

# COMMODITY PRICES AND MACROECONOMIC POLICY: AN OVERVIEW

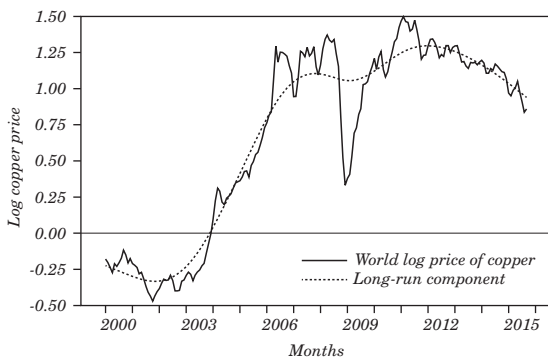
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World commodity prices and their macroeconomic impact, especially on emerging economies, have long been a main concern in economic research. Decades ago, the Prebisch-Singer hypothesis of secularly deteriorating terms of trade (Prebisch, 1950; Singer, 1950) was the subject of intense debate and became a cornerstone of major development theories and, especially in Latin America, of influential policy approaches.<sup>1</sup> In a related fashion, extensive literature has studied the long-run behavior of commodity prices. Although there is some controversy about the main drivers of the relative prices of commodities, there is consensus that, since the nineteenth century, four commodity “super cycles” have taken place. These super cycles have been related to strong demand associated with moments of rapid industrialization and urbanization in major areas of the world. Each of them, lasting on average 20 years, ended once the supply of commodities increased to match the growing demand (Canuto, 2014).

Recent events have brought similar issues back to the top of the economics agenda. During the current commodity super cycle, which began in the late 1990s, the world economy has seen wide swings in the world prices of primary items such as oil, food, and metals. Echoing past debates, commodity prices are again posing urgent

1. Both Structuralism and Dependency Theory relied heavily of the Prebisch-Singer hypothesis. These theories, in turn, underpinned the strategy of Industrialization via Import Substitution. For a recent empirical evaluation of the Prebisch-Singer hypothesis, see Arestski and others (2013).

**Figure 1. Copper Prices<sup>a</sup>**

Source: Central Bank of Chile.

a. Monthly data spanning January 2000 – October 2015.

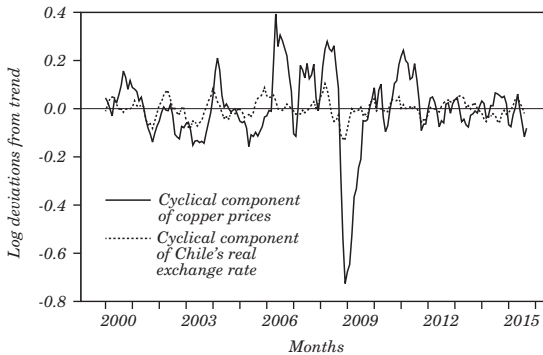
questions to academics and policymakers. The questions are both positive (such as, what is the impact of commodity price shocks on macroeconomic aggregates?) and normative (how should monetary and fiscal policy best react to those shocks?); they pertain to both the short run (are copper funds and other stabilization schemes a good idea?) and the long-run (should developing countries try to change their productive structures to diversify exports away from primary products?). Research on these and related issues is badly needed, particularly for emerging economies that are heavily exposed to commodity price fluctuations.

To contribute to the debate, this volume gathers six studies written for the XVIII Annual Research Conference of the Central Bank of Chile. The unifying theme of the conference was to examine appropriate macroeconomic policies in light of the increased volatility of world commodity prices. The studies in this volume explore different dimensions and aspects of that theme, as well as diverse policy alternatives, instruments, and strategies.

This diversity, to a large extent, reflects the many facets of the problem suggested by the raw behavior of commodity prices. To understand this, it is illustrative to glance at the data. In figure 1, the trajectory of the world price of copper since 2000 is plotted in black.<sup>2</sup>

2. The raw series is the world copper price, US\$/lb, taken from the Central Bank of Chile's website. Figure 1 shows the natural log of the price.

**Figure 2. Chile: Copper Prices and Real Exchange Rate over the Cycle**



Source: Central Bank of Chile.

Copper is, of course, a key export for Chile, Peru, and other emerging economies, but its recent price fluctuations are representative of those of other metals. The raw series exhibits extremely large fluctuations; it is also clear that there is variability in both the short run and the long-run. The identification of low frequency versus high frequency components is in fact a non trivial exercise, but for concreteness the figure shows (dotted line) a “long-run” component, computed via the well known Hodrick-Prescott filter.<sup>3</sup> The short run or cyclical component can then be defined, as usual, by the difference between the raw series and its long-run component; it displays large fluctuations. It is notable from figure 1, however, that fluctuations are also quite large around the trend.

The cyclical component of copper prices is plotted in figure 2 (black line). It shows very large fluctuations: the Lehman crisis saw a crash in which the price fell by more than seventy percent relative to its trend; but the series displays also periods in which the price was above trend by twenty percent or more.

Figure 2 also shows (dotted line) the cyclical component of Chile’s real exchange rate (measured so that an increase expresses a real appreciation of the peso). Comparing it against the cyclical component of copper prices, at least two facts become apparent: the

3. The HP filter parameter is set at 14,400, consistent with monthly data.

cyclical variability of copper prices has been an order of magnitude larger than that of the real exchange rate; and there is a positive correlation between the two series (the correlation coefficient is 0.434). The first fact is surprising: it is well known that the real exchange rate is itself much more variable than other macroeconomic aggregates and relative prices; but commodity price fluctuations appear to be much bigger! The second one is also remarkable: in spite of an extensive body of literature discussing the difficulty of relating exchange rates to macroeconomic fundamentals (e.g. the exchange rate disconnect puzzle of Obstfeld and Rogoff, 2001), the relation between commodity prices and exchange rates appears to be quite robust for Chile and other emerging countries, and strongly suggestive of significant economic effects of commodity price shocks on real aggregates.

The fact that commodity price uncertainty has been high both in the short run and the long-run suggests a corresponding need for adjusting multiple policies, intended to work at different horizons. Accordingly, some chapters of this volume are devoted to monetary and fiscal policy and emphasize stabilization at short run, business cycle frequencies; but the volume also includes chapters with a focus on investment, industrial and sectoral policies, and other longer run aspects of policy.

This volume, therefore, is representative of the variety of research approaches to the topic of macroeconomic policy in response to commodity price fluctuations. Recent research has been more active and more technically sophisticated when it regards monetary policy issues and the shorter run. To a large extent, this has been due to the widespread acceptance of a basic theoretical framework for the study of monetary policy, the dynamic New Keynesian model summarized in Woodford (2003) and Galí (2008) for closed economies, and extended by Galí and Monacelli (2005) for small open economies. Also, there is a well-developed arsenal of empirical methods for the analysis of stationary time series. These tools have been applied to the question of commodity prices and macroeconomic fluctuations (although, as noted by Fornero, Kirchner, and Yani in this volume, mostly to the macroeconomic impact of oil prices in developed countries). As the focus shifts to longer horizons, there is less agreement on the usefulness of alternative analytical frameworks and on the appropriate empirical methods; accordingly, the existing literature has more diversity. This state of affairs will become apparent as the reader goes through the different parts of this book.

The rest of this introductory chapter provides a summary and discussion of the chapters in the book. Echoing the comments in the previous paragraphs, we classify them into two groups, the first one emphasizing monetary policy, and the second one addressing other, longer term issues.

## 1. CONTRIBUTIONS: MONETARY POLICY

The first part of this book deals with aspects of central bank policy in response to commodity price fluctuations. It starts with chapters, by Roberto Chang and by Constantino Hevia and Juan Pablo Nicolini, that are closely related to a recent academic debate on monetary policy. Summarizing that debate helps placing these contributions in perspective.

The basic New Keynesian framework of Woodford (2003) and Galí (2008) lent strong support to a policy of price stability, which has been taken as a theoretical justification for *flexible inflation targeting* regimes: the central bank is assigned the task of stabilizing inflation around a numerical target (close to zero) and an output objective. Indeed, one of the key contributions of Woodford (2003) was the demonstration that, in the canonical New Keynesian model, the welfare of the representative agent can be correctly approximated to second order by a linear-quadratic cost function of inflation and the output gap (the difference between output and its natural or flexible price value). In the absence of cost push shocks, keeping inflation at zero implies a zero output gap as well; therefore zero inflation is first best optimal. When cost push shocks are present, the analysis needs to be modified somewhat, but it is still the case that an optimal policy involves a trade-off between inflation and the output gap and only between those two variables.

Woodford (2003)'s model was one of a closed economy, however. Corsetti and Pesenti (2001) recognized that, in open economy versions of the New Keynesian model, the central bank may have the power and incentive to affect international relative prices in the country's favor. This incentive, sometimes called the *terms of trade externality*, indicates that a country may gain from a monetary policy that targets the real exchange rate or the terms of trade, in addition to inflation and the output gap.

Winds turned again in favor of inflation targeting after Galí and Monacelli (2005) showed that, in a New Keynesian small open

economy model, the stabilization of a producer price index (PPI) was optimal under some combinations of behavioral parameters, mostly unit elasticities. While those assumptions were quite restrictive, the suggestion that PPI targeting is indeed an appropriate rule was reinforced by the work of De Paoli (2009). De Paoli extended Galí and Monacelli's analysis in two significant directions. First, she derived a purely quadratic second order approximation to the representative agent's welfare, which turned out to depend only on PPI inflation and the deviations of output and the real exchange rate from exogenous targets. This confirmed Corsetti and Pesenti's insight, in that optimal policy can be written as a rule trading off inflation, the output gap, and the real exchange rate. But De Paoli's second contribution went in favor of Woodford and Galí-Monacelli: after calibrating Galí and Monacelli's model to empirically reasonable parameters, De Paoli found that PPI targeting resulted in a very small welfare loss with respect to the optimum. In other words, De Paoli found that PPI targeting, while suboptimal, was still an excellent monetary framework for small open economies.

De Paoli's results notwithstanding, the robustness of PPI targeting to departures from Galí and Monacelli's assumptions has been the subject of renewed research efforts, especially in view of the increased volatility of commodity prices. A plausible conjecture is that the terms of trade externality may become more of a factor in countries with larger exports or imports of commodities, and in periods in which the commodity prices are more variable. Thus a number of recent papers have explored this conjecture.

In particular, Catão and Chang (2013), Monacelli (2013), and Hevia and Nicolini (2013) extended the Galí-Monacelli model to include an exportable commodity sector as well as imports of a consumption item such as food, whose price relative to world consumption fluctuates in world markets. These papers characterized optimal monetary policy and its dependence on country specific aspects, including elasticities of demand, the volatility of the prices of a country's exports or imports, and the degree of international risk sharing. On the other hand, they all found that, for plausible parameterizations, the finding that PPI targeting is nearly optimal remained remarkably robust.

In his contribution to this volume, Roberto Chang explains the debate just mentioned in the context of a simplified version of his 2013 model with Catão. Many papers in this literature, including those just cited, are difficult to solve by hand, partly because of

the dynamics imparted by assumptions about price setting, most often taken to be a version of Calvo (1983)'s staggered price model. Chang observes that, for the comparison of monetary policy options, much of the intuition can be obtained by replacing Calvo's pricing with the alternative assumption of prices set one period in advance. This eliminates some interesting dynamics, but results in a drastic simplification: the resulting model is essentially static, and many results can be derived analytically.

In Chang's model, domestic agents consume an aggregate of a home product and an imported commodity, called "food". All goods are tradable, and the relative price of food is exogenously determined in world markets. Since that price is subject to random fluctuations, the analysis of the model depends on assumptions about international risk sharing. Most of the related literature, starting with Galí and Monacelli (2005), has assumed that risk sharing across countries is perfect. In addition to this case, Chang also examines the polar opposite of portfolio autarky, which implies balanced trade.

Two kinds of allocations are characterized: the optimal *Ramsey* outcome and the flexible price or *natural* allocation. The Ramsey outcome is the social planning solution in the absence of nominal rigidities, and it is of interest because it provides a natural benchmark against which any policy can be compared. The natural allocation, in turn, is crucial because, in this class of models, is often obtained as the result of PPI stabilization.

Chang shows that, indeed, the Ramsey outcome and the natural allocation coincide under the parameterization of Galí and Monacelli (2005); they also coincide under more general parameterizations if one assumes, as in Hevia and Nicolini (2013), that there is a sufficiently rich menu of taxes and transfers. In such cases, therefore, PPI targeting emerges as an optimal monetary strategy. It becomes apparent from Chang's analysis, however, that those cases are quite restrictive, and in general the natural allocation can be quite different from the Ramsey outcome. This depends, as mentioned, on various parameters and assumptions of the model.

A second aspect of Chang's paper is an exploration into the derivation and implications of linear quadratic approximations to welfare. As in De Paoli (2009), the welfare of the representative agent can be written as a purely quadratic function of inflation, and the deviations or gaps of output and the real exchange rate from corresponding targets. But Chang emphasizes that there are other equivalent ways to obtain a linear quadratic social welfare function.

One involves only inflation and an output gap; another one, only inflation and a real exchange gap; yet a third one may be written in terms of inflation and a consumption gap, and so on. (This is possible by redefining the appropriate concepts of gaps and targets in each case.) This point is of some practical significance for countries, such as inflation targeting ones, where there has been debate about whether central banks should (or not) stabilize exchange rates, in addition to inflation and the output gap. According to Chang's analysis, the questions have been ill-defined; the meaningful issue is not whether real exchange rates should be stabilized alongside inflation and the output gap, but how.

Hevia and Nicolini's chapter develops a model of the Galí-Monacelli type, and uses it to explore the role of price rigidities versus nominal wage rigidities. Their model extends Hevia and Nicolini (2013) and includes both an imported good ("food") and an exportable primary good, which we will call "copper"; the prices of food and copper are determined in the world market, and fluctuate randomly. Copper is produced with only labor.

As in typical New Keynesian models, there is a domestic tradable good which is an aggregate of imperfectly substitutable varieties. These varieties are, in turn, produced with labor, food, and copper, under monopolistically competitive conditions. Nominal price rigidities are introduced by assuming Calvo pricing. The main departure with respect to Hevia and Nicolini (2013) is to include wage rigidities, modeled in a similar fashion to price rigidities (this follows Erceg, Henderson, and Levin 2000).

To start the discussion of the implications of the resulting model, Hevia and Nicolini replicate and extend theoretical results of their 2013 paper. In particular, they show that nominal prices and wages can be fully stabilized if the nominal exchange rate and a payroll tax rate adjust appropriately to offset exogenous shocks. This can be seen as a special case of the more general result, already mentioned, that PPI targeting is an optimal policy when sufficiently flexible taxes and transfers are available.

To proceed, Hevia and Nicolini assume that payroll tax rates are constant, which is realistic. Also, they focus on the case in which only the price of copper is variable. They calibrate the model in the standard way, except that the stochastic process for the price of copper is estimated from observed world copper prices. The baseline version of the model assumes isoelastic preferences so that PPI stability is optimal in the absence of wage rigidities.



Under such assumptions, a main exercise involves comparing a trade-off between PPI stability and nominal wage stability. To this effect, they assume a policy rule that implies a fixed PPI on one extreme and a fixed nominal wage on the other, and that can also capture intermediate regimes, depending on the value of a policy parameter. The implications of this rule are then explored under various assumptions on the flexibility of prices versus the flexibility of wages.

The main finding is about the role of wage flexibility. When nominal wages are not that rigid, PPI stability clearly dominates a policy of nominal wage stability and, in this sense, the policy findings of Hevia and Nicolini (2013) remain basically the same. But when nominal wage rigidity is substantial, stabilizing nominal wages is welfare superior to PPI stability.

As Hevia and Nicolini explain, to understand the intuition one needs to refer to the optimal (Ramsey) response to copper price fluctuations. A favorable shock to the copper price should naturally be met with higher copper production and exports. For this to occur, the real wage must fall, so as to induce hiring more labor in the copper sector. But under PPI stabilization, the required fall in the real wage is harder to obtain when nominal wages are more rigid.

Hevia and Nicolini complete their discussion by examining a different policy trade-off: namely, between nominal price stability and exchange rate stability. For their baseline calibration, they show that a combination of PPI stabilization and dirty floating is superior to either strict PPI targeting or a fixed exchange rate. Importantly, they also find that the latter is better than the former if wage rigidities are sufficiently severe.

In sum, Hevia and Nicolini's chapter shows that, for a small open economy facing commodity price volatility, the nature of optimal policy depends on the rigidity of both nominal prices and wages. Their chapter and Chang's, therefore, coincide in stressing that the literature implies that appropriate monetary and exchange rate management should be country specific, and tailored to the particular characteristics of each economy.

In contrast with Chang's and Hevia and Nicolini's chapters, whose focus is on traditional monetary policy, Joshua Aizenman and Daniel Riera-Crichton contribute to this volume a chapter on the so-called *unconventional* monetary policy. In the context of emerging countries, the term "unconventional policy" is best understood by contrasting it against "conventional" inflation targeting. Theoretically at least,

inflation targeting involves setting a single policy instrument, often an overnight interest rate, in order to attain a certain level of inflation and, perhaps, an employment or output gap objective. Hence unconventional policy refers to cases in which the central bank has used alternative instruments, including liquidity facilities, discount lending, foreign exchange intervention, or foreign exchange reserves management; or pursued alternative goals, such as exchange rate stability or financial stability.

Interest in unconventional monetary policy has surged following the 2007-2008 global financial crisis and the subsequent policy response of some central banks in advanced countries, including the U.S. Federal Reserve. In response to the crisis, and especially after the September 2008 Lehman debacle, those central banks adjusted their policy rates all the way down to zero, but decided that additional stimulus was needed. As a consequence, they resorted to a number of operations involving the balance sheet of the central bank. In the U.S., the so-called quantitative easing and credit easing policies resulted in more than tripling the asset side of the Federal Reserve. More recently, the European Central Bank has been implementing an aggressive quantitative easing policy as well.

The use of unconventional policies in advanced economies has provided them with some impetus in emerging economies, especially in Latin America. Some differences remain, however, perhaps the most notable of which being that Latin American central banks have often conducted policies in a foreign currency, most often the U.S. dollar. Sterilized foreign exchange intervention has been a prime example, but credit facilities and liquidity mechanisms in foreign currency have also been ubiquitous (Céspedes, Chang, and Velasco, 2014).

As Chang (2007) emphasized, unconventional policies, particularly foreign exchange intervention and reserves accumulation, became more frequent in Latin America after the mid-2000s, partly in response to commodity price fluctuations, and especially with the objective of arresting strong exchange rate appreciation due to increasing export earnings and, concomitantly, capital inflows. This development raises the question of how effective such policies are, especially in the face of exacerbated commodity price volatility. It is this question that provides a focus for Aizenman and Riera-Crichton's chapter.

Using data from the largest twelve Latin American countries for the period spanning from 1980 to the present, Aizenman and Riera-Crichton study the empirical response of real exchange rates and output growth to commodity price shocks, and how that

response depends on the accumulation and management of foreign reserves and on sovereign wealth funds. The sample contains enough heterogeneity along the country dimension as well as in terms of sub-periods, so that the paper also investigates the impact of different policy regimes—such as the presence of formal inflation targeting or an exchange rate peg—, and of events—such as the Lehman crisis—on the aforementioned links.

The main technical tool for the analysis is a cointegrating equation in which one of the outcome variables (changes in the real exchange rate or output) depends on their long-run equilibrium (or cointegrating relation), as well as a measure of shocks in the commodity terms of trade, called CTOT.<sup>4</sup> The coefficient of CTOT, in turn, is allowed to depend on one of the policy variables of interest: the reserves to GDP ratio, the size in terms of GDP of sovereign wealth funds, or changes in these ratios.

The authors present and discuss several findings; here we highlight a couple of them. In the full sample, an improvement in the commodity terms of trade (an increase in CTOT) implies a real exchange rate appreciation; but the magnitude of the response decreases with the size of foreign exchange reserves (either the stock of reserves or its change), which Aizenman and Riera-Crichton call a “buffer effect”. More precisely, as they write: “a stock of reserves of 15 percent of GDP or a change in reserve holdings of 3 percent of GDP can, on average, reduce the REER effects of CTOT shocks on impact by half”. Also for the full sample, an increase in CTOT implies an increase in GDP growth. But in this case it is harder to pin down a buffer effect of foreign reserves.

Identifying the influence of sovereign wealth funds on the transmission of CTOT shocks to either the real exchange rate or output is, likewise, elusive. A notable exception, however, is the “Great Recession” period between 2008 and 2009. Aizenman and Riera-Crichton find that, indeed, the impact of CTOT shocks on the real exchange rate and GDP growth was much smaller in countries that had substantial sovereign wealth funds.

The analysis is descriptive and the estimated relationships should be seen as reduced form ones, so they do not necessarily have structural interpretations and, hence, one must be very

4. CTOT differs from the traditional measure of the terms of trade in emphasizing the prices of commodity exports and imports at the expense of the prices of industrial goods.

careful in deriving policy implications. But Aizenman and Riera Crichton's paper is highly suggestive of the fact that foreign reserves management, sovereign wealth funds and, more generally, unconventional policies, can have important real effects, especially at times of financial crises.

## **2. CONTRIBUTIONS: LONGER RUN TOPICS**

In contrast to the first three chapters, which address monetary policy and the short run, the other three chapters in the book tackle issues pertinent to the medium and long-run. One of them is the impact of commodity prices on investment, and is the central question of the contribution of Jorge Fornero, Markus Kirchner, and Andrés Yany (FKY hereon).

As FKY discuss in the introduction to their chapter, most of the literature on the macroeconomic impact of commodity prices has been concerned with the effect of oil prices on advanced economies (e.g. Blanchard and Galí 2009; Bodenstein, Erceg, and Guerrieri, 2008; Killian, 2009). The focus on oil, usually a main import in advanced economies, is less useful for many emerging economies that are exporters of metals. In those cases, a central concern is how investment in mining reacts to increases in metal prices, how that event is transmitted to the rest of the economy, and how the transmission depends on monetary and fiscal policy.

FKY approach the topic in two complementary ways. One is an empirical analysis based on identified vector autoregressions (VAR). They assemble data from seven metal exporters (Australia, Canada, Chile, New Zealand, Peru, and South Africa), from 1993 to 2013. For each country, they estimate a VAR with an exogenous foreign block that includes world GDP, U.S. inflation, the federal funds rate, and a commodity price index; and an endogenous domestic block which includes real GDP, investment in the mining and non-mining sectors, the inflation rate, the monetary policy rate, the real exchange rate, and the current account balance. In the exogenous block, identification is attained via a recursive (Choleski) decomposition, with the commodity index last; then exogenous disturbances to commodity prices are isolated and their implications can be studied in the usual way.

The VAR analysis yields many notable results. In particular, shocks to commodity prices are found to be fairly persistent, with a

half life between two and three years. They are followed by a large and also persistent increase in mining investment, with significant effects on GDP. Non-mining investment increases as well, although naturally not as strongly as mining investment. The investment responses, in turn, are reflected in changes in the current account and the real exchange rate.

A second line of attack on these issues is the analysis of a stochastic dynamic equilibrium model. To this end, FKY extend the model by Medina and Soto (2007) and calibrate it with parameters taken from a related paper by Fornero and Kirchner (2014). Medina and Soto's model is a dynamic New Keynesian one, featuring an export mining sector and also imports of an oil-like commodity, similar to the Hevia-Nicolini model reviewed earlier. FSY add investment and capital accumulation, both in the mining sector and in the non-mining sectors. In addition, the model assumes also a monetary policy rule of the Taylor type, as well as a structural balance fiscal rule resembling the one in Chile. This allows FSY to explore the implications of changing the parameters of fiscal and monetary policy on the transmission mechanism.

FSY find that the predictions of the dynamic model accord well with the VAR analysis. A favorable shock to commodity prices leads to a sizable increase in mining investment. The bonanza spills over to the rest of the economy and, in particular, non-mining investment increases as well. The surge in aggregate demand is reflected in a wider current account deficit and a real appreciation. As for the role of policy, FSY interestingly argue that, while the responses of non-mining output and investment to commodity price shocks are sensitive to fiscal and monetary policy, the corresponding responses in the mining industry are much less so. Hence they suggest that "investment decisions in the commodity sector...are mainly driven by sectoral productivity developments and, particularly, commodity prices."

Next, Radek Stefanski investigates structural transformation, in the form of labor reallocation, in a small open economy, as a consequence of windfall revenues arising from exporting natural resources. He notes three stylized facts in resource-rich countries that warrant explanation: (i) the existence of a small but productive manufacturing sector, (ii) a large yet unproductive non-manufacturing sector, and (iii) a larger proportion of workers in the government sector when compared to resource-poor countries. In a previous contribution, Kuralbayeva and Stefanski (2013) showed that facts (i)

and (ii) could be explained by a process of labor self-selection. Here, in the context of Kuralbayeva and Stefanski (2013), the target of this chapter is to explain (iii), the size of public sector employment in resource-rich countries.

Before presenting the theoretical model, Stefanski analyzes a panel of macro cross-country data and documents (i)-(iii). Resource-rich countries employ, proportionally, 27% fewer workers in manufacturing and 6% more workers in non-manufacturing than resource-poor countries. Also, resource-rich countries are 24% more productive in manufacturing and 4% less productive in non-manufacturing (relative to aggregate productivity). Finally, resource-rich countries employ 48% more workers in the public sector and 10% less workers in the non-public sector.

Stefanski then derives a small, open, multi-sector economy model with heterogeneous agents that can account for the observed facts in productivity and employment. The model closely follows Kuralbayeva and Stefanski (2013) but introduces a role for government. There are three final goods in the economy: manufacturing goods, private non-manufacturing goods (services), and a windfall good. It is assumed that manufacturing and the windfall good (endowment) are traded internationally, while services are assumed to be nontraded. It is also assumed that a government sector provides the rest of the economy with inputs such as institutional frameworks, transportation, rule of law, and arbitration, which are productivity enhancing but are external to firms (and workers). Thus, while workers can be employed in the government sector, the sector produces no final goods directly, but rather provides an input to other sectors of the economy which helps them attain a higher level of productivity.

In this model, productivity differences are explained through a process of self-selection. In particular, windfall revenues induce labor to move from the manufacturing sector to the non-manufacturing sector. Self-selection of workers takes place: only those most skilled in manufacturing work remain in the manufacturing sector. Workers that move to the non-manufacturing sector are, however, less skilled in non-manufacturing work than those who were already employed there. Resource-induced structural transformation thus results in higher productivity in manufacturing and lower productivity in non-manufacturing. Now, given that government services are non-traded, higher windfalls increase demand for all goods and services, including government services, but since these cannot be imported, workers shift to the government sector to satiate demand. Furthermore, even

with a government sector, the specialization mechanism introduced in Kuralbayeva and Stefanski (2013) is strong enough to explain a large part of the asymmetric differences in sectoral employment shares and productivity between resource-rich and resource-poor countries.

Sir Paul Collier's chapter concludes the book by addressing some of the medium-run and long-run policy challenges faced by commodity exporting countries. Collier points out that economies in which the extraction of a non-renewable natural resource is a significant activity, pose two distinctive challenges for policy. First, revenues are likely to fluctuate because commodity prices have historically been volatile. Second, the revenue from extraction is generated by depleting a finite resource and, therefore, there is a potential case for offsetting depletion with the accumulation of other assets. Collier notes that volatility and depletion work in radically different time scales, hence managing them evidently requires distinct "policy clocks".

In a first section, the chapter explores a policy clock designed to face depletion. Collier points out that a useful starting point for thinking about the depletion of a finite natural asset is the permanent income hypothesis (PIH). The PIH prescribes that the revenue from depletion should be used to give all future generations an equal increase in consumption, which is constant and equal to the interest that would be earned at a fixed world interest rate on the present value of the revenue. The PIH is compared to an alternative prescription, the so-called bird-in-hand rule advocated by the International Monetary Fund, that incorporates extreme caution. In particular, at each moment, savings are optimized subject to the assumption that no further resource revenues will accrue. Clearly, in all circumstances other than this drastic eventuality, the strategy is suboptimal.

The previous rules are designed to smooth consumption, but do not address the fundamental question of how to face depletion. In this section, Collier does not provide a unique prescription to this dilemma. Instead he offers some guidelines that could be applied to different countries. The basic idea, however, is that to face depletion a country should save a proportion of its resource income in an asset that, after the natural resource is exhausted, could be used to produce other non-resource goods.

A second section of Collier's chapter explores a policy clock designed to manage asset accumulation. Collier recognizes that assets held to offset depletion should differ from those used to smooth expenditure in the face of fluctuations in revenue. By their nature, smoothing fluctuations imply that the assets acquired during



periods of high prices will be held only temporarily. In contrast, since obsolescence and depletion are permanent states of affairs, the accumulation of assets to offset them will be held permanently.

The difference in the horizon for holding the accumulated assets has important implications for the type of assets to be acquired. Those assets acquired to smooth fluctuations must necessarily be foreign assets, since otherwise they cannot smooth domestic activity. Further, since they are being held in order to be liquidated when needed, they must be readily marketable. Illiquid holdings of private equity would not be appropriate, even though the long-term rate of return on such assets might be higher than that of liquid assets. In addition, since the assets held for smoothing will need to be liquidated in predictable circumstances, namely, a fall in the copper price, they should be chosen so as to have a marketable value that is negatively correlated with the copper price.

In contrast, assets accumulated to offset depletion are held for their long-term return rather than their ability to smooth domestic activity. Consequently, liquidity is not necessary. Instead, a key issue for assets designed to offset depletion is the choice between investment in foreign financial assets and domestic real assets. Collier offers some guidelines in this regard.

A last section of Collier's chapter discusses a third policy clock which describes how expenditures should be smoothed. Collier points out that budgets work with concepts other than depletion, namely, expenditure and revenue. In this case, revenues are the sum of consumption and savings, but expenditures are the sum of consumption and domestic investment. Because it is costly to deviate from planned expenditure, savings should accommodate deviations from planned expenditure and actual revenue. In this case, a key issue is the uncertainty about the future stream of revenues. Collier emphasizes that there is uncertainty at different horizons, and discusses policy issues related to the distinction.



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