. First, uncertainty about creditworthiness led private banks to contract credit to firms and households and, instead, choose to hoard liquidity. Secondly, firms and households increased their demand for assets perceived as safe and liquid. Both effects intensify the contraction in credit provided to the real economy, and can make interest rate reduction sterile.

As a consequence, the Federal Reserve relied on a toolbox of non-conventional policies. In the initial stage, the Fed bought massive amounts of long-term treasuries, providing large amounts of liquidity through money creation (quantitative easing). The second stage initiated even though the payment system was in no clear danger, involved *credit easing*: massive, direct buyouts of paper debt from non-banking institutions. The second policy implied that the monetary authority took patrimonial (quasi-fiscal) risk. Credit easing does not require money creation, but a reshuffling of the Fed's balance sheet, typically towards a riskier position. Moreover, it is highly discretionary as the Fed retains the right to lend to specific agents. In that sense, credit easing can be seen as a potentially effective device to unblock the credit channel as it ensures that funds are received directly by the selected firms.

Monetary policy actions were complemented by fiscal measures. For example, the U.S. and the U.K. increased deposit insurance in an attempt to boost confidence and guarantee the stability of banks by preventing potential runs. This, however, was not enough to prevent a flight to safety from British savers. As a result, the National Savings and Investments, a public bank whose deposits are fully guaranteed by the government, received a record number of deposits in the last quarter of 2008 (Warwick-Ching, 2009).

1.2 The Crisis in Chile: Effects on Financial Markets and Policy Responses

1.2.1 Effects on financial markets

Borrowing costs for domestic banks began increasing as early as September 2007, peaking with the downfall of Lehman Brothers a year later (Garcia, 2009). The subprime crisis generated a reduction of foreign financial flows, different from FDI during 2009-2010, equal to 6% of GDP that generated a reversion in the current account deficit. However, this contraction was concentrated in pensions and mutual funds, and was relatively small for banks (2.5%), lasting only a couple of months during 2009. In fact, foreign liabilities of the banking system actually increased in 2008, most likely as a precautionary measure. Foreign debt spreads peaked for the banking sector at the end of 2008, but have declined steadily ever since. Foreign debt typically had shorter maturities, especially in the second part of 2008, but by the end of 2009, the maturity structure was converging to its pre-crisis values. A significant change occurred in the sources of external financing as the share of credit provided by the three main foreign banks dropped from 53% to 29% (*Informe de Estabilidad Financiera*, 2009). This suggests that, while banks did suffer tighter conditions on foreign credit with credit lines on foreign banks being cut in September 2008, the restriction was not as severe as previous episodes, and was relatively short-lived. By the middle of 2009, access to foreign credit for trade and private firms was mostly restored, and corporate bonds were sold in international markets.

Thus, the banking sector, while not immune to the crisis, remained relatively unscathed. No bank was under significant financial stress; foreign credit was restored rapidly and, although domestic credit slowed down for a relatively long period, it did so to a smaller extent than in previous crises (Fuentes and Saravia, 2011).

Regarding the corporate sector, large firms with access to foreign credit saw reductions in the size of loans and higher interest rates, which increased their demand for credit (bonds and bank loans) in the domestic market.

1.2.2 Policy responses

At the time of the severe contraction of credit that occurred after the collapse of Lehman Brothers, inflation in Chile was accelerating due to a rise in the price of raw materials, energy and food. In response, the Central Bank increased the monetary policy interest rate during 2008, and the nominal rate was kept high at 8.25% as late as January 2009, several months after the aggressive rate cuts in most of the world. At that time, when the severity of the crisis was clear and inflation expectations had collapsed, the Central Bank reacted strongly, slashing rates 600 basis points in two months, and reaching a historic lower bound of 0.5% in August 2009.

Although the Central Bank kept rates high during the last quarter of 2008, it also took several measures to increase short-term liquidity in pesos and dollars. Among other measures, the Central Bank, collaborating closely with the Ministry of Finance, offered swap operations in foreign exchange, extended the period for liquidity provision, engaged in repo operations, and opened a medium run liquidity facility. All these operations were done directly with commercial banks, and arguably had an effect on satisfying the system's demand for liquidity, rather than on the creation of loans to households and firms. In this context, Chile's institutional framework constrained the set of potential actions for the Central Bank. Unlike the Federal Reserve and the European Central Bank, the Central Bank of Chile is legally restrained from pursuing credit-easing operations that could be directed to specific segments of the financial market.

Fiscal policy was strongly countercyclical, with a significant deficit that was financed with the large savings that the public sector had made in previous years. Among many other measures, and closer to the issues discussed in the paper, the policy package included transitory (later permanent) reductions in taxes on credit operations as well as measures targeted to reduce the short-run tax burden on firms, especially small and medium ones.

To directly impact credit provision, the Ministry of Finance implemented two policies, which were approved by Congress in December 2008: First, it increased the level of public guarantees on private credit to small firms (FOGAPE) as well as making larger firms temporarily eligible. Second, and central to our study, it instructed BancoEstado to make a special effort to provide credit to firms and households. To keep the bank's financial stability and its capital-to-loans ratio in line with private banks, BancoEstado received a capital injection of US$ 500 million (increasing the bank's capital by 50%) and, in the words of the Minister of Finance Andres Velasco, was expected to provide US$ 2.5 billion in loans.

2. BancoEstado and its Role in the 2008-2009 Crisis: An Overview

State participation in the banking sector in Chile is among the lowest in Latin America (Levy-Yeyati, Micco, and Panizza, 2007). BancoEstado is the only state-owned bank currently active in the financial sector and was created (as *Banco del Estado de Chile*) in 1953 through the merger of several smaller public financial institutions that provided credit and received savings from different economic sectors. In the increasingly centralized and state-regulated economy of the 1960s and the early 1970s, *Banco del Estado de Chile* enjoyed its heyday as it became the country's largest bank. While its relative size has diminished since, it still remains an important actor in Chile's banking sector and is especially important in specific credit segments such as housing loans and credit to small firms. On its institutional website,[2] BancoEstado claims that it aims to offer all the mainstream banking services, targeting all population segments, with priority to "high social impact activities" such as access to financial services and entrepreneurship. At the same time, it wants to offer competitive terms and prices as well as achieving the average rate of return of the financial sector.

BancoEstado is not a development bank that offers subsidized loans or systematically funds projects that are not privately profitable. BancoEstado aims to be competitive and profitable, and its public role is more related to its relative specialization in specific segments rather than on the type of credit policies it follows. In fact, its rate of return compares favorably to that of the private sector: between 2002 and 2007 the BancoEstado return on equity systemically exceeded average return in the banking system. All profits are reinvested in the bank. BancoEstado has consistently enjoyed solid credit ratings, largely because of its individual strength and because it seems to be perceived by rating agencies as being implicitly guaranteed by the Chilean state, rather than solely on its own capital (Standard and Poors, 2009). However, estimates from BancoEstado show that, in the absence of the 2009 capitalization, their credit expansion program in 2009 would have put the bank dangerously close to violating Basel II's capital adequacy standards. While investors did not perceive the bank to be in a risky position, formally, the bank would have fallen

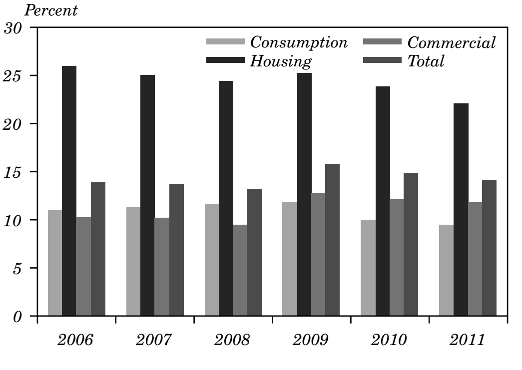
2. www.bancoestado.cl

under the scrutiny of regulatory agents in Chile and the U.S. (the bank has a New York office).

Figure 1 summarizes the market share of BancoEstado for different types of loans between 2006 and 2011. Over the years, BancoEstado has provided roughly 15% of the banking sector's total credit stock, placing it as the third largest bank in the market, with its two largest banks taking approximately 20% of total credit, each. Participation in total loans peaked in 2009, reflecting BancoEstado's countercyclical credit policy when private credit was contracting.

BancoEstado's market share differs markedly across types of credit. It is by large the main actor in mortgages, while it is a relatively smaller participant in commercial credit, where it provided less than 10% of the banking sector loans between 2006 and 2007. Participation in both mortgages and commercial credit grew in 2009. The increase in the market share in commercial credit was particularly impressive as BancoEstado gained 4 percentage points in a year, roughly increasing its participation in the segment by 40%. At first glance, it is clear that BancoEstado's credit policy, especially in commercial credit, was extremely countercyclical, fulfilling (at least on first order terms) the policy intended by the Ministry of Finance.

Figure 1. BancoEstado's Market Share in Loans



Source: SBIF

The credit behavior of BancoEstado was qualitatively similar to the one assumed by public banks in other Latin-American countries, although the extent of its credit expansion (in percentage terms) was the largest, comparable only to the behavior of banking in

Brazil and Colombia. Both countries are cases of interest as they indeed followed a similar policy approach to the one taken in Chile with BancoEstado. In the case of Brazil, capital was also injected into the main public banks, which have larger market participation than BancoEstado and they adopted targeted lending programs. In a similar spirit, the Colombian government also relied on public banks to provide credit during the crisis, targeting loans specifically to small and medium firms.

3. Credit by BancoEstado and the Private Sector During the 2008-09 Crisis

3.1 Data Sources

Most of our data comes from SBIF, the Superintendence of Banks and Financial Institutions. Our analysis relies mainly on the D30 database,[3] which provides daily information on new loans by banks in the Santiago Metropolitan Region, where 60% of the nationwide credit is provided. This dataset has been empirically validated by SBIF, and upon aggregation, the results are consistent with system level data obtained from other sources. There is no information on individual loans, but on aggregates by different size and type categories. We focus our attention on commercial credit, which cannot be identified directly, but by the difference from subtracting consumption credits from the total credit. As the remaining loans include commercial credit as well as mortgages, we only look at credits in pesos (thus excluding credits in UF), as they are seldom associated with mortgages. Our measure of commercial credit, while somehow noisy, still allows looking at credit in different size categories by individual banks. The data separates credit into 21 size segments, which we reduce to three: credits below 1,000 UF

3. Initially, we started our work with database D32. This was an ideal database to study the behavior of BancoEstado and other banks during the crisis in detail, as it is meant to provide a census of all new individual credit transactions, identifying credits by bank and type as well as providing information on size, maturity, and interest rates. Moreover, as the database also identifies the firm or household taking each credit, it could be potentially combined with other databases to obtain information on the demand side for each loan. Unfortunately, the database proved unreliable with problems in data collection and processing that made the microeconomic information for 2008 and 2009 entirely inconsistent with the (correct) aggregate data.

("small loans"), credits between 1,000 and 10,000 UF ("medium loans"), and credits above 10,000 UF ("large loans").[4] The data does not allow additional distinctions between credits above 10,000 UF. As way of comparison under this definition, large credits are those loans that roughly exceed US$400,000 at the time of the crisis. We are aware that this upper category is very broad and contains credits potentially reaching a large spectrum of firms. However, we think that our classification still allows us to provide a distinction between credits arguably associated from micro to small firms; small to medium sized firms; and medium to large (some very large) sized firms. Our sample starts in January 2006 and ends in December 2011, though we focus most of the analysis from January 2007 to December 2010. On average, across all banks, small loans represent 21% of all commercial credit, with large loans taking the lion's share with 64%. BancoEstado is relatively more concentrated on large loans, with total loans in the upper category accounting for 76% of new credit.

We complement this database with information from D11, a monthly census on credit stocks that provides information on the amount of total credit held by individual agents (firms and households). The database separates credit by characteristics such as bank and type and thus can also be used to characterize the distribution of credit held by each bank at each moment in time. With somehow unfortunate timing, the first month available for D11 is January 2009, when it replaced a similar (not identical) database, C01, which existed until December 2008.[5] This implies that direct comparisons between 2008 and 2009 at this disaggregated level are troublesome and results on D11 must be taken with a grain of salt as the database has some inconsistencies on its first month of operation.

Finally, we also use more aggregated information available on the SBIF website on credit stocks by bank, which identify total loans to different economic sectors.

We begin our analysis by looking at aggregate data, and then build our way towards a more detailed analysis.

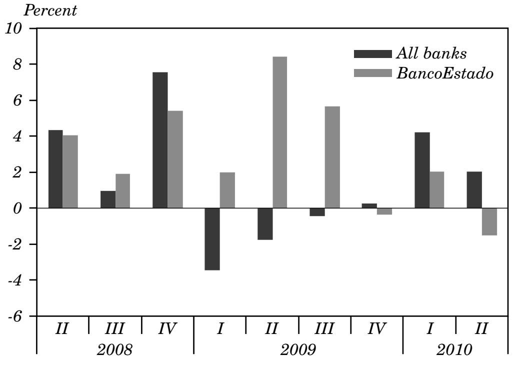
4. Recall that we focus on loans issued in nominal pesos although the size categories are defined in the dataset in terms of the indexed UF.

5. In fact, with which was, ex post, a very unfortunate timing, SBIF chose to redefine several statistical procedures at the end of 2008, which complicates the analysis of the crisis period.

3.2 Aggregate Credit Stocks

Figure 2 depicts the percentage change in the overall stock of credit during the crisis period. BancoEstado expanded credit during most of 2009 while the banking sector as a whole contracted moderately the first three semesters of that year. As discussed below, the reduction in aggregate credit is basically given by a contraction on commercial growth while BancoEstado's large expansion in the second quarter of 2009 is mainly driven by commercial credit and, to a lesser extent, by consumption loans.

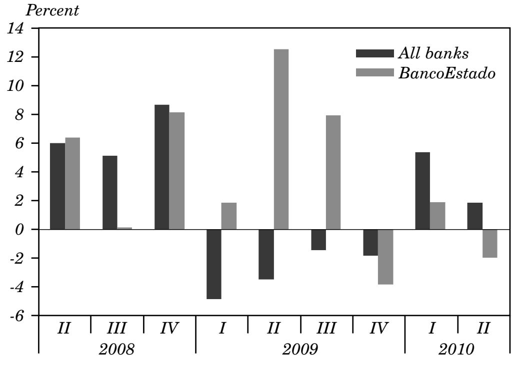
Figure 2.Change in Total Loans, 2008-2010



Source: Seasonally adjusted data from SBIF.

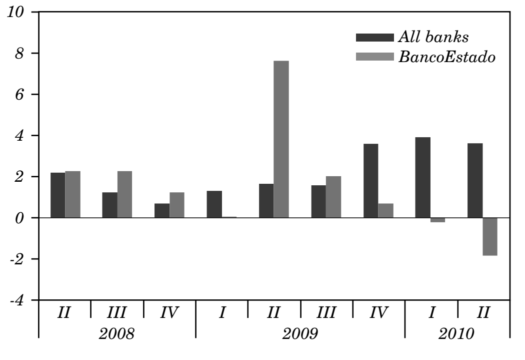
Figures 3 to 5 show the expansion of different types of credit measured as the quarterly change in credit stocks throughout the financial crisis. The countercyclical stance adopted by BancoEstado is clear in all 3 types of credit. Average credit growth for 2009 is larger for BancoEstado in commercial loans, consumption loans, and mortgages. Commercial credit, our main focus in this paper, is the most interesting case here. While the growth in commercial loans is very similar across banks in the second half of 2008, the picture for 2009 is radically different. While aggregate credit falls throughout all quarters in 2009, loans by BancoEstado increase dramatically in the first half of 2009, with stocks growing at rates that exceed 10%. The large increase in BancoEstado's market share in this segment is easy to understand with these figures. Shifts are less dramatic in the other categories. Consumption credit never drops for the banking sector as a whole, and while BancoEstado still leans against the wind, loans grow at a smaller rate in this segment. Finally, the growth in mortgages falls across all banks in 2009, though it never becomes negative. Differences between the behavior of BancoEstado and the rest of the banks are smaller in this case.

Figure 3. Change in Commercial Loans, 2008-2010



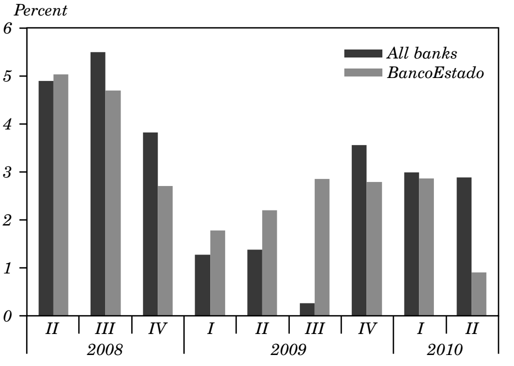
Source: Seasonally adjusted data from SBIF.

Figure 4. Change in Consumption Loans, 2008-2010



Source: Seasonally adjusted data from SBIF.

Figure 5. Change in Mortgages, 2008-2010



Source: Seasonally adjusted data from SBIF.

The direct potential impact of BancoEstado's credit policy upon overall credit supply in the economy is obviously limited by the bank's market participation. The large increases in BancoEstado's loans seen in the data should be associated with modest expansions in total credit, all else being constant, as BancoEstado has only a moderate market share.

Of course, this does not mean that the credit provided by BancoEstado did not attain what the policymakers intended. For instance, even small expansions in credit can have large social marginal returns if, for example, they allow profitable firms subject to a credit crunch to remain viable. In the context of high uncertainty in which private banks typically decided to hoard liquidity and restrict credit, a recapitalized BancoEstado may have provided credit to firms that were cut off from the private sector, but which, to a large degree of certainty, were still profitable firms. Moreover, the actions of BancoEstado can also indirectly affect overall credit by changing the behavior of other banks. Here, at least a couple of hypotheses may exist.

On one hand, the aggressive credit stance by BancoEstado may have forced other banks to follow, as otherwise they faced losing valuable clients, reducing their market shares. Similarly, providing credit to credit-constrained firms could have had a positive impact on other firms related to them, strengthening their balance sheets and allowing them to receive more credit from the private sector in the near future. Somehow, more pessimistically, BancoEstado could have ended with the banking sector's lemons as private banks might have used the opportunity to reshuffle their credit portfolios, allowing their least attractive clients to move to BancoEstado while providing better conditions and more credit to their most favored clients, and looking for new profitable clients such as the larger firms who faced tougher conditions in the international financial market. While our data will not allow us to verify any of these hypotheses directly, we try to provide evidence that highlights the direct effects of BancoEstado's actions over different margins as well as their indirect impact on private banks.

We begin by looking at the first-order direct effect on financial markets in this section, and provide a more detailed look at the composition of credit and its effects on private banks in the next section. From an ex ante perspective, the expected direct effect of BancoEstado's credit expansion on total credit can be approximated by the rate of growth in credit weighted by BancoEstado's market share in the credit market. We show this exercise in table 1. For 2009, we can see that the effect of BancoEstado's large credit expansion was equivalent to a 3.3% expansion in total commercial credit, larger than its contribution to overall credit in previous years. Relative to itself, BancoEstado increased its loans dramatically. However, the absolute

Table 1. Maximum Potential Impact
12-month change in credit stocks (percent)

	Commercial	*Consumption*	*Housing*
2001	1.5	1.9	3.0
2002	0.5	5.5	2.6
2003	-0.2	4.4	4.1
2004	2.3	2.9	3.3
2005	1.6	1.9	4.7
2006	2.0	1.9	3.6
2007	1.2	1.9	4.7
2008	1.5	0.8	3.7
2009	3.3	1.2	2.4
2010	0.4	-0.5	1.2
Difference between 2009 and the 2003-07 average	1.9	-1.4	-1.7

Source: Constructed using data on stocks from SBIF.

size of that expansion is not that large; BancoEstado is a relatively modest actor and its overall contribution is of limited scale. This, again, does not mean that the effect is negligible as overall credit would have decreased, assuming everything else being constant, significantly more than it did in the absence of BancoEstado.

3.3 Effects in Credit by Size and Economic Sectors

We now look at more disaggregated data to better understand the behavior of credit at BancoEstado and the private banks. We focus exclusively on commercial credit, first looking at credit stocks across economic sectors, and then at credit flows by different loan sizes. While the data on economic sectors relies on aggregate quarterly data on stocks, the information on credit flows is constructed by aggregating, at the monthly level, micro data on credit given in the Santiago Metropolitan Region as reported in the D30 database.

3.3.1 Credit by sector

Tables 2 and 3 present the variation in credit stocks across economic sectors between 2009 and 2008 both in absolute terms and as percentage change relative to the 2008 stock.

Table 2 shows that the amount of credit provided by BancoEstado is equivalent to 17% of the overall reduction in commercial credit. Interestingly, the composition across sectors of the credit reductions at the aggregate level and credit expansions at BancoEstado differs greatly. At the aggregate level, 60% of the reduction in loans was concentrated in two sectors, manufacturing and wholesale/retail trade. The increment in credit at BancoEstado is very small in Manufacturing (only 3% of the aggregate reduction) and non-existent in trade, where credit by BancoEstado falls in line with the other banks. BancoEstado does 50% of its expansion in Construction, where it actually reverses a reduction by the remaining banks, and expands significantly in Agriculture and Personal Services.

Table 3 shows, as discussed earlier, that BancoEstado expanded its commercial credit by 19% between December 2008 and December 2009 while the banking sector as a whole contracted by 11%. The reduction in credit to trade and manufacturing was not only large in absolute terms, but also represented a significant drop, roughly a quarter, of the stock of loans in each sector. Thus, both sectors

Table 2. Change in Commercial Loans by Economic Sector
(Variation in stocks between Dec. 2009 and Dec. 2008. 2009 million pesos)

	Banking sector	*Share of overall credit reduction*	*BancoEstado*	*Share of overall credit expansion*	*Expansion in BE relative to aggregate reduction*
Agriculture	-340,066	7%	143,879	17%	42%
Wholesale/Retail trade	-1,848,757	36%	-7,1538	—	-4%
Construction	230,088	—	444,418	53%	100%
Financial services	-1,140,633	22%	109,249	12%	10%
Manufacturing	-1,218,214	24%	31,581	3.6%	3%
Mining	-356,735	7%	-5,109	—	-1%
Personal services	-205,505	4%	153,629	18%	75%
Transportation	-7,878	0%	58,495	7%	742%
Utilities	-195,917	4%	-21,008	—	-11%
Total	-5,083,617	100%	843,593		17%

Source: Constructed using seasonally adjusted data from SBIF.

Table 3. Percentage Change in Commercial Loans by Economic Sector
Variation in stocks between Dec. 2009 and Dec. 2008 (percent)

	Banking sector	*BancoEstado*	*BancoEstado (relative to banking sector stock)*
Agriculture	-9	76	4
Wholesale and retail trade	-22	-5	-1
Construction	4	25	7
Financial services	-12	63	1
Manufacturing	-26	21	1
Mining	-39	-51	-1
Personal services	-2	28	2
Transportation	0	46	2
Utilities	-15	-29	-2
Total	-11	19	2

Source: Constructed using seasonally adjusted data from SBIF.

appear to be hit hard by the crisis. BancoEstado expanded its credit significantly in manufacturing, but only made a small dent on the aggregate stock, due to its minimal market share in that segment.

In summary, the reduction in credit was far from homogeneous across sectors with trade and manufacturing bearing most of the burden. In the absence of more detailed information on firms, disentangling supply and demand is not feasible, and the reduction in credit on a specific sector could reflect restrictions on supply, a contraction in demand, or both.

BancoEstado did not compensate in any significant way for the reduction of credit to wholesale/retail trade and manufacturing. This is coherent with an interpretation in which the credit contraction in those sectors was demand-driven, but with an interpretation in which BancoEstado decided to place its efforts on other sectors, which were relatively more profitable, either from the bank's private perspective, or from a public policy stance.

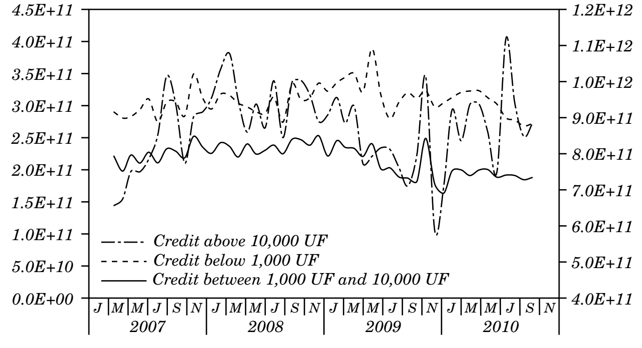
3.3.2 Credit by size

We now analyze the behavior of commercial credit by size, which we interpret as a proxy of the size of the firms receiving loans. As mentioned before, we rely on two sources of data. First, the D30 database contains data, by bank, on new loans in the Santiago Metropolitan Region, in which data on loans in pesos can be identified with a good degree of confidence as commercial loans. For each bank, we identify the total amount of new loans at the monthly level in three size categories: loans below 1,000 UF (US$40,000 in 2008), credits between 1,000 and 10,000 UF, and credits above 10,000 UF. As a caveat, recall we are dealing with a specific definition of credit that approximates commercial loans, which is additionally defined in a particular geographic area. Moreover, this is new credit and, thus, does not take into account changes in the valorization, outflows, or conditions on the stock of existing credit. Thus, comparisons with the results of aggregate stocks presented previously are not straightforward.

Figure 6 shows the evolution of new commercial credit (gross flows) at private banks (the scale for the small and medium lines is on the right hand axis). Surprisingly, we can see that the creation of credit in small and medium sizes seems to be resilient to the crisis, although one must take into consideration that we are looking at a particular definition of credit in a specific geographic region. However, the creation of larger credits does slow down, as gross credit flows after the first quarter are significantly smaller (of course, the stock can still fall with positive inflows if outflows are larger, as seems to be the case here). New credit never dries up, but it becomes weaker in 2009, recovering strongly in 2010.

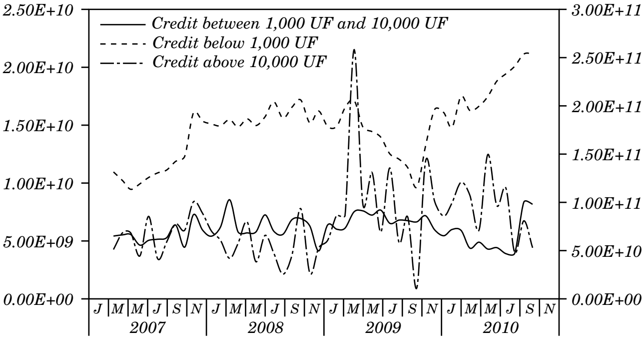
Figure 7 shows the same data for the case of BancoEstado. BancoEstado provides a significant amount of large new loans, and keeps issuing new credit on that segment during the next few

Figure 6. New Commercial Loans from Private Banks in Santiago Metropolitan Region, Constant Pesos



Source: Constructed by the authors using data from SBIF.

Figure 7. New Commercial Loans from BancoEstado in Santiago Metropolitan Region, Constant Pesos



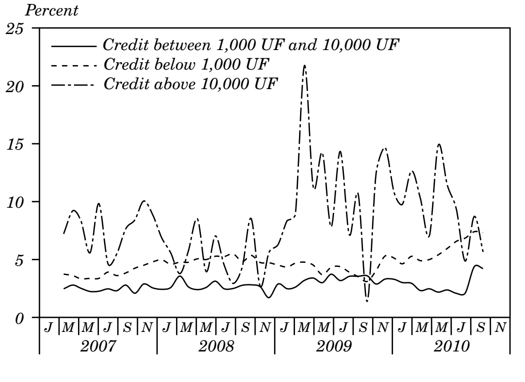
Source: Constructed by the authors using data from SBIF.

months at a faster pace than 2009. New large credits become smaller in the second half of 2009. The provision of mid-sized credit, on one hand, seems to follow a similar pattern to the expansion in 2008. New credits to small firms, on the other hand, become significant in the second half of 2009, a pattern that does not resemble what is observed across private banks.

The differences in behavior between BancoEstado and the rest of the banks can be seen more clearly when looking at the evolution across time of the share of new credit provided by BancoEstado in each segment (figure 8). BancoEstado increases its share in new "large" loans significantly during 2009, particularly in the second quarter. As loans above 10,000 UF represent roughly two-thirds of total commercial credit, it is not surprising that this larger share in this segment is consistent with the larger market share in commercial credit observed in the data on stocks. BancoEstado's share does not seem to change significantly in the other segments, suggesting that its strongest stabilizing role was played in (relatively) large loans, possibly given to medium-to-very large firms. New credit for small-to-medium firms does not appear to have been as responsive, though again, information at this level of aggregation does not allow us disentangle demand and supply effects.

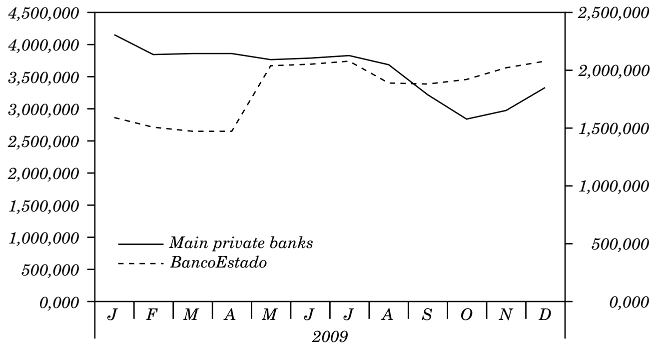
We complement the data on new credit flows with data from a detailed census on borrowers (C11 database). On this database we can identify the amount of commercial credit associated with each individual agent as well as the bank that issued the loan.

Figure 8. Share of BancoEstado in New Commercial Loans



Source: Constructed by the authors using data from SBIF.

Figure 9. Size of the Median Loan in Commercial Credit Stocks, 2009



Source: Constructed using data from SBIF.

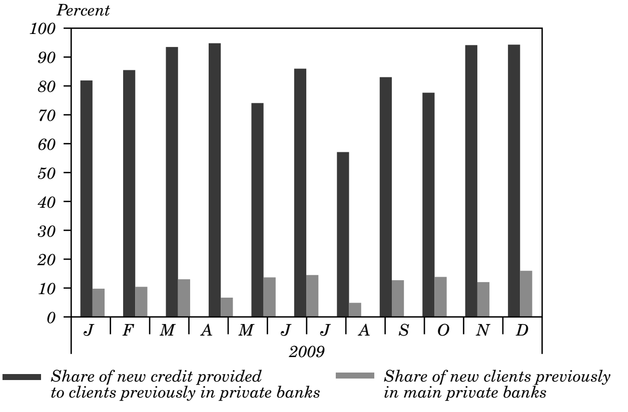
This provides a richer picture in terms of the distribution of credits of different sizes than any of the other databases used so far. Unfortunately, the database's first month is January 2009, and comparisons with the database it replaces, the D01, are not as straightforward, as some of the definitions of the variables are not identical. Moreover, the reliability of the database is allegedly imperfect in its first months of operation, so the results presented below should be taken with caution.

We use the database for two empirical exercises. First, we try to assess the evolution of the distribution of credit for BancoEstado and all other stocks by looking at the size of the median loan across time[6] (figure 9). The data suggests that BancoEstado increased the size of its median loans (and did the same for other quintiles) during 2009, while median loans decreased in private banks. This suggests that BancoEstado shifted its portfolio towards larger credits, while other banks did the reverse (once again, we have few data points and no directly comparable data for 2008).

Figure 10 tries to look again at the behavior of new credit provided by BancoEstado but, this time, focuses specifically on new clients (agents who did not have a loan from BancoEstado in the past). While

6. We perform a similar exercise for other quintiles, getting qualitatively similar results.

Figure 10. New clients at BancoEstado



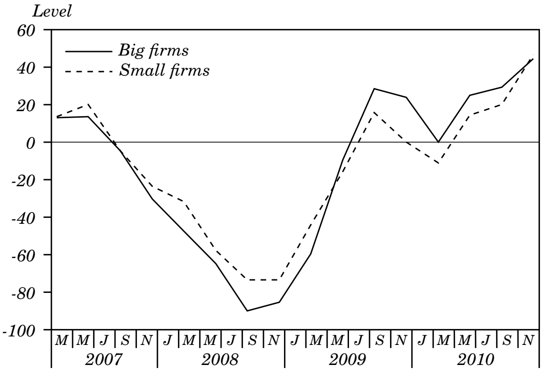
Source: Constructed using data from SBIF.

only 10% of BancoEstado's new loan recipients had a loan with the private sector in the past month, they account for 80% of the credit provided to new loan recipients. This suggests some large clients migrated from private banks to BancoEstado.

The results in this section suggest that BancoEstado's credit effort was relatively more intensive towards larger firms. This does not imply that BancoEstado did not make an effort to expand credit to small and medium firms, as some of its announcement and credit programs were specifically targeted towards that segment. Moreover, there are various reasons that might explain the asymmetry.

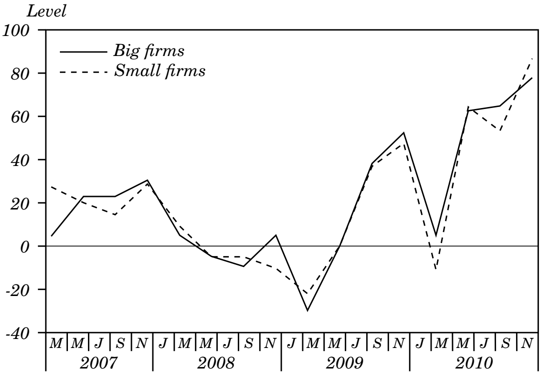
For example, the demand for credit in small firms may have been relatively more affected by the crisis so, even if BancoEstado wanted to, expanding credit more in that segment was not viable. Although we do not have firm-level data to assess this issue, an indirect measure can be obtained by looking at the bank's perceptions on credit demand surveyed by the Central Bank (figure 11). While more of an ordinal measure (in which negative numbers indicate the extent to which the surveyed banks indicate that demand has fallen relative to the previous month), there does not appear to be a clear difference in the reduction of credit demand between both types of firms. Similarly (figure 12), banks' perceptions on credit supply also suggests that the banking sector as a whole was restricted in a similar fashion among all types of firms.

Figure 11. Evolution of Perceived Restrictions on Credit Supply



Source: Central Bank of Chile
Note: Negative numbers indicate that restrictions are perceived as tighter, relative to the previous month.

Figure 12. Evolution of Perceived Restrictions on Credit Supply



Source: Central Bank of Chile.
Note: Negative numbers indicate that restrictions are perceived as tighter, relative to the previous month.

Alternatively, the difference might be associated to the technology of credit provision for each segment and their demand elasticities.[7] Namely, credit creation for small firms might be a slower process as it is more prone to information asymmetries and relies more on local

7. This argument was received in conversations with managers at BancoEstado.

distribution networks, while (given adequate capital) credit to large firms is much more elastic as information on them is much more readily available and fast decisions can be made at a central level.

A third explanation is that, in terms of profitability, either directly or indirectly, through the possibility of building up a reputation by establishing relationships with new clients, large firms were on the margin, more attractive. In fact, evidence in profitability across time suggests that BancoEstado did not lose money with its credit expansion. In that sense, it suggests that it did not shift to a portfolio filled mainly with lemons dropped by the private banks as some critics might have suggested, and no public resources were lost.

4. Regression Analysis

We conclude our analysis by looking at the potential impact of BancoEstado's policy decisions in 2008-2009 on the behavior of its private competitors. We analyze two potential channels. First, we see whether the impact of BancoEstado's credit creation on private banks had a differential effect during the period of application of the policy. Second, we determine whether the announcement of BancoEstado's crisis-contingent credit policy (and the subsequent bank's capitalization) had a direct impact on private banks.

Data is once again taken from the D31 database. We construct bank-level monthly observations of credit flows between 2006 and 2011 for BancoEstado and the nine main private banks in Chile.[8] All credit variables are measured in logs.

Tables 4 to 6 show bank-level regressions for different types of loans. All regressions include controls for macroeconomic conditions,[9] which are not reported for sake of brevity as well as individual bank fixed effects. In each regression, new credits in the Santiago Metropolitan Region are regressed on BancoEstado's own (lagged) credit creation, an interaction of that variable with the period in which the special credit policy was implemented,[10] interactions

8. Banco de Chile, Banco Santander, Corpbanca, BCI, Banco Security, BBVA, Banco Falabella, Itau, and Scotiabank.

9. Lagged activity growth (Imacec growth), monetary policy conditions (the Central Bank of Chile's policy rate), and a measure of turmoil in the international markets (the VIX index).

10. We define this period as ranging from December 2008 to October 2009, based on the descriptive analysis of the previous section as well as BancoEstado's public announcements.

with each bank's market share,[11] and dummies for BancoEstado's capitalization announcement and its lags.

Table 4 focuses on total loans, separating them by different sizes using the same classifications for size as the one in the previous section. The creation of credit by BancoEstado has a negative significant effect on all types of credit, with the larger impact on medium-sized loans. While the sign on the interaction with the policy period is positive, suggesting that the impact of BancoEstado's credit creation on overall credit (private plus BE) was larger in the policy period, the effect is non-significant. Recalling that by controlling for macroeconomic conditions, we try to isolate the effect of the capitalization announcement, the time dummy for December 2008 is positive, but non-significant. Lags that try to account for the fact that banks might have needed time to adjust their lending strategies to respond to the new scenario are also non-significant.[12]

Results are, on average, similar for table 5, which focuses on commercial credit, and table 6, which analyzes credit at different maturities, although there is evidence of a negative, economically significant impact of the capitalization announcement on both large and small commercial credits.

For the case of maturities, it appears that the impact of BancoEstado's new loans was different depending on the specific maturity during the impact of the capitalization announcement.

Thus, on average, results seem to suggest that the impact of BancoEstado's policy was limited, although it was significant and negative for certain types of commercial credit, suggesting to some extent that BancoEstado substituted private credit creation.

However, as results are not robust across different types of credit, the overall effect on banking outcomes does not seem to be strong. This seems consistent with the evolution of private banking stocks before and after the capitalization announcement. If BancoEstado's capitalization had a significant effect on its private competitors, reducing their profits by giving BancoEstado a competitive edge, the impact on the banks' valuation should be reflected in stock prices, a result that is not supported by the data.

11. Market share is measured as the bank's average market participation on each specific segment in the last two quarters.

12. Regressions without lags, or with only lag, were also estimated, and yielded qualitatively similar results.

One final consideration is that average effects across banks might be hiding significant heterogeneity, with different banks—with different size, portfolios, market niches, etc.—being affected in different ways. We explore this in tables 7 and 8, presented in the appendix. Tables 8 and 9 add interactions between the capitalization announcements and specific bank dummies, and the regressions on commercial credit and maturities. The results suggest that, as expected, BancoEstado's policies affected banks differently at different margins.

Table 4. Effects on BancoEstado 2008-09 Policies on Total Private Loans

Bank-level fixed effects, 2006-2011, 9 private banks

	Total loans	*Large loans*	*Medium loans*	*Small loans*
Lagged BE credit	-0.681 (8.20)**	-0.508 (6.05)**	-0.938 (12.33)**	-0.591 (3.88)**
Lagged BE credit*policy period dummy	0.091 (0.67)	0.096 (0.68)	0.287 (1.64)	-0.122 (0.86)
Lagged BE credit*Bank market share	39.564 (10.19)**	28.979 (6.83)**	56.425 (15.81)**	36.884 (4.52)**
Lagged BE credit*Bank market share*policy period dummy	-6.845 (0.70)	-7.325 (0.72)	-21.393 (1.71)	8.706 (0.85)
Capitalization	0.018 (0.17)	0.119 (0.81)	0.104 (1.36)	0.098 (1.12)
Capitalization $t-1$	-0.053 (0.56)	-0.298 (1.82)	-0.126 (1.60)	0.041 (0.35)
Capitalization $t-2$	-0.005 (0.04)	0.112 (0.59)	-0.137 (1.64)	-0.012 (0.13)
Capitalization $t-3$	0.118 (1.43)	-0.014 (0.10)	0.103 (1.46)	0.098 (1.43)
Constant	28.377 (18.76)**	27.461 (22.29)**	26.624 (25.07)**	23.294 (16.67)**
Observations	585	520	520	571
Adjusted R^2	0.94	0.75	0.92	0.96

Robust t statistics are in parentheses.
* Significant at 5%; ** significant at 1%.
Note: All regressions include macroeconomic controls (lags of Imacec growth, Central Bank policy rate, VIX) as well as individual bank fixed effects.

Table 5. Effects on BancoEstado 2008-09 Policy on Commercial Private Loans
Bank-level fixed effects, 2006-2011, 9 private banks

	Commercial loans	*Large commercial loans*	*Medium commercial loans*	*Small commercial loans*
Lagged BE credit	-0.318	-0.383	-0.262	0.137
	(2.55)*	(3.25)**	(2.38)*	(0.76)
Lagged BE credit*policy period dummy	-0.143	-0.152	-0.297	-0.295
	(1.33)	(1.31)	(1.12)	(1.68)
Lagged BE credit*Bank market share	19.818	17.207	28.488	18.727
	(3.67)**	(2.57)*	(5.59)**	(1.73)
Lagged BE credit*Bank market share*policy period dummy	10.128	10.587	21.243	21.190
	(1.32)	(1.28)	(1.12)	(1.67)
Capitalization	0.027	-0.305	-0.093	0.149
	(0.18)	(1.65)	(0.77)	(1.37)
Capitalization $t-1$	-0.019	0.191	0.019	-0.183
	(0.16)	(1.28)	(0.17)	(2.14)*
Capitalization $t-2$	-0.052	-0.314	-0.045	0.101
	(0.55)	(2.20)*	(0.45)	(1.49)
Capitalization $t-3$	0.005	0.050	0.074	-0.075
	(0.07)	(0.46)	(0.85)	(1.55)
Constant	24.498	25.846	20.126	15.544
	(13.78)**	(13.91)**	(12.00)**	(6.11)**
Observations	575	498	515	581
Adjusted R^2	0.93	0.80	0.88	0.88

Robust t statistics are in parentheses.
* Significant at 5%; ** significant at 1%.
All regressions include macroeconomic controls (lags of Imacec growth, Central Bank policy rate, VIX) as well as individual bank fixed effects.

Table 6. Effects on BancoEstado 2008-09 Policies on Loans of Different Maturity
Bank-level fixed effects, 2006-2011, 9 private banks

	Loans 0-30 days	*Loans 30 to 90 days*	*Loans 90 days to 1 year*	*Loans longer than a year*
Lagged BE credit	-0.376	-0.431	-0.666	-0.546
	(4.28)**	(3.94)**	(8.48)**	(4.85)**
Lagged BE credit*policy period dummy	-0.048	-0.320	-0.125	0.342
	(0.44)	(2.80)**	(0.97)	(2.68)**
Lagged BE credit*Bank market share	24.897	21.147	43.510	37.213
	(3.94)**	(3.68)**	(11.45)**	(5.62)**
Lagged BE credit*Bank market share*policy period dummy	3.507	23.174	8.918	-24.606
	(0.44)	(2.88)**	(0.96)	(2.68)**
BE Capitalization	0.164	-0.142	-0.107	-0.337
	(0.67)	(0.61)	(1.08)	(0.76)
BE Capitalization $t-1$	-0.163	0.192	0.015	0.438
	(0.62)	(1.30)	(0.18)	(1.18)
BE Capitalization $t-2$	-0.005	-0.165	-0.084	-0.287
	(0.02)	(0.88)	(1.16)	(1.14)
BE Capitalization $t-3$	0.116	0.218	0.060	0.343
	(0.63)	(1.38)	(0.88)	(1.98)*
Constant	25.981	25.065	24.730	41.890
	(17.10)**	(16.50)**	(21.13)**	(20.49)**
Observations	556	556	585	585
Adjusted R^2	0.88	0.91	0.95	0.77

Robust t statistics in parentheses.
* Significant at 5%; ** significant at 1%.
Note: All regressions include macroeconomic controls (lags of Imacec growth, Central Bank policy rate, VIX) as well as individual bank fixed effects.

5. Conclusions

This paper analyzed the role played by BancoEstado in providing credit during the 2008-2009 financial crisis.

An analysis of the data shows that, as intended by the Ministry of Finance, BancoEstado increased its credit significantly, particularly in terms of loans to firms. While the overall impact of this expansion on total credit was limited by BancoEstado's scale, BancoEstado played a significant role, smoothing the contraction on credit by private banks. Its response was relatively fast (though not automatic, as credit really didn't begin to pick up until well into 2009). Moreover, BancoEstado remained profitable, suggesting that the additional capital the government put in the bank was put to good, productive use.

In terms of size, a large share of BancoEstado's credit expansion was directed to large firms. This is not only due to the fact that larger loans have a larger share of the bank's portfolio, but because the rate of growth in credit in those segments was larger. While this was probably efficient in terms of maximizing the bank's long-term value, it might have been at odds with the ultimate objective of stabilizing the credit contraction for firms facing liquidity constraints. It can be argued that larger firms, while also restricted relative their pre-crisis position, still had multiple sources of funding both domestically and internationally. It seems likely, at least on the margin, that BancoEstado provided better conditions for firms that already had access to credit, rather than providing credit to profitable firms that had been cut off.[13] Unfortunately, providing a more specific answer is not possible with the available data.

13. Informal conversations with BancoEstado executives have indicated that, when providing loans to large firms, BancoEstado asked them to reciprocate by providing better conditions to their own debtors. Following that logic, credit to large firms would end up benefiting small firms, who would face looser conditions on their own contracts with the credit recipients. However, BancoEstado's capacity of enforce this policy is questionable.

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APPENDIX

Table A1. Effects on BancoEstado's Capitalization on Total Private Loans
(Monthly panel regression 2006-2011, 9 private banks)

	Commercial loans	*Large commercial loans*	*Medium commercial loans*	*Small commercial loans*
Lagged BE credit	-0.300 (2.31)*	-0.368 (3.02)**	-0.253 (2.22)*	0.148 (0.79)
Lagged BE credit*policy period dummy	-0.138 (1.05)	-0.171 (1.17)	-0.421 (1.30)	-0.269 (1.39)
(Lagged BE credit*Bank market share)	18.398 (3.21)**	15.980 (2.28)*	28.012 (5.16)**	18.179 (1.60)
(Lagged BE credit*Bank market share*policy period dummy)	9.819 (1.04)	11.917 (1.14)	30.111 (1.30)	19.312 (1.39)
Capitalization				
Bank 1	0.126 (1.37)	-0.053 (0.33)	0.011 (0.13)	0.150 (2.31)*
Bank 2	0.013 (0.12)	-0.123 (0.49)	0.142 (1.38)	-0.027 (0.43)
Bank 3	0.135 (1.15)	-0.021 (0.11)	0.135 (1.62)	0.019 (0.31)
Bank 4	0.041 (0.21)	-0.119 (0.35)	-0.731 (5.15)**	-0.068 (0.57)
Bank 5	-0.086 (0.71)	-0.293 (1.83)	0.056 (0.47)	-0.059 (0.87)

Table A1. (continued)

	Commercial loans	*Large commercial loans*	*Medium commercial loans*	*Small commercial loans*
Bank 6	-0.203 (1.78)	-0.575 (2.67)**	-0.091 (0.75)	0.058 (0.86)
Bank 7	-0.237 (1.87)	-0.516 (3.29)**	-0.086 (0.53)	0.201 (1.68)
Bank 8	0.946 (4.97)**	0.000 (.)	0.000 (.)	0.990 (5.92)**
Bank 9	-0.605 (3.81)**	-1.016 (3.74)**	-0.210 (2.45)*	0.037 (0.49)
Capitalization $t-1$				
Bank 1	0.093 (2.60)**	0.321 (3.62)**	0.233 (5.99)**	-0.168 (5.64)**
Bank 2	0.074 (1.02)	0.409 (1.64)	-0.009 (0.19)	-0.150 (5.17)**
Bank 3	0.107 (1.38)	0.206 (1.24)	0.011 (0.19)	-0.036 (1.25)
Bank 4	0.025 (0.44)	0.138 (1.41)	-0.393 (2.99)**	-0.076 (2.42)*
Bank 5	0.064 (0.59)	0.182 (1.74)	-0.020 (0.25)	-0.039 (1.19)
Bank 6	0.136 (1.44)	0.385 (1.88)	0.199 (2.95)**	-0.128 (2.90)**
Bank 7	0.015 (0.33)	0.124 (2.30)*	-0.069 (0.77)	-0.077 (1.86)

Table A1. (continued)

	Commercial loans	*Large commercial loans*	*Medium commercial loans*	*Small commercial loans*
Bank 8	-0.533 (2.78)**	0.000 (.)	0.000 (.)	-0.619 (3.17)**
Bank 9	-0.019 (0.12)	0.113 (0.40)	0.163 (2.90)**	-0.301 (5.90)**
Capitalization $t-2$				
Bank 1	0.013 (0.29)	-0.003 (0.03)	-0.099 (2.36)*	0.038 (1.17)
Bank 2	-0.245 (3.12)**	-0.717 (2.91)**	0.069 (0.98)	0.070 (2.02)*
Bank 3	0.119 (1.43)	0.093 (0.55)	0.089 (1.96)	0.071 (2.25)*
Bank 4	-0.366 (2.05)*	-1.183 (3.74)**	-0.318 (4.57)**	-0.032 (0.30)
Bank 5	0.008 (0.07)	-0.102 (0.92)	0.111 (1.25)	0.057 (1.45)
Bank 6	-0.152 (1.58)	-0.334 (1.62)	-0.099 (1.20)	-0.010 (0.21)
Bank 7	-0.059 (0.93)	-0.248 (3.48)**	0.111 (1.12)	0.253 (3.82)**
Bank 8	0.398 (2.04)*	0.000 (.)	0.000 (.)	0.428 (2.22)*
Bank 9	-0.383 (2.38)*	-0.575 (2.05)*	-0.233 (4.45)**	-0.045 (0.82)

Table A1. (continued)

	Commercial loans	*Large commercial loans*	*Medium commercial loans*	*Small commercial loans*
Capitalization $t-3$				
Bank 1	0.028 (0.52)	0.174 (1.69)	0.252 (5.87)**	-0.176 (4.03)**
Bank 2	-0.069 (0.95)	-0.088 (0.37)	-0.221 (4.37)**	-0.113 (3.20)**
Bank 3	-0.119 (1.46)	-0.133 (0.88)	-0.222 (2.43)*	-0.060 (1.46)
Bank 4	0.004 (0.61)	0.000 (.)	0.471 (2.74)**	0.000 (.)
Bank 5	0.154 (1.64)	0.215 (2.19)*	0.147 (1.79)	0.057 (1.45)
Bank 6	0.058 (0.68)	0.105 (0.60)	0.069 (0.82)	-0.016 (0.37)
Bank 7	-0.134 (1.68)	-0.164 (1.98)*	-0.066 (0.56)	-0.175 (2.45)*
Bank 8	-0.005 (0.03)	0.000 (.)	0.000 (.)	-0.109 (0.65)
Bank 9	0.060 (0.42)	0.066 (0.27)	0.200 (2.77)**	-0.041 (0.80)
Constant	24.487 (13.40)**	25.862 (13.63)**	20.101 (11.63)**	15.463 (5.87)**
Observations	575	498	515	581
Adjusted R^2	0.92	0.80	0.87	0.88

Robust t statistics are in parentheses.
* Significant at 5%; ** significant at 1%.
Note: All regressions include macroeconomic controls (lags of Imacec growth, Central Bank policy rate, VIX) as well as individual bank fixed effects.

Table A2. Effects on BancoEstado's Capitalization on Loans of Different Maturities
(Monthly panel regression 2006-2011, 9 private banks)

	Loans 0-30 days	*Loans 30 to 90 days*	*Loans 90 days to 1 year*	*Loans longer than a year*
Lagged BE credit	-0.406 (4.46)**	-0.438 (3.73)**	-0.664 (8.21)**	-0.541 (4.70)**
Lagged BE credit*policy period dummy	0.003 (0.02)	0.234 (3.33)**	0.401 (11.09)**	0.415 (5.45)**
(Lagged BE credit*Bank market share)	27.008 (4.11)**	24.725 (2.57)*	6.379 (0.53)	-24.622 (2.70)**
(Lagged BE credit*Bank market share*policy period dummy)	-0.012 (0.00)	-0.343 (2.50)*	-0.090 (0.54)	0.342 (2.70)**
Capitalization				
Bank 1	0.099 (0.46)	-0.293 (1.10)	0.062 (0.74)	0.367 (4.45)**
Bank 2	0.636 (2.21)*	-0.627 (2.10)*	0.224 (2.02)*	-0.344 (3.12)**
Bank 3	-1.018 (4.62)**	0.182 (0.73)	-0.032 (0.32)	-0.048 (0.44)
Bank 4	-0.076 (0.32)	-0.397 (1.45)	-0.186 (1.81)	0.155 (0.80)
Bank 5	0.081 (0.51)	-0.074 (0.33)	-0.095 (0.86)	0.119 (0.78)
Bank 6	-0.195 (1.25)	-0.136 (0.52)	-0.182 (0.94)	0.237 (2.50)*
Bank 7	0.663 (3.30)**	-0.018 (0.08)	-0.182 (2.28)*	0.066 (0.69)

Table A2. (continued)

	Loans 0-30 days	*Loans 30 to 90 days*	*Loans 90 days to 1 year*	*Loans longer than a year*
Bank 8	0.524 (1.45)	-0.195 (0.53)	-0.086 (0.54)	0.709 (3.14)**
Bank 9	0.781 (3.20)**	0.316 (1.01)	-0.482 (3.10)**	-4.288 (4.21)**
Capitalization $t-1$				
Bank 1	-0.313 (1.84)	0.046 (0.34)	-0.027 (0.64)	0.003 (0.10)
Bank 2	0.122 (0.46)	0.792 (3.20)**	0.007 (0.07)	-0.144 (1.74)
Bank 3	0.216 (1.23)	-0.044 (0.37)	-0.036 (0.55)	0.310 (3.49)**
Bank 4	-0.896 (4.20)**	0.078 (0.36)	0.097 (1.75)	-0.203 (0.95)
Bank 5	-0.064 (0.87)	-0.468 (6.24)**	-0.071 (0.72)	0.259 (1.63)
Bank 6	-0.225 (4.13)**	0.397 (2.02)*	0.405 (1.85)	0.086 (1.29)
Bank 7	-1.539 (9.92)**	0.292 (2.09)*	-0.044 (1.26)	0.191 (2.81)**
Bank 8	1.336 (7.68)**	0.411 (2.04)*	-0.024 (0.15)	-0.053 (0.20)
Bank 9	-0.095 (0.44)	0.234 (0.80)	-0.156 (0.98)	3.492 (2.81)**

Table A2. (continued)

	Loans 0-30 days	*Loans 30 to 90 days*	*Loans 90 days to 1 year*	*Loans longer than a year*
Capitalization $t-2$				
Bank 1	0.222 (1.26)	0.155 (1.03)	0.085 (1.94)	0.195 (4.72)**
Bank 2	-0.478 (1.75)	-1.544 (5.68)**	-0.231 (2.61)**	-0.349 (3.90)**
Bank 3	-0.678 (3.52)**	-0.048 (0.35)	0.127 (1.82)	-0.155 (1.64)
Bank 4	-0.555 (2.46)*	0.343 (1.45)	-0.163 (2.66)**	0.393 (1.82)
Bank 5	-0.339 (3.46)**	-0.010 (0.08)	0.020 (0.20)	-0.191 (1.18)
Bank 6	-0.695 (8.00)**	-0.276 (1.26)	-0.330 (1.49)	0.137 (1.86)
Bank 7	1.957 (11.55)**	-0.186 (1.09)	0.042 (1.06)	-0.098 (1.32)
Bank 8	0.129 (0.55)	0.093 (0.48)	-0.172 (1.08)	0.058 (0.22)
Bank 9	0.425 (1.81)	0.007 (0.02)	-0.130 (0.81)	-2.571 (2.07)*
Capitalization $t-3$				
Bank 1	0.542 (2.98)**	0.291 (1.37)	-0.201 (2.80)**	0.146 (3.50)**
Bank 2	0.010 (0.04)	0.998 (4.56)**	0.257 (1.95)	-0.436 (5.17)**

Table A2. (continued)

	Loans 0-30 days	*Loans 30 to 90 days*	*Loans 90 days to 1 year*	*Loans longer than a year*
Bank 3	-0.318	-0.332	-0.149	0.526
	(1.91)	(1.74)	(1.91)	(6.30)**
Bank 4	-0.174	0.235	0.175	0.205
	(0.91)	(1.18)	(2.44)*	(1.14)
Bank 5	0.189	-0.167	0.159	0.416
	(2.28)*	(1.76)	(1.82)	(3.10)**
Bank 6	0.152	0.613	0.187	0.185
	(1.76)	(3.50)**	(1.02)	(2.91)**
Bank 7	-0.628	0.402	0.025	0.044
	(4.18)**	(3.07)**	(0.54)	(0.67)
Bank 8	1.419	0.240	-0.017	0.524
	(4.03)**	(0.66)	(0.13)	(2.44)*
Bank 9	-0.115	-0.294	0.125	1.472
	(0.57)	(1.15)	(0.88)	(1.45)
Constant	25.958	25.038	24.709	41.879
	(16.63)**	(16.00)**	(20.59)**	(20.10)**
Observations	556	556	585	585
Adjusted R^2	0.88	0.91	0.94	0.82

Robust t statistics are in parentheses.
* Significant at 5%; ** significant at 1%.
Note: All regressions include macroeconomic controls (lags of Imacec growth, Central Bank policy rate, VIX) as well as individual bank fixed effects.

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