Causes and Consequences of Indexation: A Review of the Literature

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Automatic price adjustment mechanisms, or indexation, have arisen in a variety of economies with distinct macroeconomic environments and in different moments in time.[1] Examples include the labor market indexation implemented in various European countries in the postwar era, the indexation of financial instruments that served to develop a series of depressed Latin American financial markets in the 1960s and 1970s, and the exchange rate parity indexation recommended in the 1990s as a way of stimulating export-based growth. In the presence of inflation, most economies feature some type of indexation of contracts. These practices sometimes arise spontaneously in the market and sometimes are promoted by the authority itself, either via norms or, more directly, via the choice of exchange rate regime or an issue of indexed public debt.

The indexation of wages and the exchange rate has a considerable macroeconomic impact. It can alter the trend in the inflation rate—including its level, volatility, and persistence—and thereby affect the

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1. A price is considered indexed when there are clauses that specify the existence of a periodic adjustment rule that links the exchange rate of this nominal price to the evolution of some price index. The existence of indexation implies that a price change obeys an explicit or implicit rule, which may be based on time (fixed intervals) or variable states (triggers) or both.

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costs and benefits of stabilization programs. Indexation can also modify the economy's response to nominal and real shocks, which changes the objectives and requirements of the political economy. Financial indexation, in turn, can alter the level of saving in an economy and modify the way in which monetary policy is carried out. Finally, the effects of indexation may be reinforced when combined with indexing mechanisms in different markets.

This paper examines the specific factors that lead different markets in an economy to use contracts featuring indexation clauses. At the same time, we examine the macroeconomic implications of and motives behind indexation in labor, foreign exchange, and financial markets, and we review the literature on indexation to determine the potential macroeconomic effects of each type of indexing mechanism and the advisability of establishing or maintaining some degree of indexation. Finally, the paper also focuses on the impact of indexation mechanisms on inflation.

Studying the causes and consequences of indexation is important for several reasons. First, the need to control inflation, its costs, and the ability of the authority to achieve stabilization vary with the different forms of indexation. Monetary policy, therefore, could be adjusted to reflect the degree of indexation in the economy. Second, it is possible to modify the degree of indexation, but this first requires an evaluation of the costs and benefits that indexation generates. Third, governments need to know whether the authority should guide the market in decisions on indexation or whether the market can achieve optimal solutions on its own. For example, should the authority issue indexed bonds? Should it provide direct incentives for nominalizing the labor market? Finally, the design of an exchange rate regime should be grounded in an investigation of the problem of indexation.

Other papers review and analyze the literature on indexation, but they usually concentrate on one particular market, effect, or country.[2] This paper, in contrast, encompasses several markets, focussing the discussion on theoretical issues and analyzing the effect of indexation on the inflationary process.

2. For example, Van Gompel (1994) and Riveros (1996) review the problem of stabilization and labor market indexation. Campbell and Shiller (1996) focus on aspects of financial indexation, and Jiménez (1993) studies experiences of financial indexation in Latin America. Williamson (1985) and Dornbusch and Simonsen (1983) examine the relation between indexation and inflation in different countries. Simonsen (1995) presents empirical and theoretical aspects of the Brazilian case.

The paper is organized as follows. Section 1 presents the causes of indexation in different markets, as well as the main effects on the functioning of both the market in particular and the economy as a whole. Thus section 1.1 studies labor market indexation; section 1.2 analyzes financial indexation; and section 1.3 examines exchange rate indexation. Section 2 focuses on the relation between indexation and inflation. Section 2.1 studies the effect of labor market and exchange rate indexation on the persistence and volatility of the inflationary process, and section 2.2 reviews the effect of indexation on both the level of inflation and the ability of the authority to undertake an anti-inflationary policy. Finally, section 3 presents the summary and conclusions.

1. The Origin and Effects of Indexation

This section discusses the origin, effects, and characteristics of the different forms of indexation. For convenience, we divide indexation practices into three groups, depending on whether they affect the labor, financial, or foreign exchange markets. Although indexation always seeks to defend some relative price in the face of inflation, indexation practices respond to different specific needs in each market. This section aims to explain why they exist and what contracts with indexation clauses imply in each of the three markets.

1.1 Indexation in the Labor Market

In an economy in which there are negotiation costs, some degree of rigidity in nominal wages is inevitable as a result of contracts that fix the nominal wage for a set period of time. These labor contracts establish that throughout the period in which the contract is in force, the average real wage corresponds to the equilibrium at the moment of negotiation. In the presence of inflation, the real wage will be eroded quickly over the life of the contract, such that the effective real wage will be above the equilibrium value at the beginning of the contract and below the equilibrium toward the end. One way of minimizing this cost-splitting effect is to include indexation clauses in the labor contracts.

Wage indexation is the existence of a wage adjustment rule that ties the growth rate of nominal wages to the movement of an index

representing the price trend. The chosen index is usually one that is publicly available at a low cost, such as the consumer price index (CPI).[3] Such rules serve as a substitute for the frequent renegotiation of wage contracts and as a defense against the erosion of real wages due to inflation. Although a given indexation practice can originate in the law, indexation generally appears spontaneously in environments characterized by moderate and persistent inflation.

When wages are perfectly indexed, it is the real wage that is fixed. The literature on the optimal degree of wage indexation tries to determine the advantages—in terms of output stability—of fixed nominal wages versus fixed real wages. Because real wages should not be affected by nominal shocks, the greater the relative importance of nominal shocks in an economy, the greater is the optimal degree of indexation. This section examines this intuition, qualifying it on the basis of the characteristics of the economy under analysis and the specified labor contract.

Wage Indexation from a Microeconomic Perspective

Wage indexation is a characteristic of wage contracts established at the microeconomic level. This section analyzes the origin of wage indexation from the point of view of implied contracts theory. Two factors induce the generalization of indexation practices in the creation of wage contracts: the simultaneous existence of inflation and wage negotiation costs and a greater risk aversion among the workers than among the employers. Indexation also generates potential distributive effects.

Wage Negotiation Costs versus Maladjustment Costs. Wage indexation arises as a contractual arrangement between the worker and the firm as a way of avoiding having to renegotiate and recalculate wages in the face of periodic variations in the inflation rate. In this sense, indexation is a substitute for renegotiation, and the relative price between the two is given by the level and variance of inflation, the costs of renegotiation, and the costs of having a maladjusted real wage.

3. Riveros (1996) discusses the advisability of using this and other indicators. The paper concludes that all indexes are imperfect because they either don't reflect the producer's price or they don't reflect cost-of-living increases (for example, the wholesale price index, or WPI). Behind this lies the fact that no price index exactly reflects the inflation that heterogeneous actors face in the presence of changes in relative prices.

The existence of wage renegotiation costs makes lengthening the duration of contracts desirable. Indexation keeps the agreed real wage relatively constant, which makes it possible to extend the period between negotiations, for a certain intensity and variability of real shocks. Of course, the greater the relative importance of real shocks on the sector and the greater the cost of having a maladjusted real wage, the shorter will be the desired length of the contract. On the other hand, high, volatile inflation will induce generalized wage indexation due to the rapid erosion of real wages between negotiations.[4]

Distribution of Risk. The second microeconomic justification for wage indexation is related to the problem of the distribution of risk. If firms are better able than workers to reduce diversifiable risk, then optimal contracts will set stable real wages in exchange for a reduction in their level taken as a risk premium. In the case of nondiversifiable risk, such as inflation, achieving the same effect requires a greater degree of risk aversion on the part of workers relative to their employers.[5]

Indexation clauses reflect the existence of an implicit insurance against unexpected variation in the inflation rate, which is justified because the financial market is incomplete with regard to this type of risk. Workers will pay a premium in terms of a lower wage than what might be offered on a spot job market, in exchange for which they receive a fixed real wage by virtue of their risk aversion. The employer, in turn, gains by paying a lower wage as a result of the firm's relative neutrality in the face of risk. Wage indexation as stipulated in such contracts would be perfect if all actors had the same expectations regarding inflation and if precise, day-to-day information on the movement of the general price level were available.[6] In the absence of these conditions, indexation must be based on lagged inflation, with the distance between adjustments inversely related to the variability of inflation.

4. Gray (1978) and Aizenman (1984) show how shortening the duration of a contract reduces welfare losses caused by the deviation of the contract wage from the spot market wage. This phenomenon will be produced to the extent that the frequency of shocks is high. An optimal degree of indexation is thus associated with an optimal contract length.

5. Rationality of wage contracts as a means of securing workers is discussed and formalized in Baily (1974); Azariadis (1975); Shavell (1976).

6. Shavell (1976) analyzes the problem of implied insurance assuming the existence of perfect indexation. Simonsen (1983) considers implied insurance in the case of imperfect indexation.

Finally, the existence of these microeconomic justifications for wage indexation has important political implications. If the authority is not able to affect the inflationary process, or if changes are produced in the fundamental variables that determine the components of an optimal labor contract, then it will be very difficult to induce private actors to alter their indexation practices.[7]

Distributive Effects. Indexation probably modifies the redistributive effects of inflation significantly, although its effects are little explored in the literature. One possibility is that indexation worsens the distribution of income because only some actors—usually the richest—manage to secure protection against inflation, while the rest suffer a fall in real wages in the event of inflation. Riveros (1996) reviews precisely this case, using segmented labor market models. In that scenario, indexation only operates in the formal market, where the most skilled workers are located. Consequently, with indexation protecting real wages against inflation shocks, the distribution of income worsens. If the adjustment process requires a fall in real wages in the formal sector, indexation will impede the adjustment and cause unemployed workers in this sector to be displaced to the informal sector, further worsening the situation for workers in that sector.

The variability of real wages can also be considered an income distribution problem. In those terms, perfect indexation would be a good distributive mechanism, because it maintains a constant real wage. There is evidence, however, that the real wage is highly variable when indexation is used.[8] The reason for this is that indexation is imperfect because it is calculated with a lag, because of the dual markets mentioned above, and, most important, because it does not eliminate periodic renegotiations of real wages between workers and firms. The Chilean case is demonstrative in this sense: the typical contract lasts two years and is adjustable every six months. The real wage can be quite flexible during negotiations (Jadresic, 1995).

Finally, the existence of indexation changes the negotiating position of workers *vis-à-vis* firms. Whenever labor market participants must negotiate forms of quasi-income (for example, stemming from investments or specific training and from employee search costs), the distribution of these rents depends on the negotiating power of

7. Landerretche and Valdés (1997) analyze nine episodes of wage nominalization. In all nine cases, nominalization stemmed from the need to control inflationary inertia or from the degree of unemployment in the labor market.

8. Riveros (1996) cites works that present this evidence.

the different parties and on their external options.[9] Indexation most probably changes these parameters, thereby affecting the distribution of this type of income.

Optimal Degree of Wage Indexation in a Macroeconomic Context

From a macroeconomic perspective, wage indexation presents three main questions. What effect does wage indexation have on inflation? What effect does it have on output variability, and what rules can be recommended for determining the optimal degree of indexation? Section 2, below, analyzes the first question in detail, while this subsection reviews the literature on the remaining two issues.

An extreme position on the optimal degree of wage indexation holds that the adoption of generalized indexation in wage and financial contracts is desirable in order to reduce the collateral effects of a program for lowering the inflation rate (Friedman, 1974).[10] The application of indexation mechanisms is justified because it reduces both the political and economic costs associated with stabilization programs and the authority's incentives for maintaining a positive inflation rate. This analysis, in effect, implicitly equates a stabilization program with a nominal shock to the economy. It does not consider real shocks, which are a key component of the analysis presented in the previous subsection.

Nominal versus Real Shocks. The point of departure for a formal macroeconomic analysis of wage indexation is Gray (1976).[11] That paper's most important contribution is to show that the optimal degree of wage indexation in an economy depends on the relative importance of nominal shocks versus real shocks. In particular, the greater the variance of nominal shocks relative to real shocks, the higher is the optimal level of wage indexation.

Gray (1976) uses a traditional neoclassical model that incorporates wage rigidity in the short term and uncertainty. He assumes

9. Pissarides (1988) analyzes this issue from the perspective of a labor market search model.

10. Van Gompel (1994) reviews the literature on wage indexation and the problem of stability.

11. Gray's paper, like the literature it generated, studies the optimal degree of contingent wage indexation, that is, when wages are adjusted instantly from one period to the next.

that when the labor market is out of equilibrium, effective employment is determined all across the demand for work. The economy is subject to nominal and real shocks, and the objective function is to minimize output variance. Nominal shocks do not affect the labor demand and supply functions, such that perfect indexation (at 100 percent of past inflation) insulates the real economic activity level from nominal shocks by maintaining a constant real wage. In contrast, real shocks shift the demand for work and thus require adjustments in the real wage to stabilize the level of employment and economic activity. Indexation thus exacerbates the effect of a real shock on economic activity by maintaining a constant real wage.

This analysis shows that maintaining 100 percent indexation to the price level is not optimal in the presence of real shocks. Assuming that minimizing output variability is a prerequisite for social welfare, the optimal indexation level is less than 100 percent, with the exact level depending on the relative variances of the stochastic nominal and real components.[12] An interesting implication of this result is that given these conditions, optimal indexation does not insulate the real sector of the economy from monetary variability. Fischer (1977b) arrives at this same conclusion using a similar model.

This simple idea can be analyzed further by altering the base model. For example, if wages are allowed to be indexed to some indicator of real economic activity, it can be demonstrated that optimal indexation consists of 100 percent indexation based on past inflation and partial indexation based on the real activity level. These contracts reproduce the equilibrium that would be obtained if wages were determined ex post after the realization of shocks, and they thus effectively insulate the real sector from monetary shocks (Karni, 1983).

A supposed key to this general result of Gray's and Fischer's is that the demand for labor as a whole determines the employment level. When employment is determined by the demand for labor, indexation serves to insulate output and employment from monetary fluctuation and real demand shocks, but it increases output variability in the case of real supply shocks. In contrast, if employment is determined by trends in the labor supply, indexation can contribute to reducing fluctuations in employment in the case of real shocks

12. Gray (1978) shows that when the length of the contract is allowed to vary, optimal contract length will be longer for a lower degree of uncertainty in the economy.

(Cukierman, 1980).[13] The intuition for this result is as follows: perfect, contingent indexation maintains a constant real wage; when the economy is subjected to a real supply shock, employment and the economic activity level are not affected because the real wage remains constant.

The literature provides two additional extensions of optimal indexation. When the economy has more than one sector and when these feature different levels of productivity, the optimal indexation rule will take into account not only aggregate variables such as the price level, but also variables that are specific to the sector. In this way, each sector can partially insulate itself from aggregate nominal and real shocks, as well as from sectoral shocks. Duca and VanHoose (1991) apply the optimal indexation rule set out by Karni (1983) to an economy with two sectors, only one of which is indexed. They show that in this case, the optimal indexation rule corresponds to partial indexation based on the price level, together with an indicator of sectoral benefits. Finally, the optimal degree of indexation will be the same for workers at different levels of productivity if all can include indexation clauses in their contracts.

Kovanen (1992) analyzes the optimal degree of indexation when the work force features heterogeneity in the form of productivity differentials. Without contributing further intuition, the paper concludes that if indexation does not occur at the same time for all workers, both positive and negative externalities can be produced from the group that is indexed to the group that is not. In particular, the optimal degree of indexation will vary for the different groups of workers. Less skilled workers will prefer that more skilled workers not be indexed if they themselves do not have this option, whereas more skilled workers will always prefer an indexed economy.

Open Economy. An extension in the optimal indexation literature that deserves special attention is that of the open economy. A new element is introduced into the analysis, namely, the dependence of the optimal wage indexation level on the prevailing exchange rate regime. This dependence can be easily appreciated using a simple model for a small, open economy composed of just one sector. Under a fixed exchange rate, the economy's price level depends entirely on

13. Cukierman (1980) also shows that the results found by Gray (1976) and Fischer (1977b) are not affected by relaxing the assumption that the demand for money is inelastic with regard to the interest rate.

external shocks, such that its variations will typically be orthogonal to productivity shocks. Consequently, a 100 percent wage indexation will be desirable in order to insulate the real wage from all fluctuations in the price level. Under a flexible exchange rate, productivity shocks will affect the exchange rate and, therefore, the price level. Given the existence of a degree of covariance between price and output, establishing a system of partial wage indexation is advantageous for minimizing the variance of output. Output will not be completely insulated from external shocks under a flexible exchange rate combined with an optimal indexation level, but this arrangement is more effective than the alternative of a fixed exchange rate and perfect indexation in terms of minimizing output fluctuations (Flood and Marion, 1982). Better results can be obtained in an open economy through the combined use of partial wage indexation and exchange rate practices.

Aizenman and Frenkel (1985) present a stochastic model in which they seek to minimize the variance of employment. They obtain optimal levels of wage and exchange rate indexation through joint optimization. In this model, the optimal indexation rules completely eliminate any losses of welfare, and in some cases one of the two types of indexation is redundant (namely, when they are based on the same information and have the same objectives). Devereux (1988) studies a similar problem, but in this case the flexibility of the political instruments for reacting to shocks is restricted. The instruments are therefore incapable of eliminating welfare losses due to shocks. The paper obtains an optimal solution for exchange rate indexation that is independent of productivity shocks and a wage indexation that responds to the intuition of Gray and Fischer (and that is independent of external shocks). Turnovsky (1983) also examines the problem of joint optimization.

Another interesting aspect of this discussion is the relation between the optimal wage indexation level and the economy's degree of openness. Consider an economy with two sectors, tradables and nontradables, in which the relative price between tradables and nontradables is exogenously determined. In this context, a relatively larger tradables sector implies a greater optimal wage indexation level and thus a greater magnification of productivity shocks. Aizenman (1985) shows how a greater proportion of tradable goods implies a greater exposure to international prices, which reduces the economic relevance of the endogenous determination of the relative price of tradable and nontradable goods.

Lags in Indexation. Most of the literature on the optimal wage indexation level assumes that the automatic adjustments are realized simultaneously with variations in the price level. The consequence of this is obvious: this type of indexation implies fixed real wages. The literature reviewed up to this point is based on an analysis of the effect on output stability of the choice between fixed nominal wages (without indexation clauses) and fixed real wages. However, wages are usually indexed to lagged inflation.

Fischer (1977b) presents a taxonomy of wage contracts in an attempt to analyze this problem. Nonindexed contracts specify the nominal wage for the periods $t + 1$ and $t + 2$, and they aim to keep the expected real wage constant through the use of projections over the existing price level at the start of the contract. Indexed contracts can be of two types. First, contemporaneously indexed contracts can be adjusted to reflect events that occur after the signing of the contract. This type of contract minimizes the variance of the real wages in comparison with predetermined nominal wages. The second type of indexed contract is based on actual inflation between periods. These contracts can stabilize output in the face of nominal shocks if the shocks tend to persist through time. In the presence of transitory nominal shocks or real shocks, however, the second type of contract will tend to destabilize output.

Jadresic (1996b) analyzes the problem of optimal indexation with lagged adjustment and concludes that the Gray-Fischer results are not upheld. In this case, the wage indexation tends to destabilize output independently of the nature of the shocks.

In sum, wage indexation essentially corresponds to an alternative and partial form of nominal rigidity. Furthermore, introducing lagged inflation into the wage equation generates costs in the implementation of an anti-inflationary policy. Various authors analyze such consequences of wage indexation, and their results are discussed in section 2.2.

1.2 Financial Indexation

Financial indexation is a form of contract in which the value of the nominal payments in question is made contingent on some price or price index. As in the case of wage indexation, financial indexation can originate in contracts between private parties or in the denomination of the public debt. Either way, financial indexation allows the creation of a financial instrument that is practically riskless in terms of inflation.

Market Completion and Risk

Indexing financial instruments fills a role in terms of market completion. This is especially important in the case of long-term instruments: if these are nominal, they have no capacity for insulating their proceeds form inflationary surprises.

To evaluate the role of indexed financial instruments in protecting against inflationary risk, one should compare long-term indexed securities with a strategy of rolling over short-term nominal securities. While long-term nominal securities are clearly associated with a high inflationary risk, short-term securities are not, since the nominal rates are "instantly" adjusted. The problem, however, is that a strategy of rolling over short-term securities creates a real rate risk. On the one hand, the nominal value is locked, thereby eliminating inflationary risk, but on the other hand, shifts in the future real interest rate affect the yield on a contract that was initiated in the past (Campbell and Shiller, 1996). Thus the great merit of long-term indexed securities (when short-term nominal securities are also an option) is that they constitute an insurance against changes in the real interest rate. In the case of pensions and other long-term markets such as housing loans, this risk is probably not negligible and is highly valued.

The optimal management of public debt and risk presents incentives not only for indexing the public debt but also for keeping it nominalized. An argument for the latter is that nominal debt provides the government with implicit insurance. Because periods of high government spending (or low receipts) are correlated with periods of high inflation, the government experiences a positive correlation between expenditures and capital gains in the bond market (Bohn, 1988 and 1990; Calvo and Guidotti, 1990). Contrary to this intuition, Barro (1996) recommends fully indexing the public debt to avoid variations in the tax structure (which is assumed to be distorting). Indexed debt prevents nominal shocks from changing the real value of the debt and thus changes the tax sequence consistent with intertemporal restriction and the minimization of costs stemming from tax distortions. The key to this reasoning is the existence of a convex loss function associated with distorting taxes and the possibility of issuing explicitly contingent debt (which implies exhausting the possibilities for implicit insurance).

Additional arguments hold that the government should issue indexed bonds when these are not available in the private market.

Fischer (1983b) shows that this issue can help distribute risk across generations, although the use of direct taxes is equally necessary. The basic function in this case is to allow actors to transfer a supply of resources that does not change in the different states of nature. In simple terms, the bonds would offer a rate that is free from inflation risk, which would not exist under other conditions. Private actors would not choose to issue this type of bond because—in the case of the United States and other developed markets before 1975—the low variability of inflation would not be sufficient to offset the initiation costs (Fischer, 1977a).[14] Obviously, once indexed bonds existed in the private capital market, the government would not need to continue issuing them to generate a riskless rate.

Inflation Expectations and the Real Interest Rate: Coexistence of Nominal and Indexed Bonds

An important benefit of issuing short- and medium-term nominal and adjustable bonds is that the coexistence of both types of instruments allows the authority to infer important information for monetary policy. Essentially, the coexistence of both types of bonds facilitates the estimation of the market's inflation expectations for the different terms and periods, which, in turn, allows an evaluation of the state of the policy.

The existence of private indexed bonds (in addition to nominal public bonds) is not sufficient for the calculation of expected inflation, because they involve risk premiums that are difficult to quantify. The calculation does not require that the bonds have the same maturity, however, as long as the longer-term bonds are actively traded on a secondary market. Of course, the greater the number of maturities available, the richer will be the information that can be extracted.

The formula for calculating inflation expectations is relatively simple once the nominal and adjustable yields on both types of bonds are known. The estimation uses Fischer's equation and expectations theory for yield curves.[15] The first step is to calculate the prices (yields) of

14. Fischer (1977a) examines different theories that explain the lack of indexed bonds in the private sector in developed countries. He rejects explanations based on a tax treatment that supposedly benefits nominal bonds, on a correlation between utilities and the price level that would transform nominal bonds into a form of implicit insurance for firms, and on the problem of a call clause option.

15. See Breedon (1995) for a review of indexed bonds in the United Kingdom (gilt-edged securities).

adjustable and nominal zero-coupon bonds starting with observed market prices; this generates nominal and indexed yield curves.[16] Using the adjustable rate (of zero-coupon bonds) as a proxy for the real rate and following Fischer's equation, we calculate inflation expectations (plus a premium for inflation risk) over different periods:

$$\pi^{e}_{t,t+\tau} + \rho = I_{t,t+\tau} - U_{t,t+\tau},$$

where $\pi^{e}_{t,t+\tau}$ is expected inflation for the period t to $t + \tau$, ρ is the inflation risk premium, and r and i are the implied rates on adjustable and nominal zero-coupon bonds, respectively, that mature in $t + \tau$. The expectations hypothesis holds that the long-term rate is an average of the expected short-term rates. Thus if one supposes a constant inflation risk premium, then the expected inflation rate for the period $t + \tau$ is calculated as follows:

$$\pi^{e}_{t+\tau} = \pi^{e}_{t,t+\tau} - \pi^{e}_{t,t+\tau-1}.$$

The biggest problems with calculating expectations on the basis of indexed bonds are as follows: first, expectations theory is never precisely realized, given the existence of maturity premiums that vary over time; second, if the inflation risk premium varies systematically over time, the expectations estimation can be improved by modeling this change on the premium; and finally, expected changes in future taxes—especially differential changes between real and nominal yields—can ruin the results (Campbell and Shiller, 1996). However, the high periodicity and speed with which one can calculate inflation expectations using this method make it far superior to market surveys.[17]

Debt Drawdown and Inflation

Many countries have implemented actions such as establishing the independence of the central bank in order to address the fiscal

16. On using coupon bonds to calculate the yield curve on zero-coupon bonds, see Campbell, Lo, and MacKinlay (1996, chap. 10). See Herrera and Magendzo (1997) for an application of the expectations calculation for adjustable rates in the case of Chile.

17. Evidence from indexed markets and surveys in developed countries shows that long-term inflation expectations adjusts very slowly to changes in short-term inflation. Inflation expectations thus have a "long-term" memory (Gagnon, 1996).

authority's inability to generate perfect compromise mechanisms. These are not perfect substitutes, however, and credibility may be questioned. It is therefore advantageous to consider other actions that increase the credibility of the authority's anti-inflationary efforts. Such actions include holding the public debt in short-term, indexed, or foreign-denominated bonds, which aims to prevent the authority from "massaging" and drawing down the value of the debt via inflation (Lucas and Stokey, 1983; Calvo, 1988). Indexation, therefore, is a type of compromise mechanism that controls the government's time inconsistency.

Holding the debt in short-term and indexed bonds demonstrates to the public that the authority has nothing to gain from inflating the economy (except for possible Phillips-curve-type earnings), since the interests are immediately adjusted and the real value of the debt does not change. In a game scheme such as that developed in Barro and Gordon (1983), therefore, equilibrium inflation expectations are lower under short-term and indexed debt, as is effective inflation.[18]

Indexed debt is more effective than short-term debt in protecting the credibility of the public authority because even with short-term (not instantaneous) debt, the government stands to gain from inflating the economy.[19] Moreover, managing internal liquidity can be complicated with nominal short-term debt, since large volumes of expirations must be absorbed by the market each time the debt comes due. Indexation is preferable to foreign-denominated debt, as well: the value of the latter covaries with the richness of the country through changes in the real exchange rate, resulting in negative insurance.

Financial Indexation and Saving

One of the main arguments in favor of indexing financial instruments is that it is essential in economies with moderate to high inflation for increasing private saving in terms of both flow (personal and business saving) and stock through the development of the capital market (market size and term length). The idea is that protecting yields against inflationary shocks will generate important incentives for increasing saving and establishing long-term contracts. This argument must be qualified along several dimensions.

18. Section 2.2 discusses indexation and the inflation level in more detail.

19. A fitting question is whether the authority would have a greater motivation for liquidating the debt (which is equivalent to defaulting on some percentage) than for simply partially defaulting. One potential explanation lies in the authority's political ability to convince the public that some type of exogenous inflationary shock occurred and that they did not want to default.

First, increases in financial saving are not necessarily accompanied by increases in effective national saving.[20] Private family saving appears to depend more on the economic cycle than on the rate of return (which could be modified with indexation). Empirical evidence on the relation between saving and interest rates (for example, Deaton, 1992, 59-75) indicates that saving is not very sensitive to the real level of "normal" interest rates. There is some evidence, however, that negative rates do strongly influence saving levels (Dornbusch and Reynoso, 1989), indicating that indexation might be advantageous in economies that are susceptible to spikes in the inflation rate.

This does not necessarily invalidate the argument that indexation is desirable, since increased financial saving can provide a more efficient way of channeling resources toward productive investment. The development of the financial system gradually improves the quality of the projects that are carried out, for at least two reasons: first, intermediation allows the harmonization of project maturities with what the public is willing to accept (Diamond and Dybvig, 1983), and second, intermediaries act as monitors in the investment process (Diamond, 1984). International evidence indicates that financial development is associated with higher investment and growth rates (King and Levine, 1993).

In many developing economies, high inflation rates have coexisted with the regulatory restriction of capital markets. Financial liberalization might be better than indexation for increasing financial saving under such circumstances. Once the capital markets have been liberalized, indexation will probably have only a marginal effect on financial saving. Financial indexation modifies the variance (and other superior moments) of the distribution of the yields on the different instruments. It is not correct to associate it with a change in the level (net of risk premiums) of the expected rates of return when it occurs in a liberalized system in which the nominal rates are adjusted to inflation (through the Fischer effect). Of course, this change of variance can affect the yield through changes in the risk premiums.

A valid argument in terms of the effect of financial indexation on yield levels is based on risk premiums (especially inflation) and liquidity (which is generated by changes in the level of the financial system's development). Nominal securities should demonstrate a positive yield

20. Evidence from Chile shows that what really increases together with the proliferation of indexed saving is financial saving, not total private saving or national saving (Morandé, 1993). Other Latin American countries have had similar experiences (Jiménez, 1993).

differential as a result of the greater inflationary risk that they carry and the insufficient development of the market. One argument against indexing long-term securities in the United States was the eventual balkanization of the market (Campbell and Shiller, 1996). Issuing instruments of similar terms and different denominations could thus imply a loss of liquidity: when actors can operate in two different markets, it requires more work in information gathering. Even when these arguments are valid in terms of yields (and are thus important in terms of welfare and resource allocation), their effect on saving is probably low, especially considering that real interest rates today are usually positive.

Finally, there is a potential relation between financial indexation and (quasi-) fiscal saving. Within the debate on the launching of long-term indexed bonds in the United States, for example, it was argued that indexation would be beneficial in creating saving for the treasury, since it would eliminate inflationary risk premiums on government debt.[21] Assuming that such premiums exists, one could argue that the saved resources are only transfers between the government and the private sector, such that they do not represent real saving. If the government generates saving, it only reduces future taxes. Indexation or nominalization, therefore, should not be evaluated on the basis of the fiscal saving it generates (Campbell and Shiller, 1996). In terms of public finances, both the operation and the composition of the open market are irrelevant (Stiglitz, 1983; Wallace, 1981).

Three factors undermine this argument. First, given that the taxes that are avoided are distorting, the policy does, in fact, constitute effective saving (though probably to a lower magnitude than initially estimated). Second, if foreigners hold a portion of debt, the saving on interest involves more than simple transfers. Third, the lack of Ricardian equivalence means that the transfers are not fully compensated by the actions of the public and thus does increase total saving.

1.3 Exchange Rate Indexation

The prevailing exchange rate regime in an economy can have important consequences for inflation. A fixed exchange rate has frequently been used as a way of introducing a nominal anchor into the economy in the context of an inflation stabilization program. In contrast,

21. This same argument could be used in Chile in that the nominalization of instruments could mean overspending for the treasury.

exchange rate rules that incorporate indexation clauses based on lagged inflation tend to perpetuate the effect of transitory price shocks on inflation. This section briefly discusses the different arguments for and against the different exchange rate regimes and their possible impact on inflation. The latter issue is discussed in more detail in the following section.

Purchasing Power Parity (PPP)

The law of one price in international trade implies that a dollar (or any other currency) should be able to buy the same quantity of a good in different countries. This is known as absolute purchasing power parity (PPP). Formally, it implies that if different goods are consumed in two countries in the same proportion, then the price index of both countries will be related through the equation,

$$H = \frac{P}{P^*} \ ,$$

where P is the domestic price index, P^* is the price index of the second country, and e is the nominal exchange rate between the two currencies. Because of international arbitrage, absolute PPP implies that the price of a common basket of goods measured in a common currency will be the same in both countries regardless of the type of shock that affects one of the economies.[22]

Of course, there are many reasons that this relation cannot be realized. Many goods are not traded internationally, while others that are traded are not perfect substitutes. Transport costs, tariffs, quotas, and other barriers to international trade also cause prices to deviate. This points to the lack of price equalization at the international level and, therefore, to a more moderate version of PPP theory. In particular, relative purchasing power parity establishes that under the above circumstances, the relative domestic-foreign price can change, but variations in the exchange rate should compensate for such variations in price. That is,

$$\hat{e} = \hat{P} - \hat{P}^* \ ,$$

where ^ denotes percent change. In other words, PPP theory implies that a freely floating exchange rate will tend to compensate for differences in inflationary trends in the two countries.

22. See Dornbusch (1988) for a detailed study on the implications of PPP.

The available evidence shows that relative PPP holds fairly well for the largest economies in the long term.[23]

The main deviation affecting the exchange rate in the long term has been identified as the Balassa-Samuelson effect. Suppose that each of the two economies produces and consumes tradable and nontradable goods. Now suppose that the productivity of the tradables sector increases in the domestic economy relative to the foreign one. Given the law of one price, increased productivity will imply wage increases both in the sector and in the economy as a whole. Productivity has not increased in the nontradables sector, however, such that the increased wage costs should raise prices in that sector. Prices in the domestic economy thus increase relative to the foreign economy, which tends to generate a real appreciation of the domestic currency.

Although relative purchasing power parity holds fairly well in the long term (correcting for the Balassa-Samuelson effect), evidence indicates that in the short term this relation is much weaker, with deviations from the relative PPP lasting four years, on average.[24] As shown below, this phenomenon is due not only to the institutional arrangements of the nominal exchange rate, but also to short-term price inflexibility.

Choice of Exchange Rate Regime

The above considerations are critical for the choice of an exchange rate regime. Additional factors must also be kept in mind, however. First, it has been suggested that a flexible exchange rate is advantageous because it grants increased autonomy in the determination of monetary and fiscal policy. This is true only to the extent that the authority does not implicitly fix the exchange rate level.

A second factor to be considered is the effect of the exchange rate regime on product stability in the face of different types of shocks. Turnovsky (1976) uses a Mundell-Fleming model to show that a fixed exchange rate is preferable in the presence of monetary shocks as it insulates output from variations in monetary policy, whereas a flexible exchange rate is an advantage in the face of external price shocks. This is due to the fact that under purchasing power parity, movements in the nominal exchange rate tend to compensate for external price shocks. As discussed below, when an economy faces different

23. See Obstfeld (1995) for evidence in this regard.

24. Obstfeld (1995) shows that relative PPP fails dramatically in the short and medium terms.

types of shocks, neither of the two extreme alternatives is optimal, but rather some intermediate alternative of exchange rate intervention will produce the best results.

Third, despite the favorable evidence for relative PPP over the long term, a number of developing countries have opted for a fixed exchange rate during specific periods. The main reason for this practice is that the authority is using the exchange rate as a nominal anchor for the economy in order to bring domestic inflation down to international levels, especially in the context of stabilization programs. Of course, fixing the exchange rate triggers a real appreciation of the currency, given the existence of inflation of nontradables. Part of this appreciation represents equilibrium, due to private earnings associated with economic reforms and the stabilization program itself. A large part of the appreciation, however, stems from indexation to past inflation and credibility problems with the implemented policies. The degree of danger associated with this appreciation process will depend, to a large extent, on the level of the real exchange rate at the moment the nominal exchange rate is fixed.[25]

Fourth, suppose that two countries have similar levels of inflation and output growth and that relative purchasing power parity holds fairly well between them. The choice between a fixed and flexible exchange rate will be irrelevant in this case if prices are flexible in the short term. Evidence shows, however, that the distribution of the real exchange rate in the short term is affected by the prevailing exchange rate regime, which indicates price inflexibility. Consequently, a flexible nominal exchange rate allows one to accommodate relative price shocks without serious consequences in terms' of increased unemployment (in case a real depreciation is required).

Another obvious argument for a flexible exchange rate arises when the countries feature different inflation or output growth rates or both. Experience shows that flexible exchange rate regimes have accommodated differences between countries in these variables for long periods. The problem with flexible exchange rate regimes stems from the great volatility that is generally seen in nominal exchange rates under this regime. Bear in mind that the exchange rate is nothing more than the relative price of two financial claims, and as such, it is subject to fluctuations stemming from changes in expectations and other variables that determine this type of price. It is not a problem

25. For a detailed discussion of this issue, see Dornbusch (1993); Dornbusch, Goldfajn, and Valdés (1995); Edwards (1993, 1996).

if the variability of the exchange rate causes profits or losses for financial investors who deliberately expose themselves to exchange rate risk. In some cases, however, excessive exchange rate volatility can negatively affect the level of international trade or of foreign direct investment received by a country.

There is no reason to assume that the volatility demonstrated by the exchange rate might be due to irrational behavior on the part of the actors involved. Dornbusch's theory of overshooting (Dornbusch, 1976), for example, predicts the rapid and strong adjustment of the nominal exchange rate in the face of changes in monetary conditions. This known effect is simply due to the existence of short-term price rigidity and arbitrage on international assets, which gives rise to uncovered interest rate parity.

There are several alternatives to the extreme cases of fixed and flexible exchange rate regimes. One intermediate exchange rate regime that aims to reduce exchange rate volatility is the dirty float. Under this arrangement, the authority allows the nominal exchange rate to adjust freely in response to relative price shocks, but is disposed to intervene actively whenever it estimates that the nominal exchange rate is deviating from what is considered to be the equilibrium level.

Another much-used alternative in developing countries—and one that is directly related to the topic of indexation—is the crawling peg. This exchange rate regime corresponds to a preannounced exchange rate (similar to a fixed rate) that varies according to the difference between domestic and external inflation. This regime seeks to achieve the stability generated by a fixed exchange rate while avoiding significant appreciation of the real exchange rate. The idea behind this type of exchange rate regime is that relative purchasing power parity holds in the medium term. Deviations stemming from the Balassa-Samuelson effect can be accommodated in the indexation rule. In general, the exchange rate adjustment rule is constructed using domestic inflation in the preceding month, which is why this regime is considered an indexation practice. There are convincing arguments that this administered exchange rate introduces a significant degree of inflationary inertia into the economy. Edwards (1993) discusses this trade-off between exchange rate appreciation and disinflation on the basis of a simple model that is analyzed in the next section.

To allow short-term deviations in purchasing power parity and gain flexibility in managing the exchange rate, the authority can allow the nominal rate to fluctuate freely within a band around the announced exchange rate. If the band is credible, this exchange rate

regime tends to soften fluctuations of the exchange rate within the band. The reason for this is that given the authority's performance, when the exchange rate approaches the floor (or ceiling) of the band, expectations for devaluation (or appreciation) increase, which tends to keep the exchange rate within the band (Krugman, 1991). If, on the other hand, the authority's credibility is low and the probability of realignment is estimated to be high, then the extremes of the band will act as magnets, thereby increasing the volatility of the exchange rate (Bertola and Caballero, 1992).

Wage Indexation and the Choice of Exchange Rate Regime

Two aspects of the relation between the degree of wage indexation and the exchange rate regime are particularly interesting. First, the degree of wage indexation affects the optimal choice of the exchange rate regime. Under full, perfect wage indexation, monetary shocks cannot affect the real wage, which makes the choice of exchange rate regime irrelevant with regard to the stability of output. Marston (1992) shows that, in general, the greater the degree of wage indexation, the lower is the difference among exchange rate regimes in the performance of the economic activity level in the face of different shocks.

Second, while this may be valid with regard to output stability, it is not with regard to prices. When wage indexation is not perfect, but rather depends in part on past inflation, a greater degree of exchange rate indexation, in combination with wage indexation, will increase inflationary inertia and variance. These issues are discussed in detail in the next section.

The choice of exchange rate regime and the optimal degree of wage indexation should thus be resolved in a joint optimization program in which the functional objective takes into account the stabilization of the economic activity level as well as the price level. Aizenman and Frenkel (1985) show that when purchasing power parity holds, a greater degree of exchange rate flexibility will generally be required given a greater optimal degree of wage indexation.

2. Indexation and Inflation

This section reviews the interaction between indexation and inflation. The different forms of indexation affect inflation in a variety of ways. Inflationary persistence and variability can increase if

several or all of the sectors of the economy are indexed. If monetary policy is linked to endogenous factors in order to ameliorate inflation shocks, then specific real or nominal shocks—however small—that start in a particular market can be propagated and magnified by the indexation clauses. The existing degree of indexation can also affect the long-term inflation level. On the one hand, indexation reduces the costs of inflation, while on the other, it limits the real effects of an inflationary shock, since it is less tempting for the government to generate unexpected inflation. At the same time, the optimal degree of indexation hinges on the level and predictability of inflation. This could generate multiple equilibriums depending on the level and variability of inflation and the degree of indexation. There are also potential interactions between optimal private inflation (such as in wage indexation) and the degree of indexation chosen by the government (such as its debt denomination).

2.1 Indexation, the Exchange Rate Regime, and the Dynamics of Inflation

The main motivation for studying the macroeconomic effects of indexation is the presumption that a greater degree of indexation in the different markets generates a greater degree of inflationary inertia.[26] This section analyzes this proposition, which is generally sustained by economic authorities, as well as the effect of indexation on the variability of inflation. The next section discusses the characteristics of indexation that increase the costs of implementing stabilization programs.

The first step in determining how a random price shock is transmitted to the inflationary process is identifying the degree of homogeneity in the equation governing the price level as a function of lagged prices. If the equation has a unit root, then shocks will have a permanent effect on inflation.

A simple analytical framework from which to start is the decomposition of the inflation in period t into the variations of the price of tradable and nontradable goods:

$$\hat{P}_t = \alpha \hat{P}_{T,t} + (1-\alpha)\hat{P}_{N,t} \ ,$$

26. With the exception of financial indexation, which probably does not influence inflationary persistence.

where T denotes tradables, N nontradables, and α the participation of tradables in the consumer price index. If we assume that monetary policy is elastic, that the law of one price applies for tradables at all times, and that the prices of nontradables are partially indexed to a lagged indicator (for example, because wages are perfectly indexed to past inflation), we obtain

$$\hat{P}_{N,t} = \theta \hat{P}_{t-1} + \mu_t \text{ and}$$

$$\hat{P}_{T,t} = \hat{e}_t + \hat{P}_t^* + \nu_t ,$$

where θ is the degree of indexation of the prices of nontradable goods, $\hat{e}$ is the percentage effective devaluation, * indicates the external nature of a variable, and μ_t and ν_t are price shocks to nontradables and tradables, respectively, with mean zero and variance σ. Additionally, if the exchange rate is administered by the authority and indexed to the differential between domestic and external inflation, we obtain

$$\hat{e}_t = \hat{P}_{t-1} - \hat{P}_{t-1}^* .$$

Replacing the tradables and nontradables price equations in the economy's general price equation produces the equation that governs inflation:

$$\hat{P}_t = (\alpha + \theta - \alpha\theta)\hat{P}_{t-1} + \alpha\left(\hat{P}_t^* - \hat{P}_{t-1}^*\right) + \alpha\nu_t + (1-\alpha)\mu_t .$$

To the extent that there is perfect indexation in nontradables prices (that is, $\theta = 1$) and in the exchange rate relative to the differential of domestic and external inflation rates, the economy's price equation will have a unit root. An inflation shock in the economy will therefore have a permanent effect. The variance of the inflation rate, in turn, will be given by the expression

$$\sigma_{\hat{p}}^2 = \frac{2\alpha^2\sigma^{*2} + \alpha^2\sigma_\nu^2 + (1-\alpha)^2\sigma_\mu^2}{1-(\alpha+\theta-\alpha\theta)^2} ,$$

where σ^{*2} is the variance of external prices. It follows that if the indexation of nontradables is perfect, the volatility of inflation is infinite. Moreover, a greater degree of indexation generates greater inflationary variability:

$$\frac{d\sigma_{\hat{p}}^2}{d\theta} > 0 .$$

In sum, indexation increases both the variance and persistence of inflation. This is due to the fact that in the presence of well-behaved, random shocks, lags in the formation of the inflation rate will cause increases in the rate to be added into the total several times.[27]

The preceding model can be expanded on the basis of Edwards (1993). The law of one price is here assumed to apply ex ante in the tradables market, which means that these prices are adjusted according to expectations for external inflation and devaluation:

$$\hat{P}_{T,t} = (\ _{t-1}\left[\phi\left(\hat{P}_{t-1} - \hat{P}^*_{t-1}\right) + \hat{P}^*_t\right],$$

where ϕ is the degree to which the exchange rate is indexed to the differential between domestic and external inflation and E_{t-1} indicates expectations in the period $t-1$. Full indexation to this differential is precisely the PPP rule discussed above.

Edwards also derives a nontradables price equation based on the market equilibrium for these goods. It is assumed that the demand for nontradables depends on the real exchange rate and that supply is a function of the real wage (measured in nontradables units). The market equilibrium for nontradables is represented as follows:

$$\eta\left(\hat{P}_{N,t} - \hat{P}_{T,t}\right) + \delta\left(\hat{z}_t\right) = \varepsilon\left(\hat{W}_t - \hat{P}_{N,t}\right),$$

where W_t denotes wage, η is the elasticity of demand for nontradables relative to the real exchange rate, ε is the elasticity of supply for nontradables relative to the real wage in nontradables units, and z_t is an indicator of monetary policy. It is further assumed that the nominal wage is determined jointly by the degree of indexation and changes in inflation expectations. From this we obtain

$$\hat{W}_t = \gamma\hat{P}_{t-1} + (1-\gamma)(\ _{t-1}\hat{P}_t,$$

where γ is the degree of wage indexation relative to lagged inflation and $1-\gamma$ is the degree of wage indexation relative to inflation

27. Fischer (1983a) shows that the degree of wage indexation increases the variance of the price level. The paper discusses the price level, however, and not the variability of inflation (although that is not significant in a logarithmic context without implicit functions) and creates a static model, which is a consequence of indexing wages to contingent, nonlagged prices.

expectations one period ahead. Combining the equations generates the equation that governs the inflation level:

$$\hat{P}_t = D_1 \hat{P}_{t-1} + D_2 \hat{P}^*_{t-1} + D_3 \hat{z}_t + \psi_t \ ,$$

where ψ_t is a composition of the different shocks to the system and where

$$a_1 = \frac{(\eta + \alpha\varepsilon)\phi + \varepsilon(1-\alpha)\gamma}{(\eta + \alpha\varepsilon) + \varepsilon(1-\alpha)\gamma} \ ,$$

$$a_2 = \frac{(\eta + \alpha\varepsilon)(1-\phi)}{(\eta + \alpha\varepsilon) + \varepsilon(1-\alpha)\gamma} \ , \text{ and}$$

$$a_3 = \frac{-\delta(1-\phi)}{(\eta + \alpha\varepsilon) + \varepsilon(1-\alpha)\gamma} \ .$$

This equation provides the basis for studying the effect of the different forms of indexation on inflationary volatility and persistence, which is summarized in table 1. The table clearly highlights the fact that full, lagged indexation of the exchange rate causes the price equation to have a unit root and, therefore, an explosive variance, independently of the prevailing type of wage adjustment mechanism (cases A and B). In the absence of wage indexation and given a fixed exchange rate (case C), the inflation trend will be determined by the evolution of external inflation and the performance of the economic policy. In this case, the variance of inflation will be finite. Finally, when a fixed exchange rate is combined with full wage indexation to lagged inflation (case D), both domestic and external prices will influence the price trend and thus the variance of inflation.

The price equations analyzed up to this point have considered only a one-period lag. However, while wage negotiations occur continuously in the economy, indexation clauses generally have a duration of six months or a year. This means that the inflation equations can have more than one lag from a monthly perspective. One way to analyze this is to use Bruno's average lag principle (Bruno, 1993 and 1994). Starting with an equation of the type

$$\hat{P}_t = \theta \hat{P}_{t-1} + (1-\theta)\hat{P}_{t-2} + \omega_t \ ,$$

where ω_t is a random shock, the change in inflation can be written as follows:

$$\Delta\hat{P}_t = -(1-\theta)\Delta\hat{P}_{t-1} + \omega_t \ .$$

After a particular realization of the shock denoted by ω, this constitutes a convergent series whose steady state is

$$\Delta\hat{P}_{ss} = \frac{\omega}{2-\theta} \ ,$$

where $\Delta\hat{P}_{ss}$ is steady-state inflation.

Consequently, the greater the concentration of the unit root in recent lags, the greater will be the inflationary response to shocks. This phenomenon can have a considerable impact if it is considered a function of the reaction of actors, who define the average lag as a function of either their inflation expectations or the inflationary trend of the past few months. In that case, the average lag could increase in the face of an acceleration of inflation, which would raise the level of steady-state inflation that would otherwise obtain as a consequence of the shock.

Table 1. Indexation: Inflationary Persistence and Volatility

Case identification	*Exchange rate regime and wage indexation* (θ, γ)[a]	*Inflationary persistence* a_1	*Impact of external inflation* a_2	*Inflationary variability* $\sigma^2_{\hat{p}}$
A	PPP without indexation $(\theta=1, \gamma=0)$	$a_1 = 1$	$a_2 = 0$	Infinite
B	PPP with indexation $(\theta=1, \gamma=1)$	$a_1 = 1$	$a_2 = 0$	Infinite
C	Fixed exchange rate without indexation $(\theta=0, \gamma=0)$	$a_1 = 0$	$a_2 = 1$	Finite
D	Fixed exchange rate with indexation $(\theta=0, \gamma=1)$	$0 < a_1 < 1$	$0 < a_2 < 1$	Finite

Source: Authors' calculations.
a. PPP is purchasing power parity.

There is relatively little evidence on the relation between indexation and inflationary volatility or persistence. The reason for this is that it is difficult to find good instruments for addressing the problem of dual causality between indexation and inflation. Fischer (1983a) tries to solve the problem of dual causality by introducing the 1974 oil shock as a natural experiment. However, the analysis centers on the inflation level, finding that countries with indexation are not substantively better off than others after the oil shock. Landerretche and Valdés (1997), who study nine countries without controlling for causality, find that the indexation periods do not match the periods of inflationary acceleration. They find, rather, that periods of wage indexation feature a higher level of inflation and greater inflationary volatility and persistence. Similarly, they find that the level, variability, and persistence of inflation is greater under PPP regimes than under fixed exchange rate regimes and that the PPP regimes have a higher inflationary level and persistence, although a lower variability, than flexible exchange rate regimes.

Edwards (1993) analyzes the experiments with fixing the exchange rate regime that were carried out in Chile (1979-82), Mexico (1988-89), and Yugoslavia (1990-91). The paper finds that in the Chilean case—unlike the Mexican or Yugoslavian cases—fixing the exchange rate did not modify inflationary persistence. (This is attributed to Chile's inability to nominalize the labor market.) Finally, McNelis (1987) decomposes the persistence coefficient into the effects of exchange rate and wage indexation for Latin America in the 1970s and 1980s. McNelis's findings are consistent with Edwards (1993): in Brazil and Chile, inflationary persistence is dominated by wages; in Argentina, Ecuador, and Peru, inflationary persistence is dominated by the exchange rate; and in Uruguay, the fall in persistence is associated with the general liberalization of the economy.

2.2 Indexation, the Inflation Level, and Monetary Policy

Disinflation Costs and Inflationary Persistence

An area of particular interest in the study of indexation and its effects on the economy has to do with the effect of indexation on the costs incurred during the process of inflationary stabilization and its consequences for inflationary persistence. A stabilization

program that aims to rapidly reduce the inflation rate can be considered a nominal shock. Therefore, the best way to minimize disinflation costs in terms of output is to have 100 percent perfect indexation. This idea is what motivates Friedman (1974) to advocate the proliferation of indexed contracts throughout the economy when the authority seeks to disinflate: the nominal magnitudes would be modified at the same time without any impact on real magnitudes. Riveros (1996) qualifies that conclusion, taking into account the fact that real wages may lie outside the full-employment equilibrium at the time the disinflation effort is initiated (for example, due to a trade shock). If that is the case, the adjustment policy, in combination with indexation, may have extremely high costs in terms of unemployment, because real wages could not be adjusted. The intuition behind this qualification is the same as in the Gray-Fischer models, in that it considers the relative importance of nominal and real shocks. Friedman's rule does not consider real shocks, whereas Riveros's qualification shows the exact consequence of a real shock.

In addition, as discussed above in subsection 1.1, wage contracts, in practice, do not stipulate perfect indexation. Most contracts contemplate adjustments that are a function of lagged inflation, which causes the real wage to be affected by nominal shocks. Disinflation costs in this case are greater in the presence of rigid nominal wages. Indexation based on lagged inflation provides retrospective feedback for nominal wages, which pushes real wages upward (or causes them to be more persistent) and deepens the recessive effect of disinflation. Disinflation costs are then determined by the degree of indexation in the contracts and the sensitivity of wages to the unemployment level (Simonsen, 1983; Bonomo and García, 1994).

Disinflation can also have costs in the presence of rigid nominal wages, since these also introduce a degree of inertia. This results from the fact that all contracts established before the initiation of the stabilization program stipulate nominal salaries that implicitly consider expected inflation over the life of the contract.[28]

An interesting case for comparison is that of contracts that fix wages through adjustments based on expected inflation at the

28. Jadresic (1995) analyzes the effects of the duration of nominal and indexed contracts on disinflation costs. Calvo (1983) and Ball (1994a) examine the costs of stabilization in the presence of rigid nominal salaries. They conclude that it is possible to have zero disinflation costs even in the presence of nominal rigidities. The costs reflect, rather, a lack of credibility. Ball (1994b) provides empirical evidence on the determinants of the sacrifice ratio (the cost in terms of growth for every one percent reduction in inflation), using a panel of developed countries.

moment of signing the contract. Such contracts can have a significant effect on stabilization programs. When the amount of the inflation adjustments is specified at the beginning of the contract, the effective duration of the indexation clause is greater than in the case of traditional contracts using lagged inflation. The inflationary inertia introduced into the system is therefore greater, and the costs of disinflation rise (Jadresic, 1996a). Indexed contracts based on expected inflation at the moment of each adjustment are more flexible, since they allow the wage determination to incorporate the lower inflation expectations generated by the stabilization program.

Wage indexation is not the only factor influencing disinflation costs. Another important element is inflationary inertia originating from the prevailing exchange rate regime. As seen in the previous subsection, administered exchange rate systems in which the exchange rate is frequently devalued as a function of the difference between the domestic and external inflation rates introduce inflationary inertia. A number of stabilization programs have tried to get around this effect by using the exchange rate as a nominal anchor. Most of the economies that have subscribed to this type of stabilization program are characterized by widespread indexation practices and an elastic monetary policy. Under such circumstances, it is normal for an important degree of inflationary inertia to persist even after the nominal exchange rate is fixed. The resulting exchange rate appreciation can lead to a loss of the plan's credibility as the relevant actors lose faith in the success of the program. There is no obvious recipe or simple solution in these cases. The lack of credibility may imply that inflationary inertia persists unaltered for a long time after the stabilization program is launched.[29] In contrast, if the stabilization plan is based on monetary control while the exchange rate regime follows a PPP rule, then a stabilization program will encounter rigidities to the extent that past inflation is transmitted to the exchange rate and, in turn, to the prices of imported inputs.[30]

29. Rebelo and Végh (1995) analyze different theories to explain the real appreciation following a stabilization plan based on the exchange rate. The appreciation can reflect a lack of credibility in the program and not a problem of inflationary inertia. Dornbusch (1982b) and Edwards (1993, 1996) discuss the problems of inertia for stabilization programs in the context of adjustment programs in Latin America.

30. For a detailed discussion of this mechanism, see Dornbusch (1982a).

Disinflation Costs, Time Consistency, and Monetary Policy

It is well known that an economy's inflation level cannot depend directly on its degree of indexation. Monetary policy, especially the growth rate of aggregates, must be consistent with the inflation rate. Consequently, an analysis of the interaction between indexation and the inflation level must incorporate decisions on monetary policy as an endogenous variable.

A simple way to construct this endogenous variable is to assume that the authority does not lower inflation more than necessary because such a measure would have negative real effects, namely, unemployment and recession. As discussed above, Friedman (1974) argues that full indexation would avoid these costs. However, lags in indexation generate disinflation costs that are not negligible (at least in the short term) and could explain the existence of a certain level of inflation (Simonsen, 1983).

A more modern conceptual framework for analyzing the role of indexation in generating a response can be derived from Barro and Gordon's model (Barro and Gordon, 1983). In this model, the government faces a problem of time inconsistency due to the existence of a Phillips-curve-type relation, and the government chooses the inflation level given market expectations. The public anticipates the government's action and expects equilibrium inflation, which generates a suboptimal solution of high inflation and unemployment rates.[31]

Following Fischer and Summers (1989), we derive a Phillips curve relation of the following type:

$$U = U^* - a\left(\pi - \pi^e\right),$$

where

$$L = \left(U - \kappa U^*\right)^2 + b\pi^2,$$

with $\kappa < 1$. Because κ is less than one, the authority has incentives for choosing positive inflation whenever expected inflation is zero.

31. The classic article on time inconsistency is Kydland and Prescott (1977).

This produces a problem of time inconsistency: however much the authority promises low inflation, the promise is not credible because if that were the case, it would no longer be optimal for the government to pursue the low inflation plan. Furthermore, in equilibrium, private actors pass over this problem and expect an equilibrium inflation level that is effectively realized.

Once private expectations are determined, the government selects the inflation level, trying to minimize L subject to the Phillips curve condition. This produces the following first-order condition for the optimal inflation level (from the government's perspective):

$$\pi^* = \frac{a(1-\kappa)U^* + a^2\pi^e}{a^2 + b} .$$

The assumption of rational expectations on the part of private actors implies that

$$\pi^* = \pi^e = \frac{D}{E}U^*(1-\kappa) .$$

Paradoxically, in equilibrium, the government does not achieve a reduction in unemployment and creates inflation. The government would be in a better situation if it had access to mechanisms for making a zero-inflation objective credible.

The generation of dynamic inconsistency does not hinge on a Phillips-curve-trade-off in the short term (in which unemployment changes in response to errors in inflationary projections). Any mechanism that allows the government to benefit from surprising the private sector with unexpected inflation will produce a similar effect. The practice of managing inflation in order to draw down the stock of public debt is a highly relevant example.[32]

Indexing different prices in the economy has two complementary effects in the context of this model. First, indexation helps limit the real effects of transitory shocks, since nominal wages (and other prices) are automatically adjusted to inflation. In terms of the Phillips curve,

32. Lucas and Stokey (1983) discuss this problem. Calvo (1988) studies how drawing down the debt can imply a multiple-equilibrium solution. In that case, the interest rate not only reflects inflation expectations, but also is a direct determinant of inflation through the government reaction (drawdown) function. Guidotti (1993) incorporates the problem of dynamic inconsistency in an optimal indexation model.

the parameter a is reduced, creating a more vertical relation. Wage indexation would be responsible for this effect in the model as presented. Second, the costs of inflation fall with indexation because private actors and the government both protect themselves against price changes. In terms of the government's loss function, the parameter b is reduced. Nonwage indexation contracts also generate this effect.[33]

Fischer and Summers (1989) analyze the implications of these two changes for the inflation level, associating wage indexation with changes in the Phillips curve. Their most important conclusions are that indexation can increase the inflation level (diminishing a and b simultaneously) and that measures for reducing the costs of inflation wind up creating a higher inflation level (by reducing b). In political terms, this may be reflected in less pressure to lower inflation if inflation is not costly, which could eventually have a negative effect on welfare (under the assumption that the government's loss function L extends directly to the general public). Moreover, indexation will be more or less desirable, in terms of welfare, depending on the degree to which the authority can control inflation. If the authority has a limited control on inflation, then a higher level of indexation will be preferable, since in this case the higher inflation generated by dynamic inconsistency represents less of a problem than the real effects of an inflation shock.

Beyond providing a valuable intuition that indexation can increase inflation, the model does not offer a definitive answer with regard to the exact conditions under which inflation rises. Nor does it give a definitive result with regard to what happens to the welfare level—assuming that inflation increases with indexation. Fischer and Summers address this latter problem by analyzing the restrictions that must be imposed on more general loss functions in order to produce a social loss if the costs of inflation are lowered. In those cases, the time inconsistency effect is stronger than the direct effect of lower inflationary costs.

Ball and Cecchetti (1991) and Mourmouras (1993) reach similar conclusions regarding the idea that indexation alters the inflation level. The first of these papers sets up a Barro-Gordon model, expanded to encompass staggered wage adjustments (as in the Fischer-Gray model). The resulting model has the virtue of unambiguously determining weather wage indexation increases inflation. By explicitly including in the labor market a parameter that measures the

33. In a model based on nominal debt, this role would be fulfilled by financial indexation.

level of contract indexation, the authors are able to conclude that an increase in wage indexation unequivocally increases inflation.[34] In terms of the effects described above, lower inflation costs trigger a stronger effect than a lower slope on the Phillips curve. They further conclude that wage indexation unambiguously increases welfare. Mourmouras (1993) uses the Barro-Gordon model with indexation, taking into account the existence of real shocks in the economy. The paper concludes that the inclusion of this shock does not change the intuitions set out by Fischer and Summers.

Indexation can also affect the inflation level by modifying the reputational dynamics between the authority and the general public. For example, expanding the Barro-Gordon model to cover several periods creates the possibility of sustaining a low level of inflation if the public and the authority develop a supergame. In the game, if the authority deviates from its established objective, thereby generating higher inflation than promised, then the public punishes the authority by expecting high inflation for several periods. If the discount rate faced by the authority is sufficiently low, then the government will find it advantageous to keep inflation low and not to deviate. In the context of the game, indexation has several effects on the possibility of maintaining an equilibrium of low inflation. Fischer and Summers (1989) argue that cooperation could improve with regard to maintaining a lower inflation level, because indexation would raise the level of "punishment inflation" (corresponding to the inflation level that would exist in a one-shot game such as that analyzed above). In addition, indexation serves to coordinate public action in the event that the authority needs to be punished, such that indexation again helps to keep the inflation level down. Indexation generates the opposite effect, however, in games in which there is more than one type of government and in which the authority's actions serve to signal the type. If the government carries out measures that reduce the costs of inflation, then the public may think that the government is of the type that is disposed to move the economy to a state of high inflation.

There is little empirical evidence on the relation between indexation and inflation. As mentioned above, Fischer (1983a) analyzes the inflationary response of different countries in the face of

34. The loss from inflation is caused by undesired variability in real wages. Indexation is modeled as if wages were modified instantaneously with price variation in a proportion p of the firms in an economy. Inflation increases when p increases. This conclusion is robust when other inflation costs are included.

the 1974 oil shock, controlling for the degree of indexation and the different forms this takes. He does not find a significant difference in the post-shock inflation performance of countries with high and low levels of indexation. Landerretche and Valdés (1997) analyze the history of nine countries and conclude that indexation correlates positively with the inflation level (without controlling for dual causality).

Inflation and Optimal Indexation

Beyond the stability and output considerations addressed in the classic articles on indexation (Gray, 1976; Fischer, 1977a), additional elements can be incorporated into the analysis of the optimal indexation level. This section reviews arguments on optimal indexation that take into account what happens with inflation, the dynamic inconsistency problems described above, and the political games that different parties sustain.

Waller and VanHoose (1992) consider only the effects of indexation on the inflation-unemployment trade-off, using a Barro-Gordon-type model in which the degree of indexation is chosen through a decentralized mechanism. In this case, they find that the public's choice of indexation level is suboptimal. The authors assume that the direct effect of indexation is to lower inflation, because it makes it less tempting for the government to surprise the private sector with unexpected inflation (that is, the Phillips curve is more vertical). Private actors act atomistically, however, and do not take into account the effect of their actions on the final inflation level. The chosen indexation level is thus lower than is socially desirable.

Another scenario that has been considered in the literature is what happens if the authority determines the level of wage indexation in a centralized fashion, thereby obviating the problem of suboptimality. To determine the optimal level of indexation under these conditions, Milesi-Ferretti (1994) incorporates the existence of nominal and real shocks into a Barro-Gordon-type model. The model considers just the Phillips curve effect of indexation, which this reduces the inflation level by improving the problem of time inconsistency. Milesi-Ferretti's main conclusions are that the indexation level should be higher if nominal shocks are more important (which confirms Gray and Fischer's result) or if the time inconsistency problem is more serious (a reflection of either a more horizontal Phillips curve or less aversion to inflation on the part of

the government). These findings are consistent with Devereux (1989), who presents a similar model but in which monetary policy is chosen before the shocks are felt.

Another dimension of optimal indexation that has been analyzed is the interaction between workers' decisions to index wages and the authority's decision to index financial instruments, specifically the government debt. Guidotti (1993) describes the government's and atomistic agent's decisions on indexation as endogenously given, setting up a model covering two periods and three shocks (namely, output, nominal, and government spending shocks). The government is faced with the alternative of loading more indexation into its debt structure to avoid the inflation-producing problem of dynamic inconsistency versus incorporating less indexation in order to use the debt as insurance against raising distorting taxes in bad states of nature (caused by government spending and output shocks).[35] Private agents, in turn, choose their indexation level as in the Gray-Fischer-type models: if nominal shocks are more important, then more indexation is desirable. The key to the model, however, is that a portion of the nominal shocks are endogenous to indexation because of the government's dynamic inconsistency problem.

The main results of this analysis indicate that the government will choose to have less nominal debt (that is, more indexation) whenever spending shocks are less variable, wage indexation is higher, and the variance of the nominal and output shocks is greater. This means that a higher level of wage indexation lowers inflation, because debt indexation increases and reduces the problem of time inconsistency.[36] The workers, for their part, choose a wage indexation level that is not monotonic with regard to debt indexation. At low levels of debt indexation, wage indexation increases with debt indexation, and vice versa. Finally, if the government prefers a more stable output, one can expect less wage indexation and both more and less financial indexation.

A different dimension is exposed through the ways in which different political parties manipulate indexation levels in order to gain (and stay in) power. Milesi-Ferretti (1994) shows that if the decisions on indexation are irrevocable or have a long horizon, then a party

35. Bohn (1988) analyzes the problem of nominal debt as insurance. See section 1.2 in this paper.

36. Even if the government can commit to a certain monetary policy, some degree of indexation is desirable to avoid unwanted changes in the value of the debt.

that is in power and that is more averse to inflation than the average voter will choose to reduce indexation in an election year. This strategy ensures that the average voter will not vote for the other party (which is assumed to be less averse to inflation than the average voter) because if the economy is unindexed the other party would generate a higher-than-desired inflation. Crosby (1995) reaches a similar conclusion in a model in which indexation is used as a method of commitment in the context of a time consistency problem. In this scheme, the parties that are less averse to inflation will try to index wages as a strategy for gaining power, because by doing so they cease to be an "inflationary danger" from the perspective of the voters. The paper analyzes the case of Australia in 1983, in which the liberal government indexed the economy and maintained an excellent inflation record.

Indexation of Monetary Policy Instruments

Indexation and the control of inflation can be examined at a more concrete level, in relation to the implementation of monetary policy. The question is whether it is more advantageous in a widely indexed economy to use a nominal or adjustable interest rate as the main instrument of monetary policy. The answer has to do with the variability exhibited by the chosen instrument.[37]

Real and nominal interest rates are related through Fischer's equation:

$$i_t = R + \pi_t^e ,$$

where R is the ex ante real interest rate and i_t is the nominal interest rate. If indexation is lagged and if the authority wants to prevent arbitrage between adjustable and nominal securities, the equation should be rewritten as

$$I_t = U + \pi_{t-1} .$$

In other words, the adjustable interest rate (r) is equal to the ex ante real rate plus the differential between expected and lagged inflation.

37. See Fontaine (1991) for a discussion of this issue in the context of the Chilean economy.

This implies two considerations with regard to interest rate variability. First, because indexation has lags, the adjustable interest rate on short-term securities does not correspond exactly to the real interest rate in the economy. Second, there is no reason, in theory, that nominal rates should be more volatile than adjustable rates. Of course, once one of the two is chosen as a political instrument and thus controlled by the authority, the other should undergo all pertinent adjustments in order to deter arbitrage.

The answer to the initial question should therefore be phrased in terms of which interest rate is easier to interpret for the purpose of measuring the state of monetary policy, thereby facilitating policymaking. There are two reasons for this. First, the ex post real rate that an individual faces depends on both the adjustable rate and the relative price change between that individual's idiosyncratic price (wage, exchange rate, raw material prices, and so forth) and lagged inflation. For example, if the real exchange rate appreciates, the ex post real rate for an exporter will effectively be lowered. In the case of Chile, this effect is manifested in the fact that it is difficult to find a stable, systematic relation between adjustable rates, output, and inflation (Mendoza and Fernández, 1994).[38] The process of monetary policymaking is based, in the end, on raising interests rates if the spending-output gap is greater than deemed advantageous and then maintaining this increase as long as the gap does not respond. There is not, a priori, a level of rates that is known ex ante to be correct for achieving an inflationary deceleration of a predetermined amount. It is not necessarily correct, therefore, to associate a specific level of adjustable rates with the state of monetary policy.

The second consideration has to do with the monetary policy's transmission mechanism. If the most important variable is either the short-term nominal rate (for example, if the mechanism is based on capital inflows and exchange rate appreciation) or the volume of monetary aggregates (for example, if the mechanism centers on consumer credit in a context of imperfect information), then the optimal choice is a nominal policy. In both examples, the stability of the adjustable (as opposed to the nominal) rate simply

38. In fact, the profitability of three-month adjustable operations are practically as volatile as nominal operations (Mendoza, 1991; Mendoza and Fernández, 1994). In Chile, Valdés (1997) finds a systematic relation between the adjustable interest rate and output growth and between the interest rate and the gap between target and actual inflation.

creates variability in the nominal rate and noise in terms of discovering the true monetary policy. Worse still, it is not even very relevant in terms of affecting aggregate demand, assuming that the transmission mechanisms are those mentioned. The adjustable rate provides a clear policy signal only when the traditional transmission mechanism is in operation, namely, when the medium-term real rate is influenced by the adjustable rate and also determines the changes in aggregate spending and inflation.[39] Tobin (1971), for example, uses this type of reasoning. Because investment critically depends on q and because the closest substitute for q is the indexed bonds rate, adjustable bonds should be used for monetary policymaking.

3. Summary and Conclusions

This paper has analyzed indexing practices in the labor, financial, and foreign exchange markets. Wage indexation derives from the need to halt the erosion of nominal wages by inflation in the presence of negotiation costs. It also represents a form of implicit insurance between the employer and employee. The fixation of the real wage is achieved, theoretically, through the use of perfect indexation. If the stabilization of output or employment is an objective, the optimal degree of perfect wage indexation will depend on the relative importance of nominal versus real shocks to the economy. In practice, however, it is impossible to achieve perfect wage indexation. Wage indexation therefore takes a variety of forms, all of which seek to approximate fixed real wages. In most cases, indexation is not perfect: wage contracts commonly specify indexation clauses as a function of lagged inflation, which complicates the analysis of the optimal degree of indexation. At the same time, other factors, such as the degree of openness in the economy, also influence the optimal indexation level.

Financial indexation, in turn, aims to complete markets by offering an instrument that is effectively free of inflation risk. Such instruments could affect both public and private saving. Analogously, the indexation of financial instruments issued by the economic

39. Mendoza and Fernández (1994) present evidence against the existence of a monetary policy transmission mechanism from adjustable rates to the spending-output gap and inflation, using vector autoregressions. Valdés (1997) does find evidence for this mechanism.

authority provides an incentive for stabilizing inflation, by eliminating the possibility of drawing down the public debt. In the case of exchange rate indexation, the authority has the faculty of including indexation clauses in the exchange rate rule, with the objective of stabilizing the real exchange rate. Exchange rate indexation contributes to inflationary persistence, however. The choice of exchange rate regime and the optimal indexation level must therefore be resolved through a joint optimization that attains some degree of optimal stabilization of economic activity and the price level.

Another interesting aspect of indexation that is explored in the paper involves the consequences of indexation practices on inflation. In particular, wage and exchange rate indexation can have a strong effect on inflationary inertia and variability. An extreme case is that of an economy that combines a high degree of wage indexation with a purchasing power parity rule for the exchange rate. In this case, the nominal anchor tends to be lost, and the magnitude of inflationary inertia is exacerbated. This implies, therefore, that the type and degree of indexation existing in an economy will affect the costs that are incurred during the implementation of a program for stabilizing the price level.

The degree of indexation in an economy affects not only inflationary dynamics, but also the optimal inflation level. On the one hand, indexation (mainly wage indexation) reduces the effect of nominal shocks on real variables, making the Phillips curve more vertical and reducing the incentives for the authority to inflate the economy. On the other, it lowers the costs of inflation and can therefore induce the government to postpone the application of inflation-fighting measures indefinitely.

While the particular effect of each type of indexation on inflation, output, or the real exchange rate is not ambiguous, the general, combined effect of different forms of indexation is. The effect often depends on the particular form of implementation (such as the type of financial instrument or the wage adjustment rule), which can vary considerably. Otherwise, the optimal degree of some type of indexation will depend on the form of the economic authority's loss function or on the stochastic characteristics of the actual situation (that is, on the relative variance of different types of exogenous prices). It is very difficult to isolate all the elements, yet combining them in any single model is also complicated. Therefore the interest of compiling and analyzing them together, in an effort to understand the combined effect.

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