Ensayos en Macroeconomía Internacional

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Essays in International Macroeconomics

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TABLE OF CONTENTS

LIST OF FIGURES

FIGURE

LIST OF TABLES

TABLE

LIST OF APPENDICES

ABSTRACT

This dissertation contains three essays in International Macroeconomics and Macroeconomics, more broadly defined. Together, they examine how macroeconomic shocks and policy responses shape income distribution, employment dynamics, and welfare in both open and closed economies. The chapters approach this central theme from complementary angles. The first focuses on the distributional consequences of external shocks, analyzing how commodity price booms affect inequality in commodity-exporting economies. The second examines the recovery of labor markets following financial crises, highlighting the role of financial frictions and nominal rigidities. The third studies the costs of disinflation and the potential use of price controls during stabilization episodes. Collectively, these essays contribute to a broader understanding of the interplay between macroeconomic shocks, policy design, and distributional outcomes.

Chapter 1 examines the response of income inequality to commodity price shocks and identifies the underlying mechanisms at play. I provide novel cross-country evidence from commodity-exporting nations, showing that positive commodity price shocks reduce labor income inequality between skilled and unskilled workers. This reduction in inequality is primarily driven by a fall in the skill premium, arising from the expansion of unskilled-labor-intensive sectors, such as construction, which grow more rapidly than skilled-labor-intensive ones, such as services. To interpret these results, I develop a quantitative multisector small-open-economy model that incorporates sectoral heterogeneity in both skilled-labor intensity and sensitivity to commodity price shocks. I use the model as a laboratory to explore the distributional impacts of various policy responses to commodity windfalls, demonstrating how saving or spending these gains can either reinforce or moderate the reduction in inequality. This analysis provides new insights into the broader economic and social impacts of commodity price shocks in emerging markets.

Chapter 2, which is work co-authored with Tato2, Tato3 and Tato4, we document the macroeconomic patterns that characterize labor market recovery from financial crises. Using a sample of postwar recession episodes from around the world, we show that financial crises are typically followed by jobless recoveries, with a sluggish recovery of employment relative to output. A departure from this empirical regularity occurs in emerging-market crises with high inflation, which feature strong employment recoveries but persistent declines in

real wages and result in "wageless recoveries." Our findings highlight the central role of financial components in labor input costs and nominal wage rigidities in shaping labor market dynamics following economic crises.

Chapter 3 examines the desirability of implementing price controls during inflation stabilization plans. To address this question, I develop a New Keynesian model with sticky information, which I use to assess the welfare costs associated with transitioning from a high-inflation to a low-inflation steady state. My findings show that even when the monetary authority commits to a new regime and agents do not anticipate future policy changes, welfare costs arise during the transition due to firms' gradual adaptation to the new regime. In this context, I introduce price controls as a policy tool aimed at mitigating the real costs of disinflation caused by information frictions. I then explore the trade-offs they create for policymakers. On the one hand, price controls offer macroeconomic benefits by coordinating prices during the transition, leading to a faster and less costly disinflation. On the other hand, they impose microeconomic costs by preventing firms from adjusting prices freely in response to idiosyncratic shocks. Ultimately, the optimality of price controls depends on the scale of disinflation relative to the magnitude of firm-level shocks.

CHAPTER 1

The Distributional Consequences of Commodity Booms

Abstract

This paper examines the response of income inequality to commodity price shocks and identifies the underlying mechanisms at play. I provide novel cross-country evidence from commodity-exporting nations, showing that positive commodity price shocks reduce labor income inequality between skilled and unskilled workers. This reduction in inequality is primarily driven by a fall in the skill premium, arising from the expansion of unskilled-labor-intensive sectors, such as construction, which grow more rapidly than skilled-labor-intensive ones, such as services. To interpret these results, I develop a quantitative multisector small-open-economy model that incorporates sectoral heterogeneity in both skilled-labor intensity and sensitivity to commodity price shocks. I use the model as a laboratory to explore the distributional impacts of various policy responses to commodity windfalls, demonstrating how saving or spending these gains can either reinforce or moderate the reduction in inequality. This analysis provides new insights into the broader economic and social impacts of commodity price shocks in emerging markets.

1.1 Introduction

Commodity price shocks present significant challenges for policymakers in commodity-exporting economies. A large body of research has examined the macroeconomic effects of these shocks, including how they propagate through the economy and the appropriate responses to manage their impact (Schmitt-Grohé and Uribe, 2018; Fernández et al., 2018; Drechsel and Tenreyro, 2018). Relatively little, however, is known about their potential distributional impact. Given the high and persistent levels of income inequality in commodity-dependent economies (e.g. Stiglitz, 2007, Williamson, 2015), understanding how these shocks affect the distribution of income becomes a first-order question from a policy perspective.

This paper sheds light on how labor income inequality responds to commodity price shocks and identifies the underlying mechanisms at play. I proceed in three steps. First, I provide novel cross-country evidence showing that labor income inequality between skilled and unskilled workers— the *labor income gap*—declines following positive commodity price shocks in commodity-exporting economies. Second, using detailed sectoral level data, I show that the reduction in income inequality is primarily driven by a fall in the skill premium, arising from the expansion of unskilled-labor-intensive sectors, such as construction, which grow more rapidly than skilled-labor-intensive ones, such as services. Finally, I incorporate this mechanism into a multisector small open economy (SOE) model with household heterogeneity, which I use to quantify the distributional implications of these shocks and study the implications of government policies aimed at addressing the impact of commodity booms.

It is not obvious, ex ante, whether commodity booms increase or reduce income inequality. On the one hand, because these are sectoral shocks, it is natural to anticipate that the main beneficiaries of a favorable price change might be the workers directly employed by commodity-producing sectors. The strength of this effect, however, depends on the amount of labor employed in these sectors. In this paper, I focus on commodity exporters specializing in metals or energy, sectors that employ a small share of the overall labor force. As a result, the direct employment effects within the commodity sectors are limited. On the other hand, these sectors are significant enough in terms of GDP to generate sizable national wealth effects, leading to increases in aggregate income that spill over to the rest of the economy. Whether these shocks increase or decrease inequality depends on which sectors benefit from these wealth effects and who is employed in those sectors. In simple models, these wealth effects lead to an expansion of the nontraded goods sector which tends to be dominated by relatively high skilled workers. My proposed mechanism differentiates between nontraded services and nontraded construction. Consistent with the empirical evidence, it is the impact of commodity booms on construction that drives the reduction in inequality.

I begin by empirically analyzing the effects of commodity price shocks in a sample of Latin American commodity exporters specializing in metals or energy, covering the period 1992–2019. I use a panel local-projection design with the identification assumption that changes in commodity prices are exogenous with respect to the domestic conditions of small open economies. Then, I establish three key findings. First, I find that these shocks are expansionary, triggering investment booms, real exchange rate appreciations, and reductions in interest rate spreads—findings consistent with the literature. Second, commodity price shocks lead to a decline in labor income inequality, measured as the ratio of skilled to unskilled workers' average labor income—a novel contribution to the limited research on the distributional effects of commodity booms. Finally, I provide suggestive evidence of a novel mechanism operating outside the commodity sector. Commodity booms lead to a reallocation of production toward nontradables, disproportionately benefiting unskilled-labor-intensive sectors such as construction, which experience significantly more growth compared to skilled-labor-intensive sectors such as services.

Motivated by these stylized facts, I develop a quantitative, multisector SOE model to examine the distributional effects of commodity price shocks. The foundation is an SOE model that includes tradables, nontradables, and a commodity sector treated as an endowment fully exported at an exogenous price. I enrich this setting with two key ingredients. First, I introduce heterogeneous workers, distinguishing between skilled and unskilled labor, to capture labor income inequality. For simplicity, workers live hand-to-mouth, while a single capitalist owns all assets—including the commodity endowment— and manages all saving and borrowing decisions. Second, I divide the nontradable sector into services and construction to capture their distinct responses to a commodity price shock. These sectoral differences play a critical role in shaping inequality dynamics since they employ skilled and unskilled workers with different intensities. Finally, for quantitative reasons, I incorporate an interest rate that is sensitive to commodity price fluctuations which captures common financial frictions in emerging economies.

Qualitatively, the direction of the labor-income-inequality response to a commodity price shock depends on how sectors with different skill intensities react to such shock. In both the model and the data, services are the most skilled-labor-intensive sector, while construction is the most intensive in unskilled labor. The tradeable sector lies in between, less skill-intensive than services but more skill-intensive than construction. A positive commodity price shock triggers an exchange rate appreciation, leading to a contraction in the tradable sector and an expansion in nontradables. However, within the nontradable sector, construction booms while services experience milder growth. Labor income inequality declines when the expansion in construction is large enough to offset the contraction in the tradable sector (which employs a significant number of unskilled workers) and the growth in services (which benefits skilled workers).

While the relative expansion of the nontradable sector vis-à-vis the tradable sector follows from standard Dutch-disease arguments (Corden and Neary 1982), capturing the heterogeneous responses within the nontradable sector itself requires a clear rationale for why different subsectors react differently to the same aggregate shock.[1] In the model, I incorporate the

[1]In their seminal paper, Corden and Neary (1982) introduce the term "Dutch disease" to refer to the negative economic consequences that can arise when a country experiences a boom in one sector, typically

data-supported assumption that services and construction serve as inputs for distinct final goods: services contribute to consumption goods and construction contributes to investment goods. Since commodity booms trigger investment surges, they lead to a large expansion in construction, further boosting wages and labor demand for unskilled workers.

To analyze the model's quantitative predictions, I parameterize it to a sample of Latin American economies. I begin by calibrating a set of parameters directly from the data to capture key steady-state features of these economies, including the skilled labor intensity across sectors, the relative size of the commodity sector, and additional macroeconomic moments. A second set of parameters is then estimated to match the model's impulse response functions to a commodity price shock with their empirical counterparts. To validate the model, I compare its predictions to nontargeted outcomes. The model successfully replicates the dynamic of the labor income gap and the differential response of the tradable, services, and construction sectors to a commodity price shock.

Then, I use the model as a laboratory to evaluate the distributional implications of alternative ways to allocate the revenue generated by the commodity windfall. I compare a scenario in which the entire commodity endowment is privately owned by a capitalist with a counterfactual economy where the government appropriates a share of these resources, utilizing them to implement various policies. I consider two policy options reflecting real-world practices.[2]

The first counterfactual examines a policy in which the government uses commodity revenue to make direct transfers to workers. Under this policy, a positive commodity price shock leads to a more moderate decline in labor income inequality. Since workers exhibit hand-to-mouth behavior while the capitalist is the only agent accumulating capital, this policy results in a transfer of resources from households with low marginal propensity to consume to those with high marginal propensity to consume. At the aggregate level, this generates a smaller investment response and a larger expansion in consumption, leading to a smaller boom in construction and a more significant expansion in services. This suggests a potential cost to using transfers to reduce income inequality. The cost is a reduction in investment and that reduction in investment disproportionately reduces the incomes of

due to the discovery or exploitation of natural resources (such as oil or minerals). The authors divide an economy experiencing an export boom into three sectors: the booming commodity sector and the lagging export sector, both of which are tradable-goods sectors; and the nontradable-goods sector. The influx of wealth from the resource sector leads to an appreciation of the domestic currency, making the country's other export sectors (such as manufacturing or agriculture) less competitive internationally. At the same time, resources (capital and labor) shift toward the booming resource sector and nontradable sectors such as construction or services, leaving the tradable sector underdeveloped. This imbalance can result in slower long-term growth and increased economic vulnerability when the resource boom ends.

[2] See Frankel (2010) for a detailed discussion of policies that have been implemented in resource-rich economies.

unskilled workers.

The second counterfactual examines a policy in which the government saves the majority of the windfall in a sovereign wealth fund (SWF). This policy increases national savings and reduces the interest rate, further stimulating investment and the construction sector. As a result, the decline in labor income inequality following a commodity price shock is amplified. The main takeaway from these exercises is that how income from the commodity boom is allocated has important consequences for the distribution of income.

I conduct additional empirical exercises to validate my findings. First, I perform robustness checks, confirming that the results are consistent across alternative measures of labor income inequality, different definitions of skilled and unskilled workers, and ensuring that no single country disproportionately influences the results. Second, I broaden the analysis to include a larger sample of commodity-exporting countries, demonstrating the external validity of my findings. Lastly, I discuss potential model extensions and their broader implications for understanding the distributional effects of commodity price shocks

Literature. This paper is related to several strands of the literature. First, it contributes to the literature on the effects of terms-of-trade shocks (Mendoza 1995; Kose 2002; Schmitt-Grohé and Uribe 2018) and, particularly, the effects of commodity price shocks in SOEs (García-Cicco and Kawamura 2015; Shousha 2016; Fernández et al. 2018; Drechsel and Tenreyro 2018; Alberola and Benigno 2017; Benguria et al. 2024). This body of research has made progress in quantifying the macroeconomic impacts of these shocks, including how they propagate through the economy, their role in business cycle fluctuations, and the appropriate policy responses. However, relatively little attention has been given to their potential distributional effects. I contribute to this literature by providing new evidence and develop a quantitative model that addresses the underexplored link between commodity price shocks and labor income inequality.

Second, my paper relates to the broader literature on the distributional effects of external shocks (Goldberg and Pavcnik 2007; Topalova 2010; Helpman et al. 2010; Autor et al. 2013; Adão 2015; Cravino and Levchenko 2017; Blanco et al. 2024; Aldunate et al. 2024; Benguria et al. 2024). My work shares the insights of Benguria et al. (2024), who find that positive commodity price shocks reduced the skill premium in Brazil, a large commodity exporter, during the 2000s. Their focus, however, is on mechanisms operating directly through the commodity sector, which employs a significant portion of the workforce in their context. In contrast, my study examines economies whose main commodity sector employs a small share of the labor force. I propose a new mechanism that operates indirectly through effects on non-commodity sectors. In particular, I explore the heterogeneous response within the nontradable sector, which helps explain the distributional consequences of commodity price shocks.

Third, this paper contributes to the literature on the resource curse, particularly the Dutch disease phenomenon (Corden and Neary 1982; Corden 1984; Wijnbergen 1984; Krugman 1987; Sachs 1995; Torvik 2001). Specifically, I use this theory as a starting point to examine how the reallocation of production and resources across sectors triggered by a commodity boom affects labor income inequality. I begin by showing that when the canonical Dutch-disease model is calibrated with plausible assumptions about skilled-labor intensity across sectors, it predicts a positive relationship between commodity booms and income inequality.[3] This prediction contrasts with the empirical evidence I present in this paper, which indicates a negative relationship. To reconcile the conflicting patterns between the predictions of the canonical model and the data, I extend the framework to account for heterogeneity within the nontradable sector. I demonstrate that a model distinguishing between services and construction is crucial for understanding how commodity price shocks affect labor income inequality. To the best of my knowledge, this is the first model to explicitly differentiate between these two sectors as inputs for distinct final goods. Additionally, I extend the empirical literature on Dutch disease, which has primarily focused on the divergence between tradable and nontradable sectors (Spatafora and Warner 1995; Sachs and Warner 2001; Sala-i Martin and Subramanian 2013; Magud and Sosa 2013) by providing evidence of an economy running at two-speed also within the nontradable sector.[4]

Lastly, this paper speaks to the empirical microeconomic literature examining the decline in income inequality in Latin America during the 2000s. Potential drivers identified in the literature include shifts in the supply of skilled and unskilled labor, fiscal policies, economic cycles, institutional changes, and trade liberalization (Attanasio et al., 2004; Verhoogen, 2008; Ferreira et al., 2009; Gasparini et al., 2009, 2011; López-Calva and Lustig, 2010b; Lustig and Pessino, 2014; Rodríguez-Castelán et al., 2016; Messina and Silva, 2021). My research complements these findings by providing empirical evidence that the 2000s commodity boom contributed to reductions in labor income inequality and the skill premium through the expansion of unskilled-labor-intensive nontradable sectors. Additionally, I develop a quantitative macroeconomic model that isolates this specific mechanism.

Outline. The rest of the paper is organized as follows. Section 1.2 presents evidence of the main empirical regularities that characterize episodes of favorable change in commodity

[3]Galiani et al. (2010) show that this theoretical result is also plausible in a Heckscher-Ohlin-Samuelson (HOS) model with a non-tradable sector and skilled/unskilled labor.

[4]An exception is Bjørnland and Thorsrud (2016), who analyze productivity spillovers from the booming sector to other domestic sectors.

prices with a focus on the link between them and labor income inequality. Section 1.3 presents the model. Section 1.4 describes the parameterization of the model and its main predictions for labor income inequality with data counterparts. Section 1.5 studies the distributional implications of alternative policies to use revenue generated by the commodity windfall. Finally, Section 2.4 concludes.

1.2 Empirical Evidence on Commodity Booms

This section provides descriptive evidence about the empirical regularities that characterize favorable changes in commodity prices for a sample of commodity-exporting countries. First, I corroborate the finding that commodity price shocks are an important source of business cycle fluctuations in these countries. Second, I document a negative correlation between commodity booms and labor income inequality. Finally, I show that following favorable changes in commodity prices, there is an expansion led by unskilled-labor-intensive sectors. Section 1.2.1 presents my sample and the main data sources. Section 1.2.2 discusses the empirical model. Section 1.2.3 presents the results. Section 1.2.4 and 1.2.5 performs a series of additional exercises to ensure the validity of the results.

1.2.1 Data, Sample, and Definitions

Sample. I focus on a sample of six Latin American countries from 1992 to 2019: Bolivia, Chile, Colombia, Ecuador, Mexico, and Peru. Latin America is a suitable region for studying my topic for a few reasons. First, it is the most unequal region in the world in terms of income, making the topic highly relevant to public policy. Second, during the 2000s, the region experienced a commodity boom that coincided with a fall in income inequality; since then, academics and policy analysts have investigated whether these events were related.[5] Finally, the availability of harmonized microdata across these countries allows for a reliable comparison of inequality measures between them without major concerns.

These countries have some common features worth mentioning (see Table 1.1). First, commodities represent a large share of their total exports. Second, their export profile is biased toward metals or energy commodities (ME) such as gold, copper, coal, and oil; ME represents, on average, more than 73% of their total commodity exports.[6] Third, these

[5] See López-Calva and Lustig (2010a); Gasparini et al. (2011); Lustig et al. (2016); Messina and Silva (2021)

[6] Appendix A.1 gives a detailed list of the 13 commodities that fall into this category. To give some sense of the export profile of these countries, in Appendix Table A.1 I list their largest export commodities as a share of total commodity exports.

sectors are tiny in terms of employment (employing less than 2% of the labor force) but large in terms of GDP (with an average share close to 10%). This evidence suggests that the direct effects of commodity price shocks (within the commodity sector) may be limited in these countries. Instead, the main transmission mechanisms influencing labor income inequality likely operate through indirect channels (outside the commodity sector).

Table 1.1: Countries included in the sample - Main Characteristics

	(1)	(2)	(3)	(4)
Country	Commodities (% of total exports)	ME Commodities (% of total Commodity exports)	Employment in ME (% of total) employment)	ME Commodities (% of GDP)
Bolivia	92.2%	75.0%	1.7%	11.1%
Chile	85.9%	76.2%	1.8%	11.6%
Colombia	70.7%	71.1%	1.1%	8.9%
Ecuador	91.9%	56.1%	1.5%	7.3%
Mexico	25.8%	88.9%	0.5%	6.8%
Peru	87.3%	76.2%	1.0%	10.1%
Average	75.6%	73.9%	1.3%	9.3%

Notes: This table presents some key summary statistics for the countries included in my sample. Column (1) shows the share of all commodities in total exports. Column (2) shows the share of metals and energy commodities in total commodity exports. Column (3) shows the share of employment in metals and energy commodities in the total labor force. Column (4) shows the value added of metals and energy commodities as a share of GDP. Values for each country are averages for the period 1992–2019.

Commodity prices. Since the study countries specialize in metals or energy commodities, I construct country-specific commodity price indexes that only include these goods, following standard practices in the literature (see Shousha 2016, Fernández et al. 2018, or, more recently, Gruss and Kebhaj 2019). Commodity price index $P_{i,t}^{Co}$ for country i in period t is defined as follows:

$$P_{i,t}^{Co} = \frac{\sum_{j=1}^{N} \Omega_{i,0}^{j} P_t^j}{P_t^M}$$

Here, P_t^j is commodity j's real USD spot price in world markets at time t and $\Omega_{i,0}^j$ represents its weight for country i. The weights are computed as the ratio of country i's exports of commodity j to total commodity exports at the beginning of the sample using UN Comtrade data.[7] I take $P_{j,t}$ from the Gruss and Kebhaj (2019) database, which uses nominal prices from the International Monetary Fund's Primary Commodity Price Database, and deflate them by the organization's unit value index for manufacturing exports (MUV index), denoted by P_t^M.

[7] Using the average across all period for weights generates very similar commodity price indexes for all countries.

Labor income inequality measure. For my labor income inequality measure I use the Socio-Economic Database for Latin America (SEDLAC), which relies on household surveys to generate statistics about labor income, education level, and other social indicators for Latin American countries. The main feature of this dataset is that all the indicators provided are constructed following the same methodology in all countries, which allows for a reliable comparison among them over time.[8] My main measure of labor income inequality is the *labor income gap*, which I define as the ratio of the average labor income of skilled (or high-skilled) workers (y_t^H) to the average labor income of unskilled (or low-skilled) workers (y_t^L):[9]

$$\eta = \frac{\text{Skilled labor income } (y_t^H)}{\text{Unskilled labor income } (y_t^L)}$$

Labor income is measured after taxes and does not include government transfers. I choose this measure to be consistent with the measure that I use below in the quantitative model. In Appendix Table A.2 , I show high comovement between this measure and alternative measures of income inequality such as the Gini coefficient and the ratio of the 90th percentile to the 10th percentile, among others. Skilled workers are defined as those who have at least completed high school, while unskilled workers are those who have not completed high school. Using this measure, I arrive at a balanced sample between the two groups. During the study period, the average share of skilled workers over total working population across countries is around 46%.[10]

Aggregate data. Data on GDP, consumption, and investment are expressed in constant prices in local currency units. The real exchange rate is constructed using the nominal exchange rate (measured in units of local currency per US dollar), the domestic consumer price index, and the US consumer price index. All these data come from the International Monetary Fund's International Financial Statistics Dataset. I use the country-specific J.P. Morgan's Emerging Market Bond Index (henceforth, EMBI) as a proxy variable to measure country credit spreads in emerging markets; the data are from Bloomberg.

[8] A detailed description of the database and variable definitions can be found in Appendix A.1.

[9] Throughout the paper, I use labor income or labor earnings as equivalent terms. This measure of inequality has been used in other works; see Giarda (2021, 2023).

[10] Appendix Table A.3 shows that using an alternative measure of skilled worker, such as "some college or more," would imply that skilled workers are, for the average of countries in my sample, only 16% of the total working population. This is mainly because we are considering developing economies. Applying the "some college or more" measure to the US would yield a value of 59.8%, while applying the "high school or more" measure would give us a value of 90.1%. My measure of labor income inequality compares something like the top 50 to the bottom 50 of the income distribution.

Sectoral data. I take value added in each sector from national accounts of each country. Additionally, for each country and sector, the SEDLAC database allows me to observe the fraction of total workers that are skilled or unskilled. Based on this database, I define a sector's skilled-labor intensity as the share of skilled workers relative to total workers in that sector.[11]

1.2.2 Empirical specification

I now provide descriptive evidence to characterize the response of key variables to changes in commodity prices by estimating local projections in the style of Jordà (2005). My empirical model is closest to that in Gruss and Kebhaj (2019) and Gazzani et al. (2024). I rely on the standard identification assumption that changes in commodity prices are exogenous to the domestic conditions of small open economies (see, for example, Mendoza 1995; Schmitt-Grohé and Uribe 2018). I make two small departures: First, I analyze commodity price shocks that arise only because of changes in metals or energy commodities; second, I use measures of labor income inequality as outcome variables.

I estimate equations of the following form:

$$y_{i,t+h} - y_{i,t-1} = \alpha_i^h + \phi\, T + \beta_0^h p_{i,t}^{Co} + \sum_{j=1}^{J_p} \beta_j^h p_{i,t-j}^{Co} + \sum_{j=1}^{J_y} \rho_j^h \Delta y_{i,t-j} + \epsilon_{i,t+h}, \tag{1.1}$$

where y is a variable of interest; $p_{i,t}^{Co}$ is my measure of a commodity price shock, which I denote as the detrended commodity price index for country i in period t;[12] α_t^h is a country fixed effect; and $\epsilon_{i,t+h}$ is the residual at horizon h clustered at the country level. Additionally, I include a quadratic trend T for nonstationary outcome variables. This specification is estimated by ordinary least squares for each horizon h. The main coefficient of interest is β_0^h, which measures the cumulative growth of variable y, h years after a change in the commodity price index. Notice that I assume that the coefficients are common across countries,i.e., I

[11] I classify sectors according to ISIC-4: agriculture & fishing, mining, manufacturing, utilities, construction, commerce, hotels & restaurants, transport & communication, finance, business, public administration, teaching, health, and others. I follow Benguria et al. (2024) and leave out domestic services. For each country, I define skill intensity in sector s as $SI^s = \sum \omega_j^s \left(\frac{H_j}{H_j+L_j}\right)$, where ω_j^s is the weight that subsector j has on sector s and is given by the number of workers in j over the number of workers in s; H_j, L_j are the proportions of high- and low-skill workers in subsector j, respectively.

[12] The reason to study stationary shocks is to be consistent with the model that I work with, which is also stationary. In the baseline case, I obtain the detrended component of the commodity price index by estimating for each country a quadratic-trend time polynomial of the form $y_t = \gamma_0 + \gamma_1 t + \gamma_2 t^2 + \epsilon_t$, where $p_t^{Co} = \epsilon_t$ is the cyclical component of the series. This is standard practice in the literature (see Shousha (2016), Schmitt-Grohé and Uribe (2018), among others). Recently, Bilal and Känzig (2024) use a similar approach to identify global temperature shocks and study the macroeconomic impact of climate change. In a robustness exercise in Appendix A.2.1, I use alternative filters like a linear trend and the HP filter.

compute a pooled estimator to obtain an average effect. The country fixed effects control for permanent differences across countries, while the time trend captures systematic long-term changes in the dependent variable.[13] In the baseline specification, I use $J_p = J_y = 2$.

1.2.3 Evidence on Commodity Booms

This section presents three key findings on the empirical patterns that emerge from favorable changes in commodity prices in commodity-exporting countries. First, I show that commodity booms are expansionary, leading to surges in investment, real exchange rate appreciation, and a narrowing of interest rate spreads. Second, I document a novel finding: Labor income inequality declines following commodity price shocks. Finally, I provide suggestive evidence of a potential mechanism driving this reduction in inequality. Specifically, commodity price shocks have heterogeneous effects across sectors, disproportionately benefiting unskilled-labor-intensive industries, such as construction, which experience stronger growth compared to skilled-labor-intensive industries, such as services.

Fact 1: Macroeconomic effects around Commodity Booms

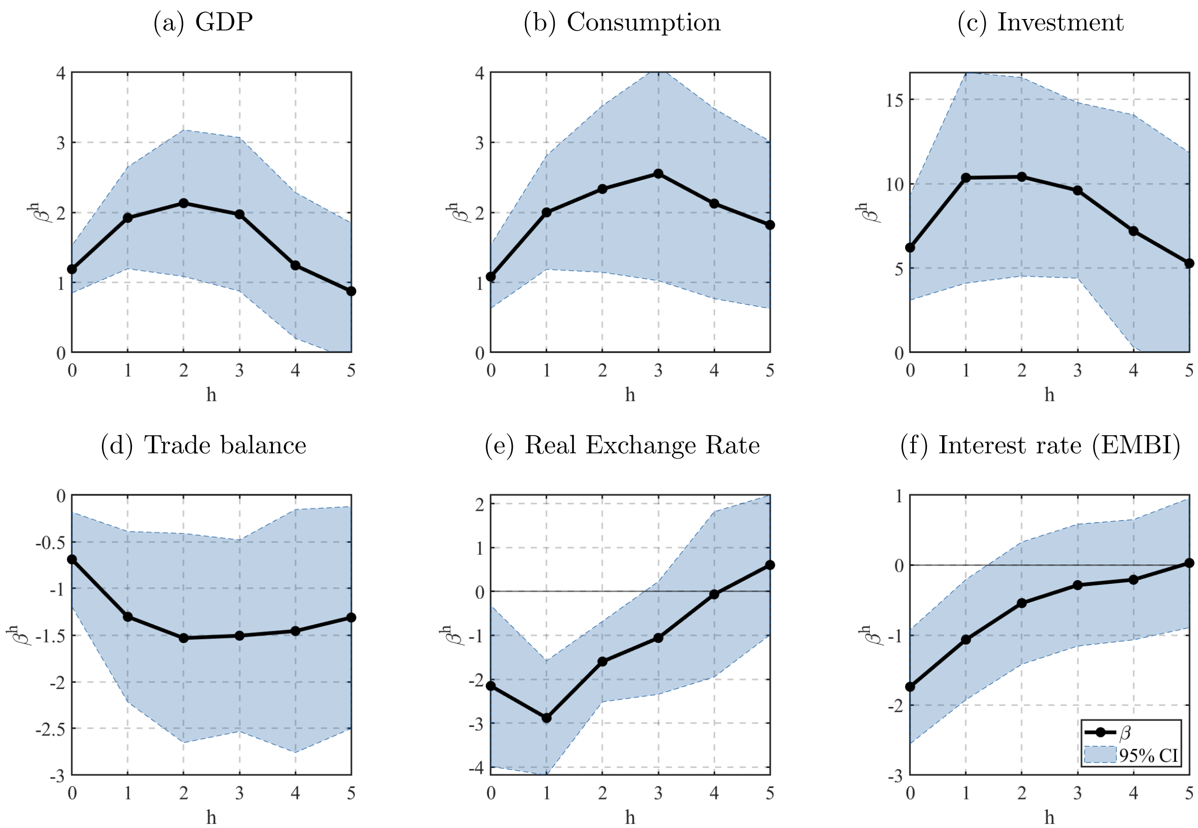
Figure 1.1, panels (a)–(f) show the response of key macroeconomic variables to a 10% increase in commodity prices, obtained by estimating equation (1.1). For the sample of countries considered, this 10% increase in $p_{i,t}^{Co}$ corresponds to a shock of approximately one standard deviation. The black solid lines depict the estimates of β_0^h for different horizons h, while shaded areas represent 95% confidence intervals. The results show persistent, statistically and economically significant positive responses of output, consumption, and investment. Investment displays the largest response with cumulative growth of around 12% four years after the shock. These responses are in line with those found in previous works (see Shousha, 2016; Fernández et al., 2017; Schmitt-Grohé and Uribe, 2018).

The total trade-balance to GDP ratio response is negative on impact of the shock, and there is a persistent real exchange rate appreciation, which means that the improvement in the commodity price index causes the countries' exports to become more expensive vis-à-vis the rest of the world. While the response of the real exchange rate is as expected, the response of the ratio of trade balance to GDP only mirrors findings by Drechsel and Tenreyro (2018) and Gazzani et al. (2024).

[13] The way I have written my empirical specification allows the model to determine by itself the weight assigned to long-term factors (captured by the quadratic trend) and the rest of the explanatory variables. An alternative way to proceed would be to detrend the dependent variables before including them in the model.

Finally, there is a significant and negative response of interest rate spreads: A 10% increase in commodity prices generates a fall in spreads of around 1.7 percentage points on impact. This result confirms previous findings highlighting the existence of strong negative comovement between commodity prices and interest rate spreads (see Bastourre et al. 2012, Shousha 2016, Drechsel and Tenreyro 2018). If the spread falls during a commodity boom, then there is an additional source of amplification of the shock on the aggregate economy. Appendix Figure A.7 presents the response of some additional variables.

Figure 1.1: Dynamics around Commodity Booms



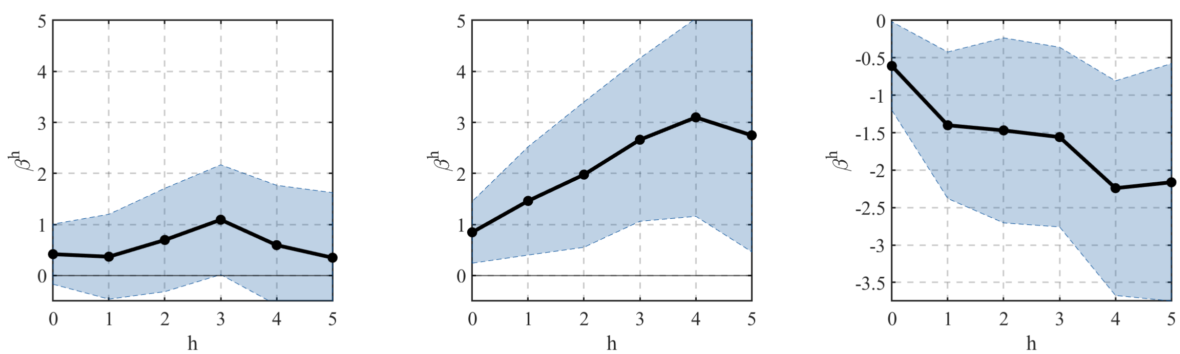
Notes: This figure plots the responses of (a) GDP, (b) consumption, (c) investment, (d) ratio of trade balance to GDP, (e) real exchange rate, and (f) EMBI to a 10% change in commodity prices. Each plot shows the coefficient β_h^0 obtained by running equation (1.1) in the text for different horizons h. Error bands represent 95% confidence intervals. All variables are expressed in log differences except for the ratio of trade balance to GDP and the EMBI index, which are expressed in absolute differences.

<u>Fact 2</u>: Commodity Booms reduce labor income inequality

While the macroeconomic effects of commodity price fluctuations have been widely studied, their potential distributional impacts remain less understood. This study attempts to fill this gap. Figure 1.2 illustrates the dynamics of labor income for high- and low-skilled workers to a 10% increase in commodity prices. Both groups experience income growth, but the income of unskilled workers rises twice as much on impact and continues to increase over the first four years. This divergence leads to a cumulative reduction in the labor income gap of 2.3% four years after the shock.

Figure 1.2: Labor income dynamic around Commodity Booms

(a) High-skill labor income (b) Low-skill labor income (c) Labor income gap $\frac{y^H}{y^L}$



Notes: This figure plots the responses of (a) real average labor income of high-skilled workers, (b) real average labor income of low-skilled workers, and (c) the labor income gap (log difference between average high-skilled and average low-skilled labor income) to a 10% change in commodity prices. Each plot shows the coefficient β_h^0 obtained by running equation (1.1) in the text for different horizons h. Error bands represent 95% confidence intervals.

These responses are substantial, especially considering the inherent volatility of commodity prices and their tendency to experience significant fluctuations. For instance, under price increases similar to those seen during the 2000s commodity boom—when the detrended component of the commodity price index rose by around 30% for the average country in my sample—the baseline results indicate a reduction in labor income inequality of around 6.7%, four years after the shock.

However, examining labor income alone provides limited insight into whether the observed reduction in labor income inequality stems from shifts in relative wages, hours worked, or both. Appendix Figures A.8 and A.9 display the separate responses of wages and hours worked for each worker type to a positive commodity price shock. I find that the reduction in labor income inequality is primarily driven by a contraction in the skill premium, which cumulatively falls by 2.5% within four years after the shock. Meanwhile, number of hours worked shows similar responses across skilled and unskilled workers, with no significant statistical or economic response. These results align with studies attributing a preponderant role to the skill premium in accounting for the fall in labor income inequality observed in Latin America during the 2000s (López-Calva and Lustig, 2010a; Gasparini et al., 2011; Azevedo et al., 2013; Rodríguez-Castelán et al., 2016; Benguria et al., 2024, among others).

It is also worth noting that the labor income inequality measure used here is inherently conservative. When alternative inequality measures, such as the income ratios of the 90th to 10th or 95th to 5th percentiles, are applied, the estimated effects nearly double. A similar conclusion is reached when considering the Gini coefficient, which exhibits a cumulative reduction of 2 percentage points in response to a 10% increase in commodity prices five years post-shock (see Appendix A.2.2.1). In what follows, I provide suggestive evidence on the potential forces linking positive commodity price shocks with changes in income inequality."

Fact 3: Commodity booms lead to booms in unskilled-labor-intensive sectors

As I documented above, commodity sectors employ only a small fraction of the total labor force in the economies in my sample. Understanding how the other sectors are affected by commodity price shocks and who works in these sectors is essential to understand the consequences for labor income inequality. I start by dividing the noncommodity part of the economy into two types of sectors: tradable and nontradable.[14]

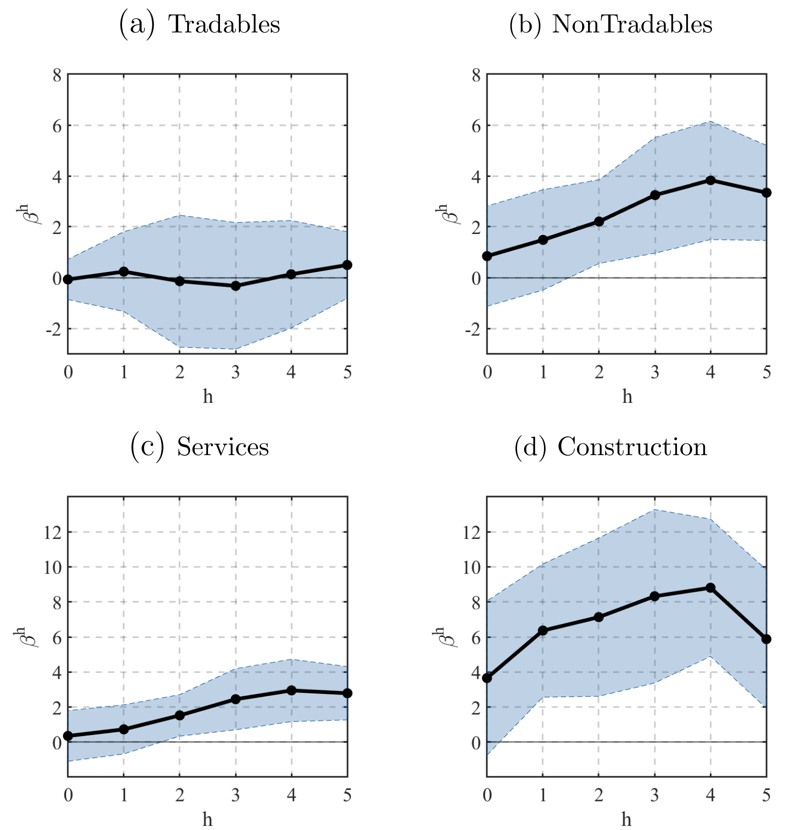
Figure 1.3, panels (a)–(b) show that following a favorable change in commodity prices, there is a relative expansion of the nontradable sector vis-à-vis the tradable sector. This behavior can be interpreted through the lens of the Dutch-disease framework. A boom in the commodity sector triggers an increase in national income and a rise in spending on all goods. While traded goods can be bought abroad, the increased demand for nontradable goods can only be satisfied with domestic production. This generates an appreciation of the real exchange rate and a reallocation of production and resources from the tradable to the nontradable sector.

When looking at skilled labor intensity across these sectors, it is evident that it is very different. Figure 1.4, panel (a) shows that the nontradable sector is intensive in skilled labor relative to the tradable sector; in the former the share of skilled workers is 53.2%, whereas

[14]Tradables include agriculture and manufacturing; nontradables include construction, utilities, commerce, hotels & restaurants, transport & communication, finance, business, public administration, teaching, health, and others. This is the same grouping used by Corden and Neary (1982); Corden (1984).

in the latter it is 29.6%.[15] If the skilled-labor-intensive sector (nontradable) is expanding relative to the unskilled-labor-intensive one (tradable), then we should expect a rise in the labor income gap instead of the fall I document in the data. How is it possible to reconcile these apparently contradictory patterns?

Figure 1.3: Sectoral dynamic around Commodity Booms



Notes: This figure plots the output response of the (a) tradable sector, (b) nontradable sector, (c) services sector, and (d) construction sector to a 10% increase in commodity prices. Each plot shows the coefficient β_h^0 obtained by running equation (1.1) in the text for different horizons h. Error bands represent 95% confidence intervals. All variables are expressed in log differences.

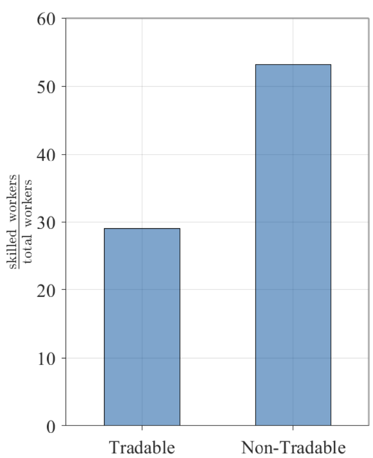
While it is true that the nontradable sector is intensive in skilled labor overall, it hides a lot of heterogeneity inside. Figure 1.4, panel (b) illustrates this point: While in some sectors more than 90% of workers are skilled (teaching and finance), others, such as construction,

[15] This result is interesting in itself since it contradicts part of the common wisdom that considers the nontradable sector as intensive in unskilled labor relative to the tradable sector (see Goderis and Malone, 2011; Guerra-Salas, 2018; Rodríguez-Castelán et al., 2016). Moreover, this result holds even when I do not consider agriculture as part of the tradable sector and I just compare manufacturing against the nontradable sector (see Appendix Table A.5)

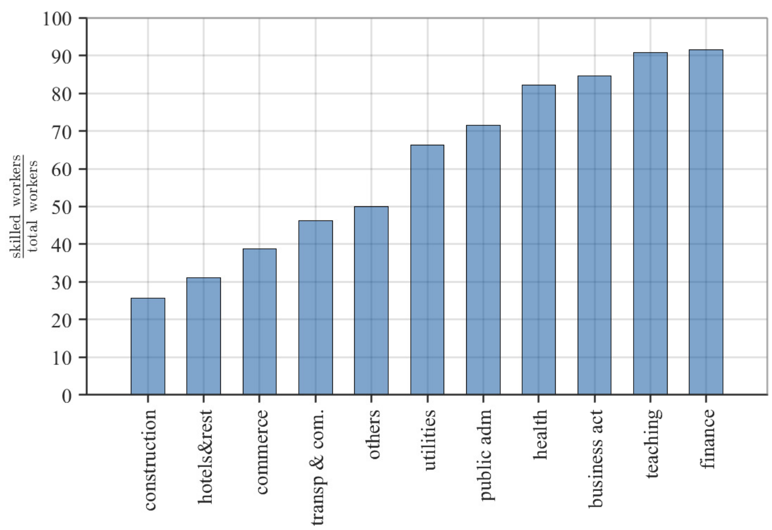
are highly intensive in unskilled labor.[16] Construction is even more intensive in unskilled labor than the tradable sector, with a share of skilled workers of 26.4%.[17] How production in these subsectors responds to commodity price shocks may be informative about potential channels driving the dynamics of labor income inequality. For a few reasons, a natural comparison consists of disaggregating the nontradable sector into services and construction: (i) Construction is the most unskilled-labor-intensive sector within the nontradable sector; (ii) construction is the only goods-producing sector in the nontradable sector; (iii) the two categories differ in the nature of their use (services are more linked to consumption, while construction is more linked to investment).

Figure 1.4: Skilled labor intensity across sectors

(a)



(b)



Notes: Panel (a) plots the fraction of skilled workers in total workers in the tradable and nontradable sectors. Panel (b) plots the fraction of skilled workers out of total workers for each subsector within the nontradable sector. The tradable sector includes agriculture and manufacturing. The nontradable sector includes construction, hotels & restaurants, commerce, transportation & communication, others, utilities, public administration, health, business activities, teaching, and finance. To get a single value for tradables and nontradables I compute a weighted average of skilled labor intensity for each country in each year. Then, I take the average across time and countries.

[16] Appendix Figures A.1–A.6 show that this pattern also holds within each country in the sample.

[17] Appendix Table A.4 compares the skilled labor intensity for each country between the tradable sector, services, and construction.

Figure 1.3, panels (c)–(d), shows sharp differences within the non-tradable sector. Following a 10% increase in commodity prices, the construction sector experiences cumulative growth of around 8% two years after the shock, while services expand by less than 2% over the same period. Appendix-Figure A.10 shows that the same pattern arises when looking at the employment shares across sectors.[18] This distinction has been overlooked in the empirical literature on Dutch Disease, which has primarily focused on the divergence between tradable and non-tradable sectors.

Together, these results support the following narrative: Commodity booms lead to non-uniform behavior across sectors. As predicted by the Dutch-disease framework, the non-tradable sector expands at the expense of the non-commodity tradable sector. This dynamic alone might suggest an increase in inequality, given the varying skill intensities across sectors. However, a closer look at the nontradable sectors reveals the existence of a two-speed economy: Construction, the most unskilled-labor-intensive sector, grows four times faster than services, the most skilled-labor-intensive sector in the economy. This differential increase can boost the labor demand and wages of unskilled workers, contributing to a reduction of labor income inequality.

1.2.4 Robustness

I perform a number of robustness checks to ensure the validity of the results: (i) Appendix A.2.2.1 examines alternative inequality measures; (ii) Appendix A.2.2.2 modifies the definition of skilled and unskilled workers, defining skilled workers as those with at least some college education rather than only a completed high school education; (iii) Appendix A.2.2.3 assess whether outliers influence any of the results regarding labor income inequality by excluding one country at a time; (iv) Appendix A.2.2.4 detrends the country specific commodity price index by alternative methods; (v) Appendix A.2.2.5 includes additional control measures in the baseline specification to account for global factors that may influence commodity prices; these include the series of U.S. monetary policy shocks from Jarociński and Karadi (2020), a measure of the global financial cycle highlighted by Rey (2015) and Miranda-Agrippino and Rey (2020), and a measure of the nominal broad dollar index from Obstfeld and Zhou (2022). In all cases, the main conclusions remain unchanged.

[18] In a complementary exercise, I show that labor reallocation increases following commodity booms (see Appendix-Figure A.11). Here, I construct a reallocation index based on Chodorow-Reich and Wieland (2020)

1.2.5 External validity

How representative are my results for other commodity exporters not included in the sample? I build a sample of countries classified by UNCTAD (2021) as commodity-dependent economies specializing in metals or energy commodities, for the period 1980 to 2018. I use the Gini coefficient as my measure of income inequality since it is the indicator that allows for a wider comparison across countries and time. Given my interest in studying income inequality, I only keep countries that have at least 10 years of continuous data for this variable. I end up with a sample of 52 countries. The list of countries is reported in Appendix Table A.6. Qualitatively, the main results remain unchanged.

Taking stock

This section presented three key pieces of empirical evidence on the macroeconomic, distributional, and sectoral effects of commodity booms. First, commodity price shocks trigger investment surges and reductions in interest rates. Second, they lead to a decline in labor income inequality between skilled and unskilled workers. Moreover, the sectors that experience the most significant expansion are those that are intensive in unskilled labor. Building on these empirical patterns, the next section introduces a quantitative SOE model to analyze the distributional consequences of commodity price shocks.

1.3 Model

In this section, I develop a quantitative model to study the distributional consequences of commodity price shocks. Later, I use the model as a laboratory to think about the distributional implications of alternative ways of using revenue generated by the commodity windfall.

Time is discrete, infinite, and indexed by t. The backbone is an SOE model with tradable goods, nontradable goods, and a commodity sector, which is an endowment fully exported at an exogenous price. The main ingredients of the model are the following. First, given the emphasis on labor income inequality, I add heterogeneous workers who differ in their skills and in which sectors they are more intensively employed in. Second, I model two nontradable sectors: services and construction that are used as inputs of different final goods. With this modelling choice, I aim to capture the heterogeneous response of these sectors to the commodity price shock, which is key to explaining the behavior of labor income inequality. Finally, for quantitative reasons, I model an interest rate that is sensitive to commodity price fluctuations which captures common financial frictions in emerging economies.

The economy is populated by heterogeneous workers, a single capitalist who owns the commodity endowment, final consumption-good, and investment-good producers, and three intermediate goods producers operating in the tradable, service, and construction sectors. The rest of the model is kept as simple as possible.

Next, I describe each agent's problem, define the competitive equilibrium of this economy, and briefly describe the solution method.

1.3.1 Production

The economy is populated by final consumption-good producers, final investment-good producers, and three intermediate-good producers operating in the tradable (T) sector and the nontradable sectors, services (S) and construction (C). Final good producers buy inputs from intermediate-goods producers and sell their production to households, who allocate it to consumption or investment purposes.

1.3.1.1 Final good producers

Final good producers behave competitively; they combine tradable and nontradable inputs to produce consumption and investment goods. I depart from standard SOE models and assume that the two types of final good producers use different nontradable inputs. In particular, final consumption-goods producers demand inputs from the service sector, while investment-goods producers demand inputs from the construction sector. This feature of the model is crucial since it allows me to generate a different dynamic for the service and construction sectors following the same aggregate shock.

Final consumption goods. There is a representative firm that produces a final consumption good c_t by combining intermediate goods from the tradable c_t^T and service sectors c_t^S with constant elasticity of substitution (CES) aggregation technology:

$$c_t = \left[\varphi^{1/\varepsilon_c}\left(c_t^S\right)^{1-1/\varepsilon_c} + (1-\varphi)^{1/\varepsilon_c}\left(c_t^T\right)^{1-1/\varepsilon_c}\right]^{\frac{\varepsilon_c}{\varepsilon_c-1}} \tag{1.2}$$

where ε_c is the elasticity of substitution and $0 < \varphi < 1$ governs the share of services in aggregate consumption. The profit-maximization problem of the final good producer is as follows:

$$\max_{c_t^S, c_t^T} \; p_t c_t - p_t^S c_t^S - c_t^T \quad \text{subject to (1.2)}$$

where p_t, p_t^S are the relative prices of the final consumption good and the inputs from the service sector in terms of the tradable good, which is the numeraire ($P_t^T = 1 \; \forall t$).

Final investment goods. A representative firm produces a final investment good i_t by combining intermediate goods from the tradable x_t^T and construction sectors x_t^C with CES aggregation technology:

$$i_t = \left[\gamma^{1/\varepsilon_i}\left(x_t^C\right)^{1-1/\varepsilon_i} + (1-\gamma)^{1/\varepsilon_i}\left(x_t^T\right)^{1-1/\varepsilon_i}\right]^{\frac{\varepsilon_i}{\varepsilon_i-1}} \tag{1.3}$$

where ε_i is the elasticity of substitution and $0 < \gamma < 1$ governs the share of construction in aggregate investment. Broadly speaking, investment goods can be classified into two types: equipment/machines and buildings/infrastructure. While the former is mostly tradable, the latter is nontradable and is associated with the construction sector in my model. Then, any shock that generates an investment boom will also generate a construction boom because the required increase in the supply of investment goods to satisfy the greater demand requires more inputs from both the tradable and construction sectors. This effect is relevant for my purposes since the construction sector is the most unskilled-labor-intensive sector in the economy. Then, the profit-maximization problem of the final good producer is as follows:

$$\max_{x_t^C, x_t^T} \; p_t^I i_t - p_t^C x_t^C - x_t^T \quad \text{subject to (1.3)}$$

where p_t^I, p_t^C are the relative prices of the final investment good and the output from the construction sector.[19] [20]

1.3.1.2 Intermediate good producers

Each intermediate good $s \in \{T, S, C\}$ is produced by a representative firm that combines capital and labor with the following Cobb-Douglas production function:

$$y_t^s = a^s \left[\left(l_t^{H,s}\right)^{\theta_s}\left(l_t^{L,s}\right)^{1-\theta_s}\right]^{\alpha_s} \left(k_t^s\right)^{1-\alpha_s}, \quad \alpha_s, \theta_s \in (0,1) \tag{1.4}$$

where y_t^s is output in sector s, $\{l_t^{H,s}, l_t^{L,s}\}$ are high- and low-skilled labor inputs, k_t^s are capital inputs, a^s is a productivity factor, and α^s and θ^s are technology parameters. Two important features of the production technology are worth highlighting. First, I depart from standard SOE models and allow for two types of labor inputs used with different intensities

[19] From the expenditure-minimization problem for aggregate consumption and investment is possible to recover their respective price indexes: $p_t = \left[\varphi(p_t^S)^{1-\varepsilon_c} + (1-\varphi)\right]^{\frac{1}{1-\varepsilon_c}}, p_t^I = \left[\gamma(p_t^C)^{1-\varepsilon_i} + (1-\gamma)\right]^{\frac{1}{1-\varepsilon_i}}$.

[20] As I show below, how I have written the model rules out the possibility that households can directly demand construction goods as could happen in a model with housing or durable goods; households demand investment goods, and these are built with construction goods. I leave the discussion about housing and commodity price shocks for future research.

in each sector. Second, I assume that the service sector is the most skilled-labor-intensive sector, while construction is the most unskilled-labor-intensive one: $\theta_S > \theta_T > \theta_C$. This assumption is supported by the observations made in Section 1.2.3.[21]

Finally, intermediate goods firms' profit maximization is achieved as follows:

$$\max_{l_t^{H,s}, l_t^{L,s}, k_t^s} \Pi_t^s = p_t^s y_t^s - w_t^H l_t^{H,s} - w_t^L l_t^{L,s} - u_t^s k_t^s, \quad \forall s \in \{T, S, C\}$$
$$\text{subject to (1.4)}$$

where p_t^s is the price of the intermediate good s and u_t^s is the rental rate of capital in sector s. Since firms are assumed to behave competitively in product and factor markets and operate constant-returns-to-scale production technologies, they always make zero profits.

1.3.2 Households

There is a mass κ of capitalists and a mass $1-\kappa$ of workers. Within the mass of workers, a mass μ is low skilled (L) and the remaining $1-\mu$ is high skilled (H). All workers of a given type are identical and cannot switch across groups. Workers consume and supply labor. Having a capitalist who owns all assets in the economy allows me to draw clear conclusions about the response of labor income inequality to commodity price shocks; the conclusions do not depend on how assets are distributed across workers.

1.3.2.1 Workers

Workers supply labor to the firms and make consumption decisions; they cannot save or borrow, so they behave in hand-to-mouth fashion, entirely consuming their current labor income. Each worker type is indexed by $j = \{H, L\}$, where H refers to high skilled (or skilled) and L refers to low skilled (or unskilled). Worker j has lifetime utility given as follows:

$$\mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} \beta^t u^w \left(c_t^j, l_t^j \right) \right\} \tag{1.5}$$

where, c_t^j denotes the final consumption good in period t by worker j; l_t^j are total hours worked by worker j; $u^w(.)$ is a continuous, differentiable, increasing, and concave function in which w denotes workers, $\beta \in (0,1)$ denotes the subjective discount factor, and $\mathbb{E}_t$ denotes

[21] Proposition I in Appendix A.3.2 shows that under perfect labor mobility and equal labor shares across sectors ($\alpha_T = \alpha_S = \alpha_C$): A sufficient condition for $\theta_S > \theta_T > \theta_C$ is that $\frac{l_t^{H,S}}{l_t^{L,S}} > \frac{l_t^{H,T}}{l_t^{L,T}} > \frac{l_t^{H,C}}{l_t^{L,C}}$. This final condition is what I showed holds true in the data in Section 1.2.3.

the expectation conditional on the information set available at time t. Under the assumption of free labor mobility, workers can move between sectors in response to wage differentials, ensuring that a single equilibrium wage exists for each worker type: $\{w_t^H$ and $w_t^L\}$.[22] I define $y_t^j = w_t^j l_t^j$ as labor income for worker j; then, $\eta_t = \frac{y_t^H}{y_t^L}$ is the same measure of labor income inequality I used in Section 1.2. Last, worker j solves an intratemporal problem choosing sequences $\{c_t^j, l_t^j\}_{t=0}^{\infty}$ that maximize expected utility (1.5) subject to the following budget constraint:

$$p_t c_t^j = w_t^j l_t^j \tag{1.6}$$

1.3.2.2 Capitalist

A representative capitalist is the sole owner of all assets in the economy: the commodity endowment, the productive capital, and all the firms. In each period, she receives income from renting capital to intermediate good producers, receives profits from the firms, and inherits capital from past investments. In addition, she consumes a final good, makes investment decisions to affect the stock of capital in each sector s, and saves or takes debt in foreign assets. The capitalist maximizes:

$$\mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} \beta^t u^k \left(c_t^k \right) \right\}, \tag{1.7}$$

subject to the period budget constraint

$$p_t c_t^k + p_t^I \sum_s i_t^s + (1 + r_{t-1}) d_{t-1}^k = d_t^k + \sum_s u_t^s k_t^s + \sum_s \Pi_t^s + p_t^{Co} y^{Co} \tag{1.8}$$

and the capital-accumulation equation:

$$k_{t+1}^s = (1-\delta) k_t^s + \left[1 - \Phi \left(\frac{i_t^s}{k_t^s} \right) \right] i_t^s, \quad \forall s = \{T, S, C\} \tag{1.9}$$

where c^k denotes the consumption of the capitalist in period t; i_t^s is investment in sector s; p_t^I is the relative price of the investment good; d_t^k is the stock of international debt; r_t is the interest rate faced by the SOE for foreign assets; $u_t^s k_t^s$ is capital income from renting capital k_t^s to firms in sector s at rental rate u_t^s; Π_t^s are profits from intermediate good producers in sector s, and $\Phi(.)$ are capital adjustment costs that I introduce to have a better fit with the data. Finally, the capitalist receives income from owning the commodity endowment y^{Co}, fully exported at an international relative price p_t^{Co}. This means that commodity price

[22] In steady state, I assume $w^H > w^L$.

shocks act as pure wealth shocks that increase capitalist revenue. Last, the capitalist chooses sequences $\{c_t^k, \{k_{t+1}^s, i_t^s\}_{\forall s}, d_{t+1}^k\}_{t=0}^{\infty}$ to maximize her lifetime utility (1.7) subject to (1.8) and (1.9).

1.3.3 Aggregation and Market Clearing

The equilibrium in final goods markets is given as follows:

$$c_t = \kappa\ c_t^k + (1-\kappa)[\mu\ c_t^L + (1-\mu)\ c_t^H] \tag{1.10}$$

$$i_t = i_t^T + i_t^S + i_t^C \tag{1.11}$$

The market-clearing condition for intermediate nontradable goods (services and construction) requires that

$$y_t^S = c_t^S \tag{1.12}$$

$$y_t^C = x_t^C. \tag{1.13}$$

Labor markets for each worker type $j = \{H, L\}$ clear according to the following equations:

$$(1-\mu)\ l_t^H = l_t^{H,T} + l_t^{H,S} + l_t^{H,C} \tag{1.14}$$

$$\mu\ l_t^L = l_t^{L,T} + l_t^{L,S} + l_t^{L,C} \tag{1.15}$$

By combining the budget constraints of all agents in the economy, I obtain the balance-of-payments equation, which evolves as follows:

$$(1+r_{t-1})d_{t-1} = d_t + y_t^T - c_t^T - x_t^T + p_t^{Co}y^{Co} \tag{1.16}$$

where, $d_t = \kappa\ d_t^k$ is the aggregate debt level of the economy.

Last, I define the real exchange rate (rer_t), the trade balance (tb_t), and real GDP as follows:

$$rer_t = \frac{1}{p_t} \tag{1.17}$$

$$tb_t = p_t^{Co}y^{Co} + y_t^T - c_t^T - x_t^T \tag{1.18}$$

$$p_t gdp_t = y_t^T + p_t^S y_t^S + p_t^C y_t^C + p_t^{Co}y^{Co} \tag{1.19}$$

1.3.4 International Capital Markets and Exogenous Processes

The real interest rate r_t is based on the SOE assumption, and it is composed of three additive terms:

$$r_t = r^* + \psi \left[\exp\left\{d_t - \bar{d}\right\} - 1\right] - \xi \left[\ln(p_t^{Co}) - \ln(p^{\bar{Co}})\right] \tag{1.20}$$

The first term, r^*, represents the interest rate paid by the SOE in steady state; it is usually thought of as the sum of the world interest rate and a spread. The second term is standard in the literature and ensures a stationary equilibrium process for external debt (Schmitt-Grohé and Uribe 2003). Parameter ψ controls the relationship between r_t and deviations of aggregate debt level of the economy (d_t^*) with respect to its steady-state value ($\bar{d}$). The third term aims to capture the empirical relationship between spreads and commodity prices for commodity-exporting economies; parameter ξ governs the strength of the relationship (see Shousha 2016; Drechsel and Tenreyro 2018).[23] The economic intuition is that increases in commodity prices over their steady-state $p^{\bar{Co}}$ value reduce spreads paid by the economy as a whole. This amplifies the expansionary effects of the shock, particularly on investment, the most interest-rate-sensitive component of aggregate output. Drechsel and Tenreyro (2018) show that this relationship can be microfounded from first principles by relying on a specific type of financial frictions in which domestic firms borrow against collateral linked to the country's terms of trade; Section 1.4.4 discusses this in detail.

I assume that the real commodity price is the only exogenous driving force in the economy.[24] To be consistent with the number of lags I used in my main empirical exercise, I assume that the logarithm of p_t^{Co} follows an AR(2) process given as follows:

$$\ln\left(p_t^{Co}\right) = (1-\rho_1-\rho_2)\ln\left(p^{\overline{Co}}\right) + \rho_1 \ln\left(p_{t-1}^{Co}\right) + \rho_2 \ln\left(p_{t-2}^{Co}\right) + \varepsilon_t^{Co} \tag{1.21}$$

where, $\{\rho_1, \rho_2\} \in (-1, 1)$ and $\varepsilon_t^{Co} \sim$ i.i.d. $(0, \sigma_{co}^2)$.

1.3.5 Competitive Equilibrium and Solution Method

Definition 1 (*Competitive equilibrium*). Given initial conditions $k_{-1}^T, k_{-1}^S, k_{-1}^C$, and d_{-1}^k, and given an exogenous process for $\{p_t^{Co}\}_{t=0}^{\infty}$, a competitive equilibrium is a sequence of allocations and prices:

[23] In Section 1.4.4 I discuss how this stylized way of modeling this relationship could also be microfounded from first principles.

[24] The model is flexible enough to include other shocks, such as productivity shocks $\{a^T, a^S, a^C\}$ or interest rate shocks $\{r^*\}$.

- Allocations: $\{\{c_t^j, l_t^j\}_{\forall j}, c_t^k, d_{t+1}^k, \{y_t^s, l_t^{H,s}, l_t^{L,s}, k_{t+1}^s, i_t^s\}_{\forall s}, c_t, c_t^S, c_t^T, i_t, x_t^C, x_t^T\}_{t=0}^{\infty}$; and
- Prices: $\{p_t, p_t^I, p_t^S, p_t^C, w_t^H, w_t^L, \{u_t^s\}_{\forall s}, r_t\}_{t=0}^{\infty}$, such that:

1. Given prices, $\{c_t^j, l_t^j\}_{t=0}^{\infty}$ solve worker j's problem.
2. Given prices, $\{c_t^k, d_t^k, \{k_{t+1}^s, i_t^s\}_{\forall s}\}_{t=0}^{\infty}$ solve the capitalist's problem.
3. Given prices, $\{l_t^{H,s}, l_t^{L,s}, k_t^s\}_{t=0}^{\infty}$ solve intermediate goods firms' problem in sector s.
4. Given prices, $\{c_t^S, c_t^T\}_{t=0}^{\infty}$ solve final consumption-good producers' problem.
5. Given prices, $\{x_t^C, x_t^T\}_{t=0}^{\infty}$ solve final investment-good producers' problem.
6. All markets clear.

Solution method. The system of nonlinear equilibrium conditions is discussed in detail in Appendix A.3. To solve the model, I apply a first-order Taylor approximation to this system of equations; then, I solve the log-linearized system with standard perturbation techniques.

1.4 Quantitative Analysis

This section analyzes the quantitative predictions of the model following a commodity price shock. Section 1.4.1 outlines the parameterization of the model. Section 1.4.2 presents the simulation results and evaluates the model's fit. Section 1.4.3 explores the main mechanisms at work in the model. Finally, Section 1.4.4 discusses the model's assumptions and potential extensions.

1.4.1 Parameterization

Let Θ be a vector containing the universe of parameters of the model. The parameters are partitioned in three sets: $\Theta = [\Theta_1, \Theta_2, \Theta_3]$. The first subset ($\Theta_1$) includes parameters that take standard values in the literature. The second subset (Θ_2) includes parameters that are obtained endogenously from the steady state of the model to match certain long-run ratios in the data. Finally, the third subset (Θ_3) includes those parameters that do not affect the model's steady state but govern its short-run dynamics. For the last of these, I implement an impulse-response-function matching approach. A period in the model is a year. Table 1.2 presents the model calibration.

Functional forms: I choose a GHH specification for worker j's preferences $u^{w,j}(.) = \frac{\left[c_t^j - \nu_j \frac{\left(l_t^j\right)^{\omega}}{\omega}\right]^{1-\sigma}}{1-\sigma}$, where σ is the constant-relative-risk-aversion coefficient, ω is the inverse of Frisch elasticity, and ν_j is a scale parameter. This specification is widely used in the literature on SOEs and has the key implication that the income effect does not affect the labor supply decision of the household. Since capitalists do not work, their preferences are different from those of workers. In particular, I assume that $u^k(.) = \frac{\left[c_t^k\right]^{1-\sigma}}{1-\sigma}$. For capital adjustment costs, I assume $\frac{\phi^s}{2}\left(\frac{i_t^s}{k_t^s} - \delta\right)^2$, for $s \in \{T, S, C\}$.

Calibrated parameters: Let $\Theta_1 = \{\sigma, \omega, \epsilon_c, \epsilon_i, \delta, \gamma, \alpha^T, \alpha^S, \alpha^C, \mu, \kappa\}$. I start with conventional parameters. I set the value of the relative risk aversion to $\sigma = 2$, a standard value in the literature; $\omega = 1.445$ following Schmitt-Grohé and Uribe (2018); the intratemporal elasticity of substitution in the consumption and investment goods' production technologies is $\{\epsilon_c = 0.7, \epsilon_i = 0.5\}$ following Akinci (2011) and Medina et al. (2007), respectively; the depreciation rate $\delta = 0.07$ and $\gamma = 0.5$ following Medina et al. (2007). The remaining parameters are also calibrated from the literature but are more specific to this paper. I assume that the labor shares in each productive sector are the same: $\alpha^T = \alpha^S = \alpha^C = 0.65$. This value is in line with Medina and Naudon (2011), Schmitt-Grohé and Uribe (2018), and others; $\mu = 0.5$, which is the median value for the share of low-skilled workers for the countries in my sample; $\kappa = 0.1$ following Drenik (2016).

Let $\Theta_2 = \{\beta, y^{Co}, \varphi, a^T, a^C, \theta_T, \theta_S, \theta_C, \nu^H, \nu^L, \mu\}$. These parameters arise endogenously in steady state to match the following targets of my sample of Latin America's commodity exporters: the share of the trade balance to GDP (S^{tb}), the share of commodity production to GDP (S^{Co}), the total interest rate paid by the country (r^*), the labor income gap between skilled and unskilled workers (η), the proportion of skilled workers in each sector ($\frac{l^{H,s}}{l^s} \forall s$) and the total number of hours worked by each worker type (l^H, l^L). I take average values among the study countries for the period of analysis in Section 1.2. All the remaining relative prices are normalized to 1 in steady state except for p^{Co}, which is set to 1.01. The resulting values for the previously mentioned endogenous parameters are $\beta = 0.934$, $y^{Co} = 0.056$, $\varphi = 0.781$, $a^T = 0.859$, $a^C = 0.642$, $\{\theta^T, \theta^S, \theta^C\} = \{0.475, 0.728, 0.426\}$, $\{\nu^H, \nu^L\} = \{0.674, 0.420\}$.

Table 1.2: Calibrated parameters and steady-state targets

Parameter	**Description**	**Value**
(a) Calibrated parameters - literature		
σ	Risk aversion	2
ω	Frisch elasticity	1.445
ϵ_c	Elast. of substitution between c_t^S and c_t^T	0.7
ϵ_i	Elast. of substitution between x_t^C and x_t^T	0.5
δ	Depreciation rate	0.07
γ	Share of in investment	0.5
(b) Calibrated parameters specific to this paper		
$\{\alpha^T, \alpha^S, \alpha^C\}$	Labor share	$\{0.7, 0.7, 0.7\}$
κ	Share of capitalists	0.1
(c) Steady state targets		
S^{tb}	Share of tb in gdp	1%
S^{Co}	Share of y^{Co} in gdp	10%
r^*	Interest rate	7%
η	Labor income gap	2.1
$\{\frac{l^{H,T}}{l^H}, \frac{l^{H,S}}{l^S}, \frac{l^{H,C}}{l^C}\}$	Fraction of skilled workers in sector s	{0.30,0.56,0.26}
$\{p^{Co}, p^S, p^C\}$	Relative prices	1

<u>*Estimated parameters*</u>: Let $\Theta_3 = \{\rho_1, \rho_2, \sigma^{Co}, \phi^T, \phi^S, \phi^C, \psi, \xi\}$ and $\tilde{\Theta}_3 = \{\phi^T, \phi^S, \phi^C, \psi, \xi\}$ with $\tilde{\Theta}_3 \subset \Theta_3$. The values for $\{\rho_1, \rho_2, \sigma^{Co}\}$ are obtained by running equation (1.21) for my panel of Latin American countries for the period 1992–2019. For the parameters included in $\tilde{\Theta}_3$, I apply an estimation procedure that follows Christiano et al. (2005) and Uribe and Yue

(2006). This method chooses values for free parameters to minimize the distance between empirical impulse response functions and the corresponding impulse responses implied by the model. In my exercise, I consider the first eight periods of the impulse responses of six variables (output, consumption, investment, real exchange rate, ratio of trade balance to GDP, and interest rate) to a commodity price shock. The empirical impulse response functions to match are the ones that I presented in Section 1.2.3. Specifically, let IR^e denote the vector of estimated impulse response functions and $IR^m(\tilde{\Theta}_3)$ the corresponding vector of impulse responses implied by the theoretical model. Then, the estimated parameters minimize Δ, which is defined as follows:

$$\Delta \equiv \min_{\tilde{\Theta}_3} \left[IR^e - IR^m(\tilde{\Theta}_3) \right]' \sum_{IR^e}^{-1} \left[IR^e - IR^m(\tilde{\Theta}_3) \right] \tag{1.22}$$

Here, Σ_{IR^e} is a diagonal matrix containing the variance of the impulse response function along the diagonal that penalized those elements of the estimated impulse response functions associated with large error intervals. Table 1.3 shows the combination of parameters that better match the data. The estimation exercise points toward three main takeaways. First, commodity price shocks are very persistent. Second, there is evidence of financial frictions. This is captured by parameter ψ, which shows that changes in the net foreign asset position of the economy could generate a non-negligible effect on the interest rate paid by the country as a whole.[25] Third, positive deviations of commodity prices from their long-run values can induce significant contraction in spreads. This is captured by parameter ξ, according to which a 10% positive deviation of commodity prices from their steady state can reduce real interest rate spreads by around 1.6 percentage points.[26] Finally, capital-adjustment-cost parameters are quite similar across sectors.

[25] While there is consensus in the literature regarding the sign of this value, there is no agreement on its exact value. If ψ is close to 0, then the only role of this parameter is to make the model stationary (Schmitt-Grohé and Uribe (2003)). On the other hand, Garcia-Cicco et al. (2010) and Drechsel and Tenreyro (2018) highlight that the data support a larger value (ψ of around 2.8), which is associated with the existence of financial frictions. Schmitt-Grohé and Uribe (2018) estimate this parameter for 38 countries and find that ψ has a mean of 17 and a median of 0.58. Finally, Germaschewski et al. (2024) finds $\psi = \{0.39, 1.28, 0.43, 2.5\}$ for Chile, Colombia, Mexico, and Peru, respectively.

[26] This value is also in line with previous findings; Drechsel and Tenreyro (2018) find $\xi = 0.199$ for Argentina, a well-known emerging economy and commodity exporter.

Table 1.3: Estimated parameters

Parameter	Description	Value
Estimated parameters		
$\{\rho_1, \rho_2\}$	AR(2) coefficients for p_t^{Co}	$\{1.1, -0.25\}$
σ^{Co}	Standard correlation for ε_t^{Co}	0.094
$\{\phi^T, \phi^S, \phi^C\}$	Adjustment cost in sector s	$\{0.98, 0.87, 0.81\}$
ψ	Elast. of country premium	0.457
ξ	Elast of r_t to p_t^{Co}	0.167

1.4.2 Model Validation and Dynamics Following a Commodity Price Shock

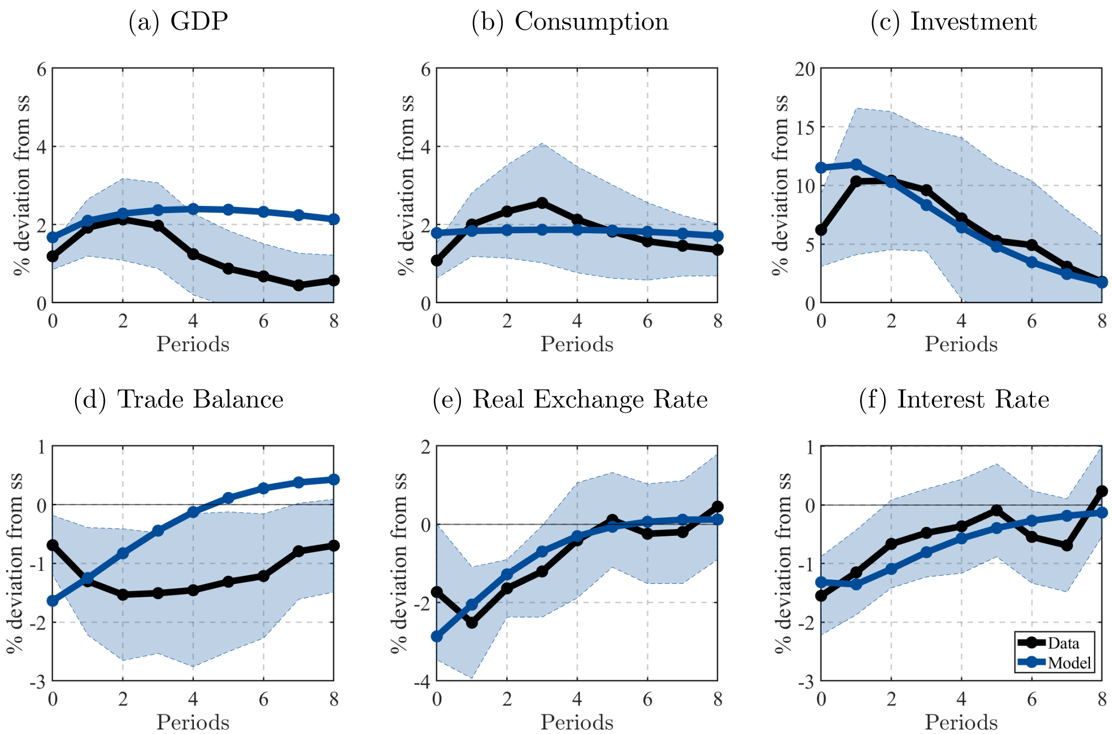
This section aims to study the responses of the model to a commodity price shock and to evaluate its ability to replicate the main empirical facts I presented in Section 1.2. I depart from an economy that is in steady state and experiences a shock that increases commodity prices p_t^{Co} in 10%. In what follows, I compare the impulse response functions of the model with the ones from the data. Before proceeding, it is worth clarifying what is targeted and untargeted in the model. From my estimation strategy, six aggregate variables are targeted: output (gdp_t), consumption (c_t), investment (i_t), ratio of trade balance to GDP (tb_t), real exchange rate (rer_t), and interest rate (r_t). The rest of the variables in the model are untargeted. Among these, I focus on my measure of labor income inequality (η_t) and on sectoral output in the tradable (y_t^T), services (y_t^S), and construction sectors (y_t^C).

Dynamics around a commodity price shock. Figure 1.5 shows that the increase in p_t^{Co} boosts the economy by increasing output, consumption, and investment. The model identifies two channels that explain these expansionary effects. First, the commodity boom induces a positive wealth effect that operates on impact through an increase in the capitalist's revenue. Second, higher commodity prices significantly reduce the interest rate spreads faced by the SOE, further stimulating the economy.

These expansionary forces leads to a real exchange rate appreciation, causing a contraction in the tradable sector and an expansion in both nontradable sectors (panels (a)–(c) in Figure 1.6). This behavior aligns with the Dutch-disease framework. Additionally, the model shows a heterogeneous response within the nontradable sector, with the construction sector expanding nearly four times faster than the services sector. To understand this two-speed economy within the nontradable sector, it is esssential to examine the behavior of aggregate consumption and investment, as services and construction serve as production inputs to these final goods. Panels (b)–(c) in Figure 1.5 demonstrate that investment is the most sensitive component of GDP to a positive commodity price shock, with a much larger response compared to consumption. Several factors drive the investment surge. First, capitalists experience a positive income shock, prompting them to increase investment. Second, the expansion of nontradable sectors raises the marginal productivity of capital, boosting demand for capital, though this effect is partially offset by the contraction in the tradable sector. Third, the reduction in real interest rates provides an additional stimulus for investment. As a result, the investment boom also drives a significant expansion in the construction sector, which plays a crucial role as a key input in production.

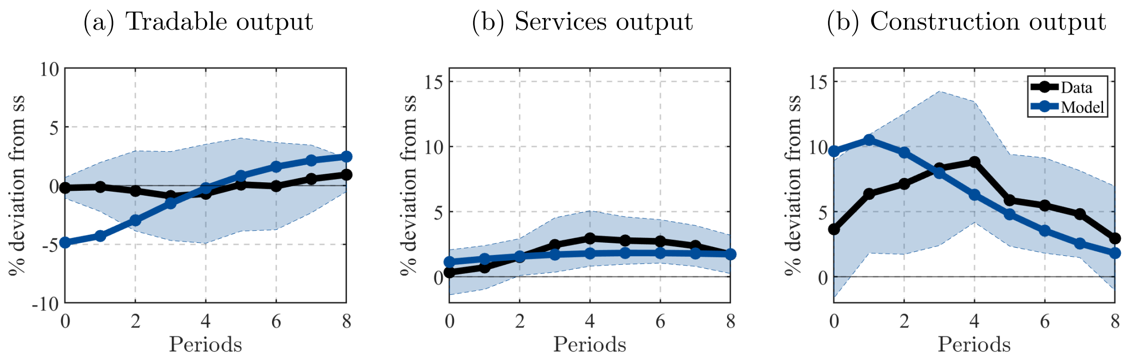
There is an immediate decline in the trade balance. Although the positive commodity price shock boosts commodity exports, this effect is offset by a decrease in net exports from the tradable sector, driven by higher demand for tradable inputs used in the production of final consumption and investment goods.

Figure 1.5: IRFs to commodity price shock - Macro Variables - targeted



Notes: This figure plots the impulse response functions for (a) GDP, (b) consumption, (c) investment, (d) ratio of trade balance to GDP, (e) real exchange rate, and (f) interest rate to a 10% increase in p_t^{Co}. The black lines are the empirical responses generated from equation (1.1), where error bands represent 95% confidence intervals. The blue lines are the models' responses expressed in percentage deviations with respect to steady state, except for the trade balance and interest rate, which are expressed in percentage-point deviations. The time units on the horizontal axis are years.

Figure 1.6: IRFs to commodity price shock - Sectoral output - untargeted



Notes: This figure plots the impulse response functions for (a) tradable output, (b) services output, and (c) construction output to a 10% increase in p_t^{Co}. The black lines are the empirical responses generated from equation (1.1), where error bands represent 95% confidence intervals. The blue lines are the models' responses expressed in percentage deviations with respect to steady state. The time units on the horizontal axis are years.

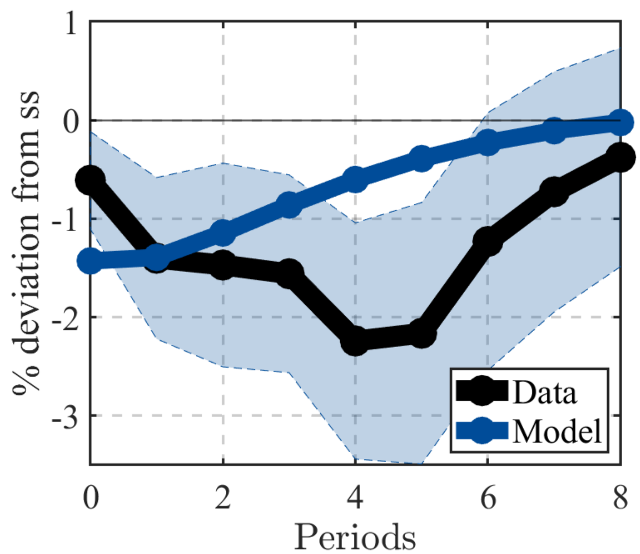
How do these aggregate and sectoral effects combine to explain labor income inequality? Figure 1.7 shows that the model predicts an initial 1.4% decline in the labor income gap, followed by a gradual return to the steady state. The contraction in the tradable sector, combined with the expansion of the nontradable sector, triggers labor reallocation from the former to the latter. Within the nontradable sector, both the service and construction sectors increase their demand for workers, though their relative demand for skilled versus unskilled labor varies significantly.

The service sector, being more intensive in skilled labor, draws relatively more high-skilled workers, while the unskilled-labor-intensive construction sector primarily hires unskilled workers. This labor reallocation into the growing nontradable sector leads to wage increases for both skilled and unskilled workers. However, unskilled workers benefit disproportionately, as they are primarily employed in the booming construction sector.

Consequently, labor income inequality declines, as the substantial expansion in construction offsets the effects of both the contraction of the tradable sector—which typically employs many unskilled workers—and the milder growth in the service sector, which favors skilled workers. [27]

[27] Appendix Figure A.20 shows the response of the skill premium and hours worked for each worker type. In the model, the fall in labor income inequality is explained by a combination of higher wages and hours worked for unskilled workers relative to skilled ones.

Figure 1.7: IRFs to commodity price shock - Labor income inequality - untargeted



Notes: This figure plots the impulse response functions for the labor income gap to a 10% increase in p_t^{Co}. The black lines are the empirical responses generated from equation (1.1), where error bands represent 90% confidence intervals. The blue lines are the models' responses expressed in percentage deviations with respect to steady state. The time units on the horizontal axis are years.

Model vs. data. Last, I discuss the fit of the model. In terms of targeted aggregate variables, the model reproduces fairly well the dynamics observed in the data; Figure 1.5 shows that most model responses are within the empirical confidence intervals. The fit is also reasonably good for untargeted variables (Figures 1.6 and 1.7). The model can replicate the dynamics of output in the service and construction sectors. There is a small discrepancy in the dynamic of the tradable sector: On impact, the model predicts a contraction, while the data show no effect. This is an inherent feature of models with tradable and nontradable goods; real exchange rate appreciations always lead to a relative expansion in the nontradable sector relative to the tradable sector, which is accounted for in the model by an absolute increase in the former and an absolute fall in the latter. In the data, the tradable sector does not contract in absolute terms.

Regarding labor income inequality, the model succeeds in replicating many of its main features. First, regarding its direction, labor income inequality falls after commodity price shocks. Second, the model matches the magnitude of the response in the first periods after the shock. Third, the model returns to a steady state in period 8, as in the data. The main differences arise between periods 3 and 5 after the shock, when inequality continues to converge to the steady state in the model but shows an additional fall in the data. To understand this behavior, note that my empirical impulse response functions are generated from local projections and not from an SVAR, as is standard in the literature.[28] While both empirical models are equivalent for large samples (see Plagborg-Møller and Wolf 2021), local projections can be less smooth in short samples since they lack the well-behaved structure imposed by construction in a VAR.

1.4.3 Inspecting the Mechanism

The model relies on two essential assumptions to produce a negative and significant response of labor income inequality following favorable commodity price shocks. The first assumption pertains to the qualitative predictions of the model, while the second focuses on its quantitative outcomes. I will now discuss the significance of these assumptions and explore the implications of modifying them.

Heterogeneity within the nontradable sector. What are the predictions for labor income inequality when there is no distinction between services and construction—that is, when there is only one nontradable sector? In this case, the model collapses into a canonical tradable-nontradable (TNT) framework, where the same nontradable good is used as an input for both final consumption and investment goods. As a result, the production technologies for final and intermediate goods simplify accordingly:

$$c_t = \left[\varphi^{1/\varepsilon_c}\left(c_t^N\right)^{1-1/\varepsilon_c} + (1-\varphi)^{1/\varepsilon_c}\left(c_t^T\right)^{1-1/\varepsilon_c}\right]^{\frac{\varepsilon_c}{\varepsilon_c-1}} \tag{1.23}$$

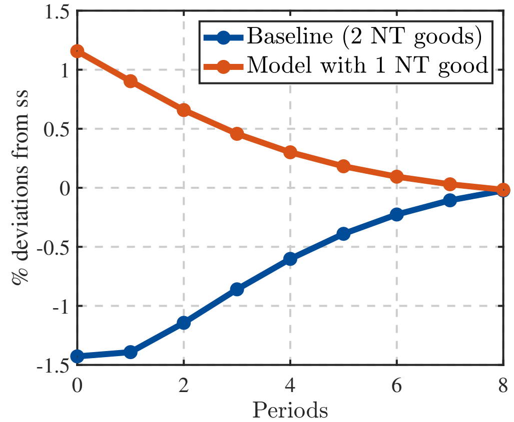
$$i_t = \left[\gamma^{1/\varepsilon_i}\left(x_t^N\right)^{1-1/\varepsilon_i} + (1-\gamma)^{1/\varepsilon_i}\left(x_t^T\right)^{1-1/\varepsilon_i}\right]^{\frac{\varepsilon_i}{\varepsilon_i-1}} \tag{1.24}$$

$$y_t^s = a^s\left[\left(l_t^{H,s}\right)^{\theta_s}\left(l_t^{L,s}\right)^{1-\theta_s}\right]^{\alpha_s}\left(k_t^s\right)^{1-\alpha_s}, \quad \alpha_s, \theta_s \in (0,1) \quad \forall s \in \{T, N\} \tag{1.25}$$

Here, $s \in \{T, N\}$ index the two productive sectors in the economy—tradables (T) and nontradables (N)—and c_t^N and x_t^N are nontradable inputs used by the final consumption-good and investment-good producers. In Appendix A.3.6 I present the modified model's complete system of nonlinear equations. I solve the model using the same calibration as in Section 1.4.1

[28]This is the case for works such as Shousha (2016); Schmitt-Grohé and Uribe (2018); Drechsel and Tenreyro (2018).

Figure 1.8: Labor income gap - baseline vs. model with one nontradable good



Notes: This figure compares the impulse response functions for the labor income gap to a 10% increase in p_t^{Co} for the baseline model and the alternative model with one nontradable good. The variables are expressed in percentage deviations with respect to steady state. The time units on the horizontal axis are years.

Figure A.22 compares the labor income gap η's response to a commodity price shock for the baseline model versus a model with a single nontradable sector. In the alternative model, labor income inequality rises following a positive commodity price shock.[29] The explanation is straightforward: Positive shocks expand the nontradable sector relative to the tradable sector. Without distinguishing between services and construction, the nontradable sector as a whole is more intensive in skilled labor than the tradable sector: $\theta^N > \theta^T$ (see Figure 1.4 or Appendix Table A.4). As a result, ignoring the skill heterogeneity within the nontradable sector, and the different ways these subsectors respond to the same shock, leads to results that contradict the empirical evidence.

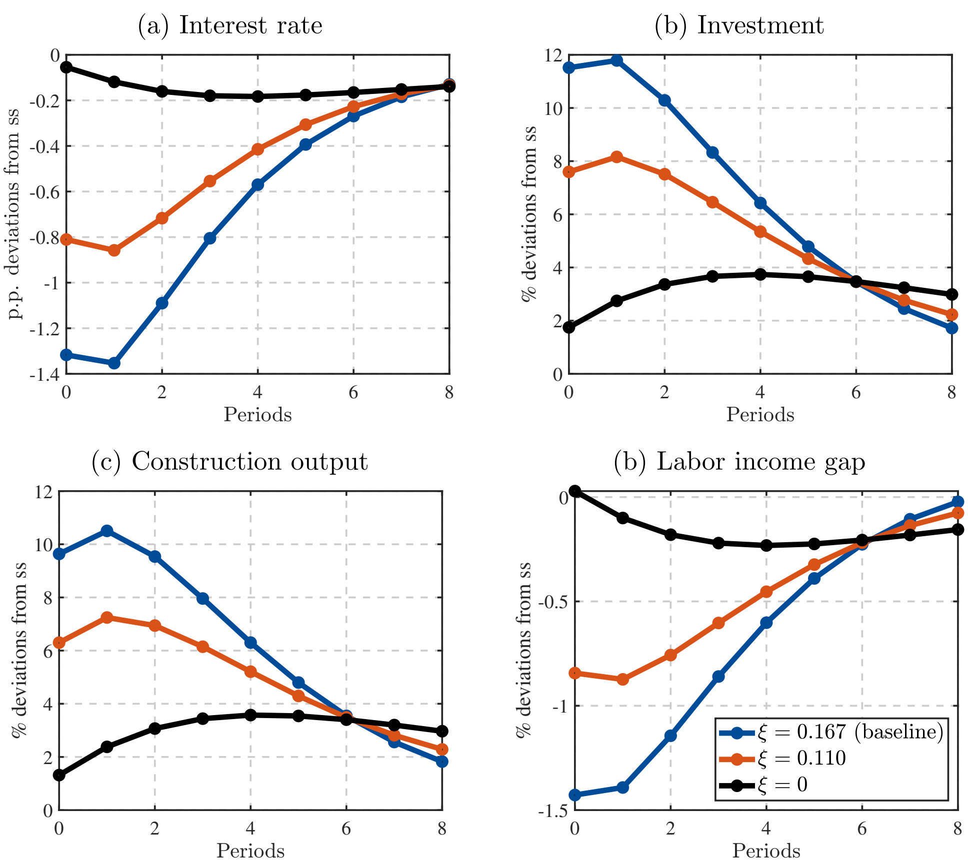
Interest rate sensitivity to commodity prices. The inclusion of p_t^{Co} in equation (1.20) is based on the observed negative relationship between interest rate spreads and commodity prices. In the model, this mechanism amplifies the economy's response to commodity shocks, particularly in terms of investment. Without this assumption, the model still predicts a decline in labor income inequality, but the magnitude is smaller than what is observed in the data. Figure 1.9 illustrates how the labor income gap η responds to a commodity price shock for different values of ξ, the parameter controlling the sensitivity of the interest rate to

[29] This theoretical result is consistent with canonical trade models. For instance, Galiani et al. (2010) employ a Heckscher-Ohlin-Samuelson (HOS) trade model with a non-tradable sector to demonstrate that positive terms-of-trade shocks increase income inequality between skilled and unskilled workers when the non-tradable sector is relatively skilled-labor intensive, while the manufacturing sector is relatively unskilled-labor intensive.

changes in commodity prices. For the responses of other variables, refer to Appendix A.3.5.

As ξ decreases, the negative effect on labor income inequality weakens. In the extreme case of $\xi = 0$, in which borrowing rates are entirely insensitive to changes in commodity prices, labor income inequality remains nearly unchanged on impact, with a delayed decline in subsequent periods. What explains this behavior? A lower ξ limits the reduction in interest rates following a commodity price shock, resulting in smaller investment booms and, therefore, a more constrained expansion in the construction sector. This moderation disproportionately harms unskilled workers, who are primarily employed in the booming construction sector.

Figure 1.9: IRFs - labor income gap for different ξ



Notes: This figure plots the impulse response functions for (a) real interest rate, (b) investment, (c) construction output, and (d) labor income gap to a 10% increase in p_t^{Co}. All variables are expressed in percentage deviations with respect to steady state, except for the interest rate, which is expressed in percentage-point deviations. The time units on the horizontal axis are years.

1.4.4 Discussion of Assumptions and Model Extensions

Interest rate sensitivity to commodity price shocks. Equation (1.20) captures, in a stylized manner, the overall effects of changes in interest rates driven by commodity price movements on the economy. Drechsel and Tenreyro (2018) show that this relationship can be microfounded from first principles. In Appendix A.3.4, I offer a formal justification of this channel, based on financial frictions: domestic firms borrow against collateral linked to the country's terms of trade. A relaxation of these constraints leads to a fall in credit spreads. Appendix A.2.4 provides further empirical evidence supporting this channel by performing the same empirical exercises in Drechsel and Tenreyro (2018) for my sample of Latin American commodity exporters. My results are in line with theirs.

Labor mobility. The model assumes that workers of each type can freely move across sectors. In Appendix A.3.7, I solve the model under imperfect labor mobility using a reduced-form approach based on Horvath (2000). I find that the main predictions regarding labor income inequality remain unchanged.

Ownership of commodity: private vs. public. The model assumes that the private sector owns the entire commodity endowment via a capitalist. This assumption is made for two reasons. First, it allows for a clear characterization of the relationship between commodity price shocks and labor income inequality, driven purely by market forces. Second, for most of the countries considered in my sample, the government does not in fact own the main companies in commodity sector. For instance, over 60% of Chile's copper mines are privately owned, while Peru privatized most of its mining industries in the 1990s. In Colombia, the state-owned Ecopetrol accounts for only a third of oil production, while the coal industry is largely privatized. Mexico is a mixed case: Oil exploration has historically been conducted by PEMEX, a public company; however, in recent years, the country has opened up its energy sector to domestic and foreign private companies. Finally, in Ecuador and Bolivia, the state owns and exploits most of the resources; Petroecuador and YPFB are the biggest firms there, respectively.

Ownership of commodities: domestic vs. foreign. The model abstracts from the possibility that part of the commodity endowment is foreign owned. In Appendix A.3.7 I introduce this possibility. Results show that foreign ownership reduces the size of the domestic commodity sector, dampening the effects of commodity price shocks, as part of the windfall is lost to foreign owners.

Commodity sector as an endowment. By modeling the commodity sector as an endowment, I abstract from any supply-side channels that might otherwise be operating. I made this choice for two main reasons. First, this approach is standard practice in the international macroeconomics literature studying the effects of commodity price shocks. Second, since my focus is on channels operating outside the commodity sector, treating it as an endowment is sufficient for the purpose of this analysis. If I were to allow for endogenous production in the commodity sector, which is highly capital intensive for countries in my sample, the production function would take the form $y_t^{Co} = f(K_t^{Co})$, where K_t^{Co} represents the capital allocated to the sector. In such a case, a commodity price shock would increase both commodity production and the return on capital in that sector. This would also boost aggregate investment, not only for the reasons already present in the model but because of the direct demand for capital in the commodity sector. As a result, the construction sector—being a key supplier of investment goods—would also expand further, amplifying the overall economic response.[30]

1.5 Policy Counterfactuals

In this section, I use the model as a laboratory to study the distributional implications of alternative uses of the revenue generated by the commodity windfall. Thus far, I have assumed that the government plays no role in the economy and that the private sector owns all the commodity endowment through the existence of a capitalist. However, even when the government does not own the commodity sector directly, it usually can appropriate part of the sector's resources through taxation.[31] Here, I explore this alternative.

I assume that there is a government that puts a tax τ on the capitalist's commodity endowment. For simplicity, this is the only source of income for the government. The capitalist receives $(1-\tau)p_t^{Co}y^{Co}$ in each period, and the government receives revenue given by:

$$rev_t = \tau p_t^{Co} y^{Co} \tag{1.26}$$

where $\tau \in [0, 1]$. When $\tau = 1$, the government gets all the commodity revenue; when $\tau = 0$, we are again in the case with no government.

In what follows, I analyze a set of policies that have been implemented by policy makers in commodity-exporting economies in response to commodity windfalls.[32] I focus on two

[30] An example of this possibility is Fornero et al. (2014), which proposes a model with endogenous production in the commodity sector calibrated to Chile, a large mining exporter. There, the authors show that mining investment is an important commodity price-shock propagation mechanism.

[31] IMF (2015) shows the importance of commodity revenue for fiscal accounts for middle-income and low-income countries.

[32] These policies are part of a broader set recommended by Frankel (2010) for commodity-exporting economies. Other recommended policies include (i) indexation of oil or mineral contracts to world commodity prices, (ii) hedging export proceeds through option markets, (iii) implementing fiscal rules, (iv) setting an inflation target for central banks that emphasizes product prices over consumer price indices, and

policies with contrasting impacts on aggregate spending and savings. In the first, the government uses commodity revenue to make lump-sum transfers to workers—a policy often aimed at redistributing the gains from commodity booms.[33] In the second, the government saves the majority of commodity revenue in an SWF, a strategy often employed to stabilize the economy and ensure that future generations benefit from finite resources.[34] I solve the model under these two policies and compare their predictions with the baseline results presented in the previous section.

1.5.1 Counterfactual I: Transfers to Workers

In each period, the government uses its commodity revenue to make direct transfers to workers. The government's and workers' budget constraints become the following:

$$rev_t = T_t^H + T_t^L \tag{1.27}$$

$$p_t c_t^L = w_t^L l_t^L + T_t^L \tag{1.28}$$

$$p_t c_t^H = w_t^H l_t^H + T_t^H \tag{1.29}$$

Here, $\{T_t^H, T_t^L\}$ are lump-sum transfers to high- and low-skilled workers. The government's policy consists in setting a tax rate τ and transfers $\{T_t^H, T_t^L\}_{t=0}^{\infty}$ that satisfy (1.27). In this setting, it follows that the dynamics of aggregate variables are not affected by which specific worker receives the transfer. This derives from the assumption that both types of workers consume the same final consumption good and have the same marginal propensity to consume.[35]

I solve the model under the same parameterization discussed in Section 1.4.1. I consider the case in which $\tau = 1$, which means the government captures all commodity revenue and nothing goes to the capitalist. This is the opposite of the baseline case of Section 1.4.2, in which there was no government ($\tau = 0$).

Figure 1.10 compares the responses of labor income inequality in the baseline model and

(v) accumulating international reserves by central banks.

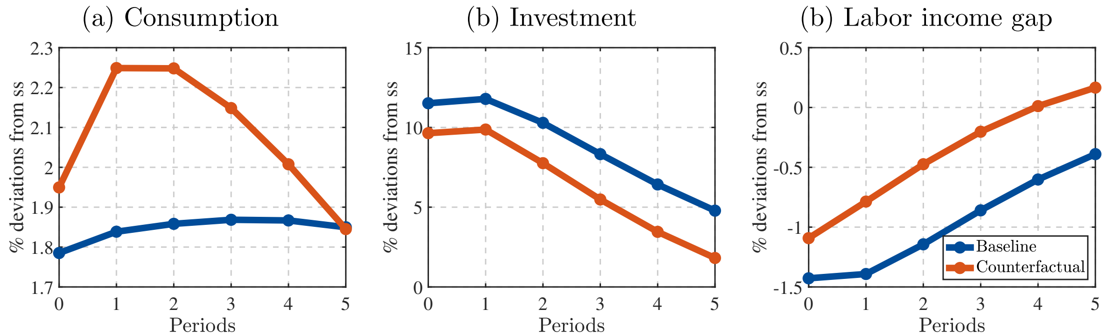
[33]This policy is inspired by the experience of Alaska. Frankel (2010) documents how the Alaska Permanent Fund saves earnings from the state's oil sector. By law, the fund must distribute half of its investment earnings equally to all residents, based on the principle that citizens can better allocate their money than the government. Sala-i Martin and Subramanian (2013) suggest that Nigeria should adopt a similar policy, while Birdsall and Subramanian (2004) propose the same for Iraq.

[34]Mohaddes and Raissi (2017) provide a detailed list of countries with existing SWFs, and IMF (2015) discusses nations planning to establish them.

[35]This framework is flexible enough to think in some departures. One possibility is to have workers types with different consumption baskets. Another possibility is to have heterogeneous marginal propensity to consume across workers; for example, allowing skilled workers to save and borrow.

the counterfactual economy following a positive commodity price shock. In the counterfactual economy, labor income inequality decreases less than in the baseline model after the shock. On impact, the decline in labor income inequality is about 20% smaller compared to the baseline. At first glance, this result may be counterintuitive. How can direct transfers to workers dampen the improvements in labor income inequality?

Figure 1.10: IRFs to commodity price shock - Counterfactual I



Notes: This figure plots the impulse response functions for (a) consumption, (b) investment and (c) labor income gap to a 10% increase in p_t^{Co} for the baseline case and the counterfactual. All models' responses are expressed in percentage deviations with respect to steady state. The time units on the horizontal axis are years.

When the government taxes the capitalist and redistributes the revenue to workers, resources are transferred from households with low marginal propensity to consume to households with high marginal propensity to consume. With fewer resources in the hands of the capitalist—the agent responsible for capital-accumulation and investment decisions—the aggregate investment response diminishes. This leads to a smaller expansion in the construction sector, which is crucial for producing investment goods. Since workers primarily use their resources for consumption, having more resources in their hands leads to higher aggregate consumption, which in turn drives a larger expansion in the service sector. Together, these effects result in a more moderate reduction in labor income inequality.

1.5.2 Counterfactual II: Government Spending and Saving in an SWF

In this case, the government uses its commodity revenue for two purposes: government spending, and savings in an SWF. The government's budget constraint and the law of motion for the SWF are given as follows:

$$p_t G_t = (1-\chi) rev_t + v\,(1+r_f)\,F_{t-1} \tag{1.30}$$

$$F_t = \chi rev_t + (1-v)\,(1+r_f)\,F_{t-1} \tag{1.31}$$

Here, G_t is government spending on the final consumption good, F_t is savings in the SWF, and r^f is the constant interest rate that the fund pays. In each period, the government allocates a fraction χ of its commodity revenue to savings in the SWF, F_t, and the remaining $(1-\chi)$ to government spending. Additionally, a fraction ν of the income generated by the SWF in each period is returned to the government. This assumption rules out the possibility of an explosive SWF.[36]

There are a few things to take into account. First, an underlying assumption here is that the government spends on the same final consumption good that households do.[37] Second, when $\chi = 0$, (1.30) and (1.31) become $p_t G_t = rev_t$ and $F_t = 0$. Under the assumption that the government spends on the same goods as households, this case is equivalent to Counterfactual I, in which the government gives direct transfers to workers. Last, including a government that can save requires a change in the balance of payments and the interest rate equation. On the one hand, the net foreign asset position of the aggregate economy needs to include not only the private debt from the capitalist (d_t) but also the savings of the government in the SWF (F_t).[38] In the same way, the interest rate responds to the aggregate external position of the economy captured by the term $(d_t - F_t)$, not just to d_t. Then, these equations become the following:

$$(1+r_{t-1})d_{t-1} + F_t = d_t + (1+r_f)F_{t-1} + tb_t \tag{1.32}$$

$$r_t = r^* + \psi\left[\exp\left\{(d_t - F_t) - (\bar{d} - \bar{F})\right\} - 1\right] - \xi\left[\ln(p_t^{Co}) - \ln(p^{\bar{Co}})\right] \tag{1.33}$$

When solving the model, I consider the case in which $\tau = 1$, meaning the government captures all commodity revenue. The remaining parameters are χ, r_f, ν. I set $r_f = 0.01$ and $\nu = 0.02$, consistent with values found in the literature (see Bergholt et al. 2019). Finally, I choose $\chi = 0.9$ to represent a scenario in which the government saves most of the commodity windfall in an SWF.

A government that saves most of its commodity revenue in an SWF increases the aggregate savings of the country. The scope for this effect to generate sizable movements in the

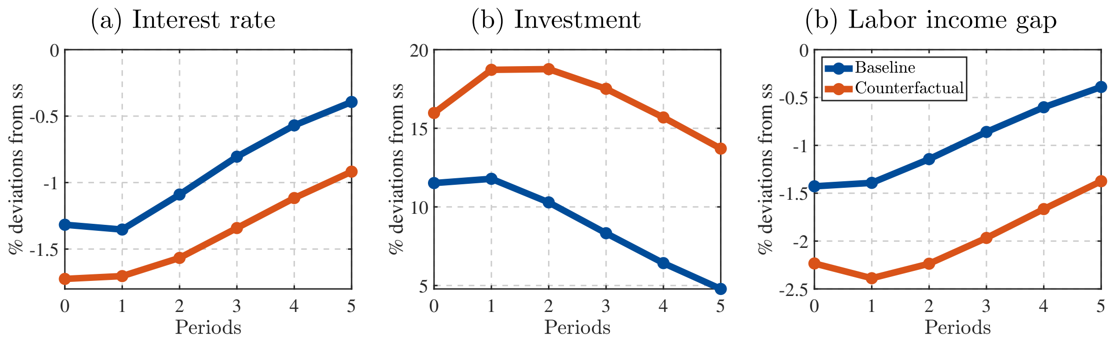
[36]A sufficient condition for this is $\nu > \frac{r_f}{1+r_f}$.

[37]The literature tends to suggest that government spending is more biased toward nontradable goods than private consumption. A potential departure is to model this difference.

[38]This is a departure from some papers that work with SWFs. Most leave out savings in the SWF from the interest rate equation for no clear reason.

interest rate faced by the SOE depends on the degree of financial frictions in the economy (captured by parameter ψ in the interest rate equation). For an estimated version of the model, I showed in Section 1.4.1 that financial frictions are quite large. This is evident from panel (a) in Figure 1.11, in which the interest rate falls by more in the counterfactual economy. This leads to a larger investment boom and larger expansion in the construction sector.[39] These results help explain the larger fall in labor income inequality that I observe in the counterfactual economy relative to the baseline case; on impact, labor income inequality falls around 50% more in the counterfactual.

Figure 1.11: IRFs to commodity price shock - Counterfactual II



Notes: This figure plots the impulse response functions for (a) interest rate, (b) investment and (c) labor income gap to a 10% increase in p_t^{Co} for the baseline case and the counterfactual. All models' responses are expressed in percentage deviations with respect to steady state. The time units on the horizontal axis are years.

1.6 Conclusion and Policy Implications

Despite the high and persistent levels of income inequality observed in commodity-dependent economies, relatively little attention has been paid to the distributional impacts of commodity price shocks. This paper seeks to fill that gap by providing new empirical evidence and developing a quantitative model to explore the distributional consequences of these shocks in a sample of Latin American economies. I found that positive commodity price shocks lead to a reduction in labor income inequality, driven not by the direct effects within the commodity sector itself but by indirect effects operating through nontradable sectors. Specifically, the

[39]The standard policy rationale for SWFs is to reduce the volatility of the economy by isolating it from abrupt fluctuations in commodity prices. However, if SWFs generate substantial reductions in the spreads faced by the SOE by increasing aggregate savings, then they could generate even more volatility. In a follow-up paper, I study this potential destabilizing role of SWF.

unskilled-labor-intensive construction sector benefits disproportionately from these shocks, while skilled-labor-intensive sectors such as services experience more moderate growth. To explain these findings, I developed a multisector SOE model that captures these sectoral differences in labor intensity and responses to commodity price shocks. Additionally, I explored the distributional consequences of alternative policy responses to commodity windfalls, including direct transfers to workers and the establishment of SWFs.

While the primary focus of this paper is on the positive effects of commodity price shocks, the results raise important questions for normative analysis. How should policy makers respond to these shocks if their objectives extend beyond growth to encompass distributional outcomes? Should policies prioritize reducing inequality or maximizing overall economic expansion? Future research could explore these normative dimensions, shedding light on how policy tools can be tailored to different distributional objectives. Moreover, a deeper analysis of the macroeconomic implications of changing income inequality due to commodity price shocks—particularly in a framework with richer heterogeneity in agents' marginal propensity to consume—offers another promising avenue for future exploration.

Ultimately, the insights from this paper contribute to a deeper understanding of the broader social and economic impacts of commodity price shocks in emerging markets, offering valuable policy lessons for commodity-exporting economies and opening the door for further research on how best to manage the distributional consequences of these global economic forces.

CHAPTER 2

Labor Markets, Financial Crises and Inflation: Jobless and Wageless Recoveries

This is joint work with Tato2, Tato3 and Tato4.

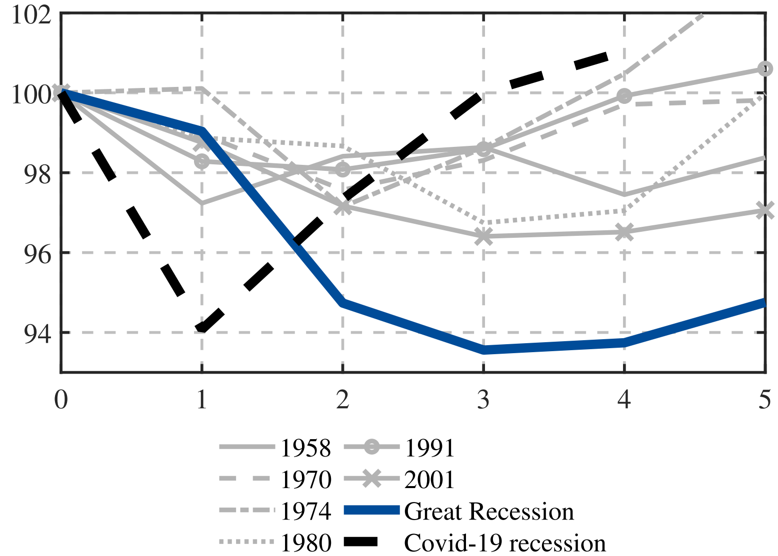
Abstract

We document the macroeconomic patterns that characterize labor market recovery from financial crises. Using a sample of postwar recession episodes from around the world, we show that financial crises are typically followed by jobless recoveries, with a sluggish recovery of employment relative to output. A departure from this empirical regularity occurs in emerging-market crises with high inflation, which feature strong employment recoveries but persistent declines in real wages and result in "wageless recoveries." Our findings highlight the central role of financial components in labor input costs and nominal wage rigidities in shaping labor market dynamics following economic crises.

2.1 Introduction

The decline in employment that accompanies economic contractions is a defining characteristic of economic crises. In recent decades, concern over labor market dynamics following recession episodes has been heightened by the occurrence of "jobless recoveries," which involve a slow recovery of the labor market (see, for example, Gordon and Baily, 1993; Bernanke, 2009; Jaimovich and Siu, 2020). In this context, Figure 2.1 illustrates that the two most recent U.S. recessions exhibit substantially different patterns. The Great Recession stands out as the crisis with the most prolonged effects on employment, with percapita employment remaining more than 5 % below its pre-crisis levels 5 years after the crisis began. In contrast, the recent pandemic recession is notable for its faster employment recovery, despite the sizable initial contraction.

Figure 2.1: Employment Recovery for U.S. recessions



Notes: This figure shows the dynamics of employment in the United States for postwar recession episodes (NBER dates). Employment is expressed in per capita terms and normalized to 100 in the year before the recession begins. Data source: Federal Reserve Bank of St. Louis.

Motivated by these patterns, we conduct an empirical investigation that characterizes labor market recovery following recession episodes observed across the globe over the last eight decades. We focus on two central dimensions of these episodes. First, guided by the role of credit market disruptions during the Great Recession (see, for example, Chodorow-Reich, 2014; Christiano et al., 2015; Gertler and Gilchrist, 2018), we examine the role of financial market conditions in shaping labor market recovery. Using a sample of 23 developed-market economies since the 1950s, we document that recessions associated with financial crises (i.e., banking or debt crises) are followed by jobless recoveries: per capita output returns to its pre-crisis level, but per capita employment does not. We also observe persistent declines in other labor market indicators, such as hours worked, participation rates, and the labor wedge. Meanwhile, the capital stock exhibits relative resilience and remains above its pre-crisis level at the output recovery point. These jobless recoveries following financial crises are significantly larger than those observed after other recession episodes of similar magnitude and are not driven by specific time periods or country-specific characteristics associated with financial crises. However, real wages increase throughout financial crises and do not exhibit a particularly different pattern from those observed during other recession episodes. This suggests that the adjustment in developed-market economies primarily occurs through changes in labor input rather than significant shifts in real wages.

Second, motivated by the inflation surge following the pandemic recession, we study the role of inflation in shaping labor market recovery. To this end, we extend our empirical analysis to a sample of 35 emerging-market economies, which exhibit significantly larger heterogeneity in inflation rates during recession episodes relative to the developed-market sample. We first document that emerging-market financial crises that feature moderate levels of inflation (i.e., below 30 %, as considered by Dornbusch and Fischer, 1993) exhibit patterns broadly aligned with those observed in developed economies, with jobless recoveries but no declines in real wages. We then show that emerging-market financial crises with higher levels of inflation exhibit a remarkably different pattern: strong recovery of employment but "wageless recoveries"—that is, persistent declines in real wages that do not recover alongside economic activity.

The empirical patterns we document suggest the presence of two key economic forces operating during jobless recoveries. First, a significant financial component in labor input costs. This can arise, for example, if labor contracts require payment in advance (see, for example, Christiano and Eichenbaum, 1992; Neumeyer and Perri, 2005; Jermann and Quadrini, 2012; Bigio, 2015) or substantial upfront costs that must be financed (see, for example, Petrosky-Nadeau, 2014). Under these conditions, the sluggish labor market recovery observed during financial crises can result from credit market disruptions, which persistently increase the financial component of labor input costs. Second, our findings are consistent with the presence of downward nominal wage rigidities, which, in a low-inflation context, prevent higher labor input costs from translating into lower real wages and instead result in lower employment (see, for example, Akerlof et al., 1996; Schmitt-Grohé and Uribe, 2016; Chodorow-Reich and Wieland, 2020; Dupraz et al., 2019, and references therein). These forces could also explain why financial crises in high-inflation environments feature a recovery of employment at the expense of lower real wages. From a policy perspective, these findings suggest that credit-market stability and inflation dynamics can play a central role in shaping labor market recoveries from economic crises.

Related literature. Our paper contributes to several strands of the literature. First, it contributes to the literature on jobless recoveries. A rich body of work has studied the role of long-run trends in driving this type of recovery, including structural change (e.g., Groshen and Potter, 2003; Jaimovich and Siu, 2020; Restrepo, 2015); gender convergence (e.g., Albanesi, 2019; Fukui et al., 2023; Olsson et al., 2019); labor mobility; workforce aging; and cultural norms (Coibion et al., 2013). We contribute to this literature by showing that jobless recoveries are more pronounced in the presence of credit market disruptions and low levels of inflation. This finding aligns with the role of wage rigidities in jobless recoveries, as studied by Shimer (2012) in the context of frictional labor markets and Schmitt-Grohé and

Uribe (2017) in the presence of nominal wage rigidities.

Our paper also contributes to the extensive body of work that studies the effects of financial crises. At the macro level, this literature has documented that financial crises are associated with particularly large and persistent contractions in economic activity and employment (see, for example, Reinhart and Rogoff, 2009, 2014; Jordà et al., 2011; Schularick and Taylor, 2012; Donovan et al., 2024). Using cross-sectional, regional, and time-series data, the literature has identified a credit-supply channel that affects employment and investment, which can help rationalize the aggregate dynamics observed during these episodes (see, for example, Chodorow-Reich, 2014; Huber, 2018; Gilchrist and Zakrajšek, 2012; Ottonello and Song, 2022). Our contribution to this literature is twofold. First, we show that credit market disruptions disproportionately affect labor inputs. Second, we provide evidence that the level of inflation may play a critical role in shaping the specific form of aggregate adjustment following credit market disruptions, and predominantly affects either employment or real wages.

Finally, our paper relates to the literature on the costs of inflation (see, for example, Burstein and Hellwig, 2008, and references therein). Our findings on wageless recoveries align with survey evidence from Stantcheva (2024), which shows that households primarily dislike inflation because it erodes their purchasing power. In this sense, our results provide evidence consistent with theoretical models that link the welfare costs of inflation to real wage adjustments (for recent studies in this area, see Afrouzi et al., 2024; Guerreiro et al., 2024; Hajdini et al., 2023; Pilossoph and Ryngaert, 2024).[1]

The rest of the paper is organized as follows. Section 2.2 presents empirical evidence that characterizes the recovery from financial crises in developed-market economies. Section 2.3 introduces data on emerging-market economies to study the role of inflation in shaping the type of labor market recovery following financial crises. Section 2.4 concludes.

2.2 Recovery from Financial Crises

We document that financial crises in developed-market economies tend to be followed by jobless recoveries. Section 2.2.1 defines our measures of recession episodes, jobless recoveries, and financial crises, and describes the data used in the empirical analysis. Section 2.2.2 presents the results.

[1] Our evidence also suggests that, during financial crises, the alternative to wageless recoveries might be jobless recoveries. This introduces a potentially interesting source of state dependency for the costs of inflation (i.e., depending on underlying financial conditions) that could be further explored using both survey evidence and theoretical models.

2.2.1 Methodology and data

An accounting framework for recession recoveries. We analyze recovery from financial crises and other recession episodes using an accounting framework in the spirit of Solow (1957). We consider a discrete-time economy in which aggregate output and inputs are connected through the production function:

$$y_t = A_t k_t^{\alpha} (\gamma^t l_t)^{1-\alpha},$$

where y_t represents per capita output, k_t and l_t represent per capita capital and labor inputs, A_t denotes a stationary total factor productivity (TFP) process, $\gamma \geq 1$ represents the growth rate of labor-augmenting technology, and $\alpha \in (0, 1)$.

To define a recession, let us assume that output in the economy contracts in period $t = t_c$ and recovers to $\gamma^{t_R - t_c - 1} y_{t_c - 1}$ in period t_R. The evolution of output between the recession peak ($t_P \equiv t_c - 1$) and the recovery point (t_R) can be decomposed into the contributions of three factors:

$$\Delta_d \log y_{t_R} = \underbrace{\gamma d + \frac{1}{1-\alpha} \Delta_d \log A_{t_R}}_{\text{productivity contribution}} + \underbrace{\frac{\alpha}{1-\alpha} \Delta_d \log \left(\frac{k_{t_R}}{y_{t_R}} \right)}_{\text{capital contribution}} + \underbrace{\Delta_d \log l_{t_R}}_{\text{labor contribution}},$$

where $d = t_R - t_P$ measures the duration of the recession episode. Along a balanced-growth path, A_t, $\frac{k_t}{y_t}$, and l_t would remain constant.[2] Relative to this benchmark, we empirically characterize recovery from a recession by investigating the contribution of different factors to production compared with their balanced-growth path evolution. Specifically, we define a "jobless recovery" as the recovery from a recession in which the labor factor exhibits a negative contribution between the output peak and the recovery, i.e., $l_{t_R} < l_{t_P}$. Our empirical analysis focuses on examining the dynamics of these factors during various types of recession episodes—both financial crises and other recessions—which we will define in subsequent sections.

Data. In this section, we provide a summary of the data used in our empirical analysis. For more detailed description of data sources, please refer to Appendix B.1. Our empirical analysis focuses on a sample of 23 high-income OECD economies: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the

[2] As is standard, to define such a balanced-growth path we would have to specify preferences, the technology for capital accumulation, and equilibrium. Because we abstract here from a particular specification of these elements, our statement refers to any economy that features a balanced-growth path.

United Kingdom, and the United States. We refer to this sample as the developed-market sample. In Section 2.3, we expand the analysis to include a sample of emerging-market economies.

We focus on data sources that have broad availability across countries and time. For real GDP, capital stock, employment, and hours worked, we use data from the Penn World Tables, which are available for our developed-market sample since the 1950s (and also for the emerging-market sample we analyze later in the paper). With this dataset, we also estimate α, computed as the average capital share of GDP, and measured productivity as the Solow residual. To express output, capital, and labor inputs in per capita terms, we use data for the working-age population. We construct this measure by combining the total population from the Penn World Tables with the working-age-to-population ratio, defined as the population aged 15–64 divided by the total population. The working-age-to-population ratio is obtained from the OECD and World Development Indicators (WDI) datasets.

Our empirical analysis also uses additional data to further characterize the dynamics during crisis recoveries across three labor market dimensions. First, we examine unemployment, which we measure using data from sources such as the WDI, World Economic Outlook (WEO), and national sources. Second, we analyze real wages, which we construct using nominal wage data from the Conference Board's International Labor Comparisons program (ILC), WEO, and national sources. These wages are then deflated using the Consumer Price Index (CPI). Third, we examine the labor wedge, defined as the ratio of the marginal rate of substitution between consumption and leisure to the marginal product of labor. The labor wedge is a variable frequently used in macro and labor literature to measure distortions in the labor market relative to the neoclassical framework (see, for example, Shimer, 2009).[3]

Definition of recession episodes and financial crises. In our empirical analysis, we define a recession episode as a time window that encompasses a contraction of annual per capita GDP followed by a recovery to pre-contraction levels. To determine the peak, trough, and recovery point of recession episodes, we identify recession episodes using the following algorithm:

1. For each country i, identify the first recession episode as the first period in which there

[3]Measuring the labor wedge requires specifying households' preferences over consumption and leisure. In our baseline computations, we assume a separable utility function for households, $\log(c_t) - \frac{\chi\eta}{1+\eta} h^{\frac{1+\eta}{\eta}}$, where η represents the Frisch elasticity of labor supply. With these preferences, we compute the evolution of the labor wedge from the recession's peak to recovery as $\Delta_d \log(1-\tau_{t_R}) = \Delta_d \log c_{t_R} - \Delta_d \log y_{t_R} + \frac{1+\eta}{\eta} \Delta_d \log h_{t_R}$ where τ_{t_R} is the labor wedge. For this computation, in addition to the output and employment variables described earlier, we use real consumption data from the Penn World Tables. In our baseline computations, we set $\eta = 1$.

is a per capita output contraction -i.e., $t_c(i,1) \in [1, T_i]$ - such that $y_{t_c(i,j)} < y_{t_c(i,j)-1}$ for $j = 1$, where T_i denotes the last year with available data for country i.

2. Define the *peak* of recession episode j as the period immediately preceding the output contraction that marks the beginning of the recession episode: $t_P(i,j) \equiv t_c(i,j) - 1$.

3. Define the *recovery point* of recession episode j as the period $t_R(i,j) > t_c(i,j)$ in which per capita output recovers its peak level or its trend (HP-filtered with a smoothing parameter of 100). If there is no recovery point within the available data, the recession is excluded from the analysis.

4. Define the *trough* of the recession episode as the period with the minimum level of per capita output between the peak and recovery points.

5. Repeat steps (1)-(3), identifying periods of output contraction after the previous recovery point. Specifically, for $j = 2, 3, \ldots$, identify $t_c(i,j) \in [t_R(i,j-1)+1, T_i]$, such that $y_{t_c(i,j)} < y_{t_c(i,j)-1}$, until there are no more output contractions in that country after the last recovery point.

Using our definition of recessions, we identify 143 recession episodes in developed countries, detailed in Appendix Tables B.1 and B.2. Table 2.1 provides summary statistics of our sample of recession episodes, which show an average per capita output contraction of 3%, an average duration of 1.6 years between peak and trough, and an average duration of 1.8 years between the trough and recovery. This results in an average duration of 3.4 years between the peak and recovery. In analyzing individual episodes, we note that our method often coincides with those frequently used by researchers in the field, such as NBER recession episodes for the U.S. and the ECRI for Europe. One notable difference is that our method bundles "double-dip" recessions, in which a second output contraction occurs before output reaches its recovery point, such as the 1980-81 recession in the U.S.

Within our sample of recession episodes, we define a *financial crisis* as an episode that coincides with a banking crisis or a debt crisis event that occurs within a window from 1 year before the output peak to 1 year after the output recovery point. Data on banking and debt crises are obtained from Reinhart and Rogoff (2009). Based on this definition, we classify 46 recession episodes as financial crises.

As shown in Table 2.1, the average output contraction in financial crises is larger than that in non-financial recessions. To create a group of non-financial recession episodes that is more comparable to financial crises in terms of economic contraction, we construct a category called "other large recessions" by excluding from non-financial recessions those episodes with output contractions below a certain cutoff value, denoted by $\underline{y}$. We set $\underline{y}$ to a value such

Table 2.1: Summary Statistics of Recession Episodes in Developed-Market Economies

	All episodes	**Financial crises**	**Other episodes**	
			Large	**Mild**
(a) Output per capita contraction (%)				
Mean	3.0	4.1	4.1	0.6
Median	1.8	4.3	3.5	0.6
Std. dev.	3.3	4.3	2.6	0.4
Min	0.0	0.1	1.4	0.0
Max	25.3	25.3	11.4	1.3
(b) Duration from peak to recovery (years)				
Mean	3.4	4.3	3.6	2.2
Median	3.0	4.0	3.0	2.0
Std. dev.	1.9	2.2	1.9	0.6
Min	2.0	2.0	2.0	2.0
Max	10.0	9.0	10.0	5.0
(c) Duration from trough to recovery (years)				
Mean	1.8	2.3	1.9	1.1
Median	1.0	2.0	2.0	1.0
Std. dev.	1.2	1.4	1.1	0.3
Min	1.0	1.0	1.0	1.0
Max	6.0	6.0	5.0	2.0
Number of episodes	143	46	52	45

Notes: This table presents descriptive statistics of the recession episodes used in the empirical analysis for our sample of developed-market economies. Panel (a) reports descriptive statistics of the output contraction observed in each episode, measured in percent, from peak to trough. Panels (b) and (c) show the duration from peak to trough and from trough to recovery, respectively, measured in years. The column labeled *All* presents descriptive statistics for the entire set of recession episodes identified using the algorithm described in Section 2.2.1, and the column labeled *financial crises* represents statistics for the recession episodes classified as financial crises according to the definition provided in Section 2.2.1. The columns labeled *Other episodes* report statistics for recession episodes that are not classified as financial crises. The *Large* category includes episodes with an output peak-to-trough contraction above -0.014, chosen to match the average contraction of financial crises. The *Mild* category encompasses the remaining episodes that do not meet the criteria for classification as large recessions. See Appendix B.1 for further information on the definition of variables and data sources.

that the average contraction in other large recessions matches that of financial crises. In our sample, we use $\underline{y} = -0.014$. Table 2.1 presents descriptive statistics for both the group of other large recessions and the group of "mild recessions," which consists of episodes in the other group with output contractions below $\underline{y}$. It is important to note that our conclusions regarding differences between recoveries from financial crises and other episodes are stronger when mild recessions are included in the comparison group of non-financial crises. The objective in constructing the comparison group with other large recessions is to ensure that the results are not driven solely by the magnitude of the output contraction.

2.2.2 Empirical Results

Financial crises. The first column of Table 2.2 presents the results of our accounting exercise for the recovery from financial crises. Specifically, it reports average changes in the log of output, employment, the capital-output ratio, and measured productivity from the episode peak to the recovery point. Complementing this, the top panels of Figure 2.2 illustrate the dynamics of these variables throughout the episodes, showing their changes from peak to trough and from trough to recovery.

Table 2.2: Recovery from Financial Crises

	Developed	Emerging Markets	
	Markets	Moderate inflation	High Inflation
(a) Accounting exercise			
Output	0.004	-0.005	-0.021*
	[0.006]	[0.010]	[0.011]
Employment per capita	-0.034***	-0.010*	0.006
	[0.007]	[0.005]	[0.008]
Capital-output ratio	0.043***	0.021**	0.023
	[0.008]	[0.010]	[0.016]
Productivity	0.006	-0.005	-0.024*
	[0.007]	[0.008]	[0.013]
(b) Labor market dynamics			
Hours worked	-0.051***	-0.016*	-0.005
	[0.009]	[0.008]	[0.010]
Unemployment rate	0.026***	0.013***	0.006
	[0.005]	[0.003]	[0.004]
Labor force participation	-0.007	0.015**	0.022***
	[0.004]	[0.006]	[0.008]
Real wages	0.024**	0.004	-0.116**
	[0.011]	[0.024]	[0.052]
Labor wedge	0.067***	0.009	-0.011
	[0.017]	[0.013]	[0.021]

Notes: This table presents the results of estimating $\Delta_{t_R(i,j)-t_P(i,j)} Z_{i,t} = \alpha + \epsilon_{i,j}$ in a sample of financial crises, where $Z_{i,t}$ represents one of the following variables: the log of GDP over working-age population, the log of employment over working-age population, the log of the capital-output ratio, the log of measured productivity, the log of hours worked over working-age population, the unemployment rate, the log of labor force participation over working-age population, the log of real wages, or the log of the labor wedge for episode j in country i. The terms $\{t_P(i,j), t_R(i,j)\}$ denote the output peak and recovery point of each episode j in country i. The table reports the estimated parameter α. For the definition of financial crises, see Section 2.2.1. The *Moderate inflation* and *High inflation* categories include episodes with maximum annual CPI inflation during a crisis below and above 30 %, respectively. $*$, $**$, and $***$ represent statistical significance at the 10%, 5%, and 1% levels, respectively.

The first two rows of Table 2.2 and Panels (a) and (b) of Figure 2.2 show that financial crises tend to be followed by jobless recoveries: when output returns to its pre-crisis level, employment remains, on average, 3% below its pre-crisis level. The third row of Table 2.2 and Panel (c) of Figure 2.2 indicate that the counterpart of jobless recoveries is the resilience of the capital stock, which increases from peak to trough and remains 4% above its pre-crisis level at the recovery point. Finally, the fourth row of Table 2.2 and Panel (d) of Figure 2.2 reveal that measured productivity, which is known to be procyclical, follows a pattern resembling that of output, with no significant changes observed from peak to recovery during financial crises.

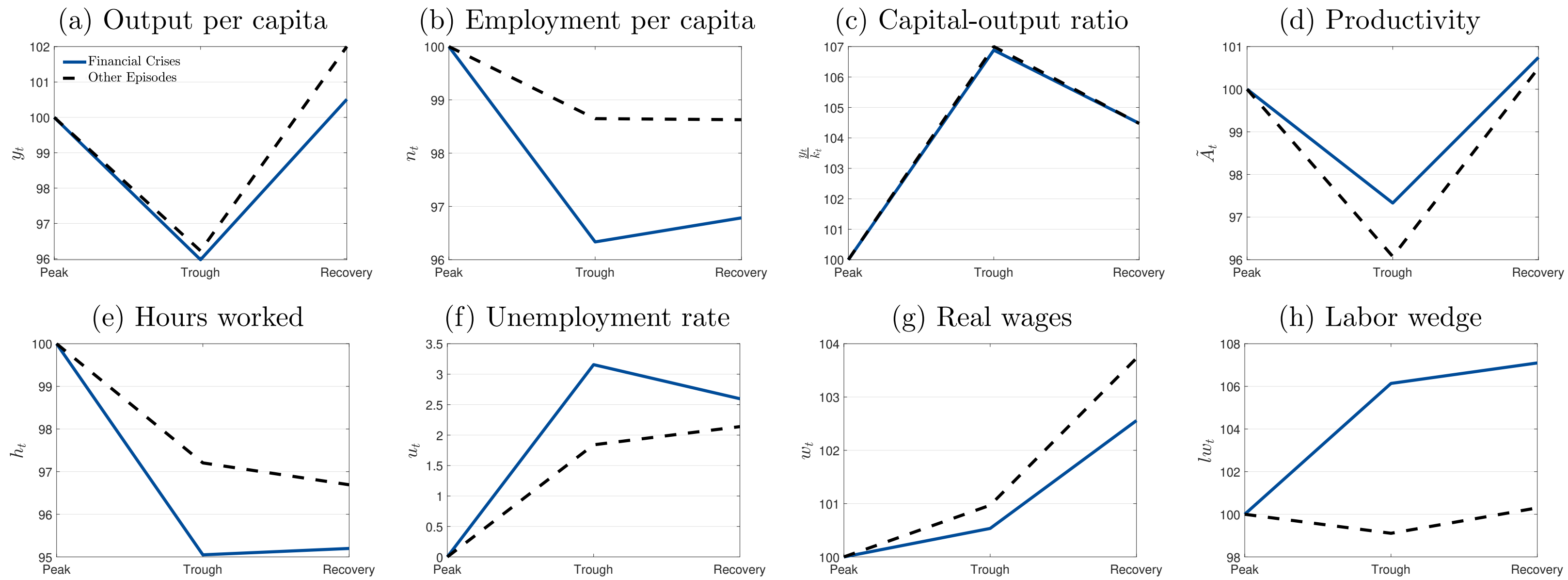
To further analyze the jobless recoveries observed following financial crises, Panel (b) of Table 2.2 and the bottom panels of Figure 2.2 examine the recovery of additional labor market variables, which yields three key results. First, the phenomenon of jobless recoveries following financial crises is also observed in hours worked and the unemployment rate. Specifically, when output returns to its pre-crisis level, hours worked remain 5% below their pre-crisis level and the unemployment rate is 3 percentage points above its pre-crisis level. There is also a small decline in participation rates, although this difference is not statistically significant. Second, despite the jobless recovery, real wages increase throughout the episode, ending up 2% above their pre-crisis level at the recovery point. Third, there is a sizable increase in the labor wedge, which is 7% above its pre-crisis level at the recovery point.

Comparison with other recessions. To put the accounting exercise during financial crises into perspective, Figure 2.2 compares the dynamics during financial crises with those observed in other large recession episodes. Complementing this, Appendix Table B.3 presents these differences in a regression format under alternative specifications (i.e., including time trends, post-1990 fixed effects, or country fixed effects) and alternative samples (i.e., including "mild" recession episodes or excluding global financial crisis episodes).

The main distinguishing aspect of the recovery from financial crises relative to other large recession episodes is the labor input, which contracts more severely in financial crises than in other recession episodes and remains 2% below that in large recession episodes at the recovery point. The capital-output ratio exhibits remarkable similarities, while measured productivity shows less pronounced contractions and slightly higher recovery in financial crises, although the difference is not statistically significant.[4] In terms of other labor market variables, a significant difference appears in the labor wedge, which increases sharply during financial crises but remains fairly stable in other large recession episodes.

[4]This smaller decline in productivity during financial crises is consistent with models that attribute the source of the contraction during financial crises to factors other than productivity (e.g., "financial shocks," as in Jermann and Quadrini, 2012; Khan and Thomas, 2013).

Figure 2.2: Recovery from Financial Crises in Developed-Market Economies



Notes: This figure reports the dynamics of GDP over the working-age population, employment over the working-age population, the capital-output ratio, measured productivity, hours worked over the working-age population, the unemployment rate, real wages, and the labor wedge during financial crises and other large recessions in developed-market economies. Each variable is indexed to 100 at the peak of each episode, except for the unemployment rate, which is expressed as deviations from its peak value. Each plot shows the average values of the respective variable at the recession peak, trough, and recovery point. The solid blue line represents financial crises and the dotted black line represents other large recession episodes. Further details on the definitions of financial crises are provided in Section 2.2.1. For additional information on the variables and data sources, see Appendix B.1.

2.3 The Role of Inflation: Evidence From Emerging-Markets

Emerging-market sample. In this section, we extend our analysis to include emerging-market economies. Our emerging-market sample consists of 35 middle-income economies: Algeria, Argentina, Brazil, Bulgaria, Chile, China, Colombia, Croatia, Czech Republic, Dominican Republic, Ecuador, Egypt, El Salvador, Hungary, Indonesia, Ivory Coast, Lebanon, Malaysia, Mexico, Morocco, Nigeria, Pakistan, Panama, Peru, Philippines, Poland, Russia, South Africa, South Korea, Thailand, Tunisia, Turkey, Ukraine, Uruguay, and Venezuela.[5]

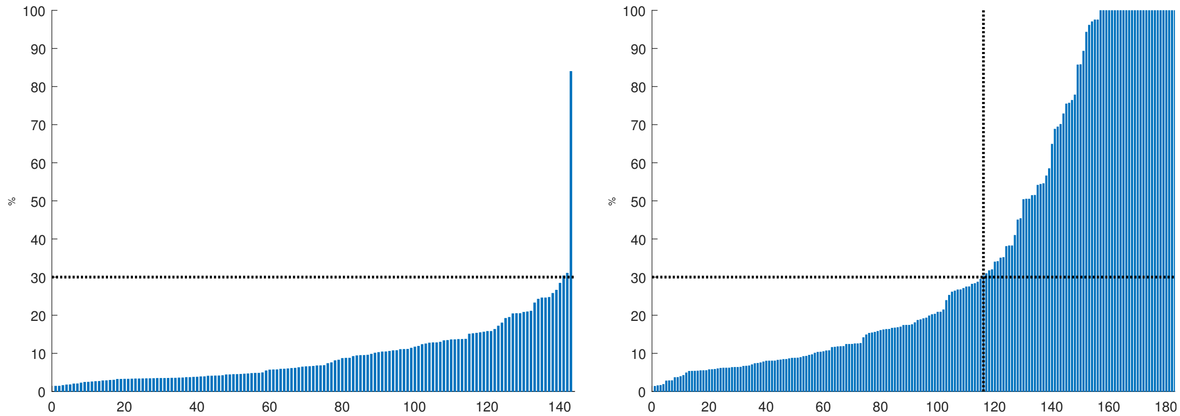
Using this sample of countries and the same procedure as in Section 2.2.1, we identify 196 recession episodes in emerging markets (detailed in Appendix Tables B.4–B.6), 53% of which are financial crises. Appendix Table B.7 provides summary statistics for these episodes. The average per capita output contraction in emerging markets is 7%, more than twice that observed in developed economies. The duration of these episodes is slightly longer than in developed economies, averaging 4 years from peak to recovery. As in developed economies, financial crises in emerging markets are associated with larger output contractions and longer durations, although the differences with non-financial recessions are smaller than those observed in their developed economy counterparts.

Moderate- and high-inflation episodes. It is well known that emerging economies tend to feature higher and more volatile inflation rates than developed economies (for a recent study, see Blanco et al., 2022, and references therein). Figure 2.3 illustrates this phenomenon in our sample of recession episodes, reporting the inflation rates reached during these episodes (after winsorizing rates above 100 %). In developed-economy recession episodes, the average annual inflation rate reached is 10%, with a standard deviation of 9%. In emerging markets, this average is 36%, with a standard deviation of 35%. This variation allows us to explore how labor market recoveries differ depending on the inflation rates experienced during the episode. For this purpose, we define "moderate" inflation episodes as those with maximum inflation rates below 30% (in the spirit of Dornbusch and Fischer, 1993), and classify the rest as "high-inflation" episodes. Moderate-inflation episodes (detailed in Appendix Tables B.4 and B.5) reach average annual inflation rates of 12%, with a standard deviation of 9%, which renders this set comparable in terms of inflation outcomes to developed economies. High-inflation episodes (detailed in Appendix Table B.6) reach average inflation rates of 76

[5] This selection of emerging-market economies follows the study by Calvo et al. (2006), which focused on sudden-stop episodes and included economies integrated into international capital markets, as indicated by their inclusion in JPMorgan's EMBI.

Figure 2.3: Inflation during Recession Episodes

(a) Developed-market Economies (b) Emerging-market Economies



Notes: This figure illustrates the maximum annual inflation rate observed between the peak and recovery years of each recession episode for developed-market economies (Panel (a)) and emerging-market economies (Panel (b)). The horizontal line marks an inflation rate of 30%, which defines the threshold used to classify episodes into moderate- and high-inflation groups. In Panel (b), the vertical line separates emerging-market episodes into these two groups. Episodes included in the analysis are detailed in Appendix Tables B.1–B.6.

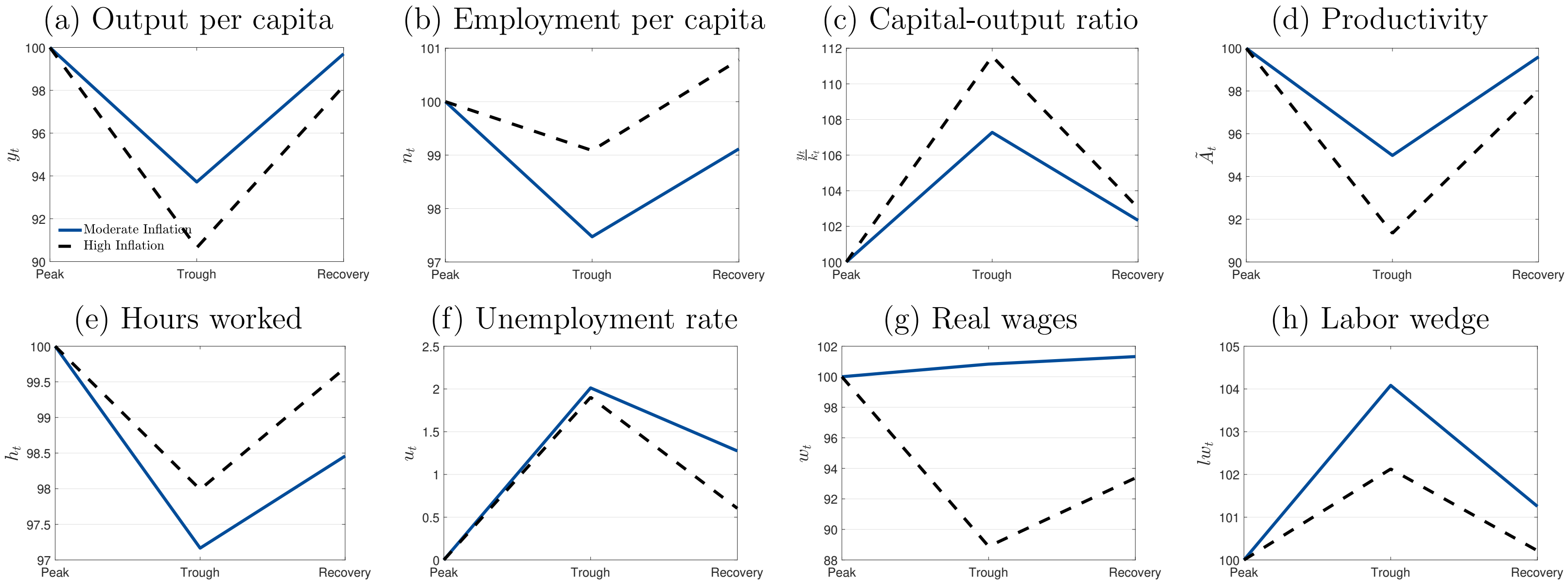
%, with a standard deviation of 26%. Appendix Table B.7 shows that within emerging-market financial crises, 54% are high-inflation episodes, which tend to feature substantially higher output contractions than moderate-inflation episodes (9% vs. 6%) and slightly longer durations.

Empirical results. The second and third columns of Table 2.2 and Figure 2.4 characterize the recovery from financial crises in emerging markets under alternative inflation environments, with two main results. First, similar to the patterns documented in developed markets, moderate-inflation financial crises in emerging markets are characterized by jobless recoveries, the resilience of capital stocks, and no declines in real wages. These episodes exhibit two key differences compared with developed economies. First, jobless recoveries are more markedly observed in unemployment rates than in employment or hours worked. Related to this, emerging-market economies feature significant increases in participation rates throughout the episode, in contrast to developed market episodes. Second, the labor wedge does not exhibit substantial adjustments, which suggests that the increase in labor market distortions during financial crises is larger for developed economies than for emerging economies.

Our second key result is that high-inflation episodes exhibit a markedly different pattern of labor market recovery. On the one hand, they do not show signs of jobless recoveries, since employment, hours worked, and unemployment rates largely recover their pre-crisis levels once output returns to its pre-crisis level. On the other hand, they experience a sizable decline in real wages, which do not recover their pre-crisis levels even after output has fully recovered. In this sense, these episodes feature a "wageless recovery."[6]

[6]In addition to the labor market patterns, high-inflation episodes are characterized by a weaker recovery in measured productivity. While lower productivity growth can contribute to the lack of recovery in real wages, it is harder to connect it simultaneously to the strong employment recovery observed in these episodes.

Figure 2.4: Recovery from Financial Crises in Emerging Markets: Moderate vs. High Inflation



Notes: This figure reports the dynamics of GDP over the working-age population, employment over the working-age population, the capital-output ratio, measured productivity, hours worked over the working-age population, the unemployment rate, real wages, and the labor wedge during financial crises in emerging markets. The analysis focuses on episodes characterized by "moderate inflation" (solid blue line) and "high inflation" (dashed black line). Moderate-inflation episodes are defined as those with a maximum annual CPI inflation below 30 %, while high-inflation episodes have a maximum annual CPI inflation above 30 %. For each crisis episode, variables are indexed to 100 at the recession peak, except for the unemployment rate, which is expressed as deviations from its value at the peak of each recession episode. The plots display the average value of each variable during the recession peak, trough, and recovery points for moderate- and high-inflation episodes. Further details on the definitions of financial crises and other recession episodes are provided in Section 2.2.1. The financial crises episodes are listed in Appendix Tables B.4-B.6. For additional information on the variables and data sources, see Appendix B.1.

2.4 Conclusion

In this paper, we documented two key facts about labor market recovery from economic crises. First, disruptions in credit markets tend to have persistent effects on the labor market, manifesting in either low employment or real wages. Second, the type of adjustment depends on the level of inflation, with low-inflation financial crises being followed by jobless recoveries and high-inflation episodes by wageless recoveries.

Our findings have two broader implications. From a positive perspective, they raise the question of why financial crises disproportionately affect labor relative to capital. Macro-finance models frequently focus on the impact of credit market disruptions on capital accumulation, which typically involves large initial investments and is directly tied to credit. However, labor—despite not requiring such large upfront credit needs—appears to be more affected by credit market disruptions than capital. Understanding this disproportionate impact represents a promising avenue for future research in this area.

From a policy perspective, our findings shed light on two key debates surrounding the last U.S. recession. First, policies aimed at stabilizing credit markets, which were swiftly implemented by the Federal Reserve at the beginning of the recession, may have played a critical role in supporting employment recovery by mitigating increases in labor input costs. Second, the inflation surge following the recession, while costly in several dimensions, might have contributed to a faster recovery in employment compared with previous recessions. Further research that combines our empirical findings with macroeconomic models could shed light on the role of these policies in shaping labor market recoveries from economic crises.

CHAPTER 3

Inflation Stabilization Plans and Price Controls

Abstract

This paper examines the desirability of implementing price controls during inflation stabilization plans. To address this question, I develop a New Keynesian model with sticky information, following the Mankiw-Reis (2002) framework, which I use to assess the welfare costs associated with transitioning from a high-inflation to a low-inflation steady state. My findings show that even when the monetary authority commits to a new regime and agents do not anticipate future policy changes, welfare costs arise during the transition due to firms' gradual adaptation to the new regime. In this context, I introduce price controls as a policy tool aimed at mitigating the real costs of disinflation caused by information frictions. I then explore the trade-offs they create for policymakers. On the one hand, price controls offer macroeconomic benefits by coordinating prices during the transition, leading to a faster and less costly disinflation. On the other hand, they impose microeconomic costs by preventing firms from adjusting prices freely in response to idiosyncratic shocks. Ultimately, the optimality of price controls depends on the scale of disinflation relative to the magnitude of firm-level shocks.

3.1 Introduction

Price controls have been used worldwide through history for inflation stabilization purposes. In the US, for example, during the 60's and the 70's. In some emerging economies, during the 80's, as part of more broad inflation stabilization plans.[1] Recently, inflation has risen to

[1] Even today, developing countries such as Argentina, Ecuador, Israel, and Panama have recently had some form of targeted price controls for food and grocery products. See Aparicio and Cavallo (2021).

its highest level in decades generating some voices calling for the need to apply price controls to complement the work of fiscal and monetary policy in fighting inflation. In this context, a natural question emerges: Are price controls desirable during disinflation periods?

To address this question, I proceed in five steps. First, I build a New Keynesian model with sticky information in the price setting of intermediate good producers (as in Mankiw and Reis, 2002). The inclusion of information frictions has two reasons: on the one hand, I want to capture the idea that it takes some time for firms in the economy to learn about changes in the macroeconomic conditions; on the other hand, this will be the key friction that price controls will try to fix.

Second, I analyze the effects of a disinflation. In my model, the policymaker controls the money supply so the disinflation is implemented by mean of a permanent reduction of the growth rate of money supply. Basically, I want to study the transition between a high inflation-high money growth steady state and a low inflation-low money growth steady state. Here I show that even in the scenario in which the policymaker decides to apply a change in the monetary regime, and even when the agents do not expect another policy change in the future, there will be welfare costs during the transition arising from firms slowly internalizing the new monetary regime.

Third, I introduce price controls in the model. The rationale for these policies is to reduce the real costs of the disinflation, which arise from the existence of information frictions. During the transition to the low inflation steady state, the government can not control the speed at which firms are learning, something that is given by the information structure of the economy. However, it can control the prices that firms are setting. In this context, I define price controls as a policy in which the government sets an exogenous path of future maximum prices that firms can set during the disinflation. Here, I show that price controls are a policy that mimics the outcomes of a reduction in the degree of information frictions in the economy.

Fourth, I study the optimality of price controls in the case in which the only shock to the economy is the aggregate disinflation shock. In this context, I will show that price controls are optimal in the sense that they contribute to reduce the welfare costs during the transition. Moreover, I will prove that there exists an optimal policy of price controls that replicates the competitive equilibrium with no information frictions. Then, disinflations will be cost-less.

Finally, I incorporate idiosyncratic shocks to the productivity of intermediate good producers. This will generate a clear trade-off for the policymaker. On the one hand, price

[1] A "disinflation" is referred as a situation in which there is a direct attempt from the policymaker to permanently reduce the rate of inflation in the economy.

controls will generate benefits at the macro level: they coordinate prices during the transition allowing for a faster and less costly disinflation. On the other hand, they will generate costs at the micro level coming from firms not being able to fully respond to the shocks that they are facing.

At the end of the day, the optimality of these controls will depend on the magnitude of the disinflation that the policymaker wants to implement, relative to the size of the idiosyncratic shocks that the firms are subject to. When the magnitude of the disinflation is large relative to the size of the idiosyncratic shocks price controls will be optimal. The reason is that the macro distortion that they are reducing are greater than the micro distortions that they generate. On the other hand, when the magnitude of the disinflation is small relative to the size of the idiosyncratic shocks price controls will not be desirable.

Related literature: This paper contributes to two strands of the literature. First, to the the literature studying the determinants of successful disinflations. Some studies have focused on the monetary policy framework, i.e. money supply rule versus interest rate rule (Ascari and Ropele 2013), others have put the emphasis on the speed and timing of the disinflation (Sargent, 1983; Ball, 1994). Additionally, some works have highlighted the relevance of credibility (Ball 1995; Erceg and Levin 2003; Goodfriend and King 2005). I complement this literature by bringing to the analysis an overlooked policy: price controls.

Second, to the large body of work studying price controls from a macroeconomic perspective. There is plenty of work studying the use of price controls during disinflations; however, most of this work has adopted a historical or "case-study" point of view (see Galbraith, 1980; Friedman, 1966; Dornbusch and Simonsen, 1987; Bruno, 1991; Rockoff, 2004; Agenor, 2015; among others). I contribute to this literature by providing a theoretical framework to interpret and quantify the trade-off generated by these policies. On the other hand, the theoretical work on the topic is quite limited. An exception is Álvarez and Werning (2020) who analyze the effects of temporary price controls without considering a change in the macroeconomic fundamentals of the economy. I contribute to this literature by providing a model to study the macroeconomic implications of price controls in the context of a permanent change in the monetary regime.

Layout: The rest of the paper is organized as follows. Section 2 presents the model. Section 3 analyses the effects of a disinflation. Section 4 introduces price controls and studies their effects in an economy with only aggregate shocks. Section 5 introduce idiosyncratic shocks and study optimal price controls. Section 6 discusses some extensions and shortcomings. Section 7 concludes.

3.2 The Model

Environment: Time is discrete, infinite and indexed by t. There are four type of agents in the economy: a representative household, a government, a final good competitive firm and a continuum of intermediate good producers.

3.2.1 Households

There is a representative household that derives utility from consumption, C_t and labor N_t. Its lifetime utility is given by:

$$U_0 = E_t\Big[\sum_{t=0}^{\infty}\beta^t u_t(C_t, N_t)\Big], \quad \text{with} \;\; u(C_t, N_t) = \Big[\log(C_t) - N_t\Big] \tag{3.1}$$

E_t denotes the mathematical expectations operator conditional on information available at time t and $\beta \in (0,1)$ represents a subjective discount factor.

The household budget constraint is given by:

$$P_tC_t + B_t \leq W_tN_t + \Pi_t - P_tT_t + R_{t-1}B_{t-1} \tag{3.2}$$

Money is the numeraire, and P_t is the price of goods in terms of money. B_{t-1} is the stock of nominal bonds a household enters the period with, and they pay out (known as of $t-1$) gross nominal interest rate R_{t-1}. W_t is the nominal wage. Π_t denotes (nominal) profits remitted by firms, and T_t is a lump sum tax paid to the government.

The problem of the households is:

$$\max_{\{C_t, L_t, B_t\}_{t=0}^{\infty}} U_0 \;\; s.t. \;\; (2) \tag{3.3}$$

The optimality conditions of this problem are:

$$P_tC_t = W_t \tag{3.4}$$

$$1 = \beta R_t E_t\Big\{\frac{C_t}{C_{t+1}}\frac{P_t}{P_{t+1}}\Big\} \tag{3.5}$$

3.2.2 Government

Money is introduced in the model by assuming that aggregate nominal spending must be equal to aggregate money supply:[2]

$$P_t C_t = M_t \tag{3.6}$$

Money supply follows a random walk:

$$\log(M_t) = g_t + \log(M_{t-1}) + \varepsilon_{m,t} \tag{3.7}$$

where $g_t = \ln M_t - \ln M_{t-1}$, is the growth rate of money and $\varepsilon_{m,t}$ is a monetary shock.

The government's budget constraint in nominal terms is:

$$0 \leq P_t T_t + M_t - M_{t-1} \tag{3.8}$$

If money growth is positive (e.g. $M_t > M_{t-1}$), then lump sum will be negative - the government will be rebating its seignorage revenue to the household lump sum. In equilibrium, bond-holding is always zero in all periods: $B_t = 0$.

3.2.3 Production

Production occurs in two stages. There is a representative competitive final goods firm which aggregates differentiated intermediate inputs according to a CES technology. Additionally, there is a continuum of mass unity of these intermediate good firms that behave as monopolistically competitive. These firms produce output using labor only and are subject to information frictions when they adjust prices, in a way that I will discuss in more depth below.

3.2.3.1 Final good producers

Let Y_t be output of the representative final good firm; $Y_{i,t}$ be input from intermediate goods producer i and $P_{i,t}$ be the associated nominal price. The production function for final goods is the following CES aggregator of intermediate goods:

$$Y_t = \left(\int_0^1 Y_{i,t}^{\frac{\epsilon_p - 1}{\epsilon_p}} di \right)^{\frac{\epsilon_p}{\epsilon_p - 1}} \tag{3.9}$$

[2] This way of proceeding money is quite accepted in the literature, especially in the one associated with menu cost models. For some references, see Midrigan (2011).

where $\epsilon_p > 1$ is the price elasticity of demand for each intermediate good.

From cost minimization, the demand for each intermediate good is given by:

$$Y_{i,t} = \left(\frac{P_{i,t}}{P_t}\right)^{-\epsilon_p} Y_t \tag{3.10}$$

and the price index is:

$$P_t = \left(\int_0^1 P_{i,t}^{1-\epsilon_p} di\right)^{\frac{1}{1-\epsilon_p}} \tag{3.11}$$

3.2.3.2 Intermediate good producers

Each intermediate good producers produce output according to a constant returns to scale technology in labor $N_t(j)$. For the sake of simplicity, I assume that there are no aggregate productivity shocks but they could be added here easily:

$$Y_{i,t} = N_{i,t} \tag{3.12}$$

These firms solve a cost minimization problem to minimize total cost subject to the constraint of producing enough output to meet the demand in (3.10):

$$\min_{N_{i,t}} W_t N_{i,t} \quad s.t. \quad N_{i,t} \geq \left(\frac{P_{i,t}}{P_t}\right)^{-\epsilon_p} Y_t$$

$$N_{i,t}: \quad mc_t = W_t$$

where mc_t is the marginal cost. Note that $mc_{i,t} = mc_t \forall i$ since the nominal wages they face is the same.

3.2.3.3 Price Setting

Information frictions: Mankiw and Reis (2002) assume that information about macroeconomic conditions diffuses slowly. Although firms can always change their prices, their pricing decisions are not always based on current information. In each period, a fraction $1-\theta$ of firms obtain new information about the state of the economy and computes a new path of optimal prices. The remaining fraction θ of firms continue to set prices based on old plans and outdated information. It is as if all information about the aggregate state is out there, but only once in a while does a firm open a newspaper and fully updates its knowledge of these states. Information arrival is analogous to the arrival of the Calvo fairy.

A firm's i desired price under complete information is given by:

$$P^*_{i,t} = \eta W_t, \quad \eta = \frac{\epsilon_p}{\epsilon_p - 1} \tag{3.13}$$

This price arises from the profit maximization problem of firm i under full information.

Let $X^k_{i,t}$ be the price that a firm i that last updated its information k periods ago set in t:

$$X^k_{i,t} = \begin{cases} P^*_{i,t} & \text{for } k = 0 \\ E_{t-k}\{P^*_{i,t}\} & \text{for } k > 0 \end{cases} \tag{3.14}$$

Equation (3.14) states that firms that collect information in the current period ($k = 0$) will set in t the full information optimal price. On the other hand, firms that collected information k periods ago will set a price equal to the expectation in $t-k$ of the optimal price in t.

A first order approximation of the aggregate price index (3.11) gives place to:

$$p_t = \int_0^1 p_{i,t} di \tag{3.15}$$

where lower case variables denote the logarithm of those variables.

Since the new information arrives at a rate $1 - \theta$, the share of firms that last adjusted their plans k periods ago will be $(1 - \theta)\theta^k$. Then, the price index can be written as:

$$p_t = (1 - \theta) \sum_{k=0}^{\infty} \theta^k x^k_{i,t} \tag{3.16}$$

By replacing (3.14) in (3.16):

$$p_t = (1 - \theta) \sum_{k=0}^{\infty} \theta^k E_{t-k}\{p^*_t(j)\} \tag{3.17}$$

A salient feature of this model is that the price level will be a weighted average of past expectations about current conditions. This is a standard result from sticky information models

Proposition 1: The optimal price set by a firm i under full information is:

$$P_{i,t}^{*} = \eta M_t \tag{3.18}$$

Proof: See Appendix C.1.

From Equations (3.4) and (3.6) $W_t = P_t C_t$ and $P_t C_t = M_t$. Then, nominal wages are proportional to money supply whose dynamics are exogenous.[3] This means that shocks to the money supply translate one-for-one into changes in the nominal marginal cost and the firm's desired price. This result occurs since there are no strategic complementarities in price setting of the type emphasized by Woodford (2001). Then, the profit-maximizing price of a firm will be independent of the other firms'actions because the nominal marginal cost will be independent of the aggregate price level.

From Eq (3.14) and Proposition 1, it is straightforward that firms observing the aggregate state of the world k periods ago will set a price in t that it is a constant mark-up over the expected money supply in $t-k$:

$$X_{i,t}^{k} = E_{t-k}\{P_{i,t}^{*}\} = \eta E_{t-k}\{M_t\} \ \forall \ k > 0 \tag{3.19}$$

Assumption 1: $E_{t-k}\{M_t\} = (1+g_{t-k})^k M_{t-k}$ for $k > 0$.

Then, from (3.14), (3.19) and Assumption 1:

$$X_t^k = \begin{cases} \eta M_t & \text{for} \quad k = 0 \\ \eta E_{t-k}\{M_t\} & \text{for} \quad k > 0 \end{cases} \tag{3.20}$$

Here, I have subtracted the sub index i since the prices set by different firms $i's$ only depend on when they collected information (k).

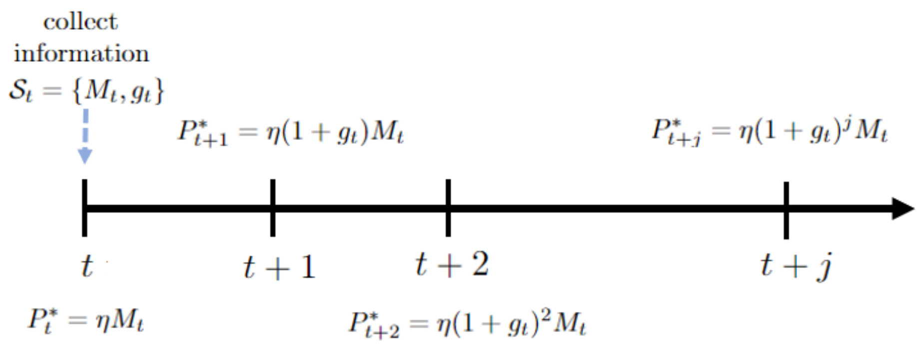
Basic mechanism of the model: Equation (3.20) allows us to compute the optimal price plan for each firm in the economy and the aggregate price level at each period of time.

[3] Here I am following Midrigan (2011). This result is first derived in Golosov and Lucas Jr (2007) who assume linear disutility of labor and log real money balances in the utility function. Then, if money supply is a random walk, there exist an equilibrium in which the nominal interest rate is constant and nominal wages are proportional to money supply.

Optimal price plan: When a firm has the opportunity to collect information about the current macroeconomic conditions at time t, it learns two things: i) the level (M_t) and, ii) the growth rate of money supply (g_t). Then, $\mathcal{S}_t = \{M_t, g_t\}$ is a sufficient statistic about the aggregate state of the world at each time t. With $\mathcal{S}_t$ in hand, each firm can compute an optimal price plan from that period forward (Figure 3.1).

Once the firms learn about a specific macroeconomic environment, that in our particular case we can associate with a specific monetary regime characterized by $\mathcal{S}$, they behave forward as if that monetary regime was to last forever.[4] They only update their optimal plans when they can collect new updated information.[5]

Figure 3.1: Optimal price path for a firm updating information at period t



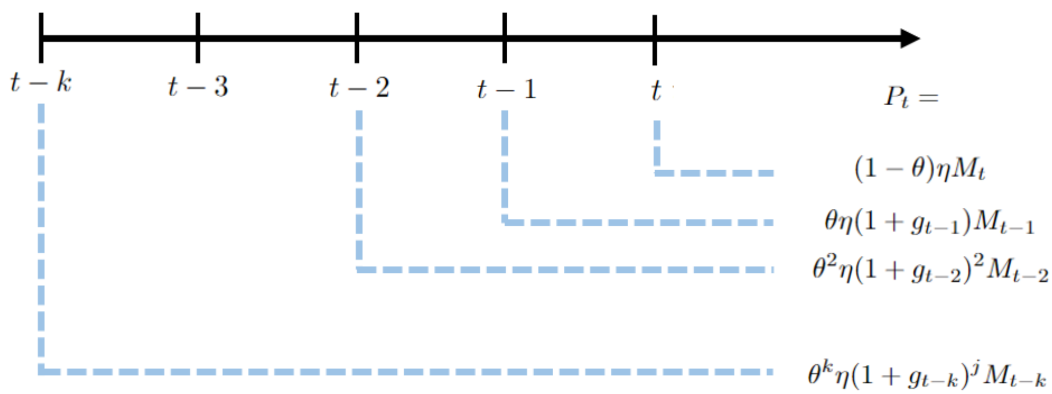
Price level: The aggregation of the optimal price plans of each firm in the economy, allows us to recover the price level (Figure 3.2). As I mentioned before, the aggregate price level will depend on past expectations about current conditions. In particular, past expectations about the current monetary regime.

Steady state: Given (3.7) and (3.20), it is straightforward to note that, in steady state, prices will grow at the same rate as money supply: $\pi^* = g$.

[4] I will use the term *monetary regime* to refer to the growth rate of money prevalent at a specific moment. Then, I will interpret different g's in different times as different monetary regimes. I will not be using the term to refer to which is the nominal anchor of the economy: inflation targeting, monetary targeting, exchange rate targeting.

[5] A possible way to formalize this is the following: monetary regimes $\mathcal{S}$ follow a Markov Chain with N states and a transition matrix Π in which all the diagonal element p_{ii} of that matrix are $= 1$. In other words, they are absorbing states.

Figure 3.2: Price level in period t



3.2.4 Equilibrium and aggregation

Since we are in a closed economy, good market clearing condition requires that:

$$Y_t = C_t$$

In the case of the labor market, the clearing condition is:

$$N_t = \int_0^1 N_{i,t} di$$

It is possible to show that aggregate output will be:

$$Y_t = \frac{A_t N_t}{v_t^p} \tag{3.21}$$

where:

$$v_t^p = \int_0^1 \left(\frac{P_{i,t}}{P_t}\right)^{-\epsilon} di \tag{3.22}$$

v_t^p is a measure of price dispersion. If all firms charged the same price, then $v_t^p = 1$. If prices charged by firms are different, then this expression is bound from below by unity. From (3.22), it is clear that $v_t^p \geq 1$, then price dispersion results in an output loss.

Definition 1 (*Competitive equilibrium*). Given initial debt B_0, and exogenous government policies $\{M_t, T_t\}_{t=0}^{\infty}$, a competitive equilibrium is a sequence of: (i) allocations $\{C_t, N_t\}_{t=0}^{\infty}$

for the representative consumer, (ii) pricing policies $\{P_{i,t}\}_{t=0}^{\infty}$ and inputs demands $\{N_{i,t}\}_{t=0}^{\infty}$ of intermediate good producers i; and (iii) final output and input demands $\{Y_t, \{Y_{i,t}\}_i\}_{t=0}^{\infty}$ of the final good producer such that:

1. Given prices, $\{C_t, N_t\}_{t=0}^{\infty}$ solve the consumer's problem.
2. Given prices, $\{Y_t, \{Y_{i,t}\}_i\}_{t=0}^{\infty}$ solve the final good producer's problem.
3. Given prices and a demand schedule, the firm's i policy $\{P_{i,t}\}_{t=0}^{\infty}$ solves its problem and the demand for inputs is optimal.
4. Given $\{M_t, T_t\}_{t=0}^{\infty}$, the government satisfy its budget constraint.
5. Labor and good markets clear.

3.3 Monetary experiment: Disinflation

In this section, I analyze the dynamics associated with a disinflation plan that is implemented by means of a permanent reduction in the growth rate of money supply. I assume that before the disinflation is actually carried out, say for $t = -\infty, ..., T-2, T-1$, the economy has been in a steady state of high inflation and high money growth characterized by g_{old}. At $t = T$, the policymaker decides to disinflate the economy by lowering the growth rate of money from g_{old} to g_{new}, with $g_{new} < g_{old}$. I assume that this shock is permanent, and that agents, once the disinflation is fully completed, do not expect any other policy change.[6]

$$M_t = \begin{cases} (1+g_{old})\, M_{t-1} & \forall t \leq T \\ (1+g_{\text{new}})\, M_{t-1} & \forall t > T \end{cases} \tag{3.23}$$

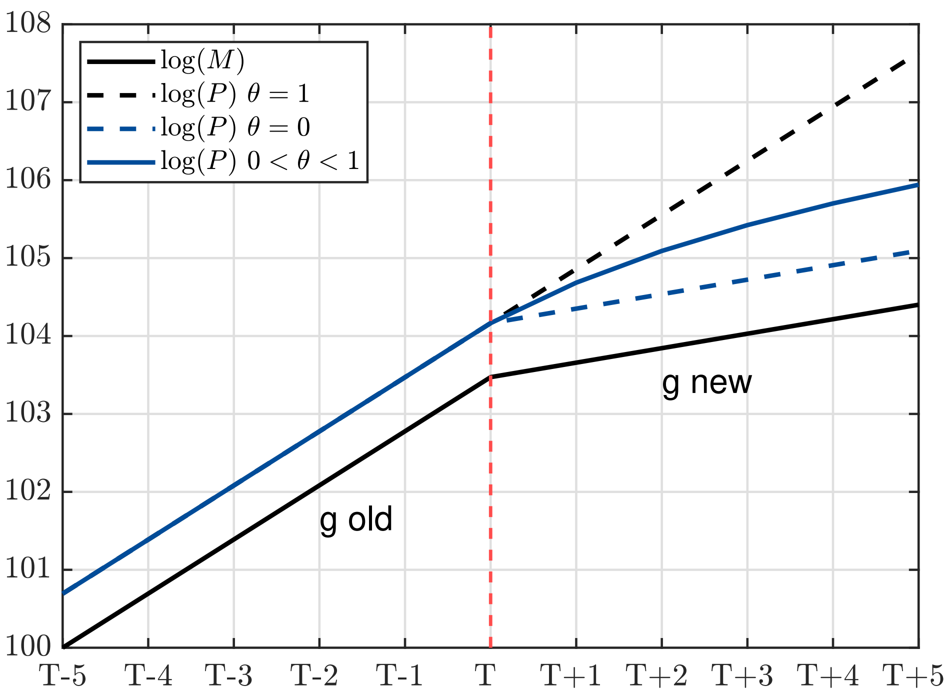
where g_{old} is the growth rate of money supply before the shock and g_{new} is the growth rate of money after the shock; with $g_{new} < g_{old}$.[7].

[6] In the literature, disinflation programs of this form are called *cold-turkey disinflations*; they are characterized by an immediate reduction of the policy target. An alternative could be a *gradual disinflation*, where the steady reduction of the policy target is completed in a certain amount of periods. For a complete description of these possible alternatives, see Ascari and Ropele (2013).

[7] The literature has long analyzed the fiscal-monetary interactions that should be consider when deciding to stabilize inflation. As Sargent has stated: "Without decreasing the budget deficit, combating inflation with monetary policy is like entering a heavyweight championship competition with one hand tied behind your back". In this model, I am not consider any monetary-fiscal interactions, I am just assuming that a permanent contraction in the growth rate of money can also generate a permanent contraction in the inflation rate. Although I am not explicitly modeling it, we can think in the permanent reduction in g as being the result of a permanent reduction in the fiscal deficit.

Figure 3.3 describes the dynamics of money supply and aggregate price level before and after the disinflation is implemented.[8] Before the shock, the economy is in a steady state where M_t and P_t growth at the same rate: g_{old}. Once the disinflation takes place, money supply changes according to the new monetary regime: g_{new} (black solid line). The response of the aggregate price level will depend on the degree of information frictions in the economy. If we were in a world of full information frictions ($\theta = 0$), firms would never learn that there has been a shock, so they would continue setting prices based on the old monetary regime, characterized by g_{old} (black dashed line). On the other hand, if we were in a world of complete information ($\theta = 1$), the price level would react immediately to the shock (blue dashed line). In an intermediate scenario ($0 < \theta < 1$), we observe that after the shock, prices grow at a rate that is approximately a weighted average of the old and new monetary regime (blue solid line).

Figure 3.3: Dynamics of money supply and aggregate price level to a disinflation shock



Note: The horizontal axis displays quarters, with $t = T$ corresponding to the period in which the disinflation starts. All variables are expressed in logs.

Proposition 2: The price level after the shock is:

[8] This graph is just an illustrative example. g_{old} and g_{new} could be whatever we want as long as $g_{new} < g_{old}$.

$$P_{T+j} = \underbrace{(1-\theta)\sum_{k=0}^{j-1}\theta^k}_{\substack{\text{fract. of firms}\\ \text{that observed}\\ \text{the shock}}} \underbrace{\eta M_{T+j}}_{\substack{\text{optimal price}\\ \text{with updated}\\ \text{inform.}}} + \underbrace{\theta^j}_{\substack{\text{fract. of firms}\\ \text{that did not}\\ \text{observed the}\\ \text{shock}}} \underbrace{\eta(1+g_{old})^j M_T}_{\substack{\text{optimal price}\\ \text{with outdated}\\ \text{inform}}} \quad \text{for } j = 1, 2, ... \tag{3.24}$$

Proof: See Appendix A.

The intuition here is the following: after the shock, the price level will be a weighted average of the optimal prices set by two group of firms. On the one hand, we have a fraction of firms that observed the aggregate state of the world after the shock; these firms recompute an optimal price plan based on the new monetary regime which, according to our previous assumptions, will last forever.[9] On the other hand, we have a group of firms who did not have the chance to recompute an optimal price plan after the shock; these firms will be setting prices based on a monetary regime that is no longer active.

Corollary 2.1: $\lim\limits_{j\to\infty} P_{T+j} \to \eta M_{T+j}$

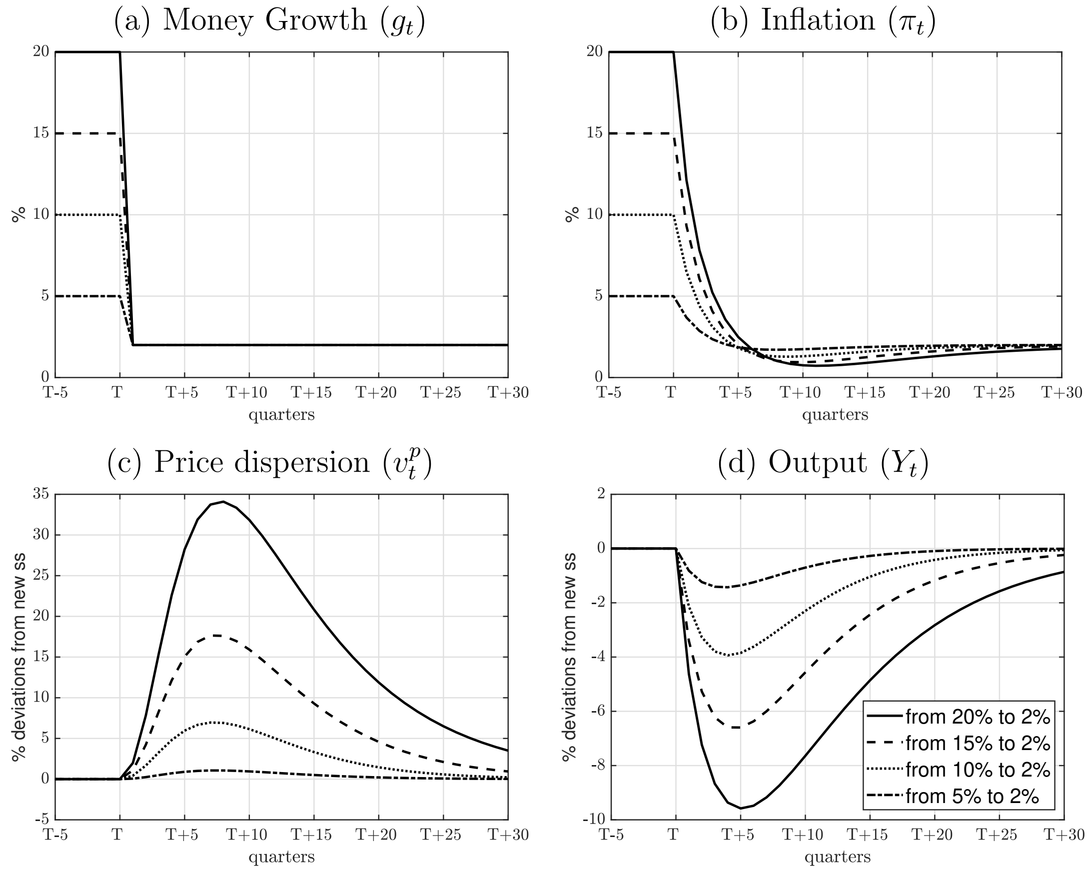
A direct Corollary from Proposition 3 is that as we move away from the moment of shock the price level will converge to be a constant over money supply. This is due to the fact that the fraction of firms that observed the shock ($(1-\theta)\sum_{k=0}^{j-1}\theta^k$) is an increasing function of j, while the fraction of firms that did not observe the shock θ^j is a decreasing function of j (see Appendix A for a formal proof of this statement).

Transitional dynamics to the new steady state: For a given parameterization of the model (Appendix Table C.1), Figure 3.4 shows the transitional dynamics of key variables when a disinflation takes place.[10] I consider 4 cases: initial inflation steady state can be $\pi^*_{old} = \{20\%, 15\%, 10\%, 5\%\}$, but the final inflation steady state is the same for all the cases $\pi^*_{new} = 2\%$.

[9]Since after T, we have that $M_t = (1+g_{new})M_{t-1}$, we can equivalently use M_{T+j} or $(1+g_{new})M_T$ in the first term of the right hand size of Eq (24).

[10]From a methodological perspective, the solution of the model requires the simulation of the path of the variables when we know the initial and the final steady state, which is usually referred as perfect foresight.

Figure 3.4: Disinflation shock: benchmark case



Note: Transitional dynamics for selected model variables to a disinflation shock for different initial inflation levels. The horizontal axis displays quarters, with $t = T$ corresponding to the period in which the disinflation starts. Inflation and money growth are expressed in percentage points. Output and price dispersion are expressed in deviations from new steady state. Values of all variables are in annualised terms.

Nominal money supply follows a random walk, so the disinflation shock results in a one time permanent shift in g_t. The response of inflation is directly linked to to our assumptions on price setting under information frictions. At time $t = T$, when the disinflation is implemented, only a random share of firms recompute their optimal plans: aware of the new monetary regime they increase prices based on this new updated information. The remaining firms, instead, mechanically adjust their prices based on optimal plans computed with information collected before the disinflation shock. This behavior generates a slow convergence of aggregate inflation to the growth rate of money in the new steady state. One way to think about this is as a "*coordination problem*" between the policymaker and the inattentive firms. Even under the scenario in which the government implements a policy to change the monetary regime, and even when this shift is fully credible, the effect of that policy takes some time to be fully internalized by all price setters in the economy. In this sense, this capture the idea often referred as "inertia": under a regime switch with no credibility issues, past behavior of certain variables still affects current's outcomes.

The pattern of price dispersion is a direct consequence of the behavior of prices. Since firms get to know about the disinflation shock sequentially, they will be setting different prices through the transition to new steady state.

Regarding output, it falls during the disinflation showing a hump shaped response. In this model, nominal spending is equal to money supply. Then, real money balances and real output move together. During the transition to the new steady state, M_t grows at a slower rate than P_t, real money balances fall, and so does output.

Lastly, is is clear from Figure 3.4 that no matter the level of the initial steady-state inflation, disinflation of the type considered give rise to qualitatively similar dynamics. The disinflation is completed in approximately 30 periods for all the cases considered. Something to remark it is that higher initial levels of steady-state inflation have strong effects on the amplitude of output and inflation declines. In percentage deviation from the new steady-state, the fall in output at the trough, which occurs between four and five periods following the disinflation, is near 10% for $\pi^*_{old} = 20\%$ and about 1% for $\pi^*_{old} = 5\%$. Likewise, the decline in inflation at the trough, which occurs after 7-10 periods, increases as π^*_{old} increases.

Measuring the costs of disinflations: One of the features of this model is that inflation does not affect real variables in steady state.[11] Then, it is necessary to focus on the transitional costs of disinflation instead of just comparing initial and final steady states. In Appendix C.3, I perform an exercise in which I measure the costs of disinflation during the transition. As it was expected, I find that, the larger the magnitude of the disinflation to be carried out, the larger the costs to be paid in terms of output and welfare.

Sensitivity to information frictions: I analyze the sensitivity of the model's predictions to the degree of information frictions of the economy. Appendix Figure C.1 presents, for a

[11] A valid question that the reader could be asking at this moment is the following: If inflation is costless in steady state but generates a cost in a disinflation; then: which are the incentives to stabilize from the policymaker's point of view? Two things to remark here. First, I am aware of the costs associated with inflation in steady state, I am just not modeling these costs; then, the policymaker decides to stabilize but for motives generated outside the model. Second, the fact that stabilizations are always welfare-reducing in this setting is due to two particular assumptions: (i) Sticky information in pricing and (ii) the way in which money is introduced in the model. Concerning (i), it is clear that models with sticky information like the one presented generate no price dispersion in steady state. This contrasts, for example, with sticky prices á la Calvo, where price dispersion is increasing in the level of steady state inflation; then, inflation has a cost, even in steady state. Regarding (ii), an alternative is to introduce money with transaction costs (Vegh, 2013).

given initial inflation steady state (20% in this case) and different values of θ, the response of the key variables in the model to a disinflation shock. It is evident from this exercise that economies with lower information frictions (lower value for θ) exhibit: i) faster convergence of inflation to the growth rate of money in the new steady state, ii) lower output losses, iii) lower price dispersion. Appendix Table C.2 confirms these results. These patterns are the result of the speed to which firms acquire new information about the aggregate state of the world. Appendix Figure C.2 displays the speed of information diffusion; for every period after the shock, it shows the fraction of firms that have observed the new monetary regime. For example, three periods after the shock ($T + 3$), near 80% of the firms have updated information for $\theta = 0.55$, while this value is below 60% for $\theta = 0.75$.

In summary, this model predicts, in response to a disinflation:

1. Slow convergence of inflation to the growth rate of money in the new steady state.
2. Output contraction and welfare losses increasing in the magnitude of the disinflation to be carried out.
3. Lower disinflation costs in economies with lower information frictions.

3.4 Introducing a new policy: the role of Price Controls

In the context of information frictions, a disinflation gives rise to a coordination problem. Since there are firms that are inattentive regarding the shift in the monetary regime, the policymaker fails to coordinate the disinflation and achieve an immediate convergence of the economy to the new steady state. If it was possible, the government would like to control the speed of the firm's learning process, i.e., the degree of information frictions prevailing in the economy. Moreover, it would like to set θ as low as possible so as to achieve a close to immediate response of prices to the new monetary regime once the disinflation is implemented (Figure 3.4). However, this is not possible since θ is a structural parameter of the economy and, obviously, policy invariant (Lucas Jr, 1976).

Definition 2 (*Price Controls*): A price control is a policy in which the government sets an exogenous path of future maximum prices for the firms.

The government can't directly control the speed to which firms adjust to the new regime. However, it can set some restrictions on price increases during the transition to the new steady state. In particular, it can force firms not to raise prices above certain level per period. In this environment, price controls arise as suitable instrument contributing to generate similar outcomes to the ones arising from reducing θ. I will show below that these policies will generate welfare gains both from the firm's point of view and at the aggregate level.

Price setting with price controls: I will study the case in which price controls are imposed taking as a reference point the price level that each firm had at the moment in which the controls were implemented.[12] Considering as the initial point the period $t = T$ in which the disinflation is implemented, price controls will be given by:

$$\bar{P}_{i,T+j} = (1 + \kappa_j)^j P_{i,T} \quad \text{for} \quad j = 1, 2, ..., J \tag{3.25}$$

Here, $P_{i,T}$ is the price set by firm i in period $t = T$, when the controls are implemented. This will set an exogenous price path for each firm that they can not exceed. Note that κ is indexed by j which means that it can change through time. Then, the price set by firm i in period t will be the minimum between the free price and the price with control:

$$X^k_{i,t} = \min\{E_{t-k}\{P^*_{i,t}\}, \bar{P}_{i,t}\} \quad \forall k > 0 \tag{3.26}$$

Assumption 2: $\kappa_t \in [g_{new}, g_{old}]$.

In what follows, I will consider price controls that lie in the region: $\kappa_t \in [g_{new}, g_{old}]$. With this assumption, the price control will only bind for inattentive firms.

Assumption 3: The information that firms receive regarding price controls does not change their perception about the aggregate state of the world.

This assumption will be relevant for when I consider a disinflation with price controls. Consider the case of those firms that did not observe the change in the monetary regime. These firms are setting prices based on g_{old}. When these firms receive a primer on the maximum price increases that they can implement, they peg to that prices only for the period in which the controls are implemented. Once these controls are removed, they return to set prices based on the last aggregate state of the world that they observed.

[12] An alternative could be to consider price controls in which firms can not raise prices more than $k\%$ with respect to the previous period. Then: $\bar{P}_{i,t} = (1 + \kappa_t)P_{i,t-1}$.

Following the analogy mentioned in Section 2, this is as if firms received two type of newspapers. Newspaper A informs firms about the aggregate state of the world: inducing a change in pricing policy from g_{old} to g_{new}. Newspaper B, informs them about the implementation of price controls: inducing a change in pricing policy from g_{old} to κ. While the government can't control the arrival rate of newspaper A (determined by the information structure of the economy), it can control the arrival rate and the information included in newspaper B.

Having said that, I am in conditions to define an Equilibrium with Price Controls.

Definition 3 (*Competitive Equilibrium with Price Controls*). Given inital debt B_0 and exogenous government policies $\{M_t, T_t, \kappa_t\}_{t=0}^{\infty}$, a competitive equilibrium with price controls is a sequence of: (i) allocations $\{C_t, N_t\}_{t=0}^{\infty}$ for the representative consumer, (ii) pricing policies $\{P_{i,t}\}_{t=0}^{\infty}$ and inputs demands $\{N_{i,t}\}_{t=0}^{\infty}$ of intermediate good producers i; and (iii) final output and input demands $\{Y_t, \{Y_{i,t}\}_i\}_{t=0}^{\infty}$ of the final good producer such that:

1. Given prices, $\{C_t, N_t\}_{t=0}^{\infty}$ solve the consumer's problem.
2. Given prices, $\{Y_t, \{Y_{i,t}\}_i\}_{t=0}^{\infty}$ solve the final good producer's problem.
3. Given prices, a demand schedule and price controls imposed by the government, the firm's i policy $\{P_t(j)\}_{t=0}^{\infty}$ solves its problem and the demand for inputs is optimal.
4. Given $\{M_t, T_t\}_{t=0}^{\infty}$, the government satisfy its budget constraint.
5. Labor and good markets clear.

3.4.1 An illustration of the application of price controls

In this section, I analyze the response of the baseline model to the inclusion of price controls. I perform three exercises:

<u>**Exercise I**</u>: Disinflation with persistent price controls.

I analyze a disinflation of the type considered before:

$$M_t = \begin{cases} (1 + g_{\text{old}})\, M_{t-1} & \forall t \leq T \\ (1 + g_{\text{new}})\, M_{t-1} & \forall t > T \end{cases}$$

Price controls are described by:

$$\kappa_t^P = \begin{cases} \infty & \forall t < T \\ \kappa_i & \forall t \leq T+i \leq T+4 \;\; \text{with } i = 0,1,2,3 \;\&\; \kappa_{i+1} < \kappa_i \\ \kappa_4 & t \geq T+5 \end{cases} \tag{3.27}$$

Eq (3.27) describes a policy of what I call persistent price controls. In time $t = T$, the government sets a sequence of exogenous price controls, not allowing firms to raise prices more than κ % per period. Two things to remark here. First, price controls are relaxed every period, which means that $\kappa_{t+1} < \kappa_t$. The idea here is that the evolution of price controls go along with the decrease in inflation expected from firms slowly learning about the new state of the world.[13] Second, price controls are persistent in the way that they will be continued until inflation reaches its new target.

Exercise II: Disinflation with temporary price controls.

This exercise is analogous to Exercise I but with a difference in the formulation of price controls, which will take the following form:

$$\kappa_t^T = \begin{cases} \infty & \forall t < T \\ \kappa_i & \forall t \leq T+i \leq T+4 \;\; \text{with } i = 0,1,2,3 \;\&\; \kappa_{i+1} < \kappa_i \\ \infty & t \geq T+5 \end{cases} \tag{3.28}$$

In this case, price controls are temporary and only implemented in the initial stages of the disinflation. After that, they are removed.

Exercise III: Temporary price controls without a disinflation.

Here, I analyze the case in which a policymaker decides to apply temporary price controls without previously implementing a change in the monetary regime (disinflation shock). Formally, price controls will be the same as in Exercise II, while money supply will be:

$$M_t = (1 + g_{old})M_{t-1} \;\; \forall t \tag{3.29}$$

[13] This sequence of price controls is totally arbitrary. Then, we can put the values that we want as long as $\kappa \in [g_{new}, g_{old}]$.

I present the rest of the details of the Exercise in Appendix C.5. Here, I will focus on the main conclusions that I can extract from it.

1 - Price controls reduce disinflations costs: Panel I and II in Appendix Figure C.3 show that a disinflation that makes use of price controls (persistent or temporary ones) generates, compared to one that does not appeal to these instruments: i) less inflation during the transition to the new steady state, ii) faster convergence, iii) less price dispersion, and iv) smaller output contractions. In this sense, price controls contribute to moderate the degree of information frictions in the aggregate economy. In the transition to the new steady state, these policies signalize an alternative pricing path for the inattentive firms promoting a faster and less costly disinflation.

2 - Timing of removal: One of the problems often arising when thinking in apply price controls is when to remove them. Appendix Panel II in Appendix- Figure C.3 presents the case in which temporary price controls are implemented together with a disinflation. For our particular case, they are operative during the first 4 periods of the disinflation and then they are removed. Their effects are analogous to the case in which price controls are persistent. Once they are removed, they generate a jump in inflation. However, since the effects of firms learning about the new monetary regime is stronger, inflation ends converging to the new steady state.

3 - Price controls are a complement but not a substitute of a change in the monetary regime: Panel III in Appendix-Figure C.3 presents the case of temporary price controls under the scenario in which the monetary regime does not change. We depart from a steady state in which prices and money growth at the same rate. Price controls are implemented in $t = T$ and discontinued in $t = T + 5$. While they are operative, these policies generate a temporary decrease in inflation. Then, since money supply is fixed, there is an increase in real balances that generates a boom in output[14]. Once price controls are removed, inflation jumps and then converges to its initial growth rate. This example points out against the use of price controls as instruments to permanently reduce the rate of inflation. Their effects are only short-term and last only for the period in which they are active. While price controls can be a complement to make disinflations less costly, they are not a substitute of the macroeconomic reforms required to bring down inflation permanently.[15]

[14]This is one of the reason of why the consumers usually support these policies and why some populist governments have fallen into the temptation to apply them to show short run success in reducing inflation, especially before elections.

[15]According to Dornbusch and Simonsen (1987), trying to reduce inflation permanently with price controls

3.4.2 Optimal policy with price controls

I have shown before that price controls can help to reduce the costs during a disinflation. Then, the natural question to consider is one that has to be with the optimality of these controls. In this Section, I will prove that there is an optimal policy that the policymaker can implement in which disinflation costs are not only minimize but eliminated at all.

Let me begin by a introducing a new concept. I define the loss function L_t as the weighted sum of the quadratic deviation between the full information optimal price (p_t^*) and the price set by firms that collected information k periods ago (x_t^k);

$$L_t = (1-\theta)\sum_{k=0}^{\infty}\theta^k(x_t^k - p_t^*)^2 \tag{3.30}$$

From Eq (3.30), it is straightforward to note that, for those firms collecting information in the present ($k = 0$), the deviation between the price that they set and the optimal price is null. Then, the magnitude of this loss function will be determined by the prices set by firms that observed the aggregate state of the world in the past ($k > 0$).

Under this setting, the policymaker can minimize the welfare costs during the transition by minimizing the loss function defined above. Its problem can be described as:

$$\min_{\{\kappa_j\}_{j=T}^{T+j}} L_{T+j} \quad s.t.\ \kappa_j \in [g_{new}, g_{old}] \ \text{ for } j = 1, 2, ..., J$$

Proposition 3: The policymaker can replicate the First Best Competitive Equilibrium with full information ($\theta = 0$) setting $\kappa = g_{new}$. Then: $L_{T+j} = 0\ \forall j$

Proof: See Appendix A.

Taking as given the information frictions in the economy, the policymaker can choose a specific sequence of price controls during the disinflation $\{\kappa_t\}_{t=T}^{t=T+j}$ so as to minimize (and ultimately eliminate) the welfare costs associated with it. If the policymaker can set any $\kappa_t \in [g_{new}, g_{old}]$, then it will set $\kappa_t = g_{new}$. With this policy, the policymaker makes sure that each firm will be setting prices based on the correct path of prices, the one that is mov-

is a duty only reserved for poets and magicians.

ing at the same rate as money supply. Then, it will obtain an immediate-costless-disinflation.

In summary:

1. Price controls mimic the outcomes generated by a reduction in the degree of information frictions faced by an economy. In a nutshell, they make disinflation less costly, both at the micro and at the macro level.

2. At the macro level, they reduce inflation, price dispersion and output contraction during the transition to a low inflation steady state.

3. At the micro level, they operate on the universe of inattentive firms, reducing the deviations between the price they set and the optimal profit-maximizing price that they should set.

4. The policymaker can choose an optimal sequence of price controls so as to totally eliminate the costs generated in a disinflation.

3.5 Price controls with idiosyncratic shocks

Up to this point, I have tried to illustrate in the simplest possible way, the role of price controls during a disinflation. However, the simplicity of this model contrasts with it realism. I have focused in only one side of the coin: price controls have benefits but are cost-less. Then, their use does not present any trade-off for the policymaker; i.e., they are always desirable. This heavily contrasts with the historical experience which points out against their use given their bad outcomes

In order to overcome this, I will introduce some minor modifications in the part of the model regarding firms. In particular, I will assume that intermediate good producers are subject to idiosyncratic productivity shocks. As I will show below this will introduce a clear trade-off for the policymaker when deciding to apply price controls.

3.5.1 Basic setting:

Final goods firm: The final good firm produces output Y_t using intermediate firm's production $Y_{i,t}$ subject to random idiosyncratic shocks $A_{i,t}$:

$$Y_t = \left(\int_0^1 \left(\frac{Y_{i,t}}{A_{i,t}} \right)^{\frac{c-1}{\epsilon_p}} di \right)^{\frac{\epsilon_p}{\epsilon_p - 1}} \tag{3.31}$$

Then, the aggregate price level and firm's demand for variety i will be given by:

$$P_t = \left(\int_0^1 \left(A_{i,t} P_{i,t} \right)^{1-\epsilon_p} di \right)^{\frac{1}{1-\epsilon_p}} \tag{3.32}$$

$$Y_{i,t} = A_{i,t}^{1-\epsilon} \left(\frac{P_{i,t}}{P_t} \right)^{-\epsilon_p} Y_t \tag{3.33}$$

Intermediate good producers: Firm i produces quantity $Y_{i,t}$ with linear production function:

$$Y_{i,t} = A_{i,t} N_{i,t} \tag{3.34}$$

where $A_{i,t}$ is firm's i productivity shock following:[16]

$$\log(A_{i,t}) = \log(A_{i,t-1}) + \sigma_\epsilon \epsilon_{i,t}$$

where: $\epsilon_{j,t} \sim \mathcal{N}(0,1)$.

Note that a decrease in $A_{i,t}$ increases the final good producer's marginal product, but at the same time, it reduces the intermediate good producer's marginal product. These two effects offset each other in such a way that the marginal product of labor in firm i for the final output is independent of $A_{i,t}$. In particular, we will be interested in the effect that $A_{i,t}$ can generate on the prices set by intermediate good producers.

Information frictions: I will keep the assumption that firms are inattentive with respect to the aggregate state of the world. However, I will add the assumption that they are totally attentive with respect to the idiosyncratic productivity shocks they receive each period: they can observe them and incorporate them into their prices.[17] In summary, the aggregate state is $\mathcal{S}_t = \{g_t, M_t\}$ and the idiosyncratic state is $s_t = \{A_{i,t}\}$.

Pricing strategy: In the model with idiosyncratic shocks, the optimal price under full information will be:

$$P_{i,t}^* = \eta \frac{M_t}{A_{i,t}} \tag{3.35}$$

[16] In the literature $A_{j,t}$ is called a *quality shock*. This formulation was first used by Woodford (2009). It is also used in Midrigan (2011), Alvarez et al. (2016), among others.

[17] This is related to Maćkowiak and Wiederholt (2009). A difference is that, in their model, the firms decide what to pay attention to. Here, this is exogenously given.

Some remarks here. First, the inclusion of idiosyncratic productivity shocks introduce a new motive for firms to change prices. Now they will change prices for two reasons: i) an aggregate motive (M_t), and ii) an idiosyncratic motive ($A_{i,t}$). Second, positive (negative) productivity shocks raise (lower) $A_{i,t}$, reduce (increase) marginal costs and induce a decrease (increase) in the price. Third, the optimal full information price will be different for each firm i; they want to respond to the current money supply and to their idiosyncratic shocks.

Then, the price set in t by a firm i that last observed the aggregate state of the world k periods ago will be:

$$X_{i,t}^{k} = \begin{cases} \eta \frac{M_t}{A_{i,t}} & \text{for} \quad k = 0 \\ \eta \frac{Et-k\{M_t\}}{A_{i,t}} & \text{for} \quad k > 0 \end{cases} \tag{3.36}$$

Trade-off: With idiosyncratic productivity shocks, the policymaker will face a trade-off when deciding to apply price controls. During the transition to the low inflation steady state, price controls signal an exogenous price path of maximum prices for all firms. As I have showed, this will be binding only for those firms that were setting prices based on the old monetary regime, the one that was no longer active. At the aggregate, this will generate benefits, inflation will converge faster to the growth rate of money in the new steady state and welfare costs will be lower during the disinflation. Moreover, these benefits will be larger, the larger the magnitude of the disinflation to be carried out ($\Delta\pi$).

However, when setting these controls, the policymaker is not internalizing the idiosyncratic productivity shocks that the firms receive. A firm receiving a negative productivity shock would like to respond with an increase in its price. This will not be possible for inattentive firms whose price is already subject to the control. Moreover, even an attentive firm setting prices based on the right path can be subject to the control for sufficiently large bad shocks. This will generate some inefficiencies. Firms want to react to their idiosyncratic shocks but they are not able to do it given the controls.

3.5.2 A Quantitative Exercise

In this section, I perform a quantitative exercise in order to find the optimal price control in the presence of idiosyncratic productivity shocks. I proceed in the following way:

1. I simulate the transition of the model between a initial high inflation-high money growth steady state to a low inflation-low money growth steady state: $\Delta\pi = g_{old} - g_{new}$

(as in Section 4).

2. I allow firms to be subject to idiosyncratic productivity shocks during the transition ($A_{i,t}$).

3. I calculate the loss function with no price controls during the transition: $L^{noPC}_{T+j} \forall j = 1, ..., J$ [18]

4. I impose a policy of price controls where κ is constant during the transition:

$$\bar{P}_{i,T+j} \leq (1+\kappa)^j P_{i,T} \quad j = 1, 2, \ldots, J, \quad \kappa \in [g_{\text{new}}, g_{old}]$$

5. I calculate the loss function with price controls during the transition: $L^{wPC}_{T+j} \forall j = 1, ..., J$.

6. I choose κ so as to minimize L^{wPC}_{T+j}

7. I compare the loss function with (L^{wPC}_{T+j}) and without price controls (L^{noPC}_{T+j}).

Table 3.1: Optimal price control κ^*

$\boldsymbol{\Delta\pi}$	$\boldsymbol{\sigma_\epsilon}$	$\boldsymbol{2\sigma_\epsilon}$	$\boldsymbol{3\sigma_\epsilon}$
(I) **20%-2%**	2%	2.8%	3.5%
(II) **15%-2%**	3%	3.1%	3.2%
(III) **5%-2%**	3%	–	–

Table 3.1 shows which is the optimal price control κ^* that minimizes the loss function of the economy during the transition to the new steady state. I perform this exercise for different magnitudes of disinflations ($\Delta\pi$) and different size of the idiosyncratic productivity shocks (σ_ϵ). The main results that I find can be summarized as follows.

- The optimality of price controls depends on the magnitude of the disinflation that the policymaker wants to implement relative to the size of the id shocks that the firms are subject to: $\frac{\Delta\pi}{var(\epsilon_t)}$.

[18] Note that, under idiosyncratic shocks, the loss function will be the sum of the deviations between the price that firm i is setting and its idiosyncratic optimal price $p^*_{i,t}$; i.e., each firm will have a different optimal price since they are receiving different idiosyncratic shocks. Then: $L_t = (1-\theta)\sum_{k=0}^{\infty}\int_0^1 (x^k_{i,t} - p^*_{i,t})di$.

- When the magnitude of the disinflation is large relative to the size of the idiosyncratic shocks (Cases I and II in Table 3.1), price controls are optimal in the sense that they increase welfare relative to the situation in which there are no any controls. The reason is that the macro distortion that they are reducing (firms setting prices based on a wrong trend for money supply) are greater than the micro distortions that they generate (firms not being able to respond to their idiosyncratic shocks).

- When the magnitude of the disinflation is small relative to the size of the id shocks (Case III in 3.1), price controls are not desirable. Consider the case in which the policymaker desires to implement a disinflation from 5% to 2%. When productivity shocks are large ($2\sigma_\epsilon$ and $3\sigma_\epsilon$), price controls are welfare reducing. The intuition here is analogous to the one mentioned before: given that the macro distortions that they are trying to fix are not that big relative to the micro distortions that they generate, they end up being a bad policy.

- The optimal κ^* is an increasing function of the size of the idiosyncratic shocks ($\frac{\partial \kappa^*}{\partial \sigma_\epsilon} > 0$) and is bounded below by g_{new}, the final steady state.

3.6 Extensions and shortcomings

3.6.1 Strategic complementarities

In my model, the firm's optimal price does not take into account what other firms in the economy are doing. A potential extension of the model could be to add strategic complementarities as in or Woodford (2001). Then, the firm's optimal price would have an additional component related to aggregate price level of the economy: firm i takes into account what firm j is doing, firm j takes into account what firm k is doing and so on. I think that the idea of "price controls as a coordination policy" could be better understood here. Additionally, strategic complementarities would give me larger effects of a disinflation and, consequently, larger welfare gains from applying price controls.

3.6.2 Shortcomings

3.6.2.1 Pricing assumption

One weakness of the model is that firms can make systematic mistakes regarding the prices that they are setting and not do anything about it. Basically, they can be setting prices for many periods as if the FED chairman was an Argentinian Central Banker, without realizing that now Paul Volcker is in charge. They would only recompute their price plan when they receive the Calvo fairy. A way to overcome this would be to allowing for endogenous acquisition of information (see Alvarez et al., 2011). In this case, the firm can decide when to collect information but has to pay a fixed cost to do it.

3.6.2.2 Hidden costs of price controls

In the analysis presented so far, I have focused on only one of the potential side effects of price controls: firms not being able to respond to idiosyncratic productivity shocks. However, this could be only the tip of the iceberg. Eventually, there are other costs not considered here. I can think of at least two.

Possibility of shortages: One of the usual side effects of price controls is that they can generate shortages. If the maximum price set by the policymaker in one specific market is below the equilibrium price then firms could be making negative profits and then output would be supply-determined. In my model, I am mute with respect to this potential problem assuming in some sense that this is a second order problem. There is some work discussing these effects from a partial equilibrium perspective. In this regard, Helpman (1988) analyses the effects of price controls under different market structure.

Costs of monitoring: Setting price controls is a costly activity for the government since it requires to use resources to monitor that firms are pegging to the controls. Since these resources could be used in alternative activities, there might be a mis-allocation of public resources. In the model presented so far, I have behaved just assuming that these costs are negligible or that they do not exist at all. A primitive way to incorporate them in the model would be with a negative transfer that the government charges to the households each time that it decides to implement price controls.

3.6.2.3 Information assumptions

One natural tension in my model has to do with the information assumptions. If the government fails to communicate the change in the monetary regime, how is it possible that it can communicate the policy of price controls? A valid interpretation could be: it is not that the government fails to communicate the policy, it is that firms are just not paying attention.

But then, why are they paying attention to the price controls? A possible explanation is that price controls are a "law" while the change in the monetary regime is a "policy".

3.7 Conclusions

In this paper, I study the effects of introducing price controls during a disinflation, in the context of an economy subject to information frictions in price setting. I find that the optimality of price controls depends on two variables: the magnitude of the disinflation to be carried out, and the size of the idiosyncratic shocks that firms are subject to. For large disinflations, even when idiosyncratic shocks are large, price controls are desirable since the macro distortions that they fix are greater than the micro distortions that they generate. For small disinflations, micro distortions arising from firms not being able to respond to the shocks that they are receiving are larger than the macro distortions to be fixed. In this context, price controls are not desirable.

APPENDIX A

Appendix to "The Distributional Consequences of Commodity Booms"

A.1 Data

The dataset includes yearly data for Bolivia, Chile, Colombia, Ecuador, Mexico and Peru. This data is included in the empirical analysis of Section 1.2.

A.1.1 Macroeconomic Data

- **Commodity prices**: I work with 13 commodities: energy (coal, crude oil, natural gas) and metals (aluminum, copper, gold, iron ore, lead, nickel, tin, uranium and zinc). For commodity prices, I use data from the IMF Primary Commodity Price Database. To construct the weights of each commodity, I use data from UN-COMTRADE.

- **GDP, Consumption, Investment, Exports, Imports and Government spending**: all the data is expressed in constant prices in local currency units.Data is from the IMF-IFS.

- **Real Exchange Rate**: It is constructed using the nominal exchange rate (measured in units of local currency per U.S. dollar), the US domestic consumer price index, and the US consumer price index. Data is from the IMF-IFS.

- **EMBI**: This measure proxies the country specific interest rates in international financial markets. It is measures as the sum of the J.P. Morgan's EMBI+ sovereign spread and the U.S. real interest. EMBI+ is a composite index of different U.S. dollar-denominated bonds on four markets: Brady bonds, Eurobonds, U.S. dollar local markets and loans. Data is from Bloomberg.

A.1.2 Sectoral Data

- **Sectoral ouput**: all data is value added in current or constant prices in local currency units. Data is from national accounts.

A.1.3 SEDLAC

- Data is from the SEDLAC database.[1] Surveys are collected by the respective national statistics offices (NSOs) and harmonized through the SEDLAC Project. Labor income is after tax and before transfers. It considers main occupation of full-time workers (35+ hours per week). When using real labor income, I deflate series by country-specific consumer price indexes. Individuals' skills are determined based on their complete years of schooling.

[1]See the SEDLAC Project webpage: https://www.cedlas.econo.unlp.edu.ar/wp/en/estadisticas/sedlac/

A.2 Appendix of Empirical Analysis

A.2.1 Additional Figures and Tables

Table A.1: Main Commodity Products

country	
Bolivia	Natural Gas (21%), Zinc (15 %), Gold (10%)
Chile	Copper (69%), Fish (12%), Soft sawn (5%)
Colombia	Crude Oil (53%), Coal (15%), Coffee (15%)
Ecuador	Crude Oil (55%), Bananas (25%), Chrimp (9%)
Mexico	Crude Oil (82%), Copper (3%), Coffee (2%)
Peru	Gold (28%), Copper (22%), Zinc (12%)

Notes: This table presents the three largest commodities exported by each country in my sample as share of total commodity exports.

Table A.2: Comovement across inequality measures

country	$corr(gini, \eta^{gap})$	$corr(p9010, \eta^{gap})$	$corr(p9550, \eta^{gap})$
BOL	0.93	0.80	0.95
CHL	0.42	0.52	0.35
COL	0.81	0.63	0.84
ECU	0.97	0.92	0.96
MEX	0.47	0.47	0.47
PER	0.91	0.76	0.90

Notes: This table presents the correlations between my baseline measure of labor income inequality (η^{gap} and alternative measures: Gini coefficient, ratio of percentile 90th to percentile 10th ($p9010$) and ratio of percentile 95th to percentile 50th ($p9010$). Sample extends from 1992 to 2018. Data is from SEDLAC.

Table A.3: Share of skilled and unskilled workers across countries

	high school or more	some college or more
BOL	40.5	15.5
CHL	54.6	18.4
COL	51.8	17.3
ECU	42.2	15.7
MEX	30.1	12.1
PER	55.5	20.8
average	45.8	16.6
US	90.1	59.8

Notes: This table presents the average share of skilled workers to total workers for each country for two definitions of skilled worlers. Values for each country are the average between 1992 and 2015.

Table A.4: Share of skilled workers across sectors and years

	Tradables	Non-tradables		
		All	Services	Construction
BOL	26.1	49.8	53.7	25.6
CHL	39.4	61.4	66.5	29.7
COL	30.7	55.2	57.7	28.3
ECU	27.4	50.6	54.3	21.9
MEX	14.5	37.7	41.1	14.1
PER	38.1	64.1	66.4	38.9
average	**29.3**	**53.2**	**56.6**	**26.4**

Notes: This table presents the average share of skilled workers for each country in my sample. Tradable sector include agriculture and manufacturing. Non-tradable sector is split into construction and services (all the remining sub-sectors). Values are average across years for each country.

Table A.5: Skilled labor intensity across sectors and countries - Manufacturing

	Manufacturing	Non-tradables		
		All	Services	Construction
BOL	40.3	49.8	53.7	25.6
CHL	54.2	61.4	66.5	29.7
COL	51.0	55.2	57.7	28.3
ECU	43.8	50.6	54.3	21.9
MEX	24.9	37.7	41.1	14.1
PER	59.0	64.1	66.4	38.9
average	**45.5**	**53.2**	**56.6**	**26.4**

Notes: This table presents the average share of skilled workers for each country in my sample. Non-tradable sector is split into construction and services. Values are average across years for each country.

Figure A.1: Skilled labor intensity within non-tradable sector - Bolivia

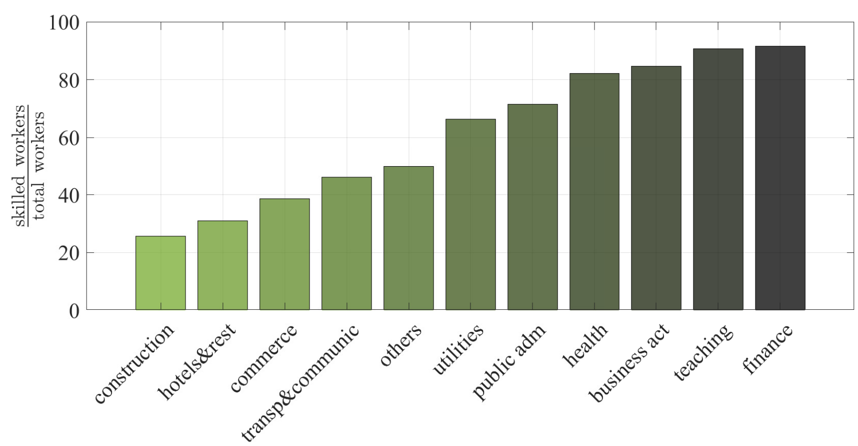


Figure A.2: Skilled labor intensity within non-tradable sector - Chile

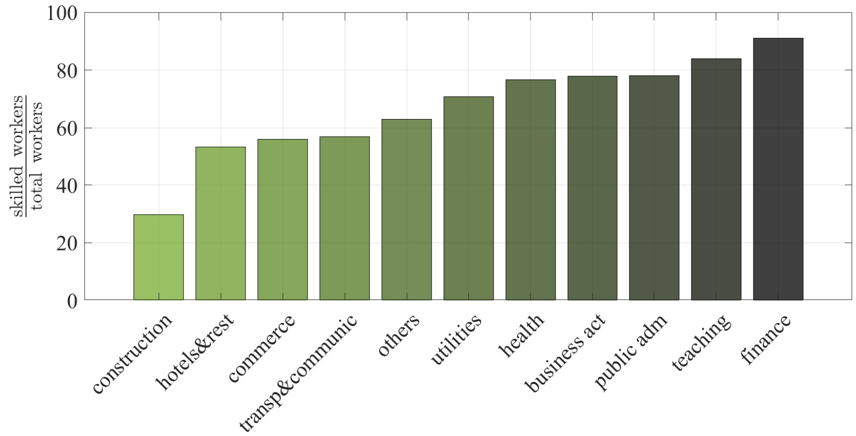


Figure A.3: Skilled labor intensity within non-tradable sector - Colombia

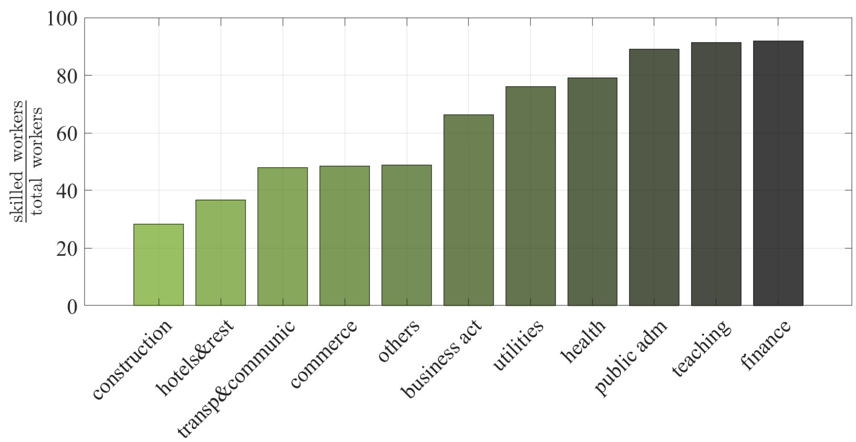


Figure A.4: Skilled labor intensity within non-tradable sector - Ecuador

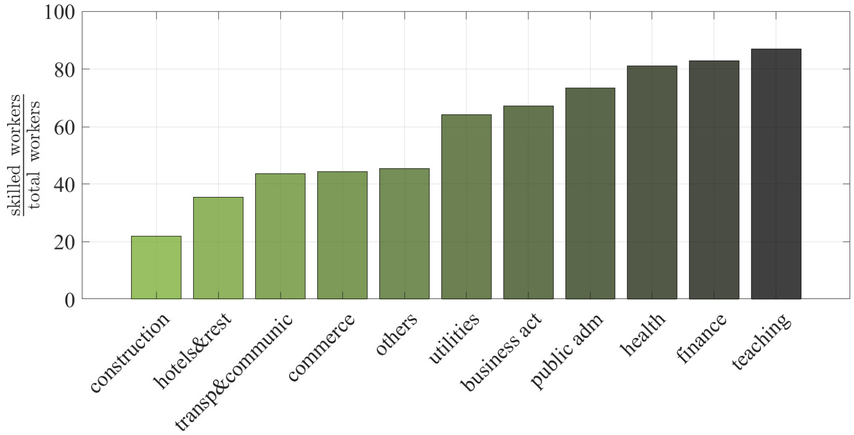


Figure A.5: Skilled labor intensity within non-tradable sector - Mexico

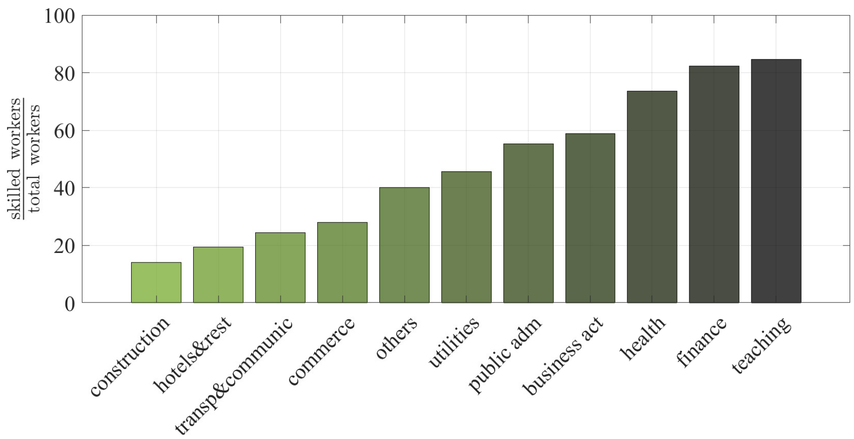


Figure A.6: Skilled labor intensity within non-tradable sector - Peru

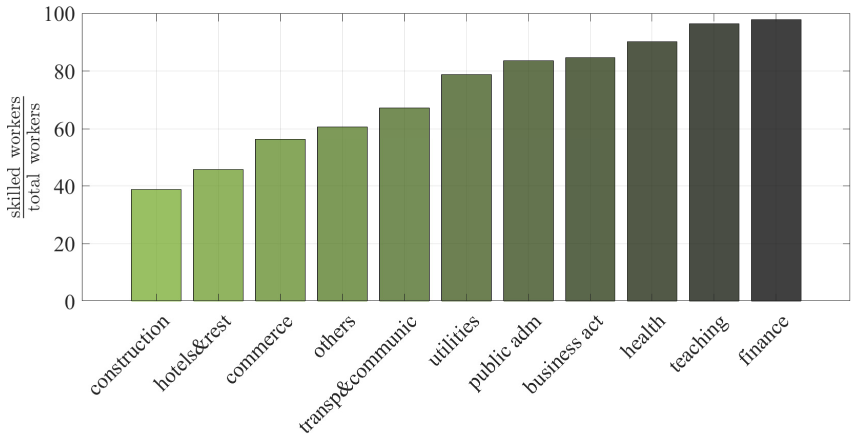
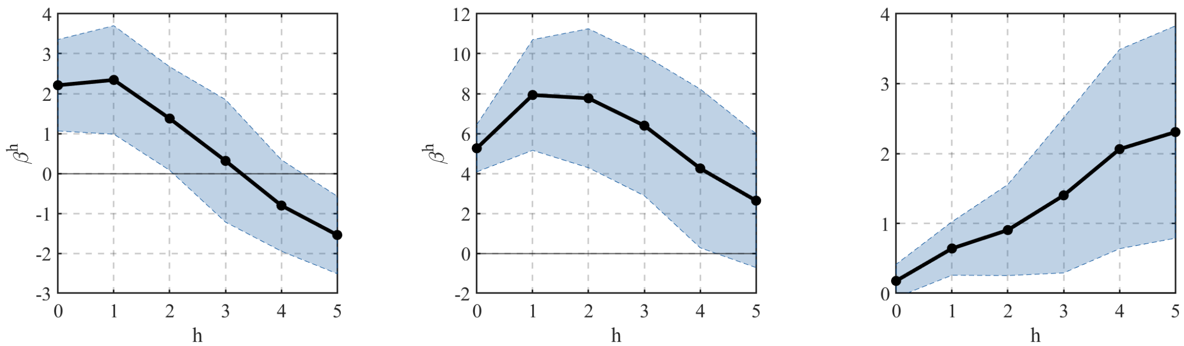


Figure A.7: Dynamics around Commodity Booms - additional variables

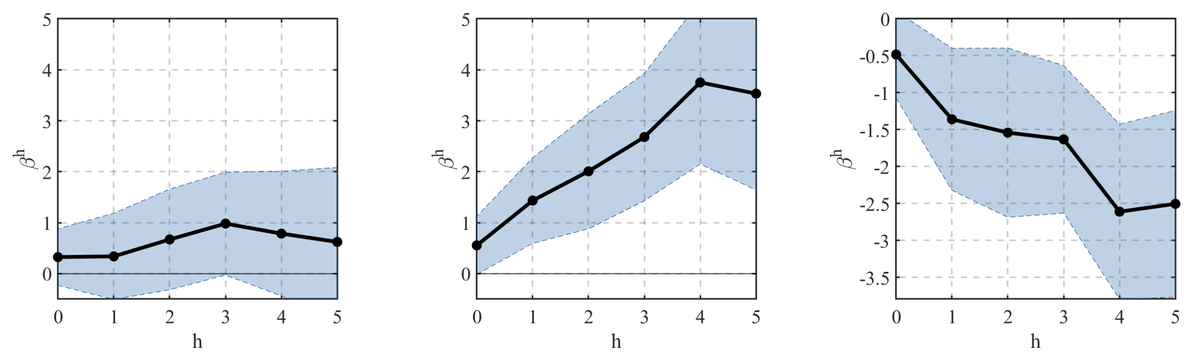
(a) Exports (b) Imports (c) Government spending



Notes: This figure plots the response of (a) Exports, (b) Imports, and (c) Government spending to a 10% changes in commodity prices. Each plot shows the coefficient β_h^0 obtained by running Equation (1.1) in the text for different horizons h. Error bands represent 95% confidence intervals. All variables are expressed in log differences.

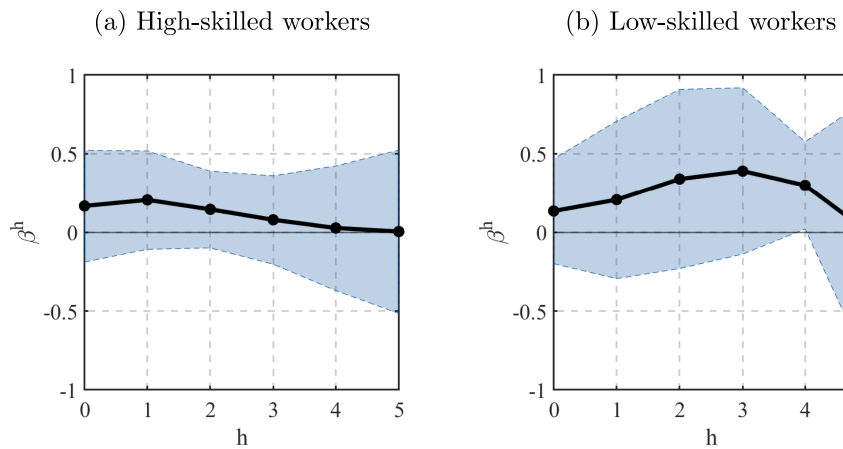
Figure A.8: Wage dynamics around Commodity Booms

(a) High-skilled wages (b) Low-skilled wages (c) Wage premium



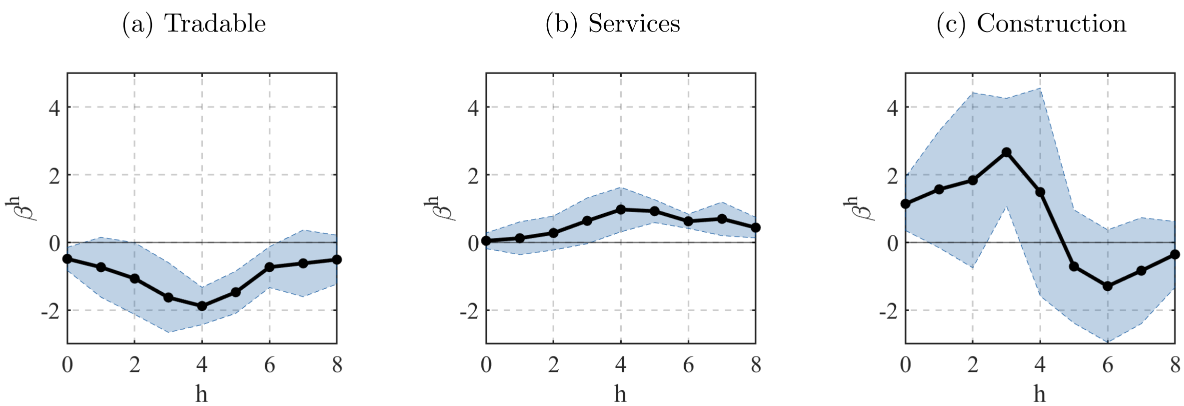
Notes: This figure plots the response of (a) Exports, (b) Imports, and (c) Government spending to a 10% changes in commodity prices. Each plot shows the coefficient β_h^0 obtained by running Equation (1.1) in the text for different horizons h. Error bands represent 95% confidence intervals. All variables are expressed in log differences.

Figure A.9: Hours worked around Commodity Booms



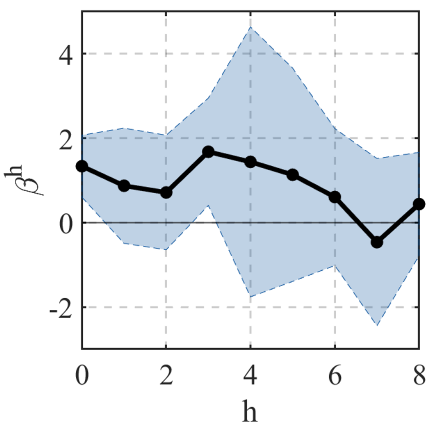
Notes: This figure plots the response of employment shares in the (a) Tradable, (b) Services, and (c) Construction sector to a 10% changes in commodity prices. Each plot shows the coefficient β_h^0 obtained by running Equation (1.1) in the text for different horizons h. Error bands represent 95% confidence intervals. Variables are expressed in percentage points.

Figure A.10: Sectoral employment dynamics around Commodity Booms



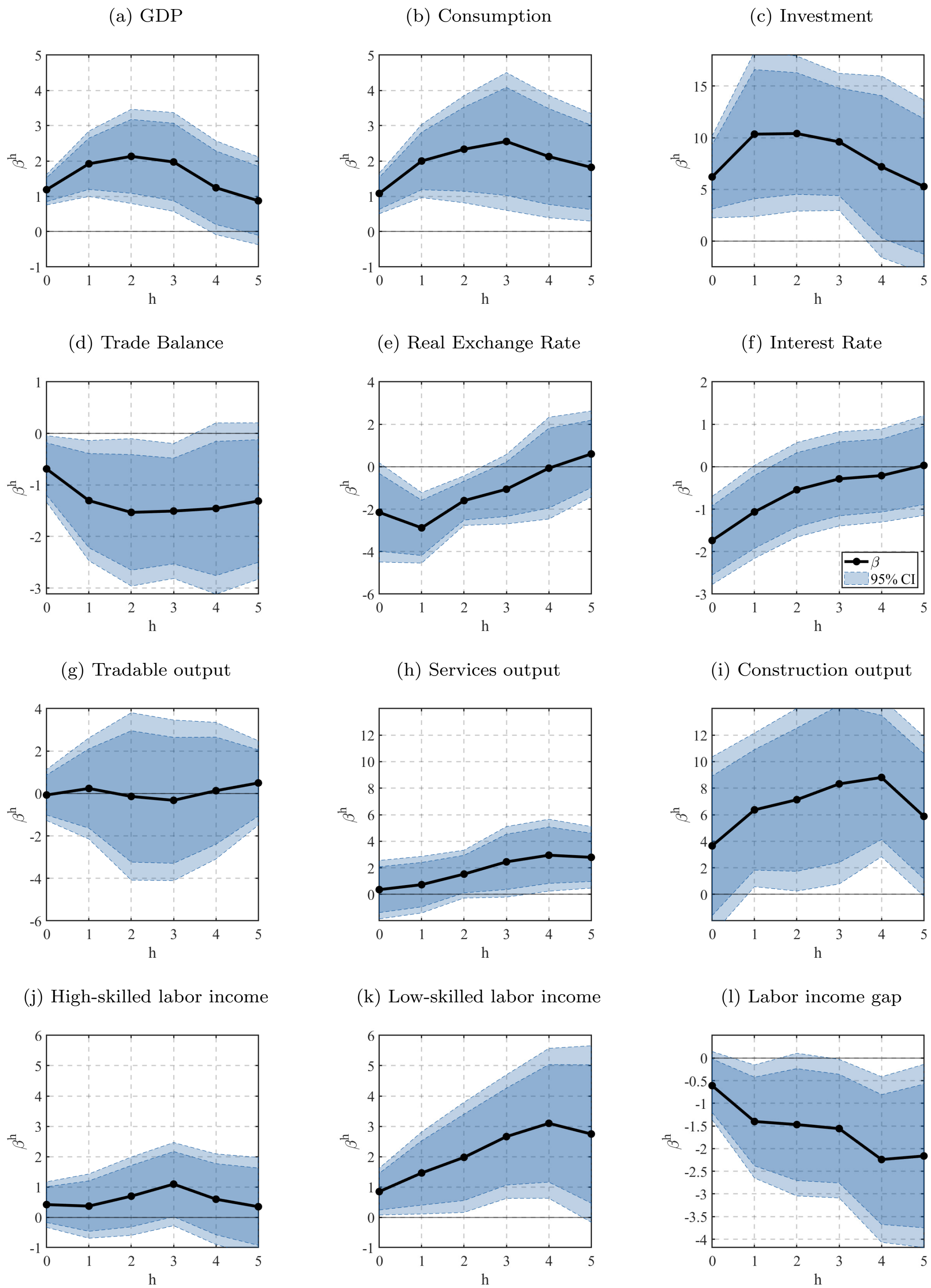
Notes: This figure plots the response of the employment shares of the (a) Non-commodity tradable, (b) Services, and (c) Constructions sectors to a 10% changes in commodity prices. Each plot shows the coefficient β_h^0 obtained by running Equation (1.1) in the text for different horizons h. Error bands represent 95% confidence intervals.

Figure A.11: Labor reallocation around commodity booms



Notes: This figure plots the response of the labor reallocation index following a 10% increase in commodity prices. Following Chodorow-Reich and Wieland (2020), the labor reallocation index is defined as: $R = \frac{1}{2}\sum_{m}^{M} s_{i,t}|\frac{1+g_{m,t,t+1}}{1+g_{t,t+j}} - 1|$ where m index sectors; g and g_m represent the aggregate and sectoral growth rates of employment e and e_m, respectively and $s_i = \frac{e_m}{e}$ is the share of employment in sector m relative to the aggregate. The index can take valuews between 0 and 1. $R_{t,t+1} = 0$ implies that the employment growth rate in every sector between t and $t+1$ is identical. The index can take the value $R_{t,t+1} = 1$ when all employment in existing sectors sectors at t dissapears by $t+1$, and new sectors with new employment at t account for all the employment in $t+1$. Each plot shows the coefficient β_h^0 obtained by running Equation (1.1) in the text for different horizons h. Error bands represent 95% confidence intervals.

Figure A.12: IRFs to commodity price shock - 99% confidence intervals

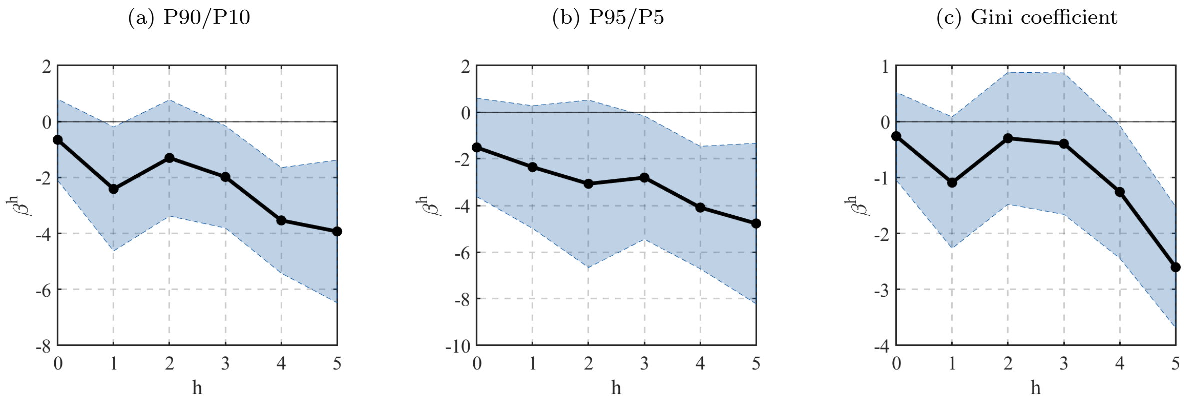


Notes: This figure plots the impulse response functions for (a) GDP, (b) Consumption, (c) Investment, (d) Trade balance to GDP ratio, (e) Real Exchange Rate,(f) Interest Rate, (g) tradable output, (h) service output, (i) construction output, (j) high-skilled labor income, (k) low-skilled labor income, and (l) labor income gap to a 10% increase in p_t^{Co}. Dark blue are 95% confidence intervals while light blue are 99% confidence intervals.

A.2.2 Robustness

A.2.2.1 Alternative inequality measures

Figure A.13: Alternatve inequality measures

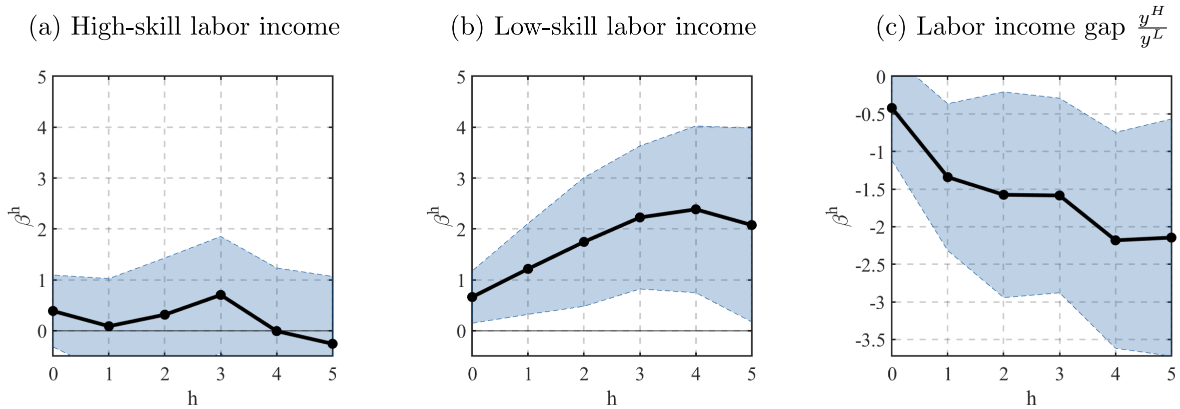


Notes: This figure plots the response of (a) ratio of percentile 90th to percentile 10th, (b) ratio of percentile 95th to percentile 5th, and (c) Gini coefficient to a 10% change in commodity prices. Each plot shows the coefficient β_h^0 obtained by running Equation (1) in the text for different horizons h. Error bands represent 95% confidence intervals. Ratio of percentile are measured in log differences while the Gini coefficient is measures in absolute differences.

A.2.2.2 Alternative definitions - skilled vs unskilled workers

Here I define skilled workers as those who have some college or more.

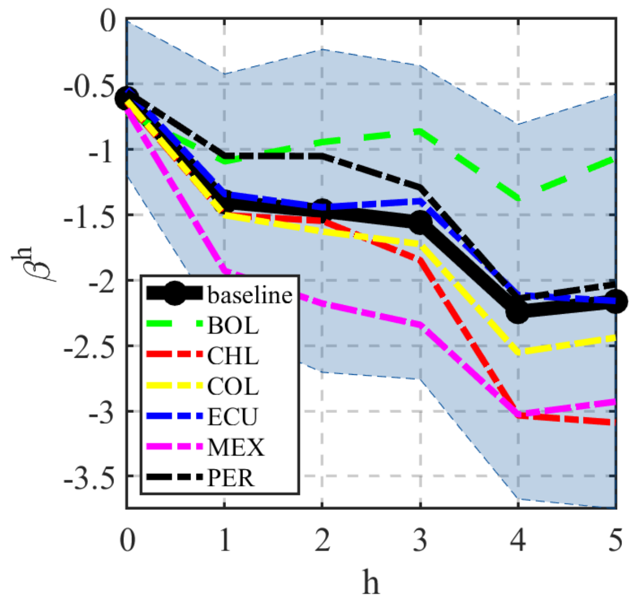
Figure A.14: Labor income dynamic around Commodity Booms - Alternative definition



Notes: This figure plots the response of (a) High-skill labor income, (b) Low-skill labor income, and (c) Labor income gap to a 10% change in commodity prices. Each plot shows the coefficient β_h^0 obtained by running Equation (1) in the text for different horizons h. Error bands represent 95% confidence intervals.

A.2.2.3 Outliers

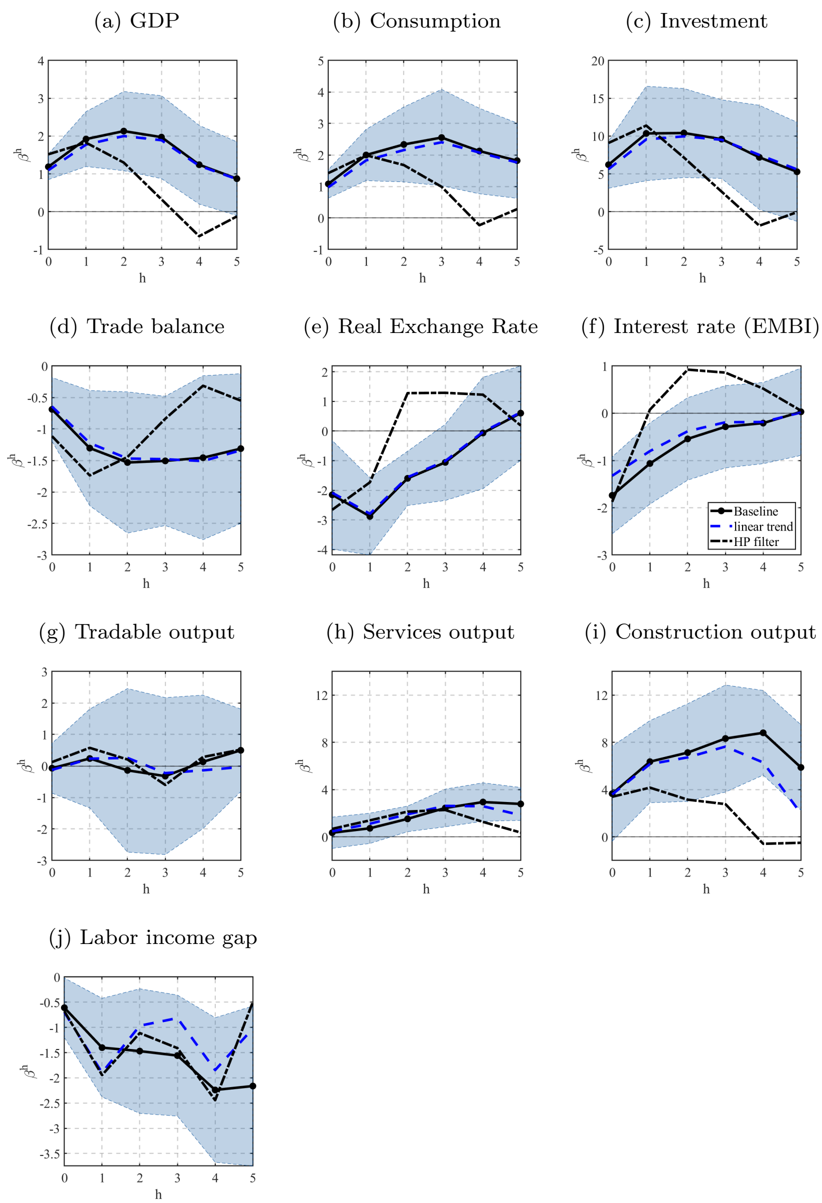
Figure A.15: Labor income inequality response to commodity price shock - Outliers



Notes: This figure plots the response of the labor income gap to a 10% change in commodity prices. Each plot shows the coefficient β_h^0 obtained by running Equation (1) in the text for different horizons h. Error bands represent 95% confidence intervals. The colour lines are the point estimates obtained when dropping that specific country from the sample.

A.2.2.4 De-trending commodity price shocks

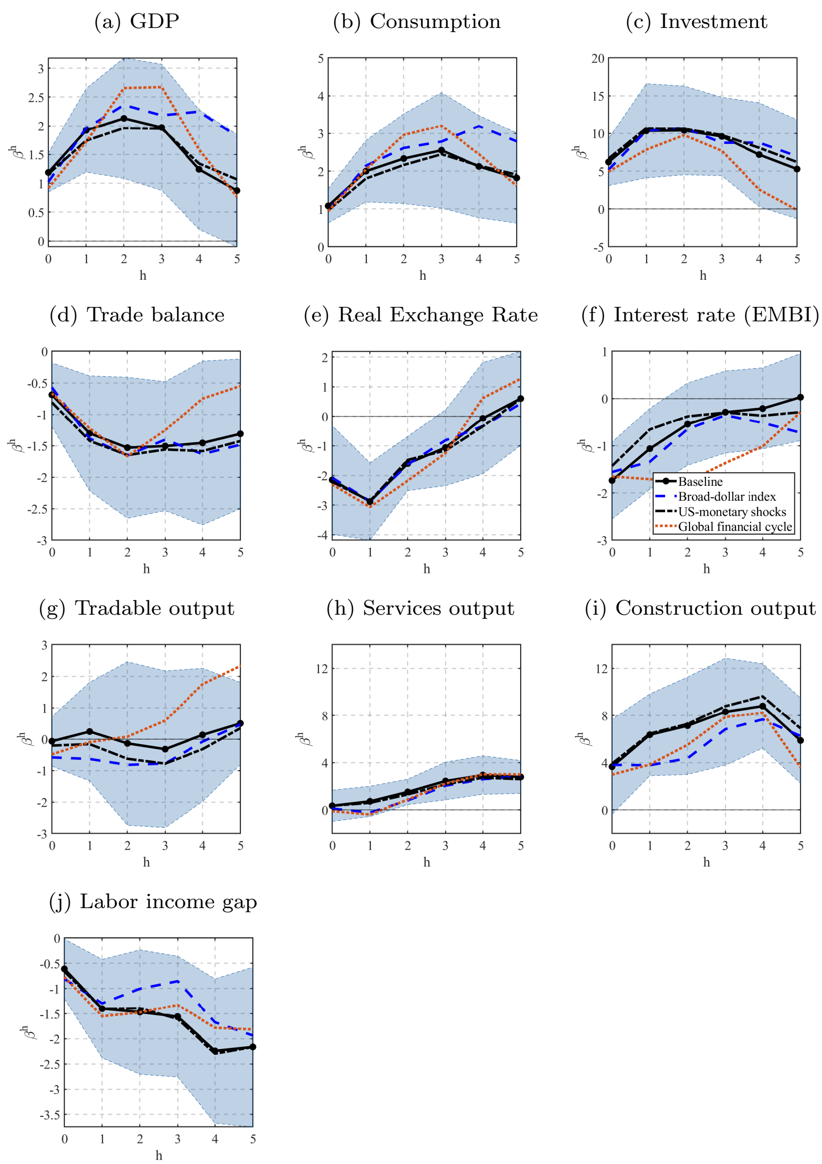
Figure A.16: Dynamics around Commodity Booms - alternative detrending



Notes: This figure plots the response of (a) GDP, (b) Consumption, (c) Investment, (d) Trade balance to GDP ratio, (e) Real exchange rate, (f) EMBI, (g) Tradable output, (h) Services output, (i) Construction output and (j) labor income gap to a 10% changes in commodity prices. Each plot shows the coefficient β_h^0 obtained by running Equation (1.1) in the text for different horizons h and alternative ways of detrending $p_{i,t}^{Co}$. Solid black lines are the impulse responses in the baseline case in which commodity price index is quadratically detrended; dashed blue lines are the responses for linear detrending; dashed black lines are the responses when the HP filter is used. Error bands represent 95% confidence intervals in the baseline case.

A.2.2.5 Additional controls to account for global factors

Figure A.17: Dynamics around Commodity Booms - global factors



Notes: This figure plots the response of (a) GDP, (b) Consumption, (c) Investment, (d) Trade balance to GDP ratio, (e) Real exchange rate, (f) EMBI, (g) Tradable output, (h) Services output, (i) Construction output and (j) labor income gap to a 10% changes in commodity prices. Each plot shows the coefficient β_h^0 obtained by running Equation (1.1) in the text for different horizons h and alternative controls. Solid black lines are the impulse responses in the baseline case with no controls; dashed blue lines are the responses when including the series of US-monetary policy shocks from Jarociński and Karadi (2020); dashed black lines are the responses when including a measure of the trade-wighted dollar index from Obstfeld and Zhou (2022); dotted red lines are the responses when including a measure of the global financial cycle from Miranda-Agrippino and Rey (2020). Error bands represent 95% confidence intervals in the baseline case.

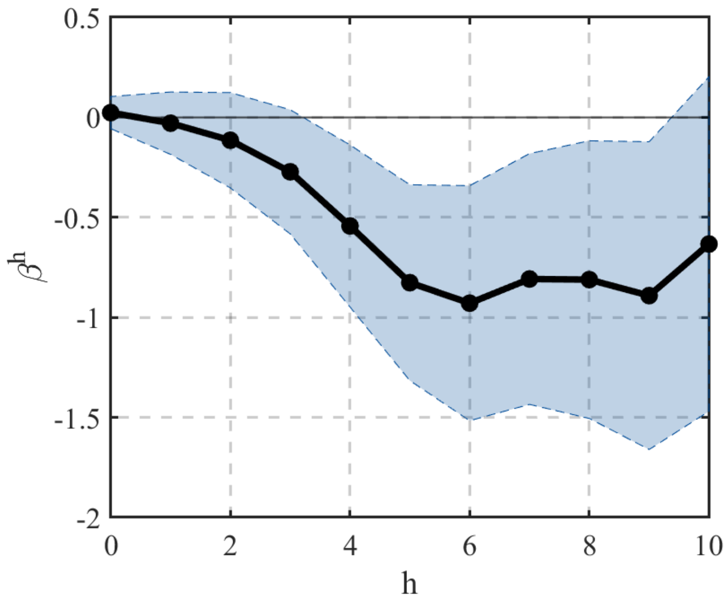
A.2.3 External validity

Table A.6: Extended sample

Country	Dependence	Country	Dependence
Algeria	Energy	Mali	Metals
Angola	Energy	Mauritania	Metals
Armenia	Metals	Mexico	Energy
Australia	Metals	Mongolia	Metals
Azerbaijan	Energy	Montenegro	Metals
Bolivia	Metals	Mozambique	Energy
Botswana	Metals	Namibia	Metals
Burkina Faso	Metals	Niger	Metals
Burundi	Metals	Nigeria	Energy
Cameroon	Energy	Norway	Energy
Chile	Metals	Oman	Energy
Colombia	Energy	Papua New Guinea	Metals
Ecuador	Energy	Peru	Metals
Eritrea	Metals	Qatar	Energy
Gabon	Energy	Russia	Energy
Ghana	Metals	Rwanda	Metals
Greece	Energy	Saudi Arabia	Energy
Guinea	Metals	Sierra Leone	Metals
Guyana	Metals	Suriname	Metals
Iran	Energy	Tajikistan	Metals
Jamaica	Metals	Togo	Energy
Kazakhstan	Energy	Turkmenistan	Energy
Kuwait	Energy	UAE	Energy
Kyrgyz Rep	Metals	Uzbekistan	Metals
Lao PDR	Metals	Venezuela, RB	Energy
Liberia	Metals	Yemen, Rep	Energy

Notes: This table presents the list of countries included in the extended sample. All these countries are commodity dependent economies according to UNCTAD (2021) and are specialized in metals or energy.

Figure A.18: Gini coefficient response to commodity price shock - Extended sample



Notes: This figure plots the response of the gini coefficient to a 10% change in commodity prices. The plot shows the coefficient β_h^0 obtained by running Equation (1) in the text for different horizons h. Error bands represent 90% confidence intervals. The variable is expressed in percentage points deviations from pre-shock level.

A.2.4 Additional Evidence on Commodity prices and spreads

The specialized literature has found the existence of a strong negative comovement of interest rates spreads and commodity prices [2]. To provide further evidence on this link, I run a regression of the real interest rate spreads on the commodity price index for my panel of Latin American commodity exporters. I follow the same specification as in Drechsel and Tenreyro (2018):

$$r_{i,t} - r_t^* = \alpha_i + \xi \left(\ln p_{i,t}^{Co} - \ln p_i^{\bar{Co}} \right) + \beta X_{i,t} + v_{i,t}, \tag{A.1}$$

where $r_{i,t}$ is the real domestic lending rate of country i in year t, r_t^* is measure of the world interest rate, the commodity price index $p_{i,t}^{Co}$ is expressed in log deviations from its mean, and $X_{i,t}$ is a set of control variables. Table A.7 and A.8 shows results for a panel regression and individual regressions by country when using the EMBI as a proxy for $r_{i,t} - r_t^*$; Table A.9 shows results for a panel regression when using the same measure of spread used in Drechsel

[2] See Bastourre et al. (2012),Drechsel and Tenreyro (2018), Fernández et al. (2018), Shousha (2016),among others.

and Tenreyro (2018). Finally A.19 plots raw data for EMBI and commodity price index for each country.

Table A.7: EMBI and Commodity Prices - Regressions Results

EMBI	(1)	(2)	(3)	(4)	(5)
Commodity Prices	-0.144***	-0.133***	-0.137***	-0.114***	-0.111***
	(0.019)	(0.020)	(0.020)	(0.021)	(0.027)
GDP growth		-0.401**			-0.185
		(0.171)			(0.211)
Trade Balance			-0.082		-0.162
			(0.100)		(0.116)
NFA				-0.001***	-0.001*
				(0.000)	(0.000)
Constant	0.573***	0.585***	0.573***	0.572***	0.572***
	(0.012)	(0.011)	(0.015)	(0.015)	(0.009)
Observations	118	118	118	118	118
Overall R-squared	0.261	0.276	0.278	0.303	0.322

Standard errors in parentheses
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Notes: Results from estimating Equation (A.1). I use the EMBI as a proxy for the difference between $r_{i.t}$ and r_t^*. The commodity price index is in log deviations from the mean. Trade balance and net foreign assets (NFA) are expressed as percentage of GDP. All variables are in annual terms. Sample period is 1992-2019.

Table A.8: EMBI and Commodity Prices - Regressions Results by country

EMBI	BOL	CHL	COL	ECU	MEX	PER
Commodity Prices	-0.204***	-0.009	-0.192***	-0.046	-0.094**	-0.226***
	(0.057)	(0.036)	(0.036)	(0.035)	(0.035)	(0.031)
Constant	0.621***	0.497***	0.577***	0.670***	0.552***	0.569***
	(0.013)	(0.009)	(0.008)	(0.010)	(0.008)	(0.007)
Observations	22	20	22	24	26	22
R-squared	0.410	0.043	0.612	0.235	0.242	0.735

Standard errors in parentheses
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Notes: Results from estimating $r_t - r_t^* = \alpha + \xi \left(\ln p_t^{Co} - \ln p^{\bar{Co}} \right) + v_t$ for each individual country . I use the EMBI as a proxy for the difference between $r_{i.t}$ and r_t^*. The commodity price index is in log deviations from the mean. All variables are in annual terms. Sample period is 1992-2019.

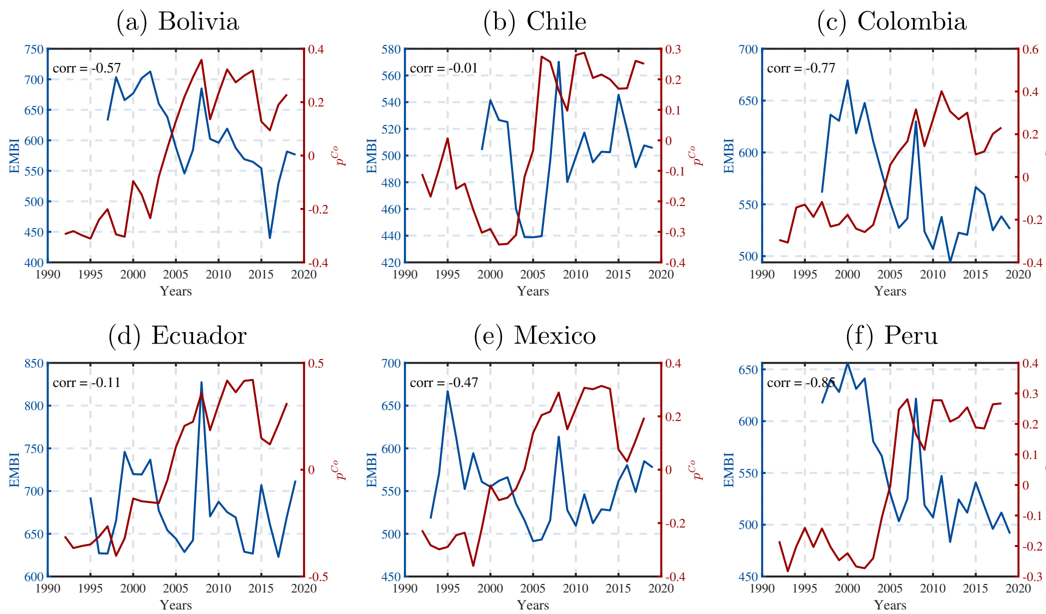
Table A.9: Lending rate and Commodity Prices - Regressions Results

EMBI	(1)	(2)	(3)	(4)	(5)
Commodity Prices	-0.131***	-0.125***	-0.088***	-0.075***	-0.083**
	(0.024)	(0.025)	(0.025)	(0.026)	(0.038)
GDP growth	0.010	0.007	0.018	0.021	0.026
	(0.017)	(0.017)	(0.016)	(0.016)	(0.024)
Trade Balance			-0.558***		-0.429**
			(0.128)		(0.182)
Debt_GDP				-0.001***	-0.001
				(0.000)	(0.000)
Constant	0.100***	0.112***	0.094**	0.104**	0.082***
	(0.033)	(0.036)	(0.046)	(0.046)	(0.014)
Observations	133	133	133	133	133
Overall R-squared	0.109	0.0925	0.167	0.144	0.193

Standard errors in parentheses
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Notes: Results from estimating Equation (A.1). The lending rate spread is calculated following the same methodology in Drechsel and Tenreyro (2018) as the difference between a real domestic lending rate and the UK real rate. The commodity price index is in log deviations from the mean. Trade balance and net foreign assets (NFA) are expressed as percentage of GDP. All variables are in annual terms. Sample period is 1992-2019. Ecuador is excluded from the sample since there is no available data for domestic lending rates during the period considered.

Figure A.19: EMBI and commodity prices - comovement

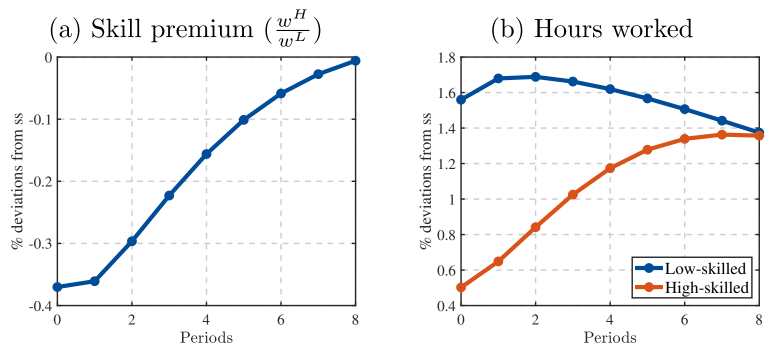


Notes: This figure compares the evolution of the JP Morga EMBI spread (left panel) and a commodity price index (p^{Co}) (right panel). The latter is expressed in log-deviations from its mean. Corr refers to the correlation between the two series for the period considered.

A.3 Model details

A.3.1 Additional figures

Figure A.20: IRF for skill premium and hours worked



Notes: This figure plots the impulse response functions for (a) Skill premium and (b) hours worked to a 10% increase in p_t^{Co}. All variables are expressed in percentage deviations with respect to steady state. The time units in the horizontal axis are years.

A.3.2 Propositions

Proposition I: Given two sectors indexed by $j = \{1, 2\}$, under the assumptions that there is (i) perfect labor mobility and (ii) equal labor shares ($\alpha_1 = \alpha_2$) across sectors, a sufficient condition for sector A to be more skilled-labor intensive than sector B, i.e., $\theta_A > \theta_B$, is that:

$$\frac{l^{H,A}}{l^{L,A}} > \frac{l^{H,B}}{l^{L,B}}$$

Proof: The skilled-labor intensity of sector j is given by: $\alpha_j \theta_j$. I want to show that:

$$\begin{aligned}
\alpha_1\theta_1 &> \alpha_2\theta_2, \\
\theta_1 &> \theta_2, \qquad\qquad \text{since } \alpha_1 = \alpha_2 \text{ given Assumption (ii)} \\
\frac{w^{H,A}l^{H,A}}{w^{H,A}l^{H,A} + w^{L,A}l^{L,A}} &> \frac{w^{H,B}l^{H,B}}{w^{H,B}l^{H,B} + w^{L,B}l^{L,B}} \\
w^{H,A}l^{H,A}w^{H,B}l^{H,B} + w^{H,A}l^{H,A}w^{L,B}l^{L,B} &> w^{H,B}l^{H,B}w^{H,A}l^{H,A} + w^{H,B}l^{H,B}w^{L,A}l^{L,A} \\
w^{H,A}l^{H,A}w^{L,B}l^{L,B} &> w^{H,B}l^{H,B}w^{L,A}l^{L,A}, \;\; \text{since } w^{H,A} = w^{H,B}, w^{L,A} = w^{L,B} \\
l^{H,A}l^{L,B} &> l^{H,B}w^{L,A}l^{L,A} \\
\frac{l^{H,A}}{l^{L,A}} &> \frac{l^{H,B}}{l^{L,B}}, \quad \text{And this can be generalizable to } N \text{ sectors.}
\end{aligned}$$

A.3.3 Model details

This section presents the non-linear system of equations that solve the model.

Capitalist's problem

$$\lambda_t p_t = \left[c_t^k\right]^{-\sigma} \tag{A.2}$$

$$\lambda_t = \beta(1 + r_t)E_t\{\lambda_{t+1}\} \tag{A.3}$$

Capital and investment in tradable sector

$$k_{t+1}^T = (1-\delta)k_t^T + \left[1 - \Phi\left(\frac{i_t^T}{k_t^T}\right)\right] i_t^T, \tag{A.4}$$

$$p_t^I = q_t^T \left[1 - \Phi\left(\frac{i_t^T}{k_t^T}\right) - \Phi'\left(\frac{i_t^T}{k_t^T}\right)\frac{i_t^T}{k_t^T}\right] + E_t\left\{\beta\frac{\lambda_{t+1}}{\lambda_t} q_{t+1}^T \Phi\left(\frac{i_{t+1}^T}{k_t^T}\right)\left(\frac{i_{t+1}^T}{k_{t+1}^T}\right)^2\right\}, \tag{A.5}$$

$$q_t^T = \beta E_t\left\{\frac{\lambda_{t+1}}{\lambda_t}[u_{t+1}^T + (1-\delta)q_{t+1}^T]\right\} \tag{A.6}$$

Capital and investment in service sector

$$k_{t+1}^S = (1-\delta)k_t^S + \left[1 - \Phi\left(\frac{i_t^S}{k_t^S}\right)\right] i_t^S, \tag{A.7}$$

$$p_t^I = q_t^S \left[1 - \Phi\left(\frac{i_t^S}{k_t^S}\right) - \Phi'\left(\frac{i_t^S}{k_t^S}\right)\frac{i_t^S}{k_t^S}\right] + E_t\left\{\beta\frac{\lambda_{t+1}}{\lambda_t} q_{t+1}^S \Phi\left(\frac{i_{t+1}^S}{k_t^S}\right)\left(\frac{i_{t+1}^S}{k_{t+1}^S}\right)^2\right\}, \tag{A.8}$$

$$q_t^S = \beta E_t\left\{\frac{\lambda_{t+1}}{\lambda_t}[u_{t+1}^S + (1-\delta)q_{t+1}^S]\right\} \tag{A.9}$$

Capital and investment in construction sector

$$k_{t+1}^C = (1-\delta)k_t^C + \left[1 - \Phi\left(\frac{i_t^C}{k_t^C}\right)\right] i_t^C, \tag{A.10}$$

$$p_t^I = q_t^C \left[1 - \Phi\left(\frac{i_t^C}{k_t^C}\right) - \Phi'\left(\frac{i_t^C}{k_t^T}\right)\frac{i_t^C}{k_t^C}\right] + E_t\left\{\beta\frac{\lambda_{t+1}}{\lambda_t} q_{t+1}^C \Phi\left(\frac{i_{t+1}^C}{k_t^C}\right)\left(\frac{i_{t+1}^C}{k_{t+1}^C}\right)^2\right\}, \tag{A.11}$$

$$q_t^C = \beta E_t\left\{\frac{\lambda_{t+1}}{\lambda_t}[u_{t+1}^C + (1-\delta)q_{t+1}^C]\right\} \tag{A.12}$$

Worker's problem

$$\nu_H \left(l_t^H\right)^{\omega-1} = \frac{w_t^H}{p_t} \tag{A.13}$$

$$\nu_L \left(l_t^L\right)^{\omega-1} = \frac{w_t^L}{p_t} \tag{A.14}$$

$$p_t c_t^L = w_t^L l_t^L \tag{A.15}$$

$$p_t c_t^H = w_t^H l_t^H \tag{A.16}$$

Labor income gap

$$\eta_t = \frac{w_t^H l_t^H}{w_t^L l_t^L} \tag{A.17}$$

Final consumption good producer

$$c_t = \left[\varphi^{1/\varepsilon_c} \left(c_t^S\right)^{1-1/\varepsilon_c} + (1-\varphi)^{1/\varepsilon_c} \left(c_t^T\right)^{1-1/\varepsilon_c}\right]^{\frac{\varepsilon_c}{\varepsilon_c-1}} \tag{A.18}$$

$$c_t^S = \varphi \left(\frac{p_t}{p_t^S}\right)^{\varepsilon_c} c_t \tag{A.19}$$

$$c_t^T = (1-\varphi)\left(p_t\right)^{\varepsilon_c} c_t \tag{A.20}$$

Final investment good producer

$$i_t = \left[\gamma^{1/\varepsilon_i} \left(x_t^C\right)^{1-1/\varepsilon_i} + (1-\gamma)^{1/\varepsilon_i} \left(x_t^T\right)^{1-1/\varepsilon_i}\right]^{\frac{\varepsilon_i}{\varepsilon_i-1}} \tag{A.21}$$

$$x_t^C = \gamma \left(\frac{p_t^I}{p_t^C}\right)^{\varepsilon_i} i_t \tag{A.22}$$

$$x_t^T = (1-\gamma)\left(p_t^I\right)^{\varepsilon_i} i_t \tag{A.23}$$

Tradable production

$$y_t^T = a^T \left[\left(l_t^{H,T}\right)^{\theta_T} \left(l_t^{L,T}\right)^{1-\theta_T}\right]^{\alpha_T} \left(k_t^T\right)^{1-\alpha_T}, \tag{A.24}$$

$$w_t^H = \alpha_T \theta_T \frac{y_t^T}{l_t^{H,T}} \tag{A.25}$$

$$w_t^L = \alpha_T (1-\theta_T) \frac{y_t^T}{l_t^{L,T}} \tag{A.26}$$

$$u_t^T = (1-\alpha_T) \frac{y_t^T}{k_t^T}, \tag{A.27}$$

Services production

$$y_t^S = a^S \left[\left(l_t^{H,S} \right)^{\theta_S} \left(l_t^{L,S} \right)^{1-\theta_S} \right]^{\alpha_S} \left(k_t^S \right)^{1-\alpha_S}, \tag{A.28}$$

$$w_t^H = p_t^S \alpha_S \theta_S \frac{y_t^S}{l_t^{H,S}} \tag{A.29}$$

$$w_t^L = p_t^S \alpha_S (1-\theta_S) \frac{y_t^S}{l_t^{L,S}} \tag{A.30}$$

$$u_t^S = p_t^S \left(1-\alpha_S\right) \frac{y_t^S}{k_t^S}, \tag{A.31}$$

Construction production

$$y_t^C = a^C \left[\left(l_t^{H,C} \right)^{\theta_C} \left(l_t^{L,C} \right)^{1-\theta_C} \right]^{\alpha_C} \left(k_t^C \right)^{1-\alpha_C}, \tag{A.32}$$

$$w_t^H = p_t^C \alpha_C \theta_C \frac{y_t^C}{l_t^{H,C}} \tag{A.33}$$

$$w_t^L = p_t^C \alpha_C (1-\theta_C) \frac{y_t^C}{l_t^{L,C}} \tag{A.34}$$

$$u_t^C = p_t^C \left(1-\alpha_C\right) \frac{y_t^C}{k_t^C}, \tag{A.35}$$

Market clearing + additional definitions

$$c_t = \kappa c_l^k + (1-\kappa) * \left(\mu c_l^L + (1-\mu) c_l^H \right) \tag{A.36}$$

$$i_t = i_t^X + i_t^N + i_t^C \tag{A.37}$$

$$y_t^S = c_t^S, \tag{A.38}$$

$$y_t^C = x_t^C, \tag{A.39}$$

$$(1-\mu)\ l_t^H = l_t^{H,T} + l_t^{H,S} + l_t^{H,C} \tag{A.40}$$

$$\mu\ l_t^L = l_t^{L,T} + l_t^{L,S} + l_t^{L,C} \tag{A.41}$$

$$tb_t = y_t^T + p_t^{Co} y_t^{Co} - c_t^T - x_t^T, \tag{A.42}$$

$$p_t gdp_t = y_t^T + p_t^S y_t^S + p_t^C y_t^C + p_t^{Co} y^{Co}, \tag{A.43}$$

$$rer_t = 1/p_t, \tag{A.44}$$

$$d_{t-1}\left(1 + r_{t-1}\right) = d_t + tb_t \tag{A.45}$$

Interest rate

$$r_t = (r^w + z^r) + \psi \left[\exp\left\{d_t - \bar{d}\right\} - 1\right] - \xi \left[\ln(p_t^{Co}) - \ln(p^{\bar{C}o})\right] \tag{A.46}$$

Exogenous process

$$\ln\left(p_t^{Co}\right) = (1 - \rho_1 - \rho_2)\ln\left(p^{\overline{Co}}\right) + \rho_1 \ln\left(p_{t-1}^{Co}\right) + \rho_2 \ln\left(p_{t-2}^{Co}\right) + \varepsilon_t^{Co} \tag{A.47}$$

This is a system of 46 equations and 46 unknowns:
$\{c_t^k, c_t^L, c_t^H, c_t, c_t^S, c_t^T, k_{t+1}^T, k_{t+1}^S, k_{t+1}^C, i_t^T, i_t^S, i_t^C, i_t, x_t^C, x_t^T, l_t^H, l_t^L, l_t^{H,T}, l_t^{H,S}, l_t^{H,C}, l_t^{L,T}, l_t^{L,S}, l_t^{L,C},$
$y_t^T, y_t^S, y_t^C, tb_t, gdp_t, d_t, p_t, p_t^I, p_t^S, p_t^C, u_t^T, u_t^S, u_t^C, w_t^H, w_t^L, q_t^T, q_t^S, q_t^C, rer_t, r_t, \eta_t, p_t^{Co}\}$

A.3.4 Microfounding the relationship between interest rate spreads and commodity prices

This section follows exactly from Drechsel and Tenreyro (2018) and has the goal to formally show that it is possible to derive a negative relationship between interest reate spreads and commodity prices.

Suppose there is a borrower who borrows amount d_t^*. With probability λ she is able to repay in full. With probability $1-\lambda$ only a repayment smaller than the borrowed amount d_t^* can be made. This repayment is a fraction ϕ of commodity output $p_t^{Co}y^{Co}$ (equivalently, $p_t^{Co}y^{Co}$ can be thought of as collateral which the lender can seize when full repayment is not possible). The presence of a risk-neutral lender who herself can obtain funds at the risk-free rate r^* and who faces perfect competition will result in the following zero profit condition:

$$(1+r^*)\,d_t^* = \lambda\,(1+r_t)\,d_t^* + (1-\lambda)\phi p_t^{Co}y^{Co},$$

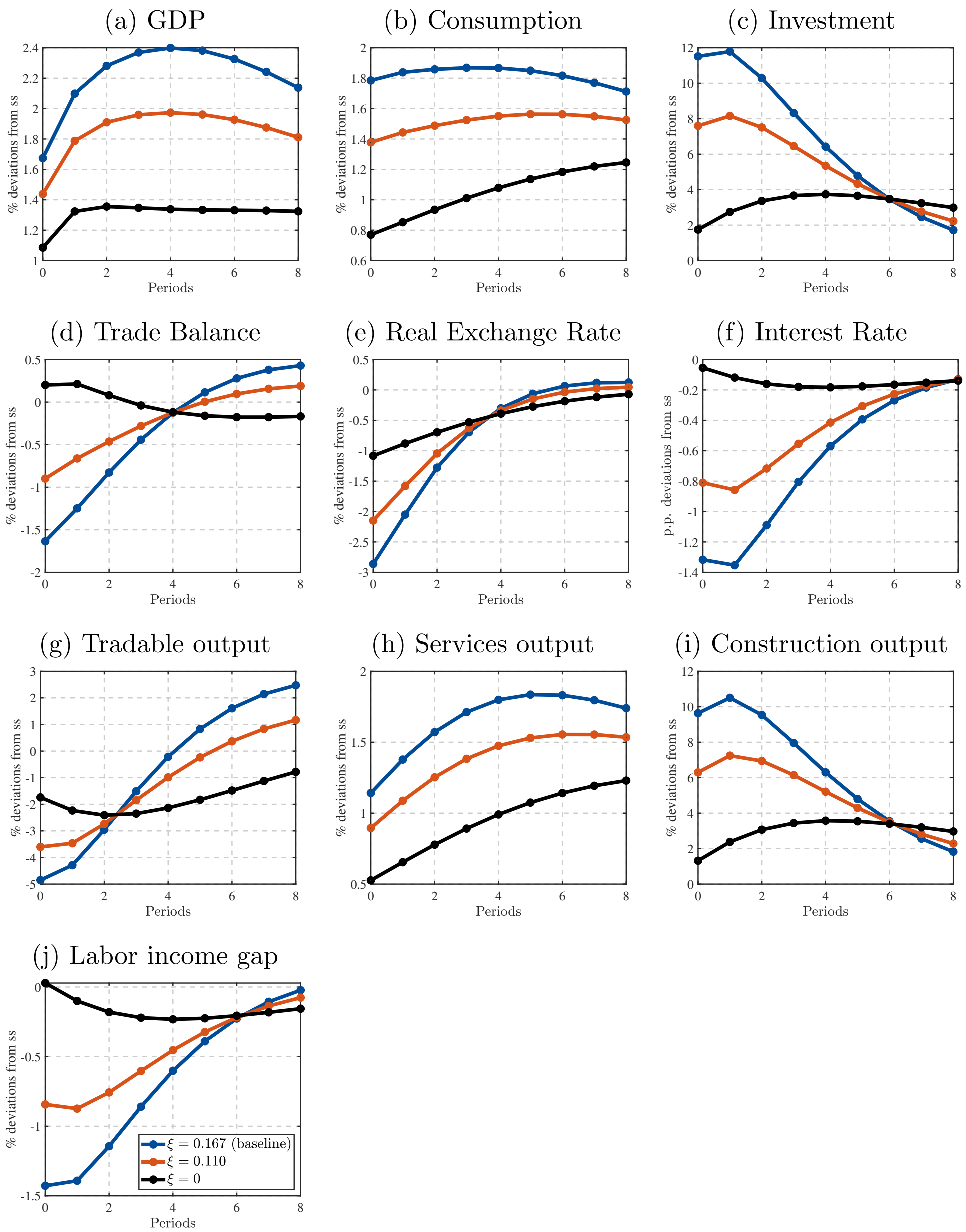
which can be rearranged to

$$r_t = \frac{1+r^*}{\lambda} - \frac{1-\lambda}{\lambda d_t^*}\phi p_t^{Co}y^{Co} - 1$$

From this expression, it is evident that: $\frac{\partial r_t}{\partial p_t^{Co}} < 0$. This backs up the existence of the third term in equation (1.20). Also consistent with the formulation in (1.20), it is straightforward from here to show that $\frac{\partial r_t}{\partial d_t^*} > 0$.

A.3.5 Interest rate sensitivity to commodity prices

Figure A.21: IRFs to commodity price shock for alternative ξ



Notes: This figure plots the impulse response functions for (a) GDP, (b) Consumption, (c) Investment, (d) Trade balance to GDP ratio, (e) Real Exchange Rate,(f) Interest Rate, (g) tradable output, (h) service output and (i) construction output) to a 10% increase in p_t^{Co} for different values of ξ. All models responses are expressed in percentage deviations with respect to steady state, except for the trade balance and interest rate, which are expressed in percentage-point deviations. The time units in the horizontal axis are years.

A.3.6 Model with one non-tradable good

This section presents the system of non-linear equations that solve the alternative model one non-tradable good:

Capitalist's problem

$$\lambda_t p_t = \left[c_t^k\right]^{-\sigma}$$
$$\lambda_t = \beta(1+r_t)E_t\{\lambda_{t+1}\}$$

Capital and investment in tradable sector

$$k_{t+1}^T = (1-\delta)k_t^T + \left[1 - \Phi\left(\frac{i_t^T}{k_t^T}\right)\right] i_t^T,$$
$$p_t^I = q_t^T\left[1 - \Phi\left(\frac{i_t^T}{k_t^T}\right) - \Phi'\left(\frac{i_t^T}{k_t^T}\right)\frac{i_t^T}{k_t^T}\right] + E_t\left\{\beta\frac{\lambda_{t+1}}{\lambda_t}q_{t+1}^T\Phi\left(\frac{i_{t+1}^T}{k_t^T}\right)\left(\frac{i_{t+1}^T}{k_{t+1}^T}\right)^2\right\},$$
$$q_t^T = \beta E_t\left\{\frac{\lambda_{t+1}}{\lambda_t}[u_{t+1}^T + (1-\delta)q_{t+1}^T]\right\}$$

Capital and investment in non-tradable sector

$$k_{t+1}^N = (1-\delta)k_t^N + \left[1 - \Phi\left(\frac{i_t^N}{k_t^N}\right)\right] i_t^N,$$
$$p_t^I = q_t^N\left[1 - \Phi\left(\frac{i_t^N}{k_t^N}\right) - \Phi'\left(\frac{i_t^N}{k_t^N}\right)\frac{i_t^N}{k_t^N}\right] + E_t\left\{\beta\frac{\lambda_{t+1}}{\lambda_t}q_{t+1}^N\Phi\left(\frac{i_{t+1}^N}{k_t^N}\right)\left(\frac{i_{t+1}^N}{k_{t+1}^N}\right)^2\right\},$$
$$q_t^N = \beta E_t\left\{\frac{\lambda_{t+1}}{\lambda_t}[u_{t+1}^N + (1-\delta)q_{t+1}^N]\right\}$$

Worker's problem

$$\nu_H\left(l_t^H\right)^{\omega-1} = \frac{w_t^H}{p_t}$$
$$\nu_L\left(l_t^L\right)^{\omega-1} = \frac{w_t^L}{p_t}$$
$$p_t c_t^L = w_t^L l_t^L$$
$$p_t c_t^H = w_t^H l_t^H$$

Labor income gap

$$\eta_t = \frac{w_t^H l_t^H}{w_t^L l_t^L}$$

Final consumption good producer

$$\begin{aligned}
c_t &= \left[\varphi^{1/\varepsilon_c} \left(c_t^N\right)^{1-1/\varepsilon_c} + (1-\varphi)^{1/\varepsilon_c} \left(c_t^T\right)^{1-1/\varepsilon_c}\right]^{\frac{\varepsilon_c}{\varepsilon_c - 1}} \\
c_t^S &= \varphi \left(\frac{p_t}{p_t^S}\right)^{\varepsilon_c} c_t \\
c_t^T &= (1-\varphi)\left(p_t\right)^{\varepsilon_c} c_t
\end{aligned}$$

Final investment good producer

$$\begin{aligned}
i_t &= \left[\gamma^{1/\varepsilon_i} \left(x_t^N\right)^{1-1/\varepsilon_i} + (1-\gamma)^{1/\varepsilon_i} \left(x_t^T\right)^{1-1/\varepsilon_i}\right]^{\frac{\varepsilon_i}{\varepsilon_i - 1}} \\
x_t^C &= \gamma \left(\frac{p_t^I}{p_t^C}\right)^{\varepsilon_i} i_t \\
x_t^T &= (1-\gamma)\left(p_t^I\right)^{\varepsilon_i} i_t
\end{aligned}$$

Tradable production

$$\begin{aligned}
y_t^T &= a^T \left[\left(l_t^{H,T}\right)^{\theta_T} \left(l_t^{L,T}\right)^{1-\theta_T}\right]^{\alpha_T} \left(k_t^T\right)^{1-\alpha_T}, \\
w_t^H &= \alpha_T \theta_T \frac{y_t^T}{l_t^{H,T}} \\
w_t^L &= \alpha_T (1-\theta_T) \frac{y_t^T}{l_t^{L,T}} \\
u_t^T &= (1-\alpha_T)\frac{y_t^T}{k_t^T},
\end{aligned}$$

Non-tradable production

$$
\begin{aligned}
y_t^N &= a^N \left[\left(l_t^{H,N} \right)^{\theta_N} \left(l_t^{L,N} \right)^{1-\theta_N} \right]^{\alpha_N} \left(k_t^N \right)^{1-\alpha_N}, \\
w_t^H &= p_t^N \alpha_N \theta_N \frac{y_t^N}{l_t^{H,N}} \\
w_t^L &= p_t^N \alpha_N (1-\theta_N) \frac{y_t^N}{l_t^{L,N}} \\
u_t^N &= p_t^N \left(1-\alpha_N\right) \frac{y_t^N}{k_t^N},
\end{aligned}
$$

Market clearing + additional definitions

$$
\begin{aligned}
& c_t = \kappa c_l^k + (1-\kappa) * \left(\mu c_l^L + (1-\mu) c_l^H \right) \\
& i_t = i_t^T + i_t^N \\
& y_t^N = c_t^N \\
& (1-\mu)\ l_t^H = l_t^{H,T} + l_t^{H,N} \\
& \mu\ l_t^L = l_t^{L,T} + l_t^{L,N} \\
& tb_t = y_t^T + p_t^{Co} y_t^{Co} - c_t^T - x_t^T, \\
& p_t gdp_t = y_t^T + p_t^N y_t^N + p_t^{Co} y^{Co}, \\
& rer_t = 1/p_t, \\
& d_{t-1} \left(1 + r_{t-1}\right) = d_t + tb_t
\end{aligned}
$$

Interest rate

$$
r_t = (r^w + z^r) + \psi \left[\exp \left\{ d_t - \bar{d} \right\} - 1 \right] - \xi \left[\ln(p_t^{Co}) - \ln(p^{\bar{C}o}) \right]
$$

Exogenous process

$$
\ln\left(p_t^{Co}\right) = (1-\rho_1-\rho_2) \ln\left(p^{\overline{Co}}\right) + \rho_1 \ln\left(p_{t-1}^{Co}\right) + \rho_2 \ln\left(p_{t-2}^{Co}\right) + \varepsilon_t^{Co}
$$

A.3.7 Model extensions

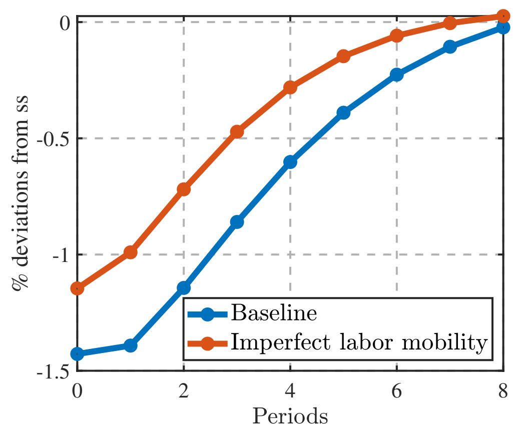
A.3.7.1 Imperfect labor mobility

Following Horvath (2000), I assume that workers of each type supply labor to firms in the three sectors according to:

$$l_t^j = \left[\left(l_t^{j,T} \right)^{\frac{1+\Lambda}{\Lambda}} + \left(l_t^{j,S} \right)^{\frac{1+\Lambda}{\Lambda}} + \left(l_t^{j,C} \right)^{\Lambda} \right]^{\frac{\Lambda}{1+\Lambda}}, \quad \forall j = \{H, L\}$$

where Λ captures the degree of labor market mobility. This is a reduced-form way to model imperfect labor mobility regardless of its root causes. Perfect labor mobility is achieved for $\Lambda \to \infty$; if $\Lambda < \infty$, the economy displays a limited degree of labor mobility; if $\Lambda \to 0$, labor becomes virtually not substitutable across sectors. I solve a version of the model in which $\Lambda = 1$. Under this specification, commodity booms still reduce labor income inequality but effects are more moderate.

Figure A.22: Labor income gap - baseline vs imperferct labor mobility



Notes: This figure compares the impulse response functions for the labor income gap to a 10% increase in p_t^{Co} for the baseline model and the alternative model with imperfect labor mobility. The variables are expressed in percentage deviations with respect to steady state. The time units on the horizontal axis are years.

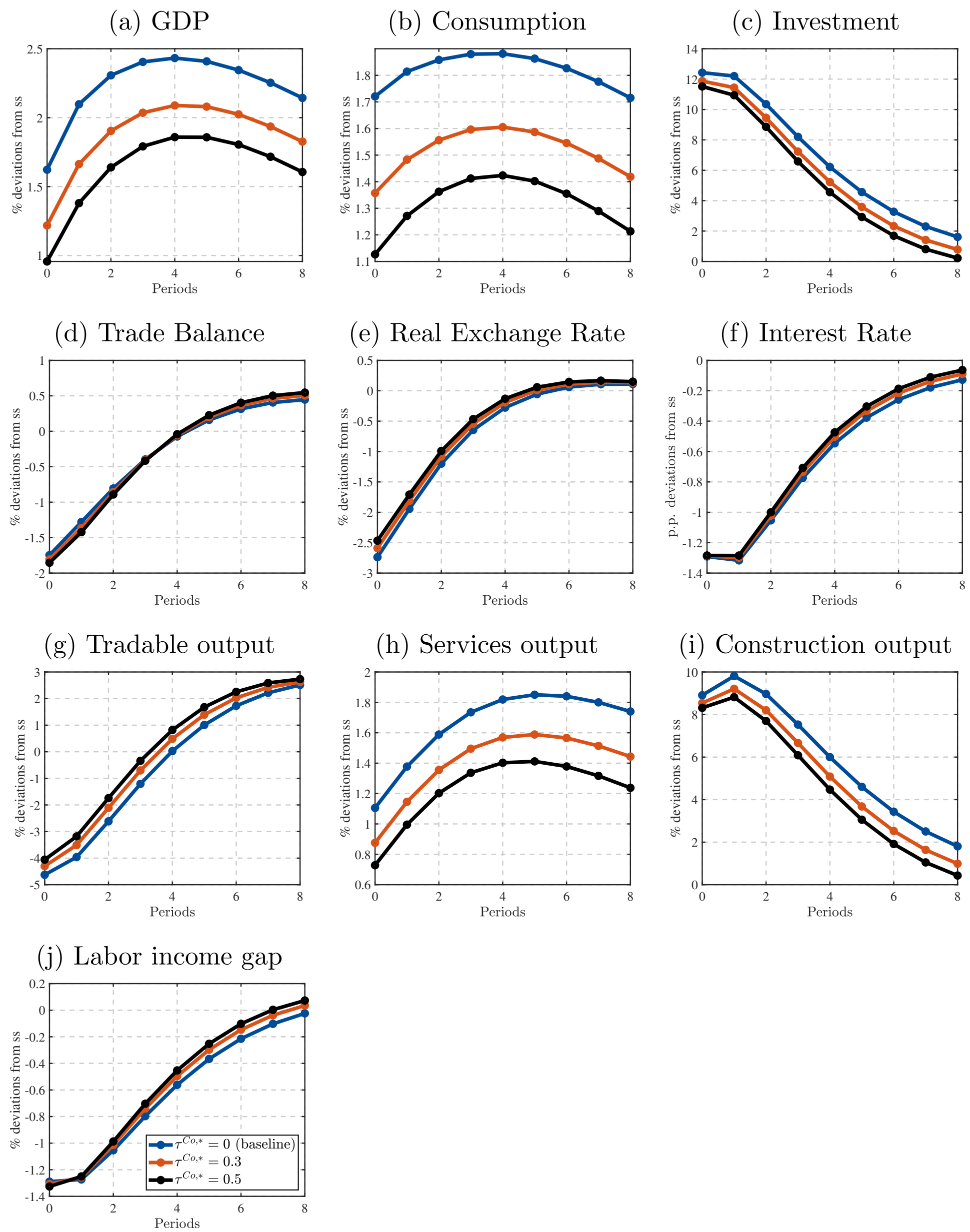
A.3.7.2 Foreign ownership of commodities

I consider here the case in which a fraction $\tau^{Co,*}$ of the commodity endowment is owned by foreign residents. If this is the case, there are two equations that will change:

$$tb_t = y_t^T + (1 - \tau^{Co,*})p_t^{Co} y_t^{Co} - c_t^T - x_t^T,$$
$$p_t gdp_t = y_t^T + p_t^N y_t^N + (1 - \tau^{Co,*})p_t^{Co} y^{Co},$$

Note that, when $\tau^{Co,*} = 0$, the model returns to the baseline one in which there is no foreign ownership of the commodity endowment. I solve the model for 3 possible values: $\tau^{Co,*} = \{0; 0.3; 0.5\}$. García-Cicco and Kawamura (2015) calibrate $\tau^{Co,*} = 0.3$ for Chile, for example.

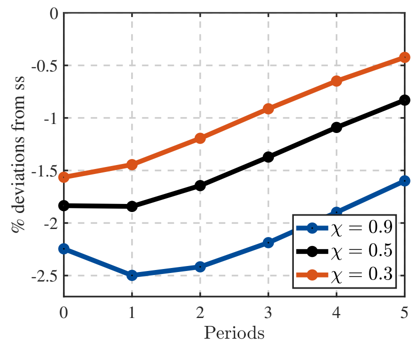
Figure A.23: IRFs to commodity price shock to alternative $\tau^{Co,*}$



Notes: This figure plots the impulse response functions for (a) GDP, (b) Consumption, (c) Investment, (d) Trade balance to GDP ratio, (e) Real Exchange Rate,(f) Interest Rate, (g) tradable output, (h) service output, (i) construction output nad (j) labor income gap to a 10% increase in p_t^{Co} for different values of $\tau^{Co,*}$. All model responses are expressed in percentage deviations with respect to steady state, except for the trade balance and interest rate, which are expressed in percentage-point deviations. The time units in the horizontal axis are years.

A.3.8 Additional Figures

Figure A.24: Labor income gap response for alternatives χ



APPENDIX B

Appendix to "Labor Markets, Financial Crises and Inflation: Jobless and Wageless Recoveries"

B.1 Data description

Data sources. The data used in the empirical analysis of Section 2.2 were obtained from the following sources:

1. GDP: Measured at constant national prices, obtained from Penn World Tables, version 9.1 (henceforth PWT; variable name: *rgdpna*).
2. Total population: Obtained from PWT (variable name: *pop*).
3. Working-age population ratio: Population aged 15–64 divided by total population, obtained from the OECD and WDI.
4. Employment: Number of individuals engaged, obtained from PWT (variable name: *emp*).
5. Capital stock: Measured at constant national prices, obtained from PWT (variable name: *rnna*).
6. Labor share: Share of labor compensation in GDP at current national prices, obtained from PWT (variable name: *labsh*).
7. Average hours worked: Average annual hours worked by persons engaged, obtained from PWT (variable name: *avh*).
8. Real consumption: Real consumption at constant 2011 national prices, obtained from PWT (variable name: *rconna*).

9. Nominal wages: Obtained primarily from The Conference Board's International Labor Comparisons program (henceforth ILC, January 2020). Refers to labor cost per hour worked for all manufacturing, expressed in national currency. For recession episodes with no available data, data from the WEO were used.

10. Consumer Price Index: Obtained from the IMF using the IFS query tool.

11. Unemployment rate: Measured as the share of the labor force that is unemployed, obtained from WDI and WEO.

The data used in the empirical analysis of Section 2.3 were obtained, for most variables, from the same sources described previously for developed-market economies. One exception is nominal wages, which, for countries with no available data from the OECD or ILC, were sourced from national datasets. For the countries in our sample that were members of the Soviet Union (i.e., Bulgaria, Czech Republic, Croatia, Hungary, Poland, Russia, and Ukraine), data prior to 1994 were excluded to remove recession episodes associated with the transition from Soviet to market economies in the early 1990s, as well as any recessions occurring during their Soviet period.

Constructed Variables. Based on the raw data, we constructed the following variables for the empirical analysis:

1. Real GDP over working-age population (y_{it}): Constructed as (1)/((2)×(3)).

2. Employment over working-age population (l_{it}): Constructed as (4)/((2)×(3)).

3. Capital stock over working-age population (k_{it}): Constructed as (5)/((2)×(3)).

4. Labor share ($1 - \alpha_i$): Constructed as the average of (6) over all years with available data.

5. Hours worked over working-age population: Constructed as (4)×(7)/((2)×(3)).

6. Consumption over working-age population (h_{it}): Constructed as (8)/((2)×(3)).

7. Total factor productivity: Constructed as $A_{it} = y_{it}/(k_{it}^{\alpha_i} l_{it}^{1-\alpha_i})$.

8. Real wages (w_{it}): Constructed as (9)/(10).

B.2 Additional figures and tables

Table B.1: Sample of Recession Episodes in Developed Market Economies (Part I)

Country	Peak	Trough	GDP change P-T	duration P-R	FC	Country	Peak	Trough	GDP change P-T	duration P-R	FC
Australia	1951	1952	-5.4	2	0	Germany	1992	1993	-1.4	2	0
Australia	1955	1956	-1.5	3	0	Germany	2002	2003	-0.5	2	0
Australia	1960	1961	-0.7	2	0	Germany	2008	2009	-5.2	3	1
Australia	1964	1965	-0.1	2	0	Greece	1951	1952	-3.3	2	0
Australia	1973	1974	-0.4	2	0	Greece	1961	1962	-0.5	2	0
Australia	1976	1977	-0.7	2	0	Greece	1973	1974	-7.2	3	0
Australia	1981	1982	-3.8	3	0	Greece	1979	1987	-8.9	10	0
Australia	1989	1991	-2.5	3	1	Greece	1989	1990	-1.2	2	1
Australia	2007	2008	-0.1	2	0	Greece	1991	1993	-3.4	5	1
Austria	1974	1975	-0.7	2	0	Greece	2007	2013	-25.3	9	1
Austria	1977	1978	-0.8	2	0	Iceland	1950	1952	-4.8	3	0
Austria	1980	1981	-1.2	3	0	Iceland	1956	1957	-1.4	2	0
Austria	1983	1984	-1.0	2	0	Iceland	1960	1961	-1.5	2	0
Austria	1992	1993	-0.1	2	0	Iceland	1966	1968	-10.2	5	0
Austria	2008	2009	-4.1	3	1	Iceland	1974	1975	-1.4	2	0
Austria	2012	2013	-0.4	3	1	Iceland	1982	1983	-3.5	3	1
Belgium	1957	1958	-0.6	2	0	Iceland	1987	1989	-2.6	3	1
Belgium	1974	1975	-2.1	2	0	Iceland	1990	1992	-5.4	6	1
Belgium	1976	1977	-0.2	2	0	Iceland	2001	2002	-0.3	2	0
Belgium	1980	1983	-1.5	4	0	Iceland	2007	2010	-11.9	9	1
Belgium	1992	1993	-1.1	2	0	Ireland	1951	1952	-1.0	2	0
Belgium	2007	2009	-3.0	4	1	Ireland	1955	1957	-4.1	4	0
Belgium	2011	2012	0.0	2	1	Ireland	1965	1965	0.0	2	0
Canada	1953	1954	-3.3	2	0	Ireland	1975	1976	-0.5	2	0
Canada	1956	1958	-0.8	3	0	Ireland	1982	1983	-1.4	2	0
Canada	1966	1967	-0.1	2	0	Ireland	1985	1986	-1.0	2	0
Canada	1974	1975	-0.6	2	0	Ireland	2007	2009	-10.9	7	1
Canada	1981	1982	-4.4	3	1	Italy	1974	1975	-2.5	2	0
Canada	1989	1992	-4.1	5	0	Italy	1980	1983	-1.2	4	0
Canada	2007	2009	-4.2	4	0	Italy	1992	1993	-0.8	2	1
Denmark	1950	1951	-2.0	3	0	Italy	2002	2003	-0.1	2	0
Denmark	1954	1955	-0.9	2	0	Italy	2007	2013	-8.0	9	1
Denmark	1973	1975	-3.1	3	0	Japan	1973	1974	-2.2	3	0
Denmark	1979	1981	-2.5	3	0	Japan	1992	1993	-0.8	2	1
Denmark	1986	1988	-0.6	4	1	Japan	1997	1999	-1.0	3	1
Denmark	1992	1993	-0.4	2	1	Japan	2007	2009	-4.9	5	0
Denmark	2007	2009	-5.9	8	1	Luxembourg	1950	1951	-5.2	2	0
Finland	1952	1953	-1.2	2	0	Luxembourg	1953	1954	-1.1	2	0
Finland	1956	1958	-1.0	3	0	Luxembourg	1974	1975	-7.9	4	0
Finland	1990	1993	-10.7	7	1	Luxembourg	1980	1981	-1.3	3	0
Finland	2008	2009	-8.5	3	0	Luxembourg	2007	2012	-11.4	7	0
Finland	2011	2014	-1.3	5	0	Netherlands	1957	1958	-2.2	2	0
France	1974	1975	-1.8	2	0	Netherlands	1974	1975	-1.5	2	0
France	1980	1981	-0.2	2	0	Netherlands	1980	1982	-4.3	6	0
France	1982	1983	0.0	2	0	Netherlands	2001	2003	-0.6	3	0
France	1992	1993	-0.9	2	1	Netherlands	2008	2009	-3.9	6	1
France	2007	2009	-3.4	4	1	New Zealand	1950	1952	-4.4	4	0
Germany	1974	1975	-1.1	2	1	New Zealand	1955	1956	-0.2	2	0
Germany	1980	1982	-1.9	4	1	New Zealand	1957	1958	-1.2	2	0

Notes: This table reports the sample of developed-market recession episodes used in the empirical analysis in Section 2.2.1. GDP change P-T refers to the contraction in real GDP per capita from the recession peak to trough (expressed in percentages). Duration P-R indicates the number of years between the peak and the recovery of GDP per capita. Financial crisis is a dummy variable that takes the value of 1 if the identified recession coincides with a financial crisis and 0 otherwise.

Table B.2: Sample of Recession Episodes in Developed Market Economies (Part II)

Country	Peak	Trough	GDP change P-T	duration P-R	FC	Country	Peak	Trough	GDP change P-T	duration P-R	FC
New Zealand	1961	1962	-0.4	2	0	Sweden	1976	1977	-1.8	3	0
New Zealand	1966	1968	-8.4	3	0	Sweden	1990	1993	-5.6	5	1
New Zealand	1969	1970	-2.2	3	0	Sweden	2007	2009	-6.9	4	1
New Zealand	1974	1978	-9.5	9	0	Sweden	2011	2012	-0.4	2	1
New Zealand	1986	1987	-5.2	2	1	Switzerland	1951	1952	-0.2	2	0
New Zealand	1988	1992	-3.8	5	1	Switzerland	1957	1958	-3.5	2	0
New Zealand	2007	2008	-2.6	5	0	Switzerland	1974	1976	-9.1	6	0
Norway	1981	1982	-0.4	2	0	Switzerland	1981	1983	-2.9	4	0
Norway	1987	1988	-0.9	3	1	Switzerland	1990	1993	-3.6	8	0
Norway	2007	2011	-4.3	8	0	Switzerland	2001	2003	-1.4	3	0
Norway	2015	2016	-0.1	2	0	Switzerland	2008	2009	-3.3	5	1
Portugal	1973	1975	-6.5	4	0	United Kingdom	1968	1969	-0.8	2	0
Portugal	1982	1984	-3.6	4	0	United Kingdom	1973	1975	-4.4	5	1
Portugal	1992	1993	-2.8	3	0	United Kingdom	1979	1981	-3.7	4	1
Portugal	2002	2003	-1.2	2	0	United Kingdom	1990	1991	-1.0	3	1
Portugal	2008	2009	-2.9	2	1	United Kingdom	2007	2009	-6.2	7	1
Portugal	2010	2013	-5.8	5	1	United States	1953	1954	-1.3	2	0
Portugal	2015	2016	-0.6	2	1	United States	1957	1958	-1.9	2	0
Spain	1952	1953	-4.2	2	0	United States	1969	1970	-1.6	2	0
Spain	1958	1959	-3.4	2	0	United States	1973	1975	-4.0	4	0
Spain	1974	1975	-0.6	2	1	United States	1979	1982	-2.8	4	1
Spain	1978	1981	-1.5	7	1	United States	1990	1991	-0.8	2	1
Spain	1992	1993	-1.8	3	0	United States	2000	2001	-0.3	2	0
Spain	2007	2013	-7.7	9	1	United States	2007	2009	-4.2	5	1

Notes: This table details the sample of developed-market recession episodes used in the empirical analysis in Section 2.2.1. GDP change *P-T* refers to the contraction in real GDP per capita from the recession peak to the trough (expressed in percentages). Duration *P-R* indicates the number of years between the peak and the recovery of GDP per capita. Financial crisis is a dummy variable that takes the value of 1 if the identified recession coincides with a financial crisis and 0 otherwise.

Table B.3: Recovery from Financial Crises: Comparison with Other Recession Episodes

	Output	Employment	Captial/ output	Productivity	Hours worked	Unemployment rate	Real wages	Labor wedge
(a) Baseline	-0.014*	-0.020**	-0.004	0.005	-0.017*	0.003	-0.008	0.057***
	[0.007]	[0.008]	[0.011]	[0.009]	[0.010]	[0.006]	[0.019]	[0.022]
(b) Time controls								
Time quadratic trend	-0.002	-0.020**	-0.012	0.014	-0.013	0.003	-0.000	0.054**
	[0.008]	[0.009]	[0.012]	[0.010]	[0.011]	[0.006]	[0.019]	[0.022]
Post-1990 fixed effect	-0.008	-0.028***	-0.003	0.013	-0.027**	0.006	-0.000	0.077***
	[0.008]	[0.009]	[0.012]	[0.010]	[0.011]	[0.006]	[0.020]	[0.022]
(c) Country fixed effects	-0.022***	-0.027***	0.002	0.002	-0.026**	0.004	-0.015	0.068***
	[0.008]	[0.008]	[0.012]	[0.009]	[0.011]	[0.006]	[0.015]	[0.020]
(d) Alternative samples								
Including mild recessions	-0.017***	-0.020***	0.006	-0.001	-0.019**	0.007*	-0.009	0.050***
	[0.006]	[0.006]	[0.008]	[0.007]	[0.008]	[0.004]	[0.013]	[0.015]
Pre-2007 sample	-0.011*	-0.034***	-0.006	0.016*	-0.028**	0.007	-0.014	0.079***
	[0.006]	[0.009]	[0.011]	[0.009]	[0.012]	[0.007]	[0.022]	[0.022]

Notes: This table presents the results of estimating $\Delta_{t_R(i,j)-t_P(i,j)} Z_{i,t} = \alpha + \beta \text{financial}_{i,j} + \gamma' X_{i,t_P(i,j)} + \epsilon_{i,j}$ in a sample of recession episodes, where $Z_{i,t}$ represents one of the following variables: the log of GDP over working-age population, the log of employment over working-age population, the log of the capital-output ratio, the log of measured productivity, the log of hours worked over working-age population, the unemployment rate, the log of real wages, or the log of the labor wedge for episode j in country i. The terms $\{t_P(i,j), t_R(i,j)\}$ denote the output peak and recovery point of each episode j in country i, $\text{financial}_{i,j}$ is a dummy variable indicating whether the episode is classified as a financial crisis, and $X_{i,t_P(i,j)}$ is a vector of controls linked to the country and the period in which the episode occurs. Panel (a) shows the baseline regression (corresponding to Figure 2.2), with no controls. Panel (b) estimates the regression including time controls in the vector $X_{i,t_P(i,j)}$, either a quadratic time trend (i.e., $\theta_1 t_P(i,j) + \theta_2 t_P(i,j)^2$) or a dummy variable equal to one if the recession peak occurs in 1990 or later (i.e., $\mathbb{I}\{t_P(i,j) \geq 1990\}$). Panel (c) includes country fixed effects α_i. Panel (d) estimates the baseline specification but for alternative samples: one including "mild recessions" and another excluding episodes with a peak in 2007 or later. The episodes included in the analysis are detailed in Appendix Tables B.1 and B.2, and specify whether each episode is a financial crisis. For the definition of financial crises and other episodes, see Section 2.2.1. $*$, $**$, and $***$ represent statistical significance at the 10%, 5%, and 1% levels, respectively.

Table B.4: Sample of Moderate Inflation Recession Episodes in Emerging Markets (Part I)

Country	Peak	Trough	GDP change P-T	duration P-R	FC	Country	Peak	Trough	GDP change P-T	duration P-R	FC
Algeria	1960	1962	-37.5	5	0	Egypt	1965	1967	-5.3	4	0
Algeria	1965	1966	-8.7	3	0	Egypt	1972	1973	-1.9	3	0
Algeria	1970	1971	-12.0	2	0	Egypt	1985	1986	-0.7	2	1
Algeria	1979	1981	-2.9	3	0	Egypt	2010	2011	-0.3	2	0
Algeria	1985	1988	-11.3	4	1	El Salvador	1960	1961	-1.1	2	0
Algeria	2005	2006	-0.6	2	0	El Salvador	1967	1969	-1.9	4	0
Algeria	2008	2009	-0.3	2	0	El Salvador	2008	2009	-4.3	8	0
Argentina	1994	1995	-4.3	2	1	Hungary	1995	1995	0.0	2	1
Argentina	2008	2009	-7.2	2	1	Hungary	2008	2009	-6.4	6	1
Brazil	1997	1999	-4.2	7	1	Indonesia	1981	1982	-0.7	2	0
Brazil	2008	2009	-1.6	2	0	Indonesia	1984	1985	-0.5	2	0
Bulgaria	2008	2009	-2.6	2	0	Lebanon	1973	1976	-71.2	6	0
Chile	1964	1965	-1.4	2	1	Lebanon	1996	1997	-3.2	2	0
Chile	1998	1999	-2.4	2	0	Lebanon	1998	2006	-7.5	10	0
Chile	2008	2009	-3.0	2	0	Malaysia	1974	1975	-2.4	2	0
China	1960	1961	-17.3	4	0	Malaysia	1984	1986	-5.9	4	1
China	1966	1968	-7.4	4	0	Malaysia	1997	1998	-10.3	3	1
China	1971	1972	-0.8	2	0	Malaysia	2000	2001	-2.2	2	1
China	1975	1976	-5.6	3	0	Malaysia	2008	2009	-3.9	2	0
China	1980	1980	-0.2	2	0	Mexico	2000	2003	-4.7	4	1
China	1988	1990	-3.4	4	1	Mexico	2007	2009	-8.4	8	0
Colombia	1964	1965	-2.0	2	0	Morocco	1964	1966	-7.4	5	0
Colombia	1980	1983	-4.4	7	1	Morocco	1977	1978	-1.2	2	0
Colombia	1997	1999	-7.4	8	1	Morocco	1980	1981	-5.7	2	1
Colombia	2008	2009	-0.2	2	0	Morocco	1982	1983	-3.5	3	1
Croatia	2008	2012	-9.2	8	0	Morocco	1986	1987	-4.9	2	1
Czech Rep.	1990	1993	-13.8	5	0	Morocco	1988	1988	0.0	2	1
Czech Rep.	1996	1998	-1.6	4	0	Morocco	1991	1993	-9.2	3	1
Czech Rep.	2008	2009	-5.0	6	0	Morocco	1994	1995	-8.8	2	0
Côte d'Ivoire	1961	1962	-3.0	2	0	Morocco	1996	1997	-4.5	2	0
Côte d'Ivoire	1964	1965	-6.6	2	0	Morocco	1998	2000	-2.3	3	0
Côte d'Ivoire	1966	1967	-0.6	2	0	Nigeria	1960	1961	-6.5	2	0
Côte d'Ivoire	1971	1972	-0.5	2	0	Nigeria	1964	1968	-31.1	7	0
Côte d'Ivoire	1973	1974	-0.6	2	0	Pakistan	1970	1972	-1.6	3	0
Côte d'Ivoire	1978	1988	-36.2	11	1	Pakistan	1992	1993	-0.8	2	0
Côte d'Ivoire	1989	1994	-17.4	7	1	Pakistan	1996	1998	-2.1	7	0
Côte d'Ivoire	1998	2007	-13.8	11	1	Pakistan	2007	2010	-2.4	7	0
Côte d'Ivoire	2009	2011	-7.4	4	1	Panama	1973	1977	-5.9	5	0
Dominican Rep.	1960	1961	-4.4	2	0	Panama	1982	1984	-5.4	3	1
Dominican Rep.	1964	1965	-13.7	6	0	Panama	1987	1989	-13.9	5	1
Dominican Rep.	1977	1978	-1.2	3	1	Panama	1994	1995	-0.8	3	1
Dominican Rep.	1981	1982	-1.3	2	1	Panama	2000	2002	-1.7	3	0
Dominican Rep.	2000	2001	-0.22	2	1	Panama	2008	2009	-0.71	2	0
Dominican Rep.	2008	2009	-1.03	2	0	Peru	1967	1968	-2.57	3	1
Ecuador	1962	1963	-0.27	2	0	Peru	1997	2001	-4.04	6	1
Ecuador	1965	1966	-0.41	2	0	Peru	2008	2009	-0.50	2	0
Ecuador	1968	1969	-1.09	2	0	Philippines	1969	1969	-0.02	2	0
Ecuador	1976	1977	-1.55	2	0	Philippines	1990	1993	-6.48	6	1
Ecuador	2008	2009	-1.56	3	1	Philippines	1997	1998	-3.09	5	1
Egypt	1961	1962	-0.28	2	0	Philippines	2008	2009	-1.37	2	0

This table details the sample of moderate-inflation emerging-market recession episodes used in the empirical analysis in Section 2.3. GDP change P-T refers to the contraction in real GDP per capita from the recession peak to the trough (expressed in percentages). Duration P-R indicates the number of years between the peak and the recovery of GDP per capita. Financial crisis is a dummy variable that takes the value of 1 if the identified recession coincides with a financial crisis and 0 otherwise.

Table B.5: Sample of Moderate Inflation Recession Episodes in Emerging Markets (Part II)

Country	Peak	Trough	GDP change P-T	duration P-R	FC	Country	Peak	Trough	GDP change P-T	duration P-R	FC
Rep. of Korea	1961	1962	-0.5	2	0	Tunisia	1966	1967	-2.6	2	0
Rep. of Korea	1979	1980	-4.2	3	1	Tunisia	1972	1973	-3.3	2	0
Rep. of Korea	1997	1998	-6.9	2	1	Tunisia	1981	1982	-4.0	3	1
Russian Fed.	2008	2009	-8.0	3	1	Tunisia	1985	1986	-5.0	5	1
Russian Fed.	2014	2015	-1.7	3	0	Tunisia	1992	1995	-1.2	4	1
South Africa	1971	1972	-1.2	2	0	Tunisia	2001	2002	-0.2	2	0
South Africa	1974	1977	-4.2	6	1	Tunisia	2010	2011	-3.1	3	0
South Africa	1981	1983	-7.0	3	1	Turkey	1960	1961	-0.6	2	1
South Africa	1984	1987	-5.8	4	1	Turkey	2007	2009	-6.9	4	0
South Africa	1988	1995	-13.4	8	1	Ukraine	2008	2009	-14.9	3	0
South Africa	1996	1999	-2.7	6	0	Uruguay	1998	2002	-15.7	9	1
South Africa	2008	2009	-2.9	2	0	Uruguay	2014	2015	-0.1	2	0
Thailand	1996	1998	-13.4	7	1	Venezuela	1965	1966	-4.2	3	0
Thailand	2008	2009	-1.4	2	0	Venezuela	1970	1972	-0.8	3	0

Notes: This table details the sample of moderate-inflation emerging-market recession episodes used in the empirical analysis of Section 2.3. GDP change *P-T* refers to the contraction in real GDP per capita from the recession peak to the trough (expressed in percentages). Duration *P-R* indicates the number of years between the peak and the recovery of GDP per capita. Financial crisis is a dummy variable that takes the value of 1 if the identified recession coincides with a financial crisis and 0 otherwise.

Table B.6: Sample of High Inflation Recession Episodes in Emerging Markets

Country	Peak	Trough	GDP change P-T	duration P-R	FC	Country	Peak	Trough	GDP change P-T	duration P-R	FC
Algeria	1989	1997	-17.9	14	1	Lebanon	1981	1982	-37.3	3	0
Argentina	1961	1963	-6.1	4	1	Lebanon	1985	1986	-7.4	2	0
Argentina	1965	1966	-1.2	2	1	Lebanon	1987	1989	-59.2	4	0
Argentina	1974	1976	-3.0	3	0	Mexico	1981	1983	-10.9	3	1
Argentina	1977	1978	-4.1	2	1	Mexico	1984	1988	-9.4	7	1
Argentina	1980	1982	-10.4	3	1	Mexico	1994	1995	-8.5	3	1
Argentina	1984	1985	-8.2	2	1	Nigeria	1974	1975	-1.8	2	0
Argentina	1987	1990	-13.8	5	1	Nigeria	1977	1984	-27.0	12	1
Argentina	1998	2002	-22.9	8	1	Nigeria	1990	1999	-7.4	12	1
Argentina	2011	2012	-2.2	2	1	Peru	1975	1978	-9.7	5	1
Brazil	1980	1983	-13.7	6	1	Peru	1981	1985	-15.9	5	1
Brazil	1987	1988	-2.4	2	1	Peru	1987	1992	-32.8	7	1
Brazil	1989	1992	-10.6	5	1	Philippines	1982	1985	-20.5	7	1
Brazil	1995	1996	-0.1	2	1	Russian Fed.	1997	1998	-5.9	3	1
Bulgaria	1995	1999	-10.2	7	0	Turkey	1977	1980	-8.9	9	1
Chile	1969	1970	-0.2	2	1	Turkey	1987	1989	-2.8	3	1
Chile	1971	1975	-25.4	7	1	Turkey	1990	1991	-1.5	2	1
Chile	1981	1983	-19.5	8	1	Turkey	1993	1994	-7.6	3	1
Colombia	1974	1975	-1.1	3	0	Turkey	1998	1999	-5.3	2	1
Colombia	1990	1991	-0.2	2	0	Turkey	2000	2001	-7.7	4	1
Dominican Rep.	1983	1985	-6.3	4	1	Uruguay	1961	1963	-4.2	3	1
Dominican Rep.	1987	1988	-0.4	2	1	Uruguay	1964	1965	-1.8	2	1
Dominican Rep.	1989	1991	-8.8	4	1	Uruguay	1966	1967	-3.6	3	1
Dominican Rep.	2002	2004	-2.8	3	1	Uruguay	1970	1972	-1.5	4	1
Ecuador	1981	1987	-8.7	10	1	Uruguay	1981	1984	-17.0	6	1
Ecuador	1991	1993	-1.5	3	1	Uruguay	1987	1988	-0.6	3	1
Ecuador	1994	1996	-1.2	3	1	Uruguay	1994	1995	-2.2	2	0
Ecuador	1998	2000	-8.0	6	1	Venezuela	1977	1985	-27.1	11	1
El Salvador	1978	1989	-30.1	15	1	Venezuela	1988	1989	-11.1	3	1
Indonesia	1961	1963	-6.2	3	0	Venezuela	1992	1994	-7.4	3	1
Indonesia	1964	1965	-0.2	2	1	Venezuela	1995	1996	-2.8	2	1
Indonesia	1966	1966	-0.1	2	1	Venezuela	1997	1999	-10.2	4	1
Indonesia	1968	1969	-1.1	2	1	Venezuela	2001	2003	-19.9	5	1
Indonesia	1997	1999	-15.9	8	1	Venezuela	2008	2010	-8.1	3	0

Notes: This table details the sample of high-inflation emerging-market recession episodes used in the empirical analysis of Section 2.3. GDP change *P-T* refers to the contraction in real GDP per capita from the recession peak to the trough (expressed in percentages). Duration *P-R* indicates the number of years between the peak and the recovery of GDP per capita. Financial crisis is a dummy variable that takes the value of 1 if the identified recession coincides with a financial crisis and 0 otherwise.

Table B.7: Summary Statistics of Recession Episodes in Emerging Markets

	All episodes	**Financial crises**	**Inflation episodes**	
			Moderate	**High**
(a) Output per capita contraction (%)				
Mean	7.0	8.0	6.3	9.4
Median	4.2	5.9	4.8	7.7
Std. dev.	9.5	7.6	6.2	8.4
Min	0.0	0.0	0.0	0.1
Max	71.2	36.2	36.2	32.8
(b) Duration from peak to recovery (years)				
Mean	3.9	4.6	4.3	4.8
Median	3.0	3.0	3.0	3.0
Std. dev.	2.5	2.9	2.4	3.3
Min	2.0	2.0	2.0	2.0
Max	15.0	15.0	11.0	15.0
(c) Duration from trough to recovery (years)				
Mean	1.9	2.2	2.1	2.2
Median	1.0	2.0	2.0	2.0
Std. dev.	1.3	1.4	1.4	1.5
Min	1.0	1.0	1.0	1.0
Max	7.0	6.0	6.0	6.0
Number of episodes	196	105	48	57

Notes: This table presents descriptive statistics of the recession episodes used in the empirical analysis for our sample of emerging-market economies. Panel (a) reports descriptive statistics of the output contraction observed in each episode, measured in percent, from peak to trough. Panels (b) and (c) show the duration from peak to trough and from trough to recovery, respectively, measured in years. The column labeled *All* presents descriptive statistics for the entire set of recession episodes identified using the algorithm described in Section 2.2.1, and the column labeled *financial crises* represents statistics for the recession episodes classified as financial crises according to the definition provided in Section 2.2.1. The columns labeled *Moderate inflation* and *High inflation* report statistics for financial crises classified as moderate-and high-inflation episodes. Specifically, the *Moderate* category includes episodes with a maximum annual CPI inflation below 30 %. The *High* category encompasses episodes with maximum annual CPI inflation above 30 %. See Appendix B.1 for further information on the definition of variables and data sources.

APPENDIX C

Appendix to "Inflation Stabilization Plans and Price Controls"

C.1 Proofs of Propositions

Proposition 1: The optimal price set by a firm j under full information is:

$$P_t^* = \eta M_t$$

Proof:
From labor-leisure choice in household's problem: $P_t C_t = W_t$. From the equilibrium condition in the aggregate economy: $P_t C_t = M_t$. Then, $W_t = M_t$.

Then: $P_t^* = \eta W_t = \eta M_t$.

Proposition 2: The price level after the shock is:

$$P_{T+j} = \underbrace{(1-\theta)\sum_{k=0}^{j-1}\theta^k}_{\substack{\text{fract. of firms}\\ \text{that observed}\\ \text{the shock}}} \underbrace{\eta M_{T+j}}_{\substack{\text{optimal price}\\ \text{with updated}\\ \text{inform.}}} + \underbrace{\theta^j}_{\substack{\text{fract. of firms}\\ \text{that did not}\\ \text{observed the}\\ \text{shock}}} \underbrace{\eta(1+g_{old})^j M_T}_{\substack{\text{optimal price}\\ \text{with outdated}\\ \text{inform}}} \quad \text{for } j = 1, 2, ... \tag{C.1}$$

Proof:

Using the definition of the price level in (3.17) and the pricing strategy given by (3.20), consider the evolution of the price level after the shock:

$$P_{T+1} = \underbrace{(1-\theta)\eta M_{T+1}}_{\text{new information}} + \underbrace{(1-\theta)\Big[\theta\eta(1+g_{old})M_T + \theta^2\eta(1+g_{old})^2 M_{T-1} + ...\Big]}_{\text{old information}}$$

$$P_{T+1} = (1-\theta)\eta M_{T+1} + \theta(1+g_{old})M_T$$

$$P_{T+2} = \underbrace{(1-\theta)(1+\theta)\eta M_{T+2}}_{\text{new information}} + \underbrace{(1-\theta)\Big[\theta^2\eta(1+g_{old})^2 M_T + \theta^3\eta(1+g_{old})^3 M_{T-1} + ...\Big]}_{\text{old information}} =$$

$$P_{T+2} = (1-\theta)(1+\theta)\eta M_{T+2} + \theta^2(1+g_{old})^2 M_T$$

.

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$$P_{T+j} = (1-\theta)\sum_{k=0}^{j-1}\eta M_{T+j} + \theta^j(1+g_{old})^j M_T \quad \text{for} \quad j = 1, 2, ...$$

Corollary 3.1: $\lim_{j\to\infty} P_{t+j} \to \eta M_{t+j}$

Proof: Let's express (.) as:

$$P_{t+j} = AM_{t+j} + BM_t$$

where $A = (1-\theta)\sum_{k=0}^{j-1}\theta^k$ and $B = (1+g_{old})^j\theta^j$.

Lemma 1: $A \to 1$.

$\lim_{j\to\infty} \sum_{k=0}^{j-1}\theta^k = \frac{1}{1-\theta}$. Then, it is straightforward that $A \to 1$.

Lemma 2: $B \to 0$.

For $g_{old} > 0$, $\lim_{j\to\infty}(1+g_{old})^j = +\infty$ and $\lim_{j\to\infty}\theta^j = 0$. A sufficient condition for $\lim_{j\to\infty}[(1+g_{old})\theta]^j = 0$ is:

$$
\begin{aligned}
[(1+g_{old})\theta]^j < 1 &\iff \\
1+g_{old} < \frac{1}{\theta} &\iff \\
g_{old} < \frac{1}{\theta} - 1.
\end{aligned}
$$

If this condition holds, then $B \to 1$. This condition can break if: a) we depart from a steady state where money growth is too big, b) firms learn very slowly about macroeconomic conditions (big θ), c) both of them.

Proposition 3: Setting $\kappa = g_{new}$, the policymaker replicates the first best competitive equilibrium with full information ($\theta = 0$).

Proof by contradiction:

-We want to show that $\kappa^* = g_{new}$ is optimal.
-Suppose that $\kappa^* = g_{new}$ is not optimal.
- Then, $\exists\ \tilde{\kappa} \neq g_{new}$ $s.t.$ $L_{\tilde{\kappa} \neq g_{new}} < L_{\kappa^* = g_{new}}$, where L is a loss function.
- We know that: $L_{\tilde{\kappa} \neq g_{new}} < 0\ \forall \tilde{\kappa} \neq g_{new}$.
- And: $L_{\kappa^* = g_{new}} = 0$ if $\kappa^* = g_{new}$.
- Then, $\kappa^* = g_{new}$ is optimal.

C.2 Calibration

Table C.1: Baseline calibration

Parameter	Description	Value
β	Discount factor	0.99
θ	Fraction of firms with old information	0.75
ϵ_p	Elasticity of substitutution for final good aggregator	6
g_{old}	Growth rate of money in the initial steady state	{0.20, 0.15, 0.10, 0.05 }
g_{new}	Growth rate of money in the final steady state	0.02

C.3 Measuring the costs of a disinflation

I follow the literature and I define two measures of costs during a disinflation:

- Sacrifice Ratio **(SR)**

$$SR = -\frac{1}{\pi^*_{old} - \pi^*_{new}} \sum_{t=T}^{T+j} \left(\frac{y_t - \bar{y}}{\bar{y}} \right)$$

  The SR measures the percentage accumulated output losses that the economy has to sacrifice for each percentage point of permanent reduction in steady-state inflation between the beginning of the disinflation at $t = T$ and some future period $t = T + J$. $\bar{y}$ is output in steady state with $\bar{y} = \bar{y}_{old} = \bar{y}_{new}$.

- Welfare Cost **(WC)**:

$$WC = \sum_{t=T}^{T+j} \beta^t \left(\frac{U_t - \bar{U}}{\bar{U}} \right)$$

  The WC measures the percentage accumulated utility gains/losses during the disinflation. U_t is the value of the utility function at time t and $\bar{U}$ is the steady state value of U. In this model, disinflations are always welfare reducing since initial and final steady state are the same.

Table C.2 calculates the sacrifice output ratio and welfare costs of disinflation for different initial levels of inflation. These results reinforces the conclusions extracted from the graphical analysis: the larger the magnitude of the disinflation to be carried out, the larger the costs to be paid in terms of output and welfare. I also perform this exercise for different values of θ. As I reduce the degree of information frictions in the economy, the costs associated with the disinflation strongly decrease.

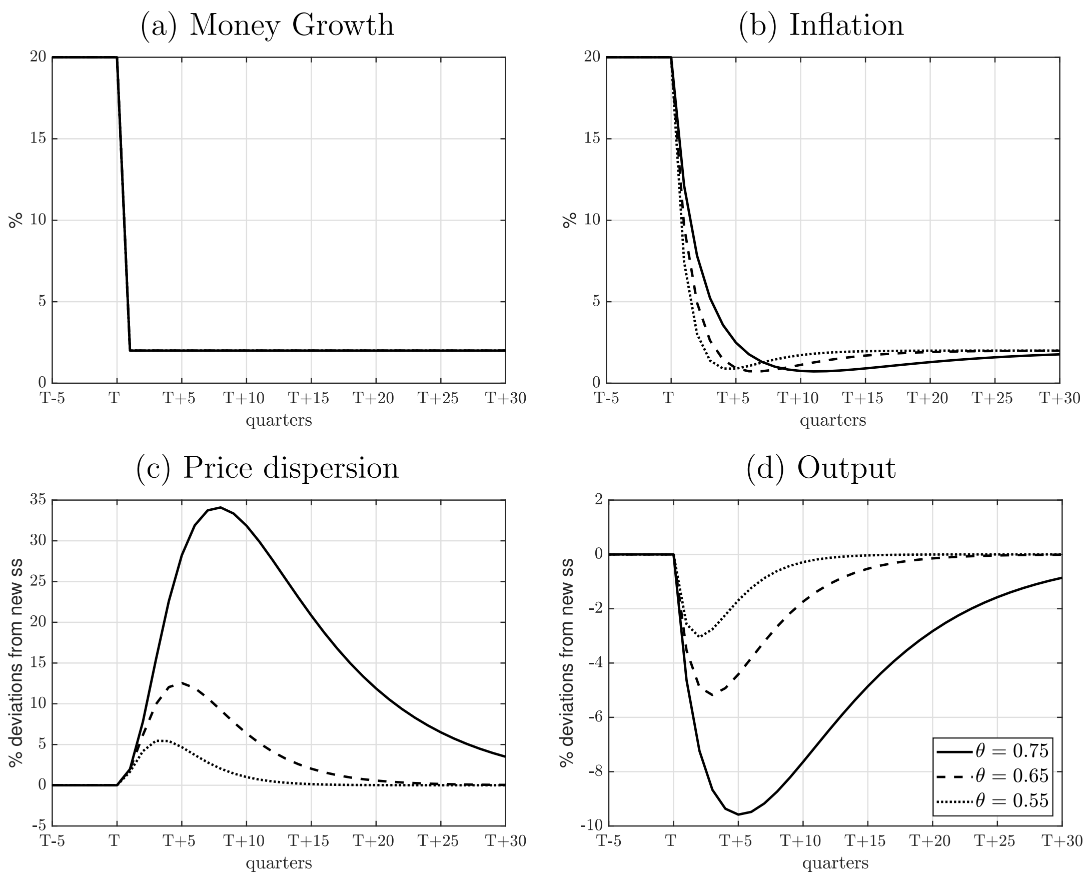
Table C.2: Costs of disinflations

$\Delta\pi$	$\theta = 0.75$ (I) **SR**	(II) **WC**	$\theta = 0.65$ (III) **SR**	(IV) **WC**	$\theta = 0.55$ (V) **SR**	(VI) **WC**
20%-2%	-8.35	6.89	-2.38	1.83	-0.90	0.65
15%-2%	-6.64	3.65	-2.13	1.09	-0.85	0.41
10%-2%	-5.53	1.66	-1.93	0.54	-0.80	0.21
8%-2%	-5.19	1.09	-1.87	0.37	-0.78	0.15
6%-2%	-4.90	0.63	-1.80	0.22	-0.76	0.09

Note: Table 3 presents the sacrifice output ratio (SR) and welfare costs (WC) accumulated during different disinflations. It also performs the Exercise for different degree of information frictions. For all cases, I consider $j = 27$ which is the average time required to complete a disinflation in this model.

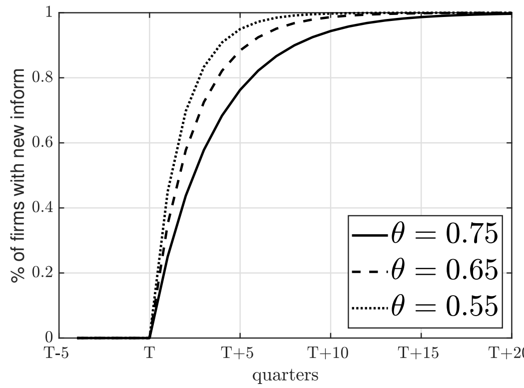
C.4 Sensitivity to information frictions

Figure C.1: Disinflation shock - sensitivity to θ



<u>Note</u>: Transitional dynamics for selected model variables to a disinflation shock for different values of θ. The horizontal axis displays quarters, with $t = T$ corresponding to the period in which the disinflation starts. Inflation and money growth are expressed in percentage points. Output and price dispersion are expressed in deviations from new steady state. Values of all variables are annualised. Despite the value assigned to θ, parameterization is analogous to the one used to generate Fig.4.

Figure C.2: Information diffusion



Note: Evolution of fraction of firms with new updated information after the shock for different values of θ. The horizontal axis displays quarters, with $t = T$ corresponding to the period in which the disinflation starts.

C.5 An illustration of the application of price controls

Table C.3: Calibration for exercise with price controls

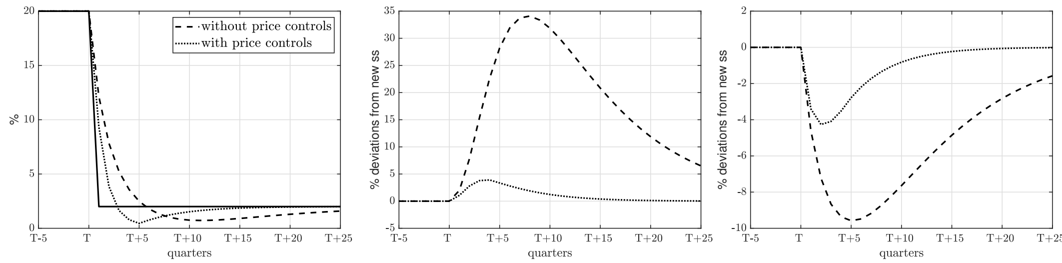
	(I) Disinflation with persistent price controls		**(II) Disinflation with temporary price controls**		**(III) Temporary price controls without isinflation**	
Monetary regime	g_{old} 20%	g_{new} 2%	g_{old} 20%	g_{new} 2%	g_{old} 20%	g_{new} 20%
	κ_T	15%	κ_T	15%	κ_T	15%
	κ_{T+1}	10%	κ_{T+1}	15%	κ_{T+1}	15%
Price controls	κ_{T+2}	7%	κ_{T+2}	7%	κ_{T+2}	7%
	κ_{T+3}	5%	κ_{T+3}	5%	κ_{T+3}	5%
	κ_{T+4}	3%	κ_{T+4}	3%	κ_{T+4}	3%
	$\forall j \geq 5$ κ_{T+j}	3%	$\forall j \geq 5$ κ_{T+j}	∞	κ_{T+j}	∞

Note: For Exercise I, when price controls are persistent, I assume that $j \sim 20$. This means that price controls are operative for at least 20 periods after the shock. I pick this value since it is, on average, what it takes inflation to converge to new steady state. The values for the rest of the parameters are the ones used in the benchmark exercise of Section 4. A last clarification comment: when $\kappa = \infty$ it means that price controls are not operative.

Figure C.3: Disinflation with price controls

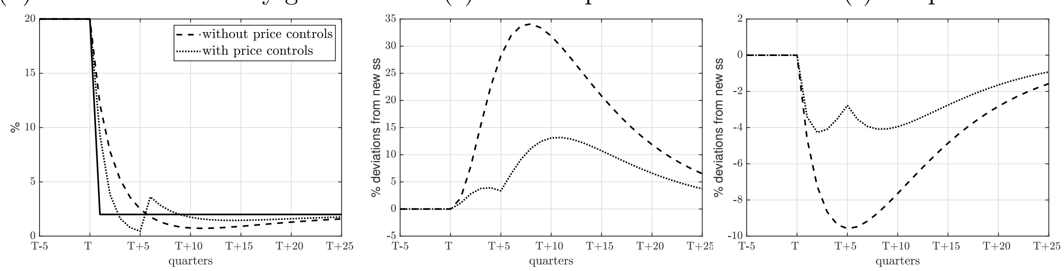
I-Disinflation with persistent price controls

(a) Inflation and money growth (b) Price dispersion (c) Output



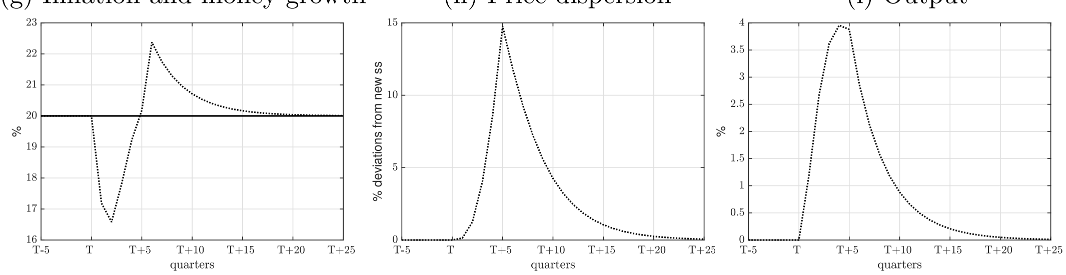
II-Disinflation with temporary price controls

(d) Inflation and money growth (e) Price dispersion (f) Output



III- Temporary price controls without disinflation

(g) Inflation and money growth (h) Price dispersion (i) Output



<u>Note</u>: This graphs presents the transitional dynamics of inflation, price dispersion and output for Exercises I-III. Panel I and II represent the case in which a disinflation is implemented together with price controls. Panel III presents the case of temporary price controls without a disinflation. The horizontal axis displays quarters, with $t = T$ corresponding to the period in which the disinflation starts (from case I and II) and temporary price controls are implements (for case III). In panel (a), (d) and (g), the black solid line represents the evolution of the growth rate of money. Inflation and money growth are expressed in percentage points. Output and price dispersion are measured as deviations from the new steady state.

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