Pontifícia Universidade Católica do Rio de Janeiro

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Pipeline Pressures for the Brazilian Economy

Dissertação de Mestrado

Masters dissertation presented to the Programa de Pós–graduação em Economia, do Departamento de Economia da PUC-Rio in partial fulfillment of the requirements for the degree of Mestre em Economia.

Advisor: Prof. Carlos Viana de Carvalho

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To my parents, for their unconditional
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Abstract

Silva,Vinicius; Carvalho, Carlos (Advisor). **Pipeline Pressures for the Brazilian Economy**. Rio de Janeiro, 2024. 66p. Dissertação de Mestrado – Departamento de Economia, Pontifícia Universidade Católica do Rio de Janeiro.

This article develops a sticky-price, Dynamic Stochastic General Equilibrium model with heterogeneous production sectors. Firms in different sectors vary in their price rigidity, production technology, and the combination of labor and intermediate inputs. They buy inputs using an adaptation of the Brazilian Input-Output Matrix, therefore we can account for the impact of idiosyncratic shocks in all sectors, up- and downstream. Our results can help to explain the existing price pass-through from producer to consumer prices.

Keywords

Input-output linkages; New-Keynesian Multisector model; Inflation propagation.

Resumo

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Este artigo desenvolve um modelo de Equilíbrio Geral Estocástico Dinâmico com preços rígidos e heterogeneidade nos setores de produção. As empresas em diferentes setores variam em sua rigidez de preços, tecnologia de produção e na combinação de trabalho e insumos intermediários. Elas compram insumos usando uma adaptação da Matriz Insumo-Produto brasileira, permitindo-nos considerar o impacto de choques idiossincráticos em todos os setores, ao longo da cadeia produtiva. Os resultados ajudam a explicar a dinâmica setorial dos repasses de preços entre os índices de preços ao produtor e ao consumidor no Brasil.

Palavras-chave

Matriz Insumo Produto; New-Keynesian Multisector model; Propagação da Inflação.

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List of Abreviations

BCB – *Brazilian Central Bank*

CPI – *Consumer Price Index*

DSGE – *Dynamic Stochastic General Equilibrium*

ECB – *European Central Bank*

FGV – *Getúlio Vargas Foundation* I-O – *Input Output*

IBGE – *Instituto Brasileiro de Geografia e Estatística (Brazilian Institute of Geography and Statistics)*

IBRE – *Brazilian Institute of Economics* IPA-OG – *Índice de Preços ao Produtor Amplo - Origem (Broad Producer Price Index)*

IPCA – *Índice de Preços ao Consumidor Amplo (Consumer Price Index for Brazil)*

IPPI – *Indicators for producer price pressures* IRF – *Impulse Response Function*

LASSO – *Least absolute shrinkage and selection operator*

LP – *Local Projections*

PPI – *Producer Price Index*

I may not have gone where I intended to go,
but I think I have ended up where I needed to
be.

Douglas Adams, *The Long Dark Tea-Time of the Soul.*

1
Introduction

The production structure of an economy is complex. It involves producing and exchanging goods across sectors that use distinct inputs. Some conventional Dynamic Stochastic General Equilibrium (DSGE) models abstract from many realistic heterogeneities, such as accounting for the differences in price rigidity, including an Input-Output matrix and modeling production in two stages. It has been shown that these features impact the model's results significantly.

Those mainstream models usually have a lower degree of monetary policy non-neutrality when compared to multisector models. By relaxing the assumption of identical price rigidity across firms and sectors Carvalho (2006) finds that monetary policy shocks have more significant and persistent effects on aggregate output than in a model with identical price rigidity.

By adding an Input-output (I-O) production network to the model one would also generate macroeconomic volatility originating from microeconomic shocks (Carvalho and Gabaix (2013); Di Giovanni et al. (2014); Atalay (2017)), Such modification induces pricing complementarities across sectors that contribute to a slower response of prices to aggregate shocks. The intuition behind this refinement is that an industry with perfectly flexible prices can be significantly impacted by a monetary policy shock, as its intermediate input producer can be highly affected by the shock due to a high level of price stickiness. Hence, the response of prices from one industry depends on upstream and downstream sectors' price rigidity.

A further development consists of incorporating a two-stage production model within the DSGE framework. This approach intends to mirror real-world economic procedures, furnishing a more precise depiction of goods' manufacturing and aggregation. Additionally, the incorporation of intermediate goods production within the model elucidates the intricate dynamics of supply chains, where inputs undergo transformation into intermediate goods before culminating as final products. Botman et al. (2007) argue that this integration comprehensively captures the complexities inherent in production relationships and supply chain dynamics. Furthermore, the application of a two-stage production model enhances the analysis of monetary policy effects by providing a comprehensive understanding of how policy alterations affect various production phases, thereby facilitating a more refined assessment of monetary policy transmission channels throughout the economy. By analyzing the supply chain and flows of intermediate inputs, one can better comprehend the propagation of shocks within the economy, consequently advancing the accuracy of macroeconomic dynamics' predictions.

The development of the models and the literature findings highlight the importance of taking the economy's production networks into account and understanding its relations. Hence, understanding and investigating this complex chain should allow a monetary policy authority to stabilize prices in the right sectors instead of purely focusing on the average impact and cumulative effects, leading to policy mistakes.

In this article, we develop a DSGE model with such heterogeneities (price stickiness, I-O linkages, two processing stages and with the presence of sectoral-specific shocks) with some particularities to make it compatible with the Brazilian economy. We also incorporate a correspondence between producer and consumer prices and an aggregation of the input-output matrix. We then use the definition of pipeline pressures developed by Smets et al. (2019) to measure the pass-through of producer prices to other producer and ultimately to consumer prices.

2
Previous Work

This paper fits in the literature on the transmission of monetary policy shocks in an economy with heterogeneous firms and input-output linkages. Some micro papers such as Carlton (1986) and Eichenbaum et al. (2011) have provided evidence that the frequency of price adjustments is different across goods. Later on, some studies extended standard sticky-price models by relaxing the assumption of identical price rigidity across firms and sectors.

Carvalho (2006) states that empirical evidence points to the existence of a high degree of heterogeneity in price-setting frictions and that heterogeneity affects the dynamic response of economies to monetary shocks. He finds that models which incorporate such differences tend to show larger and more persistent real effects originated from monetary policy shocks when compared to identical-firms models.

Nakamura and Steinsson (2010) also contribute to this matter. They use a calibrated multisector menu cost model and show that the introduction of heterogeneity in the frequency of price change can triple the degree of monetary non-neutrality generated by their model. The introduction of intermediate inputs in the model also raises the degree of monetary non-neutrality by a similar amount. Therefore, standard models of nominal price rigidity should not assume that all firms are identical in terms of price-setting behavior, as they usually do.

Bouakez et al. (2014) estimate a highly disaggregated multisector Calvo model with production networks using aggregate and sectoral data and argue that heterogeneity in price stickiness is the main driver of real output effects. They show that ignoring sectoral heterogeneity in price rigidity leads one to understate the degree of monetary non-neutrality and overstate the contribution of sector-specific shocks to aggregate fluctuations in output.

Using a similar sticky-price DSGE model but with fewer sectors, Bouakez et al. (2009) evidence the importance of modeling the I-O structure of the economy realistically to understand the transmission of monetary policy. They show that output effects of a monetary policy shock arise from price stickiness in some sectors and are transmitted to others through I–O interactions. This structure also helps to explain why some sectors with flexible prices (e.g., construction and durable manufacturing) are more sensitive to monetary disturbances. Their econometric results also indicate that price rigidity is statistically different across sectors and are in agreement with the micro literature that most good prices are relatively flexible. However, the output of sectors with high price flexibility can still react to monetary shocks if they are an investment input in producing other goods whose prices are more rigid.

Pasten et al. (2020) present some insights into the transmission of monetary policy shocks in an economy with three heterogeneities (sector size, input-output structure, and price stickiness) and analyze how they interact. They show that heterogeneous price stickiness is the central force for the real effects of nominal shocks, while heterogeneity in intermediate input usage and the I-O structure only play a marginal role. In addition, the level of disaggregation matters for the real effects of monetary policy shocks. Thus, small-scale models tend to underestimate output effects substantially, but the impact response of inflation is left unchanged. Furthermore, price stickiness that differs across sectors, heterogeneous sector size, and I-O structure change the identity of the most critical sectors for the real effects of monetary policy shocks and increase the economy's granularity.

In their subsequent work, Pasten et al. (2021) find that price rigidity has direct relevance for the modeling and understanding of business cycles. In a 341-sector New Keynesian model, they also confirm that heterogeneity in nominal price rigidity is a quantitatively strong amplifier of the aggregate effect of idiosyncratic shocks. Furthermore, if a monetary policy authority reacts to aggregate prices and wants to stabilize prices of big and central sectors, not taking into account the frictional origin of aggregate fluctuations that heterogeneity in price stickiness generates, it is liable to make systematic policy mistakes. In fact, heterogeneous price rigidity can amplify or mute the aggregate volatility from sectoral shocks, theoretically, depending on the exact interaction with other heterogeneous features of the economy. However, quantitative results show that such heterogeneity doubles the size of aggregate fluctuations originating from idiosyncratic shocks relative to an otherwise identical economy with homogeneous nominal price rigidity.

Carvalho et al. (2021) develop a variant of the New Keynesian model that can endogenously deliver differential responses of sectoral prices to aggregate and sectoral shocks. This is due to the dependence of the marginal cost on endogenous variables, in particular, on other prices. They present three different sources of endogenous responses of marginal costs to shocks: pricing interactions produced by intermediate inputs, pricing interactions produced by labor market segmentation, and monetary policy responses to endogenous variables. The input-market segmentation at a sectoral level induces within-sector pricing substitutability, which helps the model deliver a fast response of prices to sector-specific shocks. The presence of intermediate inputs also leads to strategic complementarity in pricing decisions. When reoptimizing and choosing their prices, some firms do not adjust as much in response to shocks, since marginal costs are held back by prices of firms that have not yet adjusted. Hence, monetary policy non-neutrality increases.

In a different approach, Huang and Liu (2005) develop a two-stage methodology that explores the intricate dynamics of monetary policy within an economy characterized by nominal rigidities in both intermediate and finished goods sectors. They identify that central banks face a tradeoff between stabilizing not only CPI, but also PPI inflation. Moreover, the analysis underscores the significance of considering fluctuations in both CPI and PPI inflation rates, revealing that an optimal monetary policy necessitates addressing variability in both these measures alongside the output gap and real marginal cost gaps.

Different forms of price pass-through have been also extensively explored in economic literature. Ahn et al. (2016) investigate the influence of imported goods' prices on domestic price levels, highlighting the predominant role of imported inputs in shaping domestic production and subsequently impacting producer prices. They construct the weighted average of sector-level imported input prices for each output sector by combining the I-O table with sector-level import price data. After assuming that producer and import prices cointegrate, they estimate an error correction model for Korea and find that the degree of the long-run cost pass-through of imported inputs into domestic producer prices lies around 63 percent and 79 percent.

In contrast, Clark et al. (1995) challenge the conventional notion that producer price changes reliably anticipate subsequent consumer price movements. Through historical analysis and by forecasting CPI inflation with and without the PPI using vector autoregressive models, they find that PPI changes sometimes help predict CPI changes, but they fail to do so systematically. Therefore, we cannot necessarily take increases in some producer price indexes as a presage to higher CPI inflation. A counterpoint is that they do not account for basket differences.

Smets et al. (2019) emphasize the importance of sectoral segmentation and formally introduce the concept *Pipeline Pressures* to quantify price impacts from sectoral shocks that propagate throughout the production chain. In response to the interconnected production network, the authors develop a multisector New Keynesian model that accommodates both producer and consumer prices, aiming to provide a structural definition of pipeline pressures to inflation. Bayesian estimation applied to U.S. data reveal insights into the heterogeneous nature of pipeline pressures, impacting the persistence of disaggregate inflation. The study traces these pressures to 35 disaggregate sectors, establishing them as a key source of inflation volatility, particularly for consumer prices. The research challenges the traditional interpretation of the comovement of price indices and sheds light on the importance of sectoral shocks in generating volatility and persistence.

Concerns about the limitations of dynamic factor models in distinguishing between aggregate and sectoral shocks are also addressed. They develop a DSGE with an input-output matrix, accommodating both producer and consumer prices. This approach allows for the formal definition and quantification of pipeline pressures, demonstrating their significant contribution to sectoral and headline inflation persistence. The findings provide a novel perspective, contrasting with dynamic factor models.

This article follows a similar approach. Following the evidence on the importance of incorporating the productive structure to better capture the effects of idiosyncratic shocks, we explore this relationship and transmission mechanism in our model through the inclusion of the Input-Output Matrix and the usage of intermediate inputs. The model development and the incorporation of the heterogeneities were specifically tailored to the Brazilian economic context, considering data availability and structure. We contribute in three distinct areas: empirical studies on disaggregated price data, structural dynamic stochastic general equilibrium models, and input-output literature on the granular origins of aggregate fluctuations. We also try to identify pipeline pressures for Brazil.

3
Model

In this section, we introduce our multisector New Keynesian model, building upon the framework proposed by Carvalho et al. (2021) and adapted by Pasten et al. (2020). This framework enables us to incorporate sources of heterogeneity, such as differences in price rigidity, sector size, sector-specific labor markets, and a network structure of intermediate inputs. In addition, we combine this framework with the model developed by Huang and Liu (2005) to extend it to a multisectoral version with two production stages. The first stage includes firms producing intermediate inputs, while the second stage comprises firms utilizing these inputs to manufacture final goods. A four-sector overview of the model can be found in figure A.15 in appendix.

3.1
Households

A large number of infinitely lived households exist. They derive utility from a composite consumption good and leisure. Households supply all different types of labor to all types of firms (final goods and intermediate goods producers). The representative household has access to a complete set of state-contingent claims and maximizes:

$$\max \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{{C_t}^{1-\sigma} - 1}{1-\sigma} - \sum_{k=1}^{K} \tau_k \frac{{L_{k,t}}^{1+\varphi}}{1+\varphi} - \sum_{m=1}^{M} \tau_m \frac{{L_{m,t}}^{1+\varphi}}{1+\varphi} \right) \tag{3-1}$$

subject to the budget constraint:

$$\begin{aligned} P_t^c C_t = \sum_{k=1}^{K} W_{k,t} L_{k,t} + \sum_{m=1}^{M} W_{m,t} L_{m,t} + \int_{\mathcal{I}_k} \sum_{k=1}^{K} \Pi_{k,t}(j) dj + \\ \int_{\mathcal{I}_m} \sum_{m=1}^{M} \Pi_{m,t}(j) dj + I_{t-1} B_{t-1} - B_t \end{aligned} \tag{3-2}$$

where C_t denotes period t consumption, $L_{k,t}$ and $L_{m,t}$ are hours of labor services supplied to sectors k and m, respectively. P_t^c denotes the personal consumption expenditures (CPI) price index faced by the household, B_t denotes total savings in the form of government bonds, $W_{k,t}$ and $W_{m,t}$ are wages received from sectors k and m, $\Pi_{k,t}(j)$ and $\Pi_{m,t}(j)$ are dividends (profits from firms jk and jm channeled to the household) and τ_k and τ_m are the relative disutilities of supplying labor in the respective sectors. The set of consumption goods is partitioned into a sequence of subsets $\mathcal{I}_k$ with measure $\{n_k\}_{k=1}^{K}$, such that $\sum_{k=1}^{K} n_k = 1$. The parameters σ, φ and β are, respectively, the coefficient of relative risk aversion, the inverse of the (Frisch) elasticity of labor supply and the discount factor.

Aggregate consumption is given by:

$$C_t \equiv \left[\sum_{k=1}^{K} (\xi_{ck} D_{k,t})^{\frac{1}{\eta}} C_{k,t}^{1-\frac{1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \tag{3-3}$$

where η is the elasticity of substitution between (or across) the sectoral consumption composites, $D_{k,t} > 0$ is a relative demand shock satisfying $\sum_{k=1}^{K} \xi_{ck} D_{k,t} = 1$ and $C_{k,t}$ is the aggregation of sectoral consumption:

$$C_{k,t} \equiv \left[n_k^{-1/\theta} \int_{\mathcal{I}_k} C_{k,t}(j)^{1-\frac{1}{\theta}} dj \right]^{\frac{\theta}{\theta-1}}.$$

$C_{k,t}(j)$ is the consumption of goods that firm j in sector k produces. θ is the elasticity of substitution within sectors, which we allow to differ from the elasticity of substitution across sectors η. The consumption weights, ξ_{ck}, can differ across sectors, and they determine the steady-state shares of sectors in total consumption. They satisfy $\sum_{k=1}^{K} \xi_{ck} = 1$.

The price level associated with the aggregate consumption composite is given by

$$P_t^c = \left(\sum_{k=1}^{K} (\xi_{ck} D_{k,t}) \, P_{k,t}^{1-\eta} \right)^{\frac{1}{1-\eta}} \tag{3-4}$$

where $P_{k,t}$ is the sectoral price index associated with sectoral composite consumption $C_{k,t}$ given by the following aggregator:

$$P_{k,t} = \left(\frac{1}{n_k} \int_{\mathcal{I}_k} P_{k,t}(j)^{1-\theta} dj \right)^{1/(1-\theta)} \tag{3-5}$$

Given the aggregate consumption composite C_t, and the price levels $P_{k,t}$ and P_t, the optimal demand for the sectoral composite goods minimizes total expenditure $P_t C_t$ which leads to the following sectoral and firm goods demands:

$$C_{k,t} = \xi_{ck} D_{k,t} \left(\frac{P_{k,t}}{P_t^c} \right)^{-\eta} C_t \tag{3-6}$$

$$C_{k,t}(j) = \frac{1}{n_k} \left(\frac{P_{k,t}(j)}{P_{k,t}} \right)^{-\theta} C_{k,t}. \tag{3-7}$$

3.2 Firms

3.2.1 Final goods

There exists a continuum of j monopolistic competitive firms in k sectors: $j \in [0,1]$ and $k = \{1, \ldots, K\}$. They use labor and intermediate inputs to produce according to the following production function:

$$Y_{k,t}(j) = A_t A_{k,t} L_{k,t}(j)^{1-\delta_k} Z_{k,t}(j)^{\delta_k} \tag{3-8}$$

where $Y_{k,t}(j)$ is the final good produced by firm j in sector k, i.e. firm jk. $L_{k,t}(j)$ is hours of labor that firm jk employs, δ_k is the elasticity of output with respect to intermediate inputs of sector k and $Z_{k,t}(j)$ represents firm jk's usage of intermediate inputs, which is given by an aggregator of intermediate inputs:

$$Z_{k,t}(j) \equiv \left[\sum_{m=1}^{M} (\omega_{km} D_{m,t})^{\frac{1}{\eta}} Z_{k,m,t}(j)^{1-\frac{1}{\eta}}\right]^{\frac{\eta}{\eta-1}}$$

The aggregator weights ω_{km} satisfy $\sum_{m=1}^{M} \omega_{km} = 1$ for all sectors k. We allow these weights to differ across sectors, which is a key element in the model.

$Z_{k,m,t}(j)$ denotes the intermediate input use of sector m by firm jk in period t. This variable can also be written as an aggregator of goods produced in sector m:

$$Z_{k,m,t}(j) \equiv \left[n_m^{\frac{-1}{\epsilon_{m,t}}} \int_{\mathcal{I}_k} Z_{k,m,t}(j,j')^{1-\frac{1}{\epsilon_{m,t}}} dj'\right]^{\frac{\epsilon_{m,t}}{\epsilon_{m,t}-1}}$$

where $Z_{k,m,t}(j,j')$ denotes the amount of goods that firm jk purchases from firm $j'm$. The variable $\epsilon_{mt} = \theta \nu_{F,t} \nu_{F,m,t}$. In which $\nu_{F,m,t}$ reflects a markup shock specific to intermediate goods of sector m, whereas $\nu_{F,t}$ affects all final goods sectors.

The cost-minimization problem yields sectoral and firm-specific demands for intermediate inputs, which are respectively given by:

$$Z_{k,m,t}(j) = \omega_{km} D_{m,t} \left(\frac{P_{m,t}}{P_t^k}\right)^{-\eta} Z_{k,t}(j) \tag{3-9}$$

$$Z_{k,m,t}(j,j') = \frac{1}{n_m} \left(\frac{P_{m,t}(j')}{P_{m,t}}\right)^{-\epsilon_{k,t}} Z_{k,m,t}(j) \tag{3-10}$$

with $\sum_{m=1}^{M} \omega_{km} = 1$

In steady state all firms are symmetric and ω_{km} is the share of costs that firms in sector k spend on inputs of sector m and, hence, equals cell k, m in the I-O Matrix. We do not allow final goods (Y_k) to be purchased by final goods firms and used as intermediate inputs, i.e. the sector is not roundabout. In the above expression $D_{m,t}$ is an intermediate good demand shock.

Price indices relevant to the demand for intermediate inputs across final firms sectors are defined as:

$$P_t^k = \left[\sum_{m=1}^{M} \left(\omega_{km} D_{k,t}\right) P_{k,t}^{1-\eta} \right]^{\frac{1}{1-\eta}} \tag{3-11}$$

And $P_{k,t}$ is defined as per equation 3-5.

The last optimality condition of the cost-minimization problem is given by

$$\delta_k W_{k,t} L_{k,t}(j) = (1-\delta_k)\, P_t^k Z_{k,t}(j) \tag{3-12}$$

Final firms set prices as in Calvo (1983). Each with probability $\{1-\alpha_k\}_{k=1}^K$ of reoptimizing. That is, the objective of firm jk is:

$$\max_{P_{k,t}(j)} \mathbb{E}_t \sum_{s=0}^{\infty} Q_{t,t+s} \alpha_k^s \left[P_{k,t}(j) Y_{k,t+s}(j) - MC_{k,t+s} Y_{k,t+s}(j) \right]$$

where $MC_{k,t} = \frac{1}{1-\delta_k} \left(\frac{\delta_k}{1-\delta_k}\right)^{-\delta_k} W_{k,t}^{1-\delta_k} \left(P_t^k\right)^{\delta_k}$ are marginal costs faced by firms in final sector k after imposing the optimal mix of labor and intermediate inputs given by equation 3-12.

When firms do not reoptimize, their prices are corrected by a fraction of past inflation, due to the presence of indexation:

$$P_{k,t}(j) = P_{k,t-1}(j) \left(\frac{P_{k,t-1}}{P_{k,t-2}}\right)^{\lambda_k}$$

Note that the level of indexation $\{\lambda_k\}_{k=1}^K$ can also differ in each sector. Thus, the sectoral price level $P_{k,t}$ evolves as:

$$P_{k,t} = \left[(1-\alpha_k) P_{k,t}^{*1-\theta} + \alpha_k \left(P_{k,t-1} \left(\frac{P_{k,t-1}}{P_{k,t-2}}\right)^{\lambda_k} \right)^{1-\theta} \right]^{\frac{1}{1-\theta}} \tag{3-13}$$

where $P_{k,t}^*$ is the optimal common price that firms choose when optimizing at time t.

3.2.2 Intermediate Goods

A continuum of j monopolistic competitive firms in m sectors, $j \in [0,1]$ and $m = \{1, \ldots, M\}$ use labor and a bundle of other intermediate goods to produce intermediate inputs.

The production function is given by:

$$S_{m,t}(j) = A_t A_{m,t} L_{m,t}(j)^{1-\delta_m} Z_{m,t}(j)^{\delta_m} \tag{3-14}$$

$L_{m,t}(j)$ is hours of labor used by firm j of sector m and $Z_{m,t}(j)$ is the usage of intermediate inputs given by the following aggregator:

$$Z_{m,t}(j) \equiv \left[\sum_{m'=1}^{M} (\omega_{mm'} D_{m,t})^{\frac{1}{\eta}} Z_{m,m',t}(j)^{1-\frac{1}{\eta}} \right]^{\frac{\eta}{\eta-1}}$$

$Z_{m,m',t}(j)$ denotes the intermediate input use by firm jm from sector m' in period t. Note that here we also use Z while referring to the demand for intermediate inputs, but the subscript m specifies that this demand is from firms that also produce intermediate inputs. This allows us to distinguish them from the inputs used by final firms. The intermediate goods producers purchase goods produced by other intermediate firms, hence we have a roundabout sector that also sells inputs to final goods producers.

This intermediate input use can also be written by an aggregator of goods produced in sector m':

$$Z_{m,m',t}(j) \equiv \left[n_m^{\frac{-1}{\epsilon_{m',t}}} \int_{\mathcal{I}_m} Z_{m,m',t}(j,j')^{1-\frac{1}{\epsilon_{m',t}}} dj' \right]^{\frac{\epsilon_{m',t}}{\epsilon_{m',t}-1}}$$

where $Z_{m,m',t}(j,j')$ is the amount of goods that firm jm purchases from firm $j'm'$ and $\epsilon_{m',t} = \theta \nu_{M,t} \nu_{M,m',t}$. $\nu_{M,t}$ reflects a price markup shock to producer prices that affects all sectors, whereas $\nu_{M,m',t}$ is specific to intermediate sector m'.

Sectoral and firm-specific demands for intermediate inputs are respectively given by:

$$Z_{m,m',t}(j) = \omega_{mm'} D_{m',t} \left(\frac{P_{m't}}{P_t^m} \right)^{-\eta} Z_{m,j,t} \tag{3-15}$$

$$Z_{m,m',t}(j,j') = \frac{1}{n_{m'}} \left(\frac{P_{m',t}(j')}{P_{m',t}} \right)^{-\epsilon_{m,t}} Z_{m,m',t}(j) \tag{3-16}$$

with $\sum_{m=1}^{M} \omega_{mm'} = 1$. In steady state $\omega_{mm'}$ is the share of costs that firm mj spends on inputs from sector m' and, hence, equals cell m, m' in the roundabout part of the I-O Matrix.

Price indices relevant to the demand for intermediate inputs across final firms sectors are defined as:

$$P_t^m = \left[\sum_{m'=1}^{M} (\omega_{mm'} D_{m,t}) \, P_{m,t}^{1-\eta} \right]^{\frac{1}{1-\eta}} \tag{3-17}$$

$$P_{m,t} = \left(\frac{1}{n_m} \int_{\mathcal{I}_m} P_{m,t}(j)^{1-\theta} dj \right)^{1/(1-\theta)} \tag{3-18}$$

Finally, the last optimality condition implies that:

$$\delta_m W_{m,t} L_{m,t}(j) = (1-\delta_m) P_t^m Z_{m,t}(j) \tag{3-19}$$

Intermediate firms's prices are modeled analogously. Each firm has a probability $\{1-\alpha_m\}_{m=1}^M$ of reoptimizing. That is, the objective of firm jm is:

$$\max_{P_{m,t}(j)} \mathbb{E}_t \sum_{s=0}^{\infty} Q_{t,t+s} \alpha_m^s \left[P_{m,t}(j) Y_{m,t+s}(j) - MC_{m,t+s} Y_{m,t+s}(j) \right]$$

where $MC_{m,t} = \frac{1}{1-\delta_m} \left(\frac{\delta_m}{1-\delta_m} \right)^{-\delta_m} W_{m,t}^{1-\delta_m} \left(P_t^m \right)^{\delta_m}$ are marginal costs faced by firms in sector m after imposing the optimal mix of labor and intermediate inputs given by equation 3-19.

When intermediate firms do not reoptimize, we also allow their prices to be corrected to a fraction $\{\lambda_m\}_{m=1}^M$ of past inflation:

$$P_{m,t}(j) = P_{m,t-1}(j) \left(\frac{P_{m,t-1}}{P_{m,t-2}} \right)^{\lambda_m}$$

Thus, the sectoral price level $P_{m,t}$ evolves as:

$$P_{m,t} = \left[(1-\alpha_m) P_{m,t}^{*1-\theta} + \alpha_m \left(P_{m,t-1} \left(\frac{P_{m,t-1}}{P_{m,t-2}} \right)^{\lambda_m} \right)^{1-\theta} \right]^{\frac{1}{1-\theta}} \tag{3-20}$$

where $P_{m,t}^*$ is the optimal common price that firms choose when optimizing at time t.

3.2.3 Sector size and Intermediate Inputs

I-O linkages also affect the measure of sector size: $\{n_k\}_{k=1}^K$ and $\{n_m\}_{m=1}^M$. The variable reflects the weighted average of the consumption share of sector k (m), i.e ξ_{ck} (ξ_z), and the importance of sector k (m) as a supplier to the economy, i.e ζ_k (ζ_m). In final goods firms:

$$n_k = (1-\psi_k)\xi_{ck} + \psi_k \zeta_k$$

where $\zeta_k \equiv \sum_{k'=1}^K n_{k'} \omega_{k'k}$ and $\psi_k = \delta_k \frac{(\theta-1)}{\theta}$.
And for intermediate goods firms:

$$n_m = (1-\psi_m)\xi_z + \psi_m \zeta_{mt}$$

where $\zeta_m \equiv \sum_{m'=1}^M n_{m'} \omega_{m'm}$ and $\psi_m = \delta_m \frac{(\theta-1)}{\theta}$.

3.2.4
Monetary Policy

For simplicity, we assume that the government neither collects taxes nor purchases goods. We consider a Taylor-type interest rate rule for monetary policy, in which the nominal interest rate I_t is set according to:

$$I_t = \frac{1}{\beta} I_{t-1}^{\rho_i} \left[\left(\frac{P_t}{P_{t-1}} \right)^{\phi_\pi} \left(\frac{C_t}{C} \right)^{\phi_y} \right]^{1-\rho_i} e^{\mu_t} \tag{3-21}$$

μ_t is a monetary policy shock following an AR(1) process The monetary authority reacts to aggregate inflation and aggregate consumption.

3.2.5
Market Clearing

Equilibrium is characterized by an allocation of quantities and prices that satisfy the households' optimality conditions and budget constraint, firms' optimality conditions, the monetary policy rule, and the market-clearing conditions:

$$B_t = 0$$

$$L_{k,t} = \int_{\mathcal{I}_k} L_{k,t}(j) dj \quad \forall k$$

$$L_{m,t} = \int_{\mathcal{I}_m} L_{m,t}(j) dj \quad \forall m$$

$$Y_{k,t} = C_{k,t} \quad \forall k.$$

$$S_{m,t}(j) = \sum_{k=1}^{K} \int_{\mathcal{I}_k} Z_{k,m,t}\left(j, j'\right) dj' + \sum_{m'=1}^{M} \int_{\mathcal{I}_{m'}} Z_{m',m,t}\left(j, j'\right) dj' \quad \forall j, k, m.$$

The first equation is the market-clearing condition in asset markets. Second and third define aggregate labor in the final sector k and intermediate sector m. And the last two equations equate supply and demand for each final and intermediate good, respectively (Walras' law).

We solve the model by log-linearizing the equilibrium conditions around the symmetric non-stochastic zero-inflation steady-state. We assume that the conditions $\tau_m = n_m^{-\varphi}$ and $\tau_k = n_k^{-\varphi}$ that relates the relative disutilities of labor to the size of sectors hold, equalizing steady-state sectoral wages.

The complete log-linearized system is provided in appendix A.4.

3.2.6
Exogenous processes

We assume aggregate and sectoral shocks to follow an AR(1) process. All equations are properly specified in Appendix A.4.3.

4
Data and Calibration

4.1
Input-Output Matrix

One of the key elements of the model is the input-output matrix (Ω), which includes the Use and Make tables. It is a valuable tool for monitoring the flow of goods and services in the economy. It allows us to examine fundamental aspects of the production process, such as the production structure of goods and services and the inputs used in their creation.

In the Make table, we can find the output of economic activities by product, with the products described in the lines and the activities in the columns. Cell row i, column k represents the production value of product i by industry k. The Use table presents the balance between supply and demand at buyer's prices, as well as the intermediate consumption of economic activities broken down by product.

In Brazil the last I-O Matrix available is from 2015 and it is computed by IBGE (2018). The most disaggregated version has a 127-product to 67-sector matrix.

By introducing intersectoral trade in the model, we allow for shocks to propagate through the supply chain. For instance, a shock in sector m can impact the marginal cost of sector k through Ω. The degree of price stickiness in sector k determines how long it takes to reoptimize and adjust its prices to these pipeline pressures. Consequently, sectors that depend on k will face changes in their input costs and respond slowly to the shock originated in sector m, even if they do not depend directly on inputs from sector m.

4.1.1
Intermediate Inputs

In order to construct an industry-by-industry matrix that consistently maps to our model, we aggregated the 127 products in the 67 corresponding activities to get a square Make and Use tables. Subsequently, we mapped the the PPI with the I-O matrix. In our model, the PPI is the IPA (Broad Producer Price Index) which is a producer price index from Brazil that is also built based on the national accounts concept. Therfore, we successfully mapped all its 87 items with 33 (out of 67) sectors of the I-O matrix. The remaining sectors do not relate directly with the PPI items, but they will also be incorporated into the model, which will be explained in the following section.

4.1.2 Final Goods

To define the final sectors, we aligned them with the items listed in the IPCA (Índice de Preços ao Consumidor Amplo - Broad Consumer Price Index), which is the CPI in our model. As we were not able to complete the mapping for the remaining 34 sectors of the I-O matrix, our strategy involved an attempt to correlate as many of these sectors as possible with items in the CPI, ensuring that the detailed information regarding the demand for intermediate inputs within sectors considered as *final* in the model was not discarded. Through the aggregation of some CPI items, we ultimately derived a total of 46 final sectors, each associated with a respective inflation series that could be employed in model estimation. Among these sectors, 32 were successfully matched with the input-output matrix.

Subsequently, we followed the methodology outlined by Pasten et al. (2021), detailed in appendix A.3, to compute an industry-by-industry I-O matrix that aligns with our model's structure.

For the remaining 14 sectors within the CPI, we undertook LASSO regression estimations for each series[1]. These regressions treated the series as the dependent variable against all components of producer prices and their respective 4 lags. While the LASSO regression inherently possesses variable selection properties, we also manually inspected coefficients that deviated from 0 in each estimated equation. Ultimately, the normalized coefficients served as proxies for the shares of intermediate goods used by the firms in those sectors.

Sectors from the I-O matrix not encompassed in the PPI- and CPI-I-O Matrix mappings are delineated in Table A.3, along with the corresponding mapping details.

Upon computing the matrix and incorporating the proxies for the other 14 sectors, we imposed a constraint on entries representing intermediate inputs acquired from final firms, setting them to zero. This adjustment is a simplification that aims to establish a two-stage production structure, allowing firms to be distinguished between final and intermediate. Consequently, the outcome yielded a roundabout production framework for the intermediate sector — a scenario characterized by a production process where intermediate goods serve as inputs in the creation of other intermediate goods. Firms

[1]This approach was inspired by a recent Inflation Report from the Brazilian Central Bank, which we discuss in appendix A.1.

engaged in the production of final goods utilize these intermediate inputs in their manufacturing processes. However, the goods they produce are deemed as final goods intended for sale and consumption by households, rather than being utilized by other firms.

4.2 Calvo price stickiness

The α_i parameters, which denote the frequency of price adjustments, were calibrated using data that was provided, in which microdata from IBRE - *Fundação Getúlio Vargas* (FGV) was used to compute the frequency of price adjustments by sector/product. We were able to directly calibrate the intermediate sector using our mapping from the I-O Matrix to producer prices. The final goods rigidity was based in a IPC (FGV's consumer price index) mapping with the CPI, which was fully covered as they have very similar baskets. A complete list of the used parameters can be found in the fifth column α_i of tables A.1 and A.2 and a histogram of the values is presented in A.10.

4.3 Intermediate Input share in production function

The share of intermediate input that is used by each sector, denoted by δ_k was calibrated using the column sum of the intermediate consumption found in the Use tables. Values were computed with a threshold of 0.85 and a minimum (not reached) of 0.2. A complete list of the δ_i parameters is also available in tables A.1 and A.2. Intermediate goods sectors have an average of 35.4% of usage of intermediate inputs and final goods sectors 61.7%. A histogram is also displayed at A.12.

4.4 Sectoral weights

Weights for final goods sectors, $\xi_{c,k}$, were simply calibrated as the corresponding average of CPI weights over the period for which the model was computed, as indicated in table A.2.

For intermediate sectors, the $\xi_{z,m}$ parameters were calibrated with the shares of output of each sector, which was computed by aggregating and normalizing the Make table columns. Corresponding values can be found in Table A.1

4.5 Indexation

To calibrate the λ_i, $i \in \{m, k\}$, parameters related to the level of indexation of each sector, disaggregated Phillips curve estimations were conducted using quarterly inflation series for intermediate and final sectors. For each sector, the following model was estimated:

$$\pi_{i,t} = \beta_0 + \beta_1 \pi_{i,t-1} + \beta_2 ibcbr_t + \beta_3 ibcbr_{t-1} + \beta_4 \mathbb{E}\left[\pi_{i,t+1}\right] + \beta_5 y_t^g + \varepsilon_t \qquad (4\text{-}1)$$

where $\pi_{i,t}$ represents inflation from sector i at time t, $\pi_{i,t-1}$ is the lagged inflation, *ibcbr* is the index of economic activity from Brazil, $\mathbb{E}\left[\pi_{i,t+1}\right]$ denotes the expectations of inflation one quarter ahead, from the FOCUS survey, and y_t^g represents the output gap, for which the estimated series from IBRE-FGV was used. The coefficient of lagged inflation (β_1) was utilized to calibrate the indexing parameters. Negative coefficients were transformed to zero to maintain theoretical consistency and ensure non-negative indexing parameters. The estimated values for λ_i can be found in tables A.2 and A.1 and a histogram of the values is displayed in A.11.

4.6 Sectoral shocks parameters

We performed a Bayesian estimation of the model using Brazilian quarterly data. To estimate inflation for intermediate goods firms, we used the Producer Prices Index by origin *IPA-OG DI* as our PPI inflation (data collected between the first and last day of the reference month). The data was available from January 1996 to December 2021.

The inflation series for the activities of the input-output matrix was built using the mapping described in 4.1.1. For each of the 33 sectors, an inflation series was built by aggregating its mapped PPI items, using their respective weights. Resulting sectoral weights are specified in Table A.1. We checked the accuracy of the new inflation series by aggregating sectoral inflation to obtain a new headline PPI series and compared it with the original headline. As shown in figure A.2, series overlap reasonably.

We followed guidelines from Pfeifer (2014) to transform the observed variables. Even though the model features intermediate inputs, for simplicity, we assume that variations of the gross series from the national accounts are close to the variations of the net volume of consumption. Thus, we utilized the former series in a quarterly frequency and applied an HP filter, which trend proved to be less sensitive to outliers compared to the BP filter. Given that

$y_t = c_t$, we chose to proceed exclusively with the consumption component of the GDP instead of the full headline. For sectoral inflation, we used quarterly growth rates subtracted from its mean.

Regarding the interest rate, we employed the Selic rate series. We obtained daily data from the Brazilian Central Bank, encompassing both the target interest rate and the disclosed effective value. We aggregated both series on monthly and quarterly scales. Subsequently, we took the logarithm of the series $(1 + i_t)$ and detrended them linearly. Upon plotting a graph with both series, no significant differences were observed, as expected, leading us to opt for using the series corresponding to the target interest rate. Additionally, we utilized this series to calibrate the parameter β in line with a quarterly average interest rate of 2.91% observed during the period.

However, during the Bayesian estimation process, we encountered several convergence issues. Therefore, we display values obtained from the posterior distributions and we just utilized them to have a better calibration of the sectoral parameters of persistence and variance for each shock. The parameters obtained, although preliminary, allow for a differentiation of shocks persistence and variability across sectors.

A complete table of the aggregate and remaining sectoral parameters that were used can be found in A.4. Priors are documented in Table A.7 and are based on Smets et al. (2019) and Carvalho et al. (2021).

Standard errors of aggregate shocks have inverse gamma priors with a mean 0.10 and a standard deviation of 2. This prior matches that found in most DSGE models which typically focus exclusively on aggregate shocks. Similarly, the autoregressive parameters of aggregate processes are given a beta distribution with mean 0.85 and standard deviation 0.1.

Coefficients of persistence of idiosyncratic shocks have a beta distribution, centered at 0.5 and with a standard deviation of 0.2. Since micro shocks are typically more volatile than aggregate shocks we give an inverse gamma prior for the standard errors of those shocks with a mean of 0.2 and a standard deviation of 2.

5
Results

The results presented are obtained from an estimation of the model, using the parameters detailed in the previous section, based on the literature, empirical data and from the Bayesian estimation.

5.1
Pipeline Pressures

We explore the origins of pipeline pressures to individual price indices by conducting a decomposition analysis. For this purpose, we dissect our measure of pipeline pressures defined in Appendix A.5, $(\gamma_t\,(\pi_k)_{h=\infty})$, into their sectoral origins.

Tables A.5 and A.6 present the outcomes of the relative cumulative impact of sectoral shocks on each sector. Values smaller than 1 were suppressed and each column has been normalized to unity, providing insights into the relative magnitude of shock transmission within sectors.

Several noteworthy observations emerge from the results. Firstly, in alignment with findings by Smets et al. (2019) for the U.S. economy, shocks in intermediate inputs propagate more to final sectors than to the intermediate sectors themselves. This aligns with expectations, partly due to the calibration of parameters $\delta_k > \delta_m$, on average.

Although results depend on the combination of specifications, they seem to be highly correlated to the degree of price stickiness. Intermediate sector *manufacturing and refining of sugar (Fabricação e refino de açúcar)* has the highest α_m in the model and is responsible for a share of pipeline pressures in almost all other sectors. On one hand, there is some rationale behind this result, as a shock in a more rigid sector takes time to dissipate, distorts relative prices in the most interdependent sectors (through the I-O matrix, which also could yield some disequilibrium in further sectors. Thus we could associate these findings with indirect effects that emerge through the sectoral linkages. On the other hand, the model could be significantly overestimating the degree of importance of price rigidity.

One should notice that the coefficients of pipeline pressures presented in the results table are relative in terms of sector relevance and do not reflect the magnitude of price pass-through. Furthermore, some relationships that might seem in principle spurious are, in fact, a consequence of the model structure and the parameters. For example, the final sector of 'meat' has pipeline pressures coming from most of the intermediate sectors, due to coefficients > 0 in the I-O matrix. Therefore, beyond price rigidity, the I-O structure is also capable of generating significant pipeline pressures across most sectors, due to the dynamics of price adjustments.

The results show that, even though we performed two independent mappings of inflation indices from different sources to the input-output matrix, there is consistency in the procedure, as they demonstrate some expected price pass-through. Findings in Table A.6 show that over 31% of the pressures in the 'Footwear' sector originate from the intermediate sector of 'manufacturing of shoes and leather goods'. Similarly, the inflation of 'Fish' is predominantly influenced by the sector 'Forestry production; fishing and aquaculture' (37.7%). The manufacturing of automobiles, trucks, and buses, excluding parts, exhibits a more pronounced pass-through effect on vehicle inflation. Thus, the relationship between producer and consumer inflation is somewhat captured by the model.

In Appendix A.1, we discuss an empirical examination of the producer-to-consumer price pass-through, considering a recent decoupling of the two inflation measures. The model's results contribute to this ongoing discussion.

One challenge inherent in such analysis lies in its static nature and reliance on the input-output matrix, which is considerably lagged and struggles to promptly capture changes in the economic structure. The issue of price pass-through from producers to consumers is of utmost importance, and alternative approaches are viable. In Appendix A.2, we present a purely empirical analysis, adapting a methodology developed by Rubene (2023) to the Brazilian economy. The results obtained contribute to a more accurate prediction of movements in the CPI based on the PPI.

5.2 Variance Decomposition

With the model results, we can compute a variance decomposition for both aggregate and sectoral variables. In the first chart, Figure A.13, we present the decomposition for aggregate variables. Here, we see a more pronounced influence of monetary policy shocks, especially in variables like aggregate consumption, interest rate, and aggregate output. Aggregate markup shocks also play a significant role, albeit less dominant compared to sectoral inflation, suggesting that while markups are crucial at the micro level, other factors gain prominence when considering the economy as a whole.

The second chart, Figure A.14, focuses on sectoral inflation. We observe that sectoral markup shocks consistently account for the largest portion of the variance across most variables. This indicates that changes in markups at the sectoral level are a significant source of volatility in sectoral inflation. Additionally, aggregate productivity shocks account for more volatility than disaggregated productivity shocks. Lastly, monetary policy shocks have a relatively smaller but still noticeable impact, highlighting the role of policy interventions in influencing sectoral inflation.

Overall, our results align with the literature, with aggregate shocks playing a bigger role in aggregate variables and sectoral shocks having a more localized impact, leading to significant variability within specific sectors. Nevertheless, the high importance of sectoral markup shocks in both cases also stands out and could be overestimated. Although this result is partly expected due to the model structure, in which the sectoral markup shocks affect sectoral inflation directly, it also aligns with findings in the literature that emphasize the importance of sectoral shocks in explaining aggregate volatility

5.3 Robustness

We conducted robustness tests on the impulse response functions (IRFs) of the model under various scenarios. Initially, we examined the theoretical outcomes in the fully specified model, calibrated with the developed input-output matrix and the calibrated rigidity parameters. Figure A.3 illustrates the results of a monetary policy shock on aggregate variables, aligning with existing literature. More notably, we observed the sectoral behavior in response to aggregate inflation variables. Figures A.4 and A.5 depict the responses of inflation for intermediate and final firms, respectively, to a monetary policy shock, revealing diverse sectoral behaviors influenced by input structure, price rigidity, and the use of intermediate inputs in the production function.

Subsequently, we compared the base case of the model with two alternative scenarios: one where the parameter $\alpha_i \to 0$ and another where the input-output matrix was entirely uniform and roundabout. Starting with the latter, it is interesting to note that the initial response to shocks is similar, as expected. However, the trajectory diverges over time, highlighting the impact of the introduced complexity in the production chain, often leading to a different stabilization level compared to the model with a uniform input-output matrix. In the first scenario, we find that shocks dissipate much faster in the absence of price rigidity, as firms can immediately adjust their prices.

6
Conclusion and future work

This study contributes to the DSGE literature by addressing the complexities of the production structure within the Brazilian economy. Our model, characterized by high levels of disaggregation, incorporates micro-data and a detailed calibration that allows it to reflect sector-specific characteristics.

Central to our analysis is exploring the relationship between producer and consumer prices, specifically through the IPA and the IPCA. By modeling a two-stage production structure, we take a step towards aligning the model more closely with the actual production processes of the economy, offering a deeper understanding of goods manufacturing and aggregation.

Our findings underscore the importance of considering heterogeneity and production networks in economic modeling. Identifying the most rigid and interconnected sectors can lead to more effective monetary policy strategies, by finding the potential sources of inflation volatility and persistence.

A central contribution of this thesis lies in the developed framework, with parameters calibrated across all sectors. We provide empirical data on indexation, price rigidity, and input usage. These parameters, along with the mapping of the input-output matrix using Brazilian inflation data, hold potential for diverse future applications seeking to integrate the sectoral structure of the economy

Nevertheless, the model does not come without its limitations. The intricate nature of the model, marked by its high complexity, introduces a level of instability in the estimation process. The reliance on a static and outdated input-output matrix fails to capture the intertemporal dimension of the model adequately. Additionally, the high correlation among sectoral inflation rates also emerged as a problem in the estimation.

Moving forward, potential applications and further work involve refining the estimation process by running a Hamiltonian Monte Carlo or by trying different estimation techniques more suitable for high-dimensional models. Additionally, the model and its mapping can be updated in the future once a more recent input-output matrix is published. Further exploration of the results with alternative producer price indices and mappings is also recommended.

7
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A
Appendices

A.1
Discrepancy between PPI and CPI

In a recent inflation report, the Brazilian Central Bank - BCB (2020) discussed the substantial increase in PPI during the pandemic, contrasting with the behavior of the CPI (see figure A.7. This divergence marked the largest gap since 2003, with the study exploring historical disparities and focusing on the impact of differences in sector composition.

Initially, the researchers estimated a LASSO regression to align components of PPI with those of CPI, creating a "Corresponding PPI" with a basket similar to the CPI. This allows for a thorough examination of the recent price divergence. The findings revealed that a significant portion of the historical discrepancy is explained by differences in index composition, but the recent detachment was more pronounced. This phenomenon could be partially attributed to a lag in the pass-through of certain items. Economic conditions, particularly the high levels of slack, may contribute to a pass-through effect lower than usual.

This topic remained relevant one year later in BCB (September, 2021), where the researchers updated previous analyses to assess the extent to which the persistence of the rise in prices of industrial products for consumers is linked to the continued significant increase in factory prices, which, in turn, reflect a strong pass-through of input costs.

The dynamic transmission of producer prices to consumer prices, specifically for industrial goods, reveals a significant and persistent divergence. The study emphasizes a substantial disconnection observed in the industrial goods segment, suggesting that factors other than pass-through delays may be at play. The negative output gap supports the hypothesis that economic slack contributes to a smaller-than-usual pass-through effect.

We have also reconstructed the most updated charts illustrating the "Corresponding" PPI and CPI, with compatible baskets (Figure A.8). Our LASSO estimation and subsequent manual selection contemplated 57.79% of the PPI basket and 60.14% of the CPI. Through Bayesian estimation and the computation of pipeline pressures, we aim to investigate the potential impact of price composition changes on the divergence between PPI and CPI. If we had discovered that intermediate sectors with higher pipeline pressure coefficients for other intermediate sectors experienced more significant price increases during 2020 and 2021, this insight could offer another dimension for understanding recent dynamics. But this is not what we found, which corroborates with the Central Bank's hypothesis that the detachment was probably caused by economic slack and idle capacity in the economy.

In light of the substantial surge in consumer prices observed that was observed after this period, it becomes apparent that firms initially absorbed a greater share of the input cost increase, subsequently passing it on to consumers. Hence, we sought a methodology capable of constructing an index that captured pipeline pressures, designed to monitor the rise in producer prices not yet reflected in consumer prices. Thus we could capture the temporal dynamics of price pass-through and account for sectoral variations.

A.2
Empirical exercise

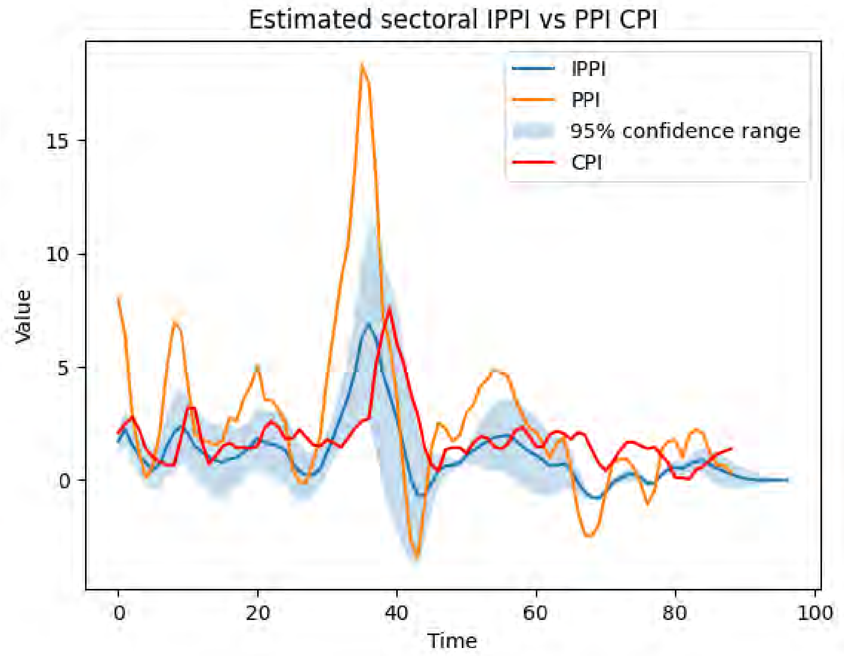
Understanding the transmission mechanism of price changes from producer to consumer levels is a commonly researched issue. The European Central Bank (ECB) has long relied on the dynamics of industrial producer prices as a leading indicator for comprehending the forthcoming consumer price pressures. However, delving deeper into this analytical framework, a recent study by Rubene (2023) elaborated in this article, utilizes an advanced methodology to identify and interpret these pressures more comprehensively.

The methodology employed in their analysis constructs *indicators for producer price pressures (IPPIs)* through the intricate examination of the time profile of impacts exerted by changes in producer prices on consumer prices over an extended period. Leveraging the local projections (LP) estimation method, this approach hinges on dynamic impulse responses, encapsulating the elasticities between consumer prices and producer prices. They develop empirical equations for consumer prices including their lags, concurrent and lagged changes in the respective producer price indices.

To obtain the IPPI, these elasticities are computed over eight quarters and transformed to an impact on the annual inflation rates of an index. Afterwards, for a given change in PPI the impact on consumer prices is calculated for the next seven quarters (taking the quarter-on-quarter change in PPI and multiplying this by the time profile of the impacts). Thereafter, the paths for changes in the PPI from the eight preceding consecutive quarters are added together to obtain the joint impact on consumer prices in a given quarter.

The ECB computes this indicator using country-level data for non-energy industrial goods and food inflation. We propose an adaptation for this methodology by using sectoral-level data to compute the IPPIs for the headline PPI and CPI. We

Figure A.1: Estimated IPPI



estimated an LP model with 20 sectors for which the mapping between PPI and CPI was reasonable. Our results show that the constructed IPPI performed much better in anticipating consumer price changes than the PPI itself, which is also much more volatile as shown in figure A.1. In addition, the IPPI using sectoral-level data also outperformed the IPPI built with headlines only. The comparison of both series can be found in figure A.9 in appendix A.6

Nevertheless, one should note that IPPIs are, by construction, backward-looking indicators, because they are based on developments in PPIs only up until their latest observation. Furthermore, they should not be evaluated in isolation but rather in conjunction with a comprehensive array of information concerning underlying price pressures in the economy. While the IPPI methodology provides invaluable insights into the intricate nexus between producer and consumer prices, its holistic interpretation necessitates a broader perspective encompassing various economic indicators.

A.3
Industry-by-industry Input-Output matrix

In order to construct an industry-by-industry matrix that consistently maps to our model, we follow the same steps as Pasten et al. (2021). First, we define the market share of industry j's production of commodities as:

$$SHARE = MAKE./(\mathbb{1} \times MAKE)$$

Where $\mathbb{1}$ is a matrix of ones with suitable dimensions and ./ is the element by element division. Then, multiply $SHARE \times USE$ to get $REVSHARE$, the amount that industry j' sells to industry j. Lastly, use the revenue-share matrix to calculate the percentage of industry j inputs purchased from industry j'

$$IOMATRIX = [REVSHARE./(\mathbb{1} \times USE)]'$$

which is an industry-by-industry matrix.

A.4
Log-linearized system

This section presents the log-linearized equations of the model. For a simplified overview, please go to A.15

A.4.1
Aggregate Equations

Euler Equation

$$c_t = c_{t+1} - \frac{1}{\sigma}(i - \pi_{t+1})$$

Aggregate inflation of final and intermediate goods

$$\pi_t = \sum_{k=1}^{K} \xi_{ck}\pi_{k,t}$$

$$\pi_{M,t} = \sum_{m=1}^{M} \xi_{z,m}\pi_{m,t}$$

Taylor Rule

$$i_t = \rho_i(i_{t-1}) + (1 - \rho_i)(\phi_\pi \pi_t + \phi_c c_t) + \mu_t$$

Intermediate input price index

$$p_t^z = \sum_{m=1}^{M} n_m p_{m,t}^m$$

Consumption goods price index

$$p_t^c = \sum_{k=1}^{K} \xi_{c,k} p_{k,t}$$

Aggregate Output

$$y_t = \sum_{i=1}^{K} n_i y_{i,t}$$

A.4.2
Sectoral equations

Equations for $k = \{1, \ldots, K\}$ final goods firms:

1. Computation of total weights of sectors

$$n_{k,t} = \xi_{c,k}(1-\psi_k) + \psi_k \left(\sum_{j=1}^{K} n_j \omega_{k,j} \right)$$

where $\psi_k = \delta_k \frac{(\theta-1)}{\theta}$

2. Marginal costs

$$mc_{k,t} = (1-\delta_k)w_{k,t} + \delta_k p^k_{k,t} - a_t - a_{k,t}$$

3. Phillips curve (with indexation)

$$\pi_{k,t} = \gamma^1_k \pi_{t+1} + \gamma^2_k \pi_{t-1} + \gamma^3_k (mc_{k,t} - p_{k,t} + \nu_{F,t} + \nu_{F_k,t})$$

where $\gamma^1_k = \frac{\beta}{1+\beta\lambda_k}$,$\gamma^2_k = \frac{\lambda_k}{1+\beta\lambda_k}$ and $\gamma^3_k = \frac{(1-\alpha_k)(1-\beta\alpha_k)}{\alpha_k(1+\beta\lambda_k)}$

4. Labor Supply

$$w_{k,t} = \sigma c_t + \varphi l_{k,t} + p^c_t$$

5. Efficiency condition

$$w_{k,t} = p^k_{k,t} + z_{k,t} - l_{k,t}$$

6. Sectoral output (demand)

$$n_{k,t} y_{k,t} = \xi_{c,k} \left[c_t - \eta(p_{k,t} - p^c_t) \right]$$

7. Sectoral output (supply - production function)

$$y_{k,t} = (1-\delta_k)l_{k,t} + \delta z_{k,t} + a_{k,t} + a$$

8. Sectoral prices

$$p^k_{k,t} = \sum_{j=1}^{K} \omega_{j,k} p_{k,t}$$

9. Sectoral inflation

$$\pi_{k,t} = p^k_{k,t} - p^k_{k,t-1}$$

Equations for $m = \{1, 2, \ldots, M\}$ intermediate firms:

Equations 2 to 5, 8 and 9 are the same replacing $p_{k,t}$ with $p_{m,t}$; $p^k_{k,t}$ with $p^m_{m,t}$; $\nu_{F_k,t}$ with $\nu_{M_m,t}$; $\nu_{F,t}$ with $\nu_{M,t}$ and remaining k subscripts with m

1. Computation of total weights of sectors

$$n_{m,t} = \xi_{z,m}(1-\psi_m) + \psi_m \left(\sum_{j=1}^{M} n_j \omega_{m,j} \right)$$

where $\psi_m = \delta_m \frac{(\theta-1)}{\theta}$

6. Sectoral output (demand)

$$s_{m,t} = \psi_m \left\{ \sum_{j=1}^{M} n_{j,t}\omega_{m,j} \left[z_{j,t} - \eta(p^m_{j,t} - p_{m,t}) \right] + \sum_{i=1}^{K} n_{i,t}\omega_{m,i} \left[z_{i,t} - \eta(p^k_{i,t} - p_{m,t}) \right] \right\}$$

7. Sectoral output (supply - production function of intermediate goods)

$$s_{m,t} = (1-\delta_m)l_{m,t} + \delta_m z_{m,t} + a_{m,t} + a$$

A.4.3 Exogenous processes

– Aggregate productivity shock

$$a_t = \rho_a a_{t-1} + \sigma_a \varepsilon_a$$

– Aggregate intermediate good mark-up shock

$$\nu_{M,t} = \rho_{\nu_M} \nu_{M,t-1} + \sigma_{\nu_M} \varepsilon_{\nu_M}$$

– Aggregate final good mark-up shock

$$\nu_{F,t} = \rho_{\nu_F} \nu_{F,t-1} + \sigma_{\nu_F} \varepsilon_{\nu_F}$$

– Monetary policy shock

$$\mu_t = \rho_\mu \mu_{t-1} + \sigma_\mu \varepsilon_\mu$$

– Sectoral productivity shocks

$$a_{x,t} = \rho_{a_x} a_{x,t-1} + \sigma_{a_x} \varepsilon_{a_x} \quad \forall x \in \{k, m\}$$

– Sectoral relative demand shocks

$$d_{x,t} = \rho_{d_x} d_{x,t-1} + \sigma_{d_x} \varepsilon_{d_x} \quad \forall x \in \{k, m\}$$

– Sectoral mark-up shocks of intermediate goods

$$\nu_{M_m,t} = \rho_{\nu_{M_m}} \nu_{M_m,t-1} + \sigma_{\nu_{M_m}} \varepsilon_{\nu_{M_m}} \quad \forall m$$

– Sectoral mark-up shocks of final goods

$$\nu_{F_k,t} = \rho_{\nu_{F_k}} \nu_{F_k,t-1} + \sigma_{\nu_{F_k}} \varepsilon_{\nu_{F_k}} \quad \forall k$$

A.4.4
Derivation of the Sectoral Phillips Curve

Take the log-linearized first order condition by the price setting firm and use it in the optimal price setting:

$$\begin{aligned} p^*_{k,t} &= (1-\alpha_k\beta)E_t \sum_{s=0}^{\infty} \alpha_k^s \beta_s mc_{k,t+s} \\ p^*_{k,t} &= (1-\alpha_k\beta)mc_{k,t} + \alpha_k \beta E_t[p^*_{k,t+1}] \end{aligned} \tag{A-1}$$

Log-linearize equation (3-20):

$$P_{k,t}^{1-\theta} = (1-\alpha_k)P_{k,t}^{*1-\theta} + \alpha_k \left(P_{k,t-1} \left(\frac{P_{k,t-1}}{P_{k,t-2}} \right)^{\lambda_k} \right)^{1-\theta} \qquad (\div P_{k,t-1}^{1-\theta})$$

$$\left(\frac{P_{k,t}}{P_{k,t-1}} \right)^{1-\theta} = (1-\alpha_j) \left(\frac{P^*_{k,t}}{P_{k,t-1}} \right)^{1-\theta} + \alpha_k \left(\frac{P_{k,t-1}}{P_{k,t-2}} \right)^{\lambda(1-\theta)}$$

After expanding each term of the equation above, we get:

$$p^*_{k,t} = \frac{\pi_{k,t} - \alpha_k \lambda_k \pi_{k,t-1}}{1-\alpha_k} + p_{k,t-1} \tag{A-2}$$

Then plug the expression (A-2) in t and $t+1$ in equation (A-1). After some calculations, we get a version of the sectoral Phillips curve (PC), as a function of the sectoral marginal cost:

$$\pi_{k,t} = \frac{\beta}{1-\alpha_k\beta\lambda} E_t[\pi_{k,t+1}] + \frac{\lambda}{1-\alpha_k\beta\lambda_k} \pi_{k,t-1} + \frac{(1-\alpha_k)(1-\alpha_k\beta)}{\alpha_k(1-\alpha_k\beta\lambda_k)} (mc_{k,t} - p_{k,t}) \tag{A-3}$$

This was the expression used in the model. Note that one could also take the expression to the deviation of the marginal cost from its steady state and replace it in the above equation to obtain a version of the PC without sectoral prices and dependent on consumption and intermediate inputs use.

A.5
Definition of Pipeline Pressures

Disaggregated inflation indices can be decomposed into a common and a sector–specific component:

$$\pi_{kt} = \underbrace{\lambda_i' f_t}_{\substack{\text{Common component} \\ \text{Aggregate Shocks}}} + \underbrace{\epsilon_{kt}}_{\substack{\text{Residual} \\ \text{Sector-specific shocks}}}$$

Foerster et al. (2008) state that $\lambda_i' \boldsymbol{f}_t$ reflects the comovement of price indices resulting from two types of Shocks, aggregate shocks and sectoral-specific shocks that have propagated through input–output linkages.

Thus $\rho\left(\boldsymbol{\lambda}_i' \boldsymbol{f}_t\right)$ and $\frac{\sigma^2\left(\boldsymbol{\lambda}_i' \boldsymbol{f}_t\right)}{\sigma^2(\pi_{it})}$ Reflects Aggregate and Sectoral Shocks

Smets et al. (2019) propose a three-way Decomposition:

$$\pi_{kt} = \underbrace{\alpha_t\left(\pi_k\right)}_{\text{Aggregate Shocks}} + \underbrace{\beta_t\left(\pi_k\right)}_{\text{Sector Shocks}} + \underbrace{\gamma_t\left(\pi_k\right)}_{\text{Pipeline Pressures}}$$

$$\pi_{kt}^{ppi} = \boldsymbol{\alpha}_t\left(\pi_k^{ppi}\right)_{h=\infty} + \boldsymbol{\beta}_t\left(\pi_k^{ppi}\right)_{h=\infty} + \gamma_t\left(\pi_k^{ppi}\right)_{h=\infty}$$

$$\text{where} \quad \gamma_t\left(\pi_k^{ppi}\right) = \sum_{s=0}^{h-1}\left(\boldsymbol{\delta}_{k,-k}^{(s)}(\mathcal{E})\right)' \varepsilon_{k,-k}(\mathcal{E})_{t-s}$$

Here, $\boldsymbol{\delta}_{k,-k}^{(s)}(\mathcal{E})$ captures the impulse response coefficients of PPI k to micro shocks related to all price indices other than k.

The equation disentangles inflation of price index k into a part that originates with aggregate shocks $\left(\boldsymbol{\alpha}_t\left(\pi_k^{ppi}\right)_{h=\infty}\right)$; direct effect of the micro shocks specific to sector k $\left(\boldsymbol{\beta}_t\left(\pi_k^{ppi}\right)_{h=\infty}\right)$. And propagation of micro shocks from elsewhere in the economy $\left(\gamma_t\left(\pi_k^{ppi}\right)_{h=\infty}\right)$, which is what we label as pipeline pressures — the cascade effect of micro-level shocks through the pipeline.

A.6
Figures

Figure A.2: IPA headline and model headline producer inflation

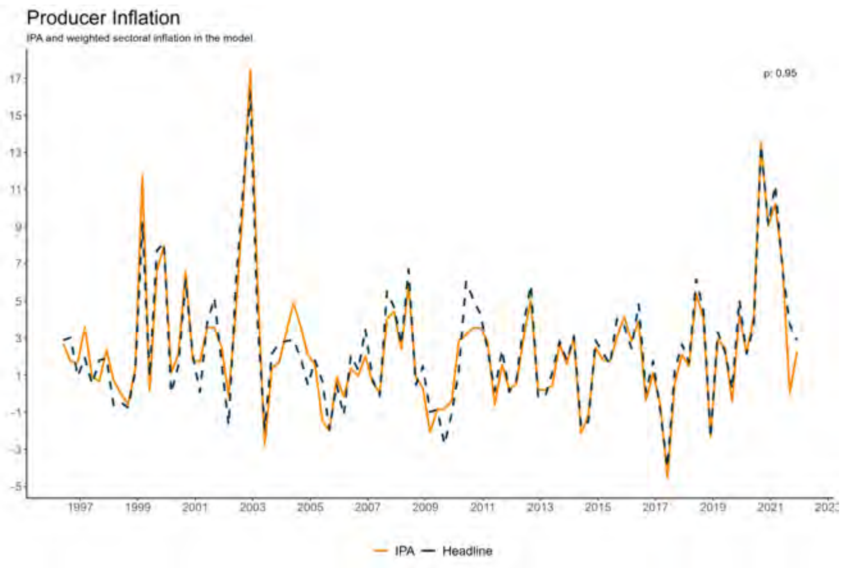


Figure A.3: IRFs from base case Model to μ_t shock

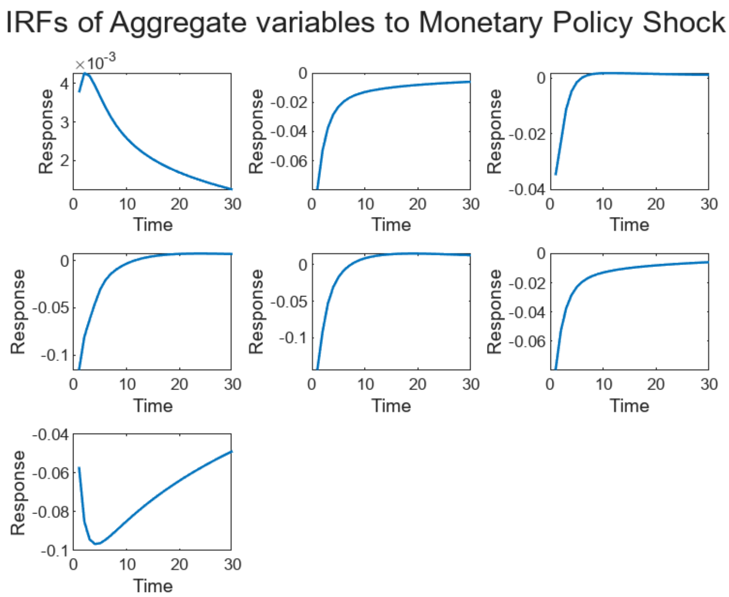


Figure A.4: IRFs of intermediate goods inflation to μ_t shock

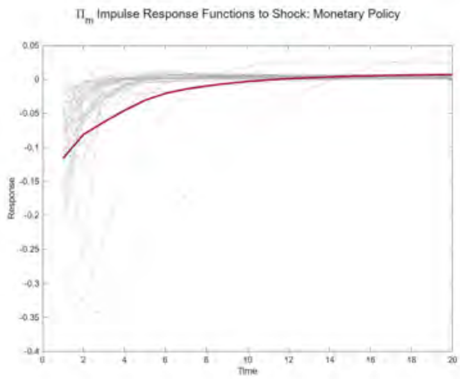


Figure A.5: IRFs of final goods inflation to μ_t shock

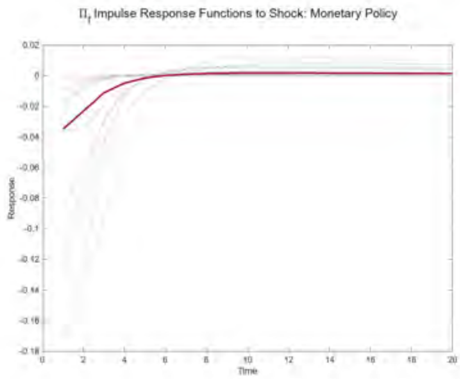


Figure A.6: IRFs of different model versions to μ_t shock

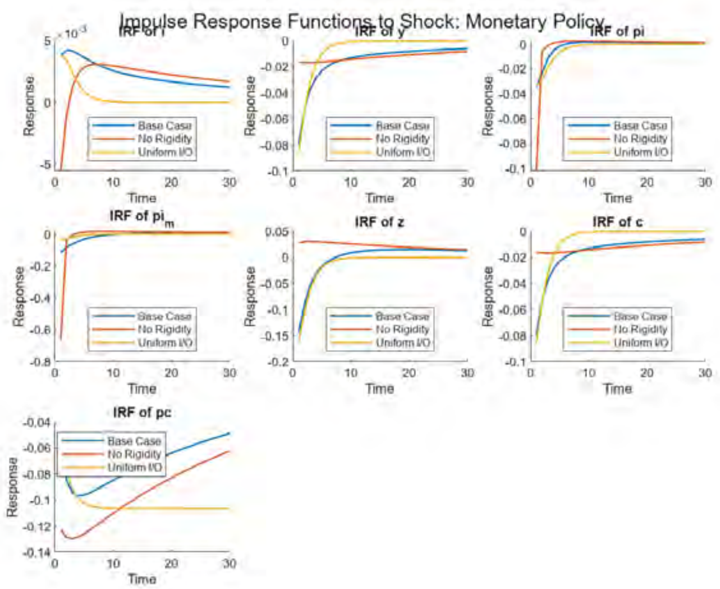


Figure A.7: Producer and Consumer prices for Brazil and recent detachment

Figure A.8: Producer and Consumer prices for Brazil with comparable baskets

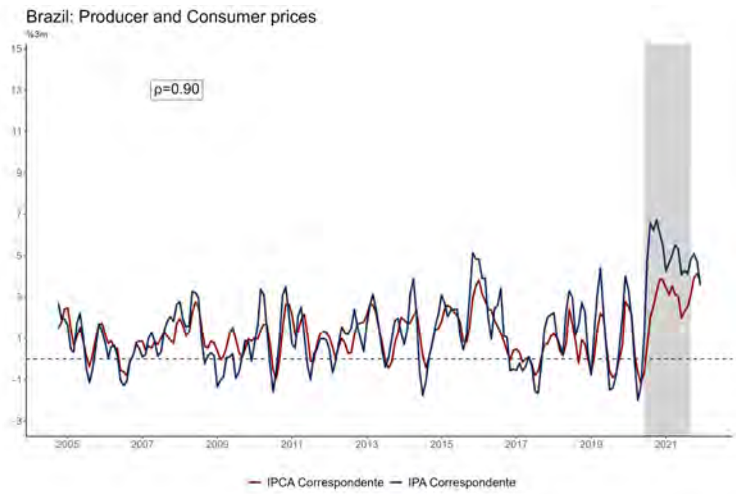


Figure A.9: Time series vs. panel IPPI

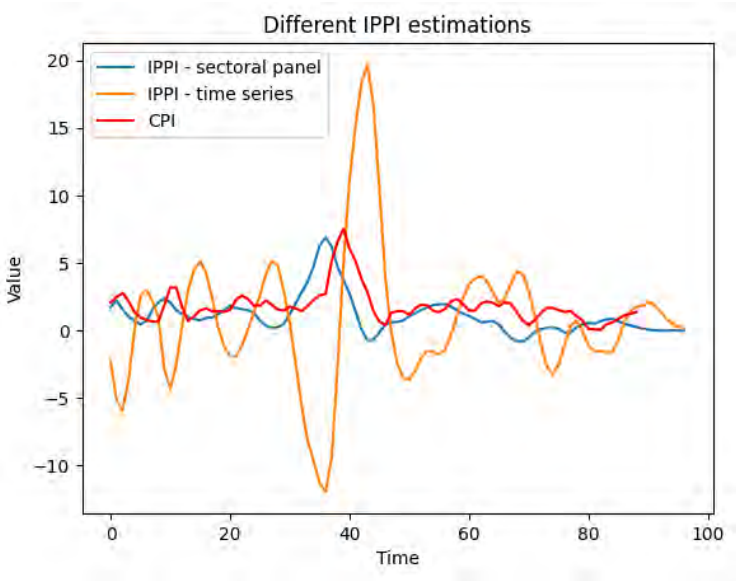


Figure A.10: Histogram of Price stickiness (α_i)

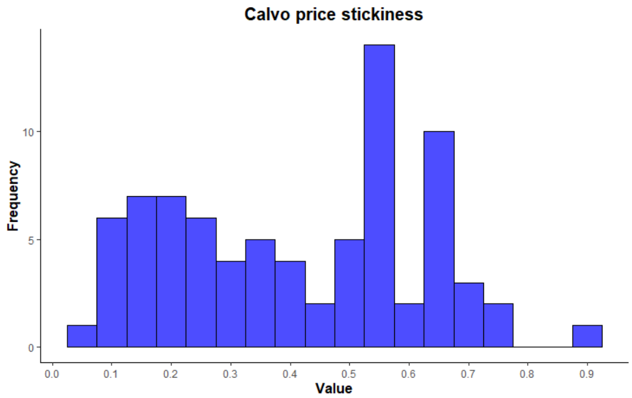


Figure A.11: Histogram of Price indexation (λ_i)

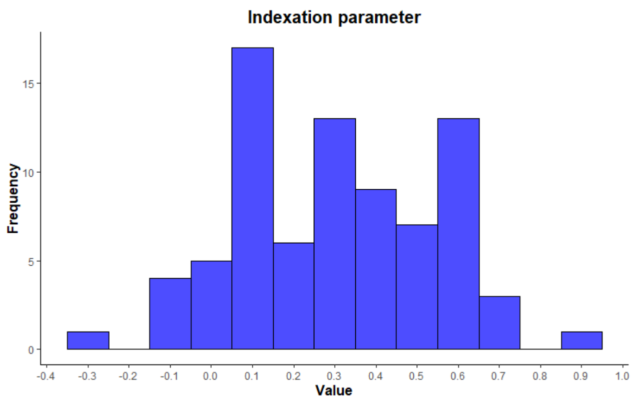


Figure A.12: Histogram of Input shares (δ_i)

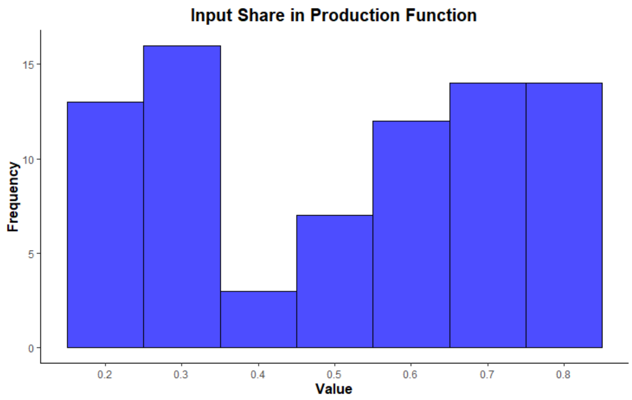


Figure A.13: Variance Decomposition - Aggregate Variables

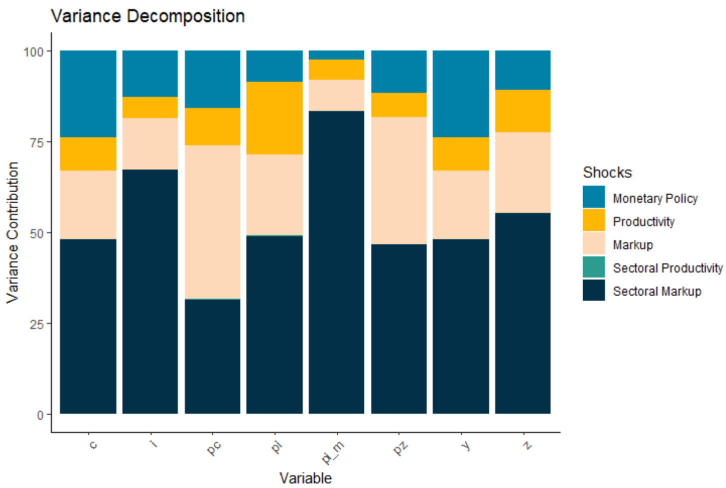
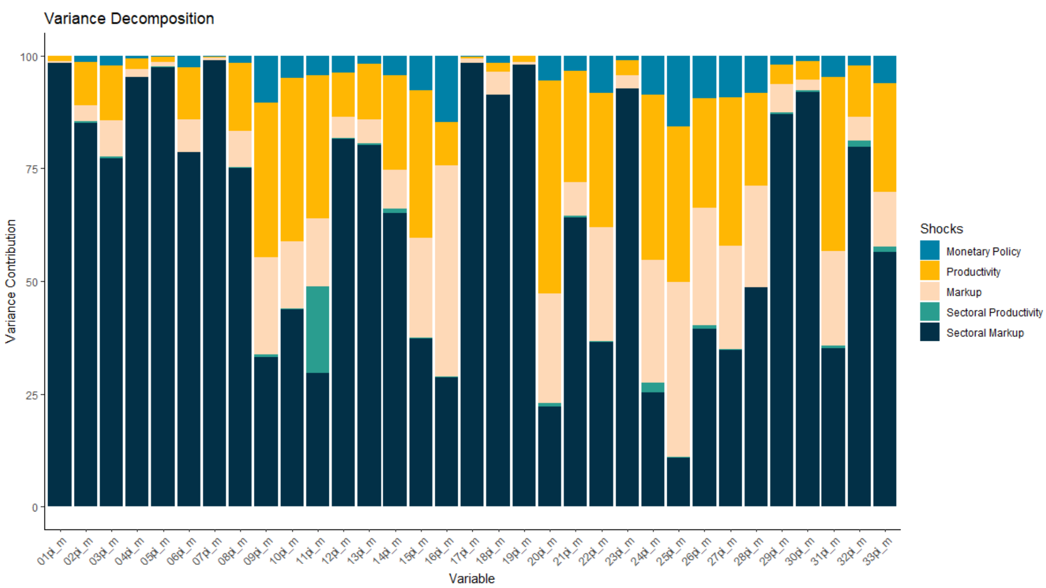
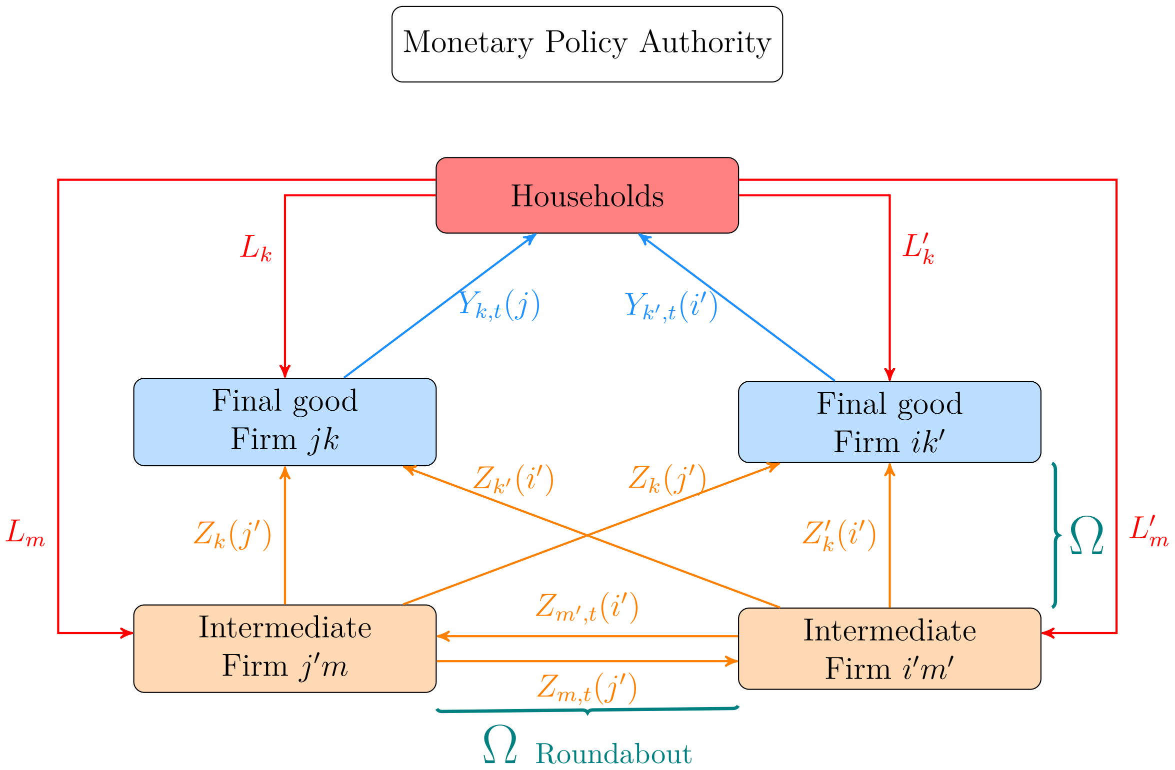


Figure A.14: Variance Decomposition - Sectoral Inflation



A.7
Model Overview

Figure A.15: Model Overview



A schematic overview of the model with two final sectors k and k' and two intermediate goods sectors m and m'.

A.8 Tables

Table A.1: Intermediate Goods Sectors

	Code	I-O Matrix Sector - PPI	Weight	α_m	δ_m	λ_m
1	0191	Agricultura, inclusive o apoio à agricultura e a pós-colheita	20.32	0.6353	0.7319	0.253
2	0192	Pecuária, inclusive o apoio à pecuária	8.92	0.6585	0.2732	0.115
3	0280	Produção florestal; pesca e aquicultura	0.06	0.493	0.1787	0.265
4	0580	Extração de carvão mineral e de minerais não metálicos	0.54	0.3387	0.2074	0.385
5	0791	Extração de minério de ferro, inclusive beneficiamentos e a aglomeração	5.36	0.7035	0.2842	0.119
6	1091	Abate e produtos de carne, inclusive os produtos do laticínio e da pesca	5.85	0.6353	0.78	0.052
7	1092	Fabricação e refino de açúcar	1.65	0.8978	0.1823	0.043
8	1093	Outros produtos alimentares	6.03	0.5295	0.7046	0.273
9	1100	Fabricação de bebidas	1.64	0.4073	0.18	0.133
10	1200	Fabricação de produtos do fumo	0.28	0.1285	0.1898	0.026
11	1300	Fabricação de produtos têxteis	0.60	0.1809	0.2979	0.495
12	1400	Confecção de artefatos do vestuário e acessórios	1.20	0.1095	0.2699	0.506
13	1500	Fabricação de calçados e de artefatos de couro	0.72	0.1059	0.2315	0.608
14	1600	Fabricação de produtos da madeira	0.50	0.1909	0.2511	0.311
15	1700	Fabricação de celulose, papel e produtos de papel	2.14	0.3473	0.2578	0.431
16	1991	Refino de petróleo e coquerias	8.85	0.6967	0.8374	0.074
17	1992	Fabricação de biocombustíveis	0.57	0.7712	0.2063	0.134
18	2091	Fabricação de químicos orgânicos e inorgânicos, resinas e elastômeros	3.68	0.6441	0.714	0.585
19	2092	Fabricação de defensivos, desinfestantes, tintas e químicos diversos	1.91	0.2457	0.3322	0.599
20	2093	Fabricação de produtos de limpeza, cosméticos/perfumaria e higiene pessoal	0.79	0.1171	0.2858	0.369
21	2100	Fabricação de produtos farmoquímicos e farmacêuticos	0.95	0.0954	0.241	0
22	2200	Fabricação de produtos de borracha e de material plástico	2.60	0.2004	0.394	0.617
23	2300	Fabricação de produtos de minerais não metálicos	1.65	0.193	0.3451	0.703
24	2491	Produção de ferro gusa/ferroligas, siderurgia e tubos de aço sem costura	3.68	0.3106	0.4598	0.637
25	2492	Metalurgia de metais não ferosos e a fundição de metais	0.87	0.5687	0.2023	0.188
26	2500	Fabricação de produtos de metal, exceto máquinas e equipamentos	2.05	0.2203	0.3262	0.628
27	2600	Fabricação de equipamentos de informática, produtos eletrônicos e ópticos	1.12	0.281	0.2707	0.353
28	2700	Fabricação de máquinas e equipamentos elétricos	1.92	0.2555	0.3114	0.321
29	2800	Fabricação de máquinas e equipamentos mecânicos	3.00	0.1332	0.4071	0.663
30	2991	Fabricação de automóveis, caminhões e ônibus, exceto peças	4.52	0.2406	0.6304	0.289
31	2992	Fabricação de peças e acessórios para veículos automotores	2.22	0.1635	0.2815	0.628
32	3000	Fabricação de outros equipamentos de transporte, exceto veículos automotores	0.34	0.1588	0.2324	0.255
33	3180	Fabricação de móveis e de produtos de indústrias diversas	0.65	0.1405	0.189	0.636

Table A.2: Final Goods Sectors

Sector #	Code	CPI (IPCA) Sector	Weight	α_k	δ_k	λ_k
34	1101	Cereais, leguminosas e oleaginosas	1.05%	0.7238	0.7989	0.302
35	1102	Farinhas, féculas e massas	0.64%	0.5337	0.7687	0.475
36	1103	Tubérculos, raízes e legumes	0.65%	0.7496	0.7867	0
37	1104	Açúcares e derivados	0.83%	0.6009	0.7351	0.250
38	1105	Hortaliças e verduras	0.20%	0.4692	0.794	0
39	1106	Frutas	0.87%	0.6717	0.7695	0.098
40	1107	Carnes	2.63%	0.5699	0.7401	0.178
41	1108	Pescados	0.30%	0.6524	0.7374	0
42[1]	1109	Carnes e peixes industrializados	0.78%	0.577	0.7467	0.097
42[1]	1110	Aves e ovos	1.18%	0.577	0.7467	0.097
42[1]	1111	Leites e derivados	2.12%	0.577	0.7467	0.097
43	1112	Panificados	1.99%	0.3721	0.7915	0.230
44	1113	Óleos e gorduras	0.49%	0.642	0.7517	0.368
45	1114	Bebidas e infusões	1.77%	0.5723	0.7844	0.563
46	1115	Enlatados e conservas	0.17%	0.487	0.7609	0.391
47	1116	Sal e condimentos	0.40%	0.4848	0.71	0.123
48	1201	Alimentação fora do domicílio	7.03%	0.2104	0.2914	0.087
49	2101	Aluguel e taxas	7.74%	0.4928	0.6758	0.082
50	2103	Reparos	1.51%	0.2391	0.6567	0.374
51	2104	Artigos de limpeza	0.84%	0.5665	0.6156	0.295
52	2201	Combustíveis (domésticos)	1.38%	0.3064	0.682	0.328
53	2202	Energia elétrica residencial	3.79%	0.427	0.7646	0
54	3101	Mobiliário	1.36%	0.5464	0.582	0.499
55	3102	Utensílios e enfeites	0.53%	0.3482	0.5644	0.386
56	3103	Cama, mesa e banho	0.27%	0.5504	0.566	0.387
57	3201	Eletrodomésticos e equipamentos	1.19%	0.5581	0.5441	0.591
58	3202	Tv, som e informática	0.94%	0.5646	0.5765	0.645
59	3301	Consertos e manutenção	0.39%	0.6414	0.5588	0.181
60[2]	4101	Roupa masculina	1.38%	0.6285	0.671	0.636
60[2]	4102	Roupa feminina	1.66%	0.6285	0.671	0.636
60[2]	4103	Roupa infantil	0.76%	0.6285	0.671	0.636
61	4201	Calçados e acessórios	1.64%	0.6287	0.6185	0.509
62	4301	Joias e bijuterias	0.32%	0.5536	0.6946	0.569
63	4401	Tecidos e armarinho	0.12%	0.5536	0.7503	0.224
64	5101	Transporte público	5.77%	0.2083	0.6907	0.110
65	5102	Veículo próprio	9.12%	0.5462	0.5242	0.535

Continued on next page

Table A.2 – Continued from previous page

Sector #	Code	CPI (IPCA) Sector	Weight	α_k	δ_k	λ_k
66	5104	Combustíveis (veículos)	5.34%	0.5236	0.8451	0.103
67	6101	Produtos farmacêuticos	3.51%	0.2637	0.5982	0
68	6102	Produtos óticos	0.32%	0.2467	0.5577	0.325
69	6201	Serviços médicos e dentários	1.28%	0.1018	0.2837	0.682
70	6202	Serviços laboratoriais e hospitalares	0.51%	0.1518	0.2049	0.133
71	6203	Plano de saúde	3.27%	0.1667	0.3173	0.930
72	6301	Higiene pessoal	2.51%	0.3602	0.5371	0.098
73	7101	Serviços pessoais	5.82%	0.5547	0.2306	0.350
74	7201	Recreação	3.17%	0.3781	0.5382	0
75	7202	Fumo	1.00%	0.1038	0.5971	0
76	8101	Cursos regulares	4.00%	0.3974	0.4659	0.107
77	8102	Leitura	0.62%	0.0673	0.4228	0.064
78	8103	Papelaria	0.28%	0.3048	0.5171	0.230
79	9101	Comunicação	4.57%	0.389	0.5836	0.502

[1] The three items were aggregated to facilitate the mapping with the I/O Matrix

[2] The three series were aggregated to facilitate the mapping with the I/O matrix. They match the *41 - Roupas* subgroup of the IPCA (Clothing)

Table A.3: I-O Matrix Mapping

Code	Activity	PPI	CPI	Out
0191	Agricultura, inclusive o apoio à agricultura e a pós-colheita	X	X	
0192	Pecuária, inclusive o apoio à pecuária	X	X	
0280	Produção florestal; pesca e aquicultura	X	X	
0580	Extração de carvão mineral e de minerais não metálicos	X		
0680	Extração de petróleo e gás, inclusive as atividades de apoio			X
0791	Extração de minério de ferro, inclusive beneficiamentos e a aglomeração	X		
0792	Extração de minerais metálicos não ferrosos, inclusive beneficiamentos			X
1091	Abate e produtos de carne, inclusive os produtos do laticínio e da pesca	X	X	
1092	Fabricação e refino de açúcar	X	X	
1093	Outros produtos alimentares	X	X	
1100	Fabricação de bebidas	X	X	
1200	Fabricação de produtos do fumo	X	X	
1300	Fabricação de produtos têxteis	X	X	
1400	Confecção de artefatos do vestuário e acessórios	X	X	
1500	Fabricação de calçados e de artefatos de couro	X	X	
1600	Fabricação de produtos da madeira	X		
1700	Fabricação de celulose, papel e produtos de papel	X	X	
1800	Impressão e reprodução de gravações		X	
1991	Refino de petróleo e coquerias	X	X	
1992	Fabricação de biocombustíveis	X		
2091	Fabricação de químicos orgânicos e inorgânicos, resinas e elastômeros	X		
2092	Fabricação de defensivos, desinfestantes, tintas e químicos diversos	X		
2093	Fabricação de produtos de limpeza, cosméticos/perfumaria e higiene pessoal	X	X	
2100	Fabricação de produtos farmoquímicos e farmacêuticos	X	X	
2200	Fabricação de produtos de borracha e de material plástico	X	X	
2300	Fabricação de produtos de minerais não metálicos	X		
2491	Produção de ferro gusa/ferroligas, siderurgia e tubos de aço sem costura	X		
2492	Metalurgia de metais não ferosos e a fundição de metais	X		
2500	Fabricação de produtos de metal, exceto máquinas e equipamentos	X		
2600	Fabricação de equipamentos de informática, produtos eletrônicos e ópticos	X	X	
2700	Fabricação de máquinas e equipamentos elétricos	X		
2800	Fabricação de máquinas e equipamentos mecânicos	X	X	
2991	Fabricação de automóveis, caminhões e ônibus, exceto peças	X	X	
2992	Fabricação de peças e acessórios para veículos automotores	X	X	
3000	Fabricação de outros equipamentos de transporte, exceto veículos automotores	X		

Continued on next page

Table A.3 – Continued from previous page

Code	Activity	PPI	CPI	Out
3180	Fabricação de móveis e de produtos de indústrias diversas	X	X	
3300	Manutenção, reparação e instalação de máquinas e equipamentos		X	
3500	Energia elétrica, gás natural e outras utilidades		X	
3680	Água, esgoto e gestão de resíduos		X	
4180	Construção		X	
4580	Comércio por atacado e varejo			X
4900	Transporte terrestre		X	
5000	Transporte aquaviário		X	
5100	Transporte aéreo		X	
5280	Armazenamento, atividades auxiliares dos transportes e correio		X	
5500	Alojamento		X	
5600	Alimentação		X	
5800	Edição e edição integrada à impressão			X
5980	Atividades de televisão, rádio, cinema e gravação/edição de som e imagem			X
6100	Telecomunicações		X	
6280	Desenvolvimento de sistemas e outros serviços de informação			X
6480	Intermediação financeira, seguros e previdência complementar			X
6800	Atividades imobiliárias		X	
6980	Atividades jurídicas, contábeis, consultoria e sedes de empresas			X
7180	Serviços de arquitetura, engenharia, testes/análises técnicas e P & D			X
7380	Outras atividades profissionais, científicas e técnicas			X
7700	Aluguéis não imobiliários e gestão de ativos de propriedade intelectual			X
7880	Outras atividades administrativas e serviços complementares			X
8000	Atividades de vigilância, segurança e investigação			X
8400	Administração pública, defesa e seguridade social			X
8591	Educação pública			X
8592	Educação privada		X	
8691	Saúde pública			X
8692	Saúde privada		X	
9080	Atividades artísticas, criativas e de espetáculos		X	
9480	Organizações associativas e outros serviços pessoais			X
9700	Serviços domésticos			X
		33	37	18

Notes: Activities from the Input-Output matrix were manually mapped to the inflation items and products from consumer prices (IPCA) and producer prices (IPA). If both indexes have a correspondent activity, the column was split in two accordingly to the share of households and government demand relative to total demand. [H]

Table A.4: Model Parameters

β	0.9717	Intertemporal discount factor
σ	1	utility CRRA parameter
δ_k	-	Intermediate input share in production function
φ	2	Inverse of Frisch elasticity
$\omega_{m,k}$	Ω	I/O linkages
α_k	-	Price rigidity (Calvo)
η	2	Elasticity of substitution across sectors
θ	5.2	Elasticity of substitution within sectors
ξ_{ck}	-	Final goods consumption weights
ξ_{zk}	-	Intermediate goods consumption weights
λ_i	-	Indexation parameter
ϕ_π	1.5	Inflation parameter in Taylor rule
ϕ_c	0.25	Consumption parameter in Taylor rule
ρ_i	0.8	Interest rate smoothing in Taylor rule
ρ_a	0.3	Persistence of agg productivity shock
ρ_μ	0.2	Persistence of monetary policy shock
ρ_{ν_M}	0.7	Persistence of agg mark-up shock in intermediate goods sectors
ρ_{ν_F}	0.7	Persistence agg mark-up shock in final goods sectors
σ_a	0.4	Std error of agg productivity shock
σ_μ	0.15	Std error of monetary policy shock
σ_{ν_M}	0.4	Std error of agg mark-up shock in intermediate goods sectors
σ_{ν_F}	0.4	Std error agg mark-up shock in final goods sectors
ρ_{a_i}	-	Persistence of sectoral productivity shock $\forall i \in \{m, k\}$
ρ_{d_i}	-	Persistence of sectoral demand shock $\forall i \in \{m, k\}$
$\rho_{\nu_{M_m}}$	-	Persistence of sectoral mark-up shock in intermediate goods sectors
$\rho_{\nu_{F_k}}$	-	Persistence of sectoral mark-up shock in final goods sectors
σ_{a_i}	-	Std error of sectoral productivity shock $\forall i \in \{m, k\}$
σ_{d_i}	-	Std error of sectoral demand shock $\forall i \in \{m, k\}$
$\sigma_{\nu_{M_m}}$	-	Std error of sectoral mark-up shock in intermediate goods sectors
$\sigma_{\nu_{F_k}}$	-	Std error of sectoral mark-up shock in final goods sectors

Table A.5: Pipeline Pressures for intermediate sectors

	Agricultura, inclusive o apoio à agricultura e a pós-colheita	Pecuária, inclusive o apoio à pecuária	Produção florestal; pesca e aquicultura	Extração de carvão mineral e de minerais não metálicos	Extração de minério de ferro, inclusive beneficiamentos e a aglomeração	Abate e produtos de carne, inclusive os produtos do laticínio e da pesca	Fabricação e refino de açúcar	Outros produtos alimentares	Fabricação de bebidas	Fabricação de produtos do fumo	Fabricação de produtos têxteis	Confecção de artefatos do vestuário e acessórios	Fabricação de calçados e de artefatos de couro	Fabricação de produtos da madeira	Fabricação de celulose, papel e produtos de papel	Refino de petróleo e coquerias	Fabricação de biocombustíveis	Fabricação de químicos orgânicos e inorgânicos, resinas e elastômeros	Fabricação de defensivos, desinfestantes, tintas e químicos diversos	Fabricação de produtos de limpeza, cosméticos/perfumaria e higiene pessoal	Fabricação de produtos farmoquímicos e farmacêuticos	Fabricação de produtos de borracha e de material plástico	Fabricação de produtos de minerais não metálicos	Produção de ferro gusa/ferroligas, siderurgia e tubos de aço sem costura	Metalurgia de metais não ferosos e a fundição de metais	Fabricação de produtos de metal, exceto máquinas e equipamentos	Fabricação de equipamentos de informática, produtos eletrônicos e ópticos	Fabricação de máquinas e equipamentos elétricos	Fabricação de máquinas e equipamentos mecânicos	Fabricação de automóveis, caminhões e ônibus, exceto peças	Fabricação de peças e acessórios para veículos automotores	Fabricação de outros equipamentos de transporte, exceto veículos automotores	Fabricação de móveis e de produtos de indústrias diversas
Agricultura, inclusive o apoio à agricultura e a pós-colheita																																	
Pecuária, inclusive o apoio à pecuária																																	
Produção florestal; pesca e aquicultura			3.210113																														
Extração de carvão mineral e de minerais não metálicos				1.633997																													
Extração de minério de ferro, inclusive beneficiamentos e a aglomeração	1.356503		1.811107	1.575497	54.12965				4.0182	3.526496	2.670395	3.7872	2.679603	3.3761	2.787106	1.710505	1.584003		1.704402	3.6409	1.789313	1.629011	2.126396	4.998095	3.873888	3.419993	5.319511	8.471592	7.152136	2.897309	2.9605	9.376409	3.866688
Abate e produtos de carne, inclusive os produtos do laticínio e da pesca	3.022406	20.21574	2.871911	3.520593	1.160299	21.84109	1.375906	8.901227						2.6362	4.116408				3.647604		12.23169	5.70074	5.463789	1.993598				1.153199				1.138701	
Fabricação e refino de açúcar	50.6524	18.20405	10.55354	40.82252	7.271393	14.04373	62.68485	16.19335	7.6773	8.353692	8.653783	6.2924	4.770905	19.26	10.76742	12.70064	7.279815	22.0756	48.62285	7.7414	15.76211	15.58861	35.85363	17.49768	9.544471	12.82847	10.85532	15.49158	25.65773	3.679011	7.1415	18.42862	5.329984
Outros produtos alimentares																																	
Fabricação de bebidas									1.8341																								
Fabricação de produtos do fumo										43.06436																							
Fabricação de produtos têxteis											5.869888																						
Confecção de artefatos do vestuário e acessórios											20.06396	26.4577																					4.938785
Fabricação de calçados e de artefatos de couro		2.038684				2.389888					2.080196		31.17183		1.043702						1.327409												
Fabricação de produtos da madeira			4.142417											23.6437	1.128502																		
Fabricação de celulose, papel e produtos de papel															14.99763																		
Refino de petróleo e coquerias																																	
Fabricação de biocombustíveis	7.806016	8.409333	1.421606	6.721787	1.124199	8.866656	4.807419	7.066021	1.5071	1.473599	1.620097	1.2247		1.4055	3.474907	4.558614	61.07762	3.5843	5.966606	1.39	5.64394	4.31893	2.429195	2.455398	3.003891	3.371993	2.341105	3.506796	4.901625	1.239104	1.6767	3.556904	1.343896
Fabricação de químicos orgânicos e inorgânicos, resinas e elastômeros			1.695007	2.182896	1.308899	1.625192	3.342013		2.6238	1.494499	1.433997	1.7983	1.210201	1.8175	2.645105	12.37074	4.010308	45.791		1.802		2.79462	1.179698	2.831697	4.674286	2.966094	2.968006	2.807997	1.426507	1.494804	2.406	1.433301	2.023794
Fabricação de defensivos, desinfestantes, tintas e químicos diversos																																	
Fabricação de produtos de limpeza, cosméticos/perfumaria e higiene pessoal																				1.3119													
Fabricação de produtos farmoquímicos e farmacêuticos																					2.010714												
Fabricação de produtos de borracha e de material plástico																																	
Fabricação de produtos de minerais não metálicos				1.025298																			1.528997										
Produção de ferro gusa/ferroligas, siderurgia e tubos de aço sem costura					1.946298																			1.945698									
Metalurgia de metais não ferosos e a fundição de metais																									4.666286								
Fabricação de produtos de metal, exceto máquinas e equipamentos					2.169898																			5.301895	1.268596	6.159588							
Fabricação de equipamentos de informática, produtos eletrônicos e ópticos																											3.411007						
Fabricação de máquinas e equipamentos elétricos																												1.581098					
Fabricação de máquinas e equipamentos mecânicos																								1.183199					1.329207				
Fabricação de automóveis, caminhões e ônibus, exceto peças																								1.216899						44.87303	9.9349		
Fabricação de peças e acessórios para veículos automotores																								2.605797	2.806692						25.2004		
Fabricação de outros equipamentos de transporte, exceto veículos automotores																								1.025099		1.322697						20.57062	
Fabricação de móveis e de produtos de indústrias diversas														4.9191											1.339696								18.13805

Table A.6: Pipeline Pressures for final sectors

	Agricultura, inclusive o apoio à agricultura e a pós-colheita	Pecuária, inclusive o apoio à pecuária	Produção florestal; pesca e aquicultura	Extração de carvão mineral e de minerais não metálicos	Extração de minério de ferro, inclusive beneficiamentos e a aglomeração	Abate e produtos de carne, inclusive os produtos do laticínio e da pesca	Fabricação e refino de açúcar	Outros produtos alimentares	Fabricação de bebidas	Fabricação de produtos do fumo	Fabricação de produtos têxteis	Confecção de artefatos do vestuário e acessórios	Fabricação de calçados e de artefatos de couro	Fabricação de produtos da madeira	Fabricação de celulose, papel e produtos de papel	Refino de petróleo e coquerias	Fabricação de biocombustíveis
Cereais, leguminosas e oleaginosas	3.557	1.973	4.134	4.006		1.964	1.657	3.324	1.735	1.493	1.203	1.431	1.068	1.899	2.357	6.272	2.462
Farinhas, féculas e massas		1.659				1.556	1.106	5.415							1.501	1.380	
Tubérculos, raízes e legumes	4.813	4.294		2.877				1.389	1.507			1.189		1.095	1.105	2.915	
Açúcares e derivados	2.525			2.384			1.520		1.269			1.143				1.090	
Hortaliças e verduras		1.925			1.142			1.189	16.072					1.120			
Frutas	3.465	1.030	1.116	3.423		1.232	1.052	1.357	1.646			1.123		1.273	1.672	3.300	1.116
Carnes	1.949	5.082	2.885	2.261	1.565	5.045	1.463	8.236	3.110	2.293	1.542	2.627	1.794	2.183	3.177	2.439	
Pescados			37.723					6.097	1.164	1.059		2.302			1.241		
Carnes ind, aves, leites	1.687	6.128	2.312	2.158	1.575	6.777	1.433	4.910	2.966	1.692	1.699	1.969	1.354	2.386	3.276	4.475	1.474
Panificados								1.153								1.212	
Óleos e gorduras				1.206			1.478	10.007	1.429		11.649				2.205		
Bebidas e infusões	1.018			1.330	1.079			1.387	13.411			1.105					
Enlatados e conservas																	
Sal e condimentos																	
Alimentação fora do domicílio		1.284				1.706			2.356			1.022		1.041	1.495	2.172	
Aluguel e taxas		1.061	1.547		1.182	1.436			2.625	1.958	1.588	2.296	1.516	1.982	2.639	2.739	
Reparos																	
Artigos de limpeza		2.088				2.249											
Combustíveis (domésticos)																	
Energia elétrica residencial			1.523	1.045	1.105	1.556	1.525		2.633	1.594	1.392	1.995	1.341	1.825	2.276	4.740	1.605
Mobiliário														1.792			
Utensílios e enfeites																	
Cama, mesa e banho																	
Eletrodomésticos e equipamentos					1.286												
Tv, som e informática																	
Consertos e manutenção					1.834												
Roupas		1.174	1.419		1.100	1.611	1.252	1.177	2.627	2.081	10.464	17.858	1.725	1.794	2.301	3.948	1.309
Calçados e acessórios	1.930	9.045	1.875	2.312		8.213	1.259	5.361			2.642		31.442	1.951	2.704	2.271	
Joias e bijuterias				1.248													
Tecidos e armarinho											5.899						
Transporte público		1.072	1.097			1.136			1.768	1.087	1.027	1.281		1.194	1.718	1.994	
Veículo próprio			1.817	1.069	1.393	1.667	1.614		2.863	1.750	1.635	2.064	1.381	1.980	2.771	5.115	1.698
Combustíveis (veículos)			2.124	1.223	1.517	2.065	1.069	1.125	4.912	4.017	2.839	4.381	3.042	3.395	3.394	3.385	1.517
Produtos farmacêuticos															1.010		
Produtos óticos																	
Serviços médicos e dentários									1.025	1.802		1.416					
Serviços laboratoriais e hospitalares									1.026			2.050					
Plano de saúde																	
Higiene pessoal																	
Serviços pessoais									2.166					1.428	1.047	1.490	
Recreação																	
Fumo										4.752							
Cursos regulares																	
Leitura															1.008		
Papelaria			1.331												1.339		
Comunicação																	

	Fabricação de químicos orgânicos e inorgânicos, resinas e elastômeros	Fabricação de defensivos, desinfestantes, tintas e químicos diversos	Fabricação de produtos de limpeza, cosméticos/perfumaria e higiene pessoal	Fabricação de produtos farmoquímicos e farmacêuticos	Fabricação de produtos de borracha e de material plástico	Fabricação de produtos de minerais não metálicos	Produção de ferro gusa/ferroligas, siderurgia e tubos de aço sem costura	Metalurgia de metais não ferosos e a fundição de metais	Fabricação de produtos de metal, exceto máquinas e equipamentos	Fabricação de equipamentos de informática, produtos eletrônicos e ópticos	Fabricação de máquinas e equipamentos elétricos	Fabricação de máquinas e equipamentos mecânicos	Fabricação de automóveis, caminhões e ônibus, exceto peças	Fabricação de peças e acessórios para veículos automotores	Fabricação de outros equipamentos de transporte, exceto veículos automotores	Fabricação de móveis e de produtos de indústrias diversas
Cereais, leguminosas e oleaginosas	1.664	4.065	1.515	4.438	2.467	2.680	2.143	2.507	2.267	1.949	2.955	2.297	1.024	1.828	1.917	1.316
Farinhas, féculas e massas				1.619	2.561		1.031	1.100	1.366							
Tubérculos, raízes e legumes	2.495	3.301	1.044	1.146	1.361	2.893	1.061	1.558		1.391		1.032		1.138		1.288
Açúcares e derivados	1.149	2.952	1.102		1.466	2.172	1.380	1.119	1.950	1.198	2.356	2.877	2.255	1.046	2.645	1.360
Hortaliças e verduras		1.109			1.892	2.443	1.844		4.562							
Frutas	1.555	3.943	1.101		1.523	2.648	1.714	2.798	1.696	1.848	1.624	1.660		1.421	1.174	1.313
Carnes		2.445	2.660	12.771	4.900	1.029	2.569	2.997	2.555	2.495	2.323	2.011	2.408	1.982	1.925	2.607
Pescados			1.191	1.076	2.211	1.323				1.141	1.921	2.285	1.135		2.058	1.596
Carnes ind, aves, leites	1.541	1.754	1.961	5.962	3.538	2.250	2.980	4.844	2.865	3.293	2.661	1.523	1.749	2.499	1.693	2.193
Panificados			2.434					1.184								
Óleos e gorduras		1.732	6.489		3.421	1.470	1.403		3.104		1.561	2.566			2.146	
Bebidas e infusões		1.492	1.107		2.331	2.082	1.887		3.597							1.065
Enlatados e conservas			5.067											2.910		
Sal e condimentos			5.978													
Alimentação fora do domicílio			1.012		1.357		1.417	2.277	1.405	1.591	1.268			1.227		1.103
Aluguel e taxas	1.006		2.180	1.388	2.198	1.103	2.355	3.464	2.213	2.671	2.006	1.038	1.745	2.176	1.155	2.304
Reparos						1.088										
Artigos de limpeza		1.007	1.373	1.612		1.597						1.315				
Combustíveis (domésticos)																
Energia elétrica residencial	1.287		1.909	1.020	1.994	1.042	2.227	3.534	2.552	2.623	4.692	1.042	1.604	2.107	1.158	2.082
Mobiliário																9.170
Utensílios e enfeites					1.171											
Cama, mesa e banho			14.092		1.146											
Eletrodomésticos e equipamentos							1.896		3.240	1.555	5.831	2.009				4.379
Tv, som e informática										21.924	1.588					
Consertos e manutenção					2.022		4.869	2.804	6.240	2.822	7.401	11.074		1.305	8.061	1.123
Roupas	1.143		2.453	1.903	2.099		2.158	3.607	2.096	2.347	1.962	1.043	1.990	1.920	1.089	7.247
Calçados e acessórios		2.115		7.702	3.760	2.857	1.702	1.563		1.016	1.104					1.709
Joias e bijuterias			4.345			9.710										
Tecidos e armarinho																
Transporte público			1.241		1.579		1.574	2.466	1.505	1.831	1.419		1.094	2.542		1.348
Veículo próprio	1.474		2.072	1.291	2.622	1.068	2.798	4.526	2.735	3.074	2.652	1.323	11.569	3.006	1.412	2.713
Combustíveis (veículos)	1.177	1.175	4.438	2.235	2.639	1.612	2.871	4.188	2.734	3.649	2.592	2.358	3.520	3.565	2.347	4.339
Produtos farmacêuticos				3.201				1.141								
Produtos óticos			1.730									1.145		4.730		
Serviços médicos e dentários																
Serviços laboratoriais e hospitalares																
Plano de saúde				1.017												2.361
Higiene pessoal			4.572													
Serviços pessoais							1.043	1.672		1.151						
Recreação																
Fumo																
Cursos regulares																
Leitura																
Papelaria																
Comunicação																

Figure A.16: Priors and Posteriors after estimation

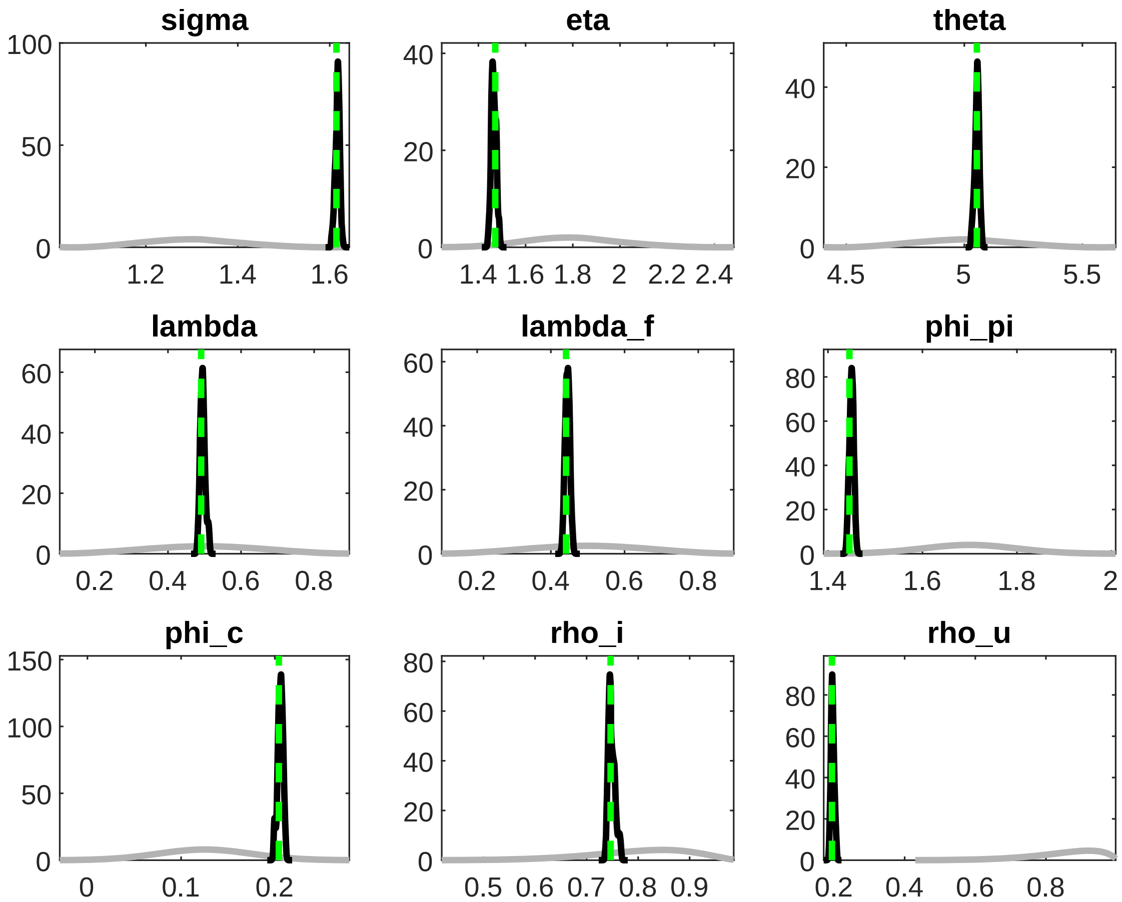


Table A.7: Prior and Posteriors

Parameter	Prior			Posterior		
	Distribution	Prior Mean	S.D	Posterior Mean	Posterior Mode	CI
σ	Γ	1.3	0.1	1.833	1.833	[1.864;1.772]
η	Γ	1.8	0.2	1.348	1.336	[1.374;1.320]
θ	Γ	5	0.2	5.216	5.225	[5.280;5.153]
$\phi_p i$	Normal	1.7	0.1	1.467	1.492	[1.499;1.437]
ϕ_c	Normal	0.125	0.05	0.288	0.290	[0.320;0.253]
ρ_i	β	0.8	0.1	0.730	0.738	[0.756;0.703]
ρ_u	β	0.85	0.1	0.100	0.083	[0.120;0.083]
ρ_a	β	0.85	0.1	0.441	0.408	[0.506;0.388]
ρ_r	β	0.85	0.1	0.997	0.996	[1.000;0.989]
σ_u	$Inv\Gamma$	0.1	2	0.141	0.157	[0.157;0.126]
σ_a	$Inv\Gamma$	0.1	2	0.431	0.430	[0.456;0.409]
σ_m	$Inv\Gamma$	0.1	2	0.494	0.467	[0.527;0.467]

Table A.8: Prior and Posteriors - Std Error of Sectoral Productivity Shocks

Parameter	Prior			Posterior		
	Distribution	Prior Mean	S.D	Posterior Mean	Posterior Mode	CI
σ_{a1}	Inv Γ	0.2	2	0.130	0.143	[0.171;0.088]
σ_{a2}	Inv Γ	0.2	2	0.112	0.090	[0.150;0.069]
σ_{a3}	Inv Γ	0.2	2	0.280	0.276	[0.326;0.225]
σ_{a4}	Inv Γ	0.2	2	0.274	0.247	[0.327;0.230]
σ_{a5}	Inv Γ	0.2	2	0.161	0.152	[0.209;0.118]
σ_{a6}	Inv Γ	0.2	2	0.449	0.449	[0.512;0.381]
σ_{a7}	Inv Γ	0.2	2	0.244	0.261	[0.308;0.201]
σ_{a8}	Inv Γ	0.2	2	0.212	0.214	[0.264;0.167]
σ_{a9}	Inv Γ	0.2	2	0.060	0.059	[0.080;0.038]
σ_{a10}	Inv Γ	0.2	2	0.153	0.161	[0.199;0.110]
σ_{a11}	Inv Γ	0.2	2	0.073	0.064	[0.093;0.048]
σ_{a12}	Inv Γ	0.2	2	2.280	2.304	[2.332;2.241]
σ_{a13}	Inv Γ	0.2	2	0.371	0.374	[0.408;0.324]
σ_{a14}	Inv Γ	0.2	2	0.556	0.591	[0.612;0.514]
σ_{a15}	Inv Γ	0.2	2	0.101	0.071	[0.137;0.067]
σ_{a16}	Inv Γ	0.2	2	0.089	0.062	[0.127;0.050]
σ_{a17}	Inv Γ	0.2	2	0.118	0.099	[0.148;0.084]
σ_{a18}	Inv Γ	0.2	2	0.598	0.612	[0.637;0.558]
σ_{a19}	Inv Γ	0.2	2	0.326	0.316	[0.358;0.275]
σ_{a20}	Inv Γ	0.2	2	0.412	0.401	[0.441;0.386]
σ_{a21}	Inv Γ	0.2	2	0.457	0.484	[0.508;0.410]
σ_{a22}	Inv Γ	0.2	2	0.128	0.151	[0.166;0.089]
σ_{a23}	Inv Γ	0.2	2	0.497	0.490	[0.536;0.443]
σ_{a24}	Inv Γ	0.2	2	0.212	0.211	[0.250;0.180]
σ_{a25}	Inv Γ	0.2	2	0.061	0.053	[0.082;0.038]
σ_{a26}	Inv Γ	0.2	2	0.674	0.703	[0.739;0.602]
σ_{a27}	Inv Γ	0.2	2	0.090	0.063	[0.121;0.060]
σ_{a28}	Inv Γ	0.2	2	0.075	0.078	[0.098;0.051]
σ_{a29}	Inv Γ	0.2	2	0.283	0.259	[0.321;0.246]
σ_{a30}	Inv Γ	0.2	2	0.231	0.236	[0.271;0.200]
σ_{a31}	Inv Γ	0.2	2	0.158	0.147	[0.199;0.114]
σ_{a32}	Inv Γ	0.2	2	0.231	0.250	[0.259;0.202]
σ_{a33}	Inv Γ	0.2	2	0.095	0.078	[0.117;0.077]
σ_{a34}	Inv Γ	0.2	2	0.231	0.227	[0.278;0.186]
σ_{a35}	Inv Γ	0.2	2	0.580	0.558	[0.610;0.546]
σ_{a36}	Inv Γ	0.2	2	0.571	0.591	[0.606;0.531]
σ_{a37}	Inv Γ	0.2	2	0.091	0.081	[0.122;0.060]
σ_{a38}	Inv Γ	0.2	2	0.412	0.426	[0.445;0.384]
σ_{a39}	Inv Γ	0.2	2	0.428	0.406	[0.471;0.398]
σ_{a40}	Inv Γ	0.2	2	0.078	0.068	[0.114;0.051]
σ_{a41}	Inv Γ	0.2	2	0.113	0.119	[0.161;0.080]
σ_{a42}	Inv Γ	0.2	2	0.090	0.092	[0.113;0.064]
σ_{a43}	Inv Γ	0.2	2	0.149	0.127	[0.208;0.097]
σ_{a44}	Inv Γ	0.2	2	0.454	0.462	[0.515;0.401]
σ_{a45}	Inv Γ	0.2	2	0.085	0.083	[0.109;0.066]
σ_{a46}	Inv Γ	0.2	2	0.228	0.231	[0.265;0.196]
σ_{a47}	Inv Γ	0.2	2	0.071	0.064	[0.091;0.046]
σ_{a48}	Inv Γ	0.2	2	0.317	0.332	[0.358;0.271]
σ_{a49}	Inv Γ	0.2	2	0.280	0.290	[0.311;0.244]
σ_{a50}	Inv Γ	0.2	2	0.257	0.270	[0.336;0.197]
σ_{a51}	Inv Γ	0.2	2	0.110	0.100	[0.158;0.059]
σ_{a52}	Inv Γ	0.2	2	0.074	0.060	[0.107;0.045]
σ_{a53}	Inv Γ	0.2	2	0.321	0.343	[0.372;0.266]
σ_{a54}	Inv Γ	0.2	2	0.230	0.200	[0.278;0.193]
σ_{a55}	Inv Γ	0.2	2	0.082	0.064	[0.121;0.055]
σ_{a56}	Inv Γ	0.2	2	0.187	0.151	[0.226;0.147]
σ_{a57}	Inv Γ	0.2	2	0.077	0.058	[0.111;0.039]
σ_{a58}	Inv Γ	0.2	2	0.115	0.113	[0.153;0.087]
σ_{a59}	Inv Γ	0.2	2	0.091	0.063	[0.123;0.055]
σ_{a60}	Inv Γ	0.2	2	0.105	0.080	[0.148;0.060]
σ_{a61}	Inv Γ	0.2	2	0.206	0.192	[0.257;0.149]
σ_{a62}	Inv Γ	0.2	2	0.160	0.152	[0.196;0.124]
σ_{a63}	Inv Γ	0.2	2	0.075	0.073	[0.102;0.049]
σ_{a64}	Inv Γ	0.2	2	0.364	0.374	[0.409;0.315]
σ_{a65}	Inv Γ	0.2	2	0.403	0.389	[0.441;0.362]
σ_{a66}	Inv Γ	0.2	2	0.078	0.070	[0.104;0.049]
σ_{a67}	Inv Γ	0.2	2	0.422	0.432	[0.465;0.377]
σ_{a68}	Inv Γ	0.2	2	0.291	0.303	[0.332;0.252]
σ_{a69}	Inv Γ	0.2	2	0.129	0.148	[0.212;0.086]
σ_{a70}	Inv Γ	0.2	2	0.103	0.107	[0.151;0.073]
σ_{a71}	Inv Γ	0.2	2	0.490	0.511	[0.540;0.446]
σ_{a72}	Inv Γ	0.2	2	0.791	0.776	[0.854;0.734]
σ_{a73}	Inv Γ	0.2	2	0.060	0.058	[0.080;0.044]
σ_{a74}	Inv Γ	0.2	2	0.520	0.518	[0.565;0.478]
σ_{a75}	Inv Γ	0.2	2	0.079	0.056	[0.109;0.049]
σ_{a76}	Inv Γ	0.2	2	0.324	0.366	[0.367;0.280]
σ_{a77}	Inv Γ	0.2	2	0.492	0.495	[0.536;0.438]
σ_{a78}	Inv Γ	0.2	2	0.305	0.326	[0.340;0.273]
σ_{a79}	Inv Γ	0.2	2	0.189	0.170	[0.248;0.153]

Table A.9: Prior and Posteriors - Shock Persistence of Sectoral Productivity Shocks

Parameter	Prior			Posterior		
	Distribution	Prior Mean	S.D	Posterior Mean	Posterior Mode	CI
ρ_{a1}	β	0.5	0.2	0.485	0.512	[0.517;0.448]
ρ_{a2}	β	0.5	0.2	0.455	0.465	[0.503;0.396]
ρ_{a3}	β	0.5	0.2	0.741	0.725	[0.784;0.697]
ρ_{a4}	β	0.5	0.2	0.600	0.582	[0.623;0.577]
ρ_{a5}	β	0.5	0.2	0.306	0.246	[0.352;0.258]
ρ_{a6}	β	0.5	0.2	0.740	0.721	[0.781;0.682]
ρ_{a7}	β	0.5	0.2	0.414	0.435	[0.447;0.379]
ρ_{a8}	β	0.5	0.2	0.369	0.353	[0.429;0.314]
ρ_{a9}	β	0.5	0.2	0.406	0.447	[0.473;0.367]
ρ_{a10}	β	0.5	0.2	0.853	0.844	[0.916;0.793]
ρ_{a11}	β	0.5	0.2	0.383	0.371	[0.412;0.341]
ρ_{a12}	β	0.5	0.2	0.057	0.046	[0.099;0.018]
ρ_{a13}	β	0.5	0.2	0.590	0.594	[0.648;0.534]
ρ_{a14}	β	0.5	0.2	0.338	0.373	[0.404;0.252]
ρ_{a15}	β	0.5	0.2	0.303	0.295	[0.345;0.267]
ρ_{a16}	β	0.5	0.2	0.931	0.952	[0.988;0.896]
ρ_{a17}	β	0.5	0.2	0.736	0.735	[0.814;0.690]
ρ_{a18}	β	0.5	0.2	0.712	0.713	[0.746;0.673]
ρ_{a19}	β	0.5	0.2	0.245	0.253	[0.291;0.198]
ρ_{a20}	β	0.5	0.2	0.190	0.227	[0.241;0.123]
ρ_{a21}	β	0.5	0.2	0.306	0.348	[0.329;0.286]
ρ_{a22}	β	0.5	0.2	0.445	0.415	[0.473;0.418]
ρ_{a23}	β	0.5	0.2	0.356	0.338	[0.379;0.333]
ρ_{a24}	β	0.5	0.2	0.100	0.092	[0.133;0.055]
ρ_{a25}	β	0.5	0.2	0.191	0.168	[0.252;0.126]
ρ_{a26}	β	0.5	0.2	0.372	0.347	[0.411;0.331]
ρ_{a27}	β	0.5	0.2	0.576	0.546	[0.618;0.545]
ρ_{a28}	β	0.5	0.2	0.448	0.461	[0.484;0.408]
ρ_{a29}	β	0.5	0.2	0.520	0.506	[0.561;0.476]
ρ_{a30}	β	0.5	0.2	0.413	0.439	[0.449;0.376]
ρ_{a31}	β	0.5	0.2	0.497	0.489	[0.546;0.452]
ρ_{a32}	β	0.5	0.2	0.357	0.336	[0.433;0.287]
ρ_{a33}	β	0.5	0.2	0.550	0.574	[0.600;0.499]
ρ_{a34}	β	0.5	0.2	0.812	0.798	[0.878;0.765]
ρ_{a35}	β	0.5	0.2	0.905	0.923	[0.943;0.853]
ρ_{a36}	β	0.5	0.2	0.697	0.641	[0.763;0.605]
ρ_{a37}	β	0.5	0.2	0.468	0.520	[0.493;0.444]
ρ_{a38}	β	0.5	0.2	0.677	0.648	[0.715;0.642]
ρ_{a39}	β	0.5	0.2	0.352	0.341	[0.400;0.311]
ρ_{a40}	β	0.5	0.2	0.703	0.697	[0.739;0.673]
ρ_{a41}	β	0.5	0.2	0.377	0.381	[0.414;0.325]
ρ_{a42}	β	0.5	0.2	0.616	0.620	[0.647;0.585]
ρ_{a43}	β	0.5	0.2	0.929	0.945	[0.965;0.895]
ρ_{a44}	β	0.5	0.2	0.698	0.730	[0.727;0.673]
ρ_{a45}	β	0.5	0.2	0.477	0.458	[0.535;0.428]
ρ_{a46}	β	0.5	0.2	0.663	0.662	[0.704;0.622]
ρ_{a47}	β	0.5	0.2	0.486	0.502	[0.518;0.453]
ρ_{a48}	β	0.5	0.2	0.578	0.590	[0.669;0.507]
ρ_{a49}	β	0.5	0.2	0.676	0.675	[0.726;0.637]
ρ_{a50}	β	0.5	0.2	0.590	0.608	[0.655;0.538]
ρ_{a51}	β	0.5	0.2	0.765	0.736	[0.835;0.680]
ρ_{a52}	β	0.5	0.2	0.631	0.629	[0.690;0.586]
ρ_{a53}	β	0.5	0.2	0.554	0.562	[0.597;0.493]
ρ_{a54}	β	0.5	0.2	0.260	0.254	[0.305;0.192]
ρ_{a55}	β	0.5	0.2	0.375	0.354	[0.406;0.333]
ρ_{a56}	β	0.5	0.2	0.554	0.582	[0.580;0.526]
ρ_{a57}	β	0.5	0.2	0.652	0.645	[0.699;0.550]
ρ_{a58}	β	0.5	0.2	0.166	0.161	[0.190;0.121]
ρ_{a59}	β	0.5	0.2	0.437	0.461	[0.479;0.399]
ρ_{a60}	β	0.5	0.2	0.558	0.529	[0.620;0.505]
ρ_{a61}	β	0.5	0.2	0.498	0.469	[0.568;0.453]
ρ_{a62}	β	0.5	0.2	0.331	0.320	[0.367;0.282]
ρ_{a63}	β	0.5	0.2	0.550	0.533	[0.577;0.521]
ρ_{a64}	β	0.5	0.2	0.384	0.388	[0.435;0.332]
ρ_{a65}	β	0.5	0.2	0.203	0.200	[0.239;0.165]
ρ_{a66}	β	0.5	0.2	0.575	0.560	[0.631;0.513]
ρ_{a67}	β	0.5	0.2	0.112	0.096	[0.199;0.038]
ρ_{a68}	β	0.5	0.2	0.165	0.150	[0.205;0.115]
ρ_{a69}	β	0.5	0.2	0.693	0.694	[0.744;0.658]
ρ_{a70}	β	0.5	0.2	0.424	0.447	[0.473;0.388]
ρ_{a71}	β	0.5	0.2	0.492	0.519	[0.544;0.439]
ρ_{a72}	β	0.5	0.2	0.309	0.279	[0.372;0.260]
ρ_{a73}	β	0.5	0.2	0.068	0.034	[0.138;0.035]
ρ_{a74}	β	0.5	0.2	0.770	0.708	[0.811;0.731]
ρ_{a75}	β	0.5	0.2	0.129	0.111	[0.184;0.083]
ρ_{a76}	β	0.5	0.2	0.584	0.565	[0.616;0.550]
ρ_{a77}	β	0.5	0.2	0.465	0.478	[0.502;0.415]
ρ_{a78}	β	0.5	0.2	0.639	0.649	[0.677;0.597]
ρ_{a79}	β	0.5	0.2	0.404	0.415	[0.443;0.345]

Table A.10: Prior and Posteriors - Std Error of Sectoral Demand Shocks

Parameter	Prior			Posterior		
	Distribution	Prior Mean	S.D	Posterior Mean	Posterior Mode	CI
σ_{d1}	Inv Γ	0.2	2	0.071	0.070	[0.090;0.046]
σ_{d2}	Inv Γ	0.2	2	0.127	0.152	[0.179;0.070]
σ_{d3}	Inv Γ	0.2	2	0.145	0.137	[0.209;0.077]
σ_{d4}	Inv Γ	0.2	2	0.293	0.295	[0.333;0.259]
σ_{d5}	Inv Γ	0.2	2	0.118	0.102	[0.170;0.068]
σ_{d6}	Inv Γ	0.2	2	0.324	0.354	[0.377;0.282]
σ_{d7}	Inv Γ	0.2	2	0.501	0.523	[0.547;0.441]
σ_{d8}	Inv Γ	0.2	2	0.061	0.058	[0.082;0.041]
σ_{d9}	Inv Γ	0.2	2	0.079	0.094	[0.103;0.051]
σ_{d10}	Inv Γ	0.2	2	0.063	0.054	[0.085;0.044]
σ_{d11}	Inv Γ	0.2	2	0.522	0.515	[0.561;0.487]
σ_{d12}	Inv Γ	0.2	2	0.270	0.284	[0.312;0.227]
σ_{d13}	Inv Γ	0.2	2	0.066	0.090	[0.090;0.042]
σ_{d14}	Inv Γ	0.2	2	0.213	0.200	[0.255;0.163]
σ_{d15}	Inv Γ	0.2	2	0.110	0.108	[0.139;0.065]
σ_{d16}	Inv Γ	0.2	2	0.065	0.055	[0.084;0.046]
σ_{d17}	Inv Γ	0.2	2	0.073	0.061	[0.094;0.045]
σ_{d18}	Inv Γ	0.2	2	0.572	0.542	[0.616;0.524]
σ_{d19}	Inv Γ	0.2	2	0.137	0.151	[0.189;0.071]
σ_{d20}	Inv Γ	0.2	2	0.289	0.281	[0.328;0.250]
σ_{d21}	Inv Γ	0.2	2	0.243	0.243	[0.285;0.193]
σ_{d22}	Inv Γ	0.2	2	0.078	0.062	[0.098;0.056]
σ_{d23}	Inv Γ	0.2	2	0.372	0.360	[0.402;0.334]
σ_{d24}	Inv Γ	0.2	2	0.288	0.284	[0.344;0.247]
σ_{d25}	Inv Γ	0.2	2	0.302	0.334	[0.350;0.255]
σ_{d26}	Inv Γ	0.2	2	0.067	0.065	[0.093;0.046]
σ_{d27}	Inv Γ	0.2	2	0.093	0.081	[0.134;0.052]
σ_{d28}	Inv Γ	0.2	2	0.144	0.140	[0.199;0.108]
σ_{d29}	Inv Γ	0.2	2	0.319	0.334	[0.419;0.241]
σ_{d30}	Inv Γ	0.2	2	0.073	0.070	[0.099;0.054]
σ_{d31}	Inv Γ	0.2	2	0.075	0.066	[0.102;0.048]
σ_{d32}	Inv Γ	0.2	2	0.220	0.240	[0.264;0.149]
σ_{d33}	Inv Γ	0.2	2	0.089	0.084	[0.113;0.059]
σ_{d34}	Inv Γ	0.2	2	0.155	0.133	[0.211;0.104]
σ_{d35}	Inv Γ	0.2	2	0.114	0.094	[0.146;0.077]
σ_{d36}	Inv Γ	0.2	2	0.099	0.109	[0.133;0.074]
σ_{d37}	Inv Γ	0.2	2	0.132	0.110	[0.186;0.087]
σ_{d38}	Inv Γ	0.2	2	0.087	0.082	[0.119;0.056]
σ_{d39}	Inv Γ	0.2	2	0.133	0.158	[0.166;0.094]
σ_{d40}	Inv Γ	0.2	2	0.123	0.095	[0.167;0.089]
σ_{d41}	Inv Γ	0.2	2	0.070	0.063	[0.098;0.047]
σ_{d42}	Inv Γ	0.2	2	0.117	0.101	[0.143;0.090]
σ_{d43}	Inv Γ	0.2	2	0.079	0.083	[0.104;0.051]
σ_{d44}	Inv Γ	0.2	2	0.069	0.064	[0.101;0.042]
σ_{d45}	Inv Γ	0.2	2	0.235	0.253	[0.265;0.178]
σ_{d46}	Inv Γ	0.2	2	0.146	0.146	[0.209;0.087]
σ_{d47}	Inv Γ	0.2	2	0.448	0.437	[0.492;0.415]
σ_{d48}	Inv Γ	0.2	2	0.412	0.437	[0.455;0.362]
σ_{d49}	Inv Γ	0.2	2	0.228	0.227	[0.267;0.195]
σ_{d50}	Inv Γ	0.2	2	0.636	0.623	[0.682;0.590]
σ_{d51}	Inv Γ	0.2	2	0.166	0.153	[0.216;0.106]
σ_{d52}	Inv Γ	0.2	2	0.126	0.140	[0.201;0.074]
σ_{d53}	Inv Γ	0.2	2	0.080	0.073	[0.108;0.054]
σ_{d54}	Inv Γ	0.2	2	0.073	0.068	[0.101;0.049]
σ_{d55}	Inv Γ	0.2	2	0.227	0.203	[0.263;0.182]
σ_{d56}	Inv Γ	0.2	2	0.142	0.167	[0.185;0.112]
σ_{d57}	Inv Γ	0.2	2	0.093	0.068	[0.135;0.060]
σ_{d58}	Inv Γ	0.2	2	0.105	0.127	[0.136;0.070]
σ_{d59}	Inv Γ	0.2	2	0.065	0.067	[0.094;0.035]
σ_{d60}	Inv Γ	0.2	2	0.067	0.064	[0.089;0.047]
σ_{d61}	Inv Γ	0.2	2	0.073	0.060	[0.100;0.044]
σ_{d62}	Inv Γ	0.2	2	0.136	0.130	[0.185;0.070]
σ_{d63}	Inv Γ	0.2	2	0.105	0.090	[0.141;0.053]
σ_{d64}	Inv Γ	0.2	2	0.515	0.500	[0.566;0.470]
σ_{d65}	Inv Γ	0.2	2	0.446	0.424	[0.516;0.386]
σ_{d66}	Inv Γ	0.2	2	0.065	0.055	[0.091;0.042]
σ_{d67}	Inv Γ	0.2	2	0.296	0.257	[0.343;0.238]
σ_{d68}	Inv Γ	0.2	2	0.082	0.064	[0.123;0.045]
σ_{d69}	Inv Γ	0.2	2	0.266	0.299	[0.313;0.216]
σ_{d70}	Inv Γ	0.2	2	0.135	0.164	[0.185;0.091]
σ_{d71}	Inv Γ	0.2	2	0.118	0.105	[0.153;0.071]
σ_{d72}	Inv Γ	0.2	2	0.332	0.340	[0.370;0.297]
σ_{d73}	Inv Γ	0.2	2	0.081	0.091	[0.103;0.056]
σ_{d74}	Inv Γ	0.2	2	0.221	0.202	[0.256;0.169]
σ_{d75}	Inv Γ	0.2	2	0.167	0.212	[0.210;0.125]
σ_{d76}	Inv Γ	0.2	2	0.188	0.182	[0.235;0.142]
σ_{d77}	Inv Γ	0.2	2	0.066	0.063	[0.098;0.043]
σ_{d78}	Inv Γ	0.2	2	0.139	0.145	[0.189;0.094]
σ_{d79}	Inv Γ	0.2	2	0.131	0.130	[0.182;0.082]

Table A.11: Prior and Posteriors - Shock Persistence of Sectoral Demand Shocks

Parameter	Prior			Posterior		
	Distribution	Prior Mean	S.D	Posterior Mean	Posterior Mode	CI
ρ_{d1}	β	0.5	0.2	0.471	0.482	[0.509;0.423]
ρ_{d2}	β	0.5	0.2	0.409	0.405	[0.470;0.361]
ρ_{d3}	β	0.5	0.2	0.646	0.641	[0.696;0.610]
ρ_{d4}	β	0.5	0.2	0.449	0.447	[0.483;0.418]
ρ_{d5}	β	0.5	0.2	0.403	0.375	[0.447;0.359]
ρ_{d6}	β	0.5	0.2	0.517	0.518	[0.551;0.476]
ρ_{d7}	β	0.5	0.2	0.372	0.357	[0.413;0.325]
ρ_{d8}	β	0.5	0.2	0.788	0.797	[0.832;0.722]
ρ_{d9}	β	0.5	0.2	0.390	0.369	[0.453;0.351]
ρ_{d10}	β	0.5	0.2	0.350	0.348	[0.445;0.286]
ρ_{d11}	β	0.5	0.2	0.177	0.158	[0.223;0.137]
ρ_{d12}	β	0.5	0.2	0.882	0.893	[0.929;0.841]
ρ_{d13}	β	0.5	0.2	0.686	0.701	[0.722;0.643]
ρ_{d14}	β	0.5	0.2	0.896	0.914	[0.937;0.818]
ρ_{d15}	β	0.5	0.2	0.885	0.880	[0.942;0.841]
ρ_{d16}	β	0.5	0.2	0.576	0.616	[0.616;0.513]
ρ_{d17}	β	0.5	0.2	0.480	0.487	[0.524;0.446]
ρ_{d18}	β	0.5	0.2	0.447	0.420	[0.475;0.414]
ρ_{d19}	β	0.5	0.2	0.474	0.470	[0.508;0.436]
ρ_{d20}	β	0.5	0.2	0.858	0.879	[0.917;0.818]
ρ_{d21}	β	0.5	0.2	0.045	0.053	[0.077;0.016]
ρ_{d22}	β	0.5	0.2	0.425	0.414	[0.467;0.349]
ρ_{d23}	β	0.5	0.2	0.711	0.742	[0.777;0.656]
ρ_{d24}	β	0.5	0.2	0.595	0.566	[0.640;0.530]
ρ_{d25}	β	0.5	0.2	0.613	0.606	[0.666;0.572]
ρ_{d26}	β	0.5	0.2	0.478	0.471	[0.519;0.428]
ρ_{d27}	β	0.5	0.2	0.399	0.357	[0.436;0.356]
ρ_{d28}	β	0.5	0.2	0.472	0.454	[0.522;0.421]
ρ_{d29}	β	0.5	0.2	0.437	0.426	[0.483;0.390]
ρ_{d30}	β	0.5	0.2	0.657	0.647	[0.698;0.621]
ρ_{d31}	β	0.5	0.2	0.408	0.423	[0.462;0.366]
ρ_{d32}	β	0.5	0.2	0.603	0.637	[0.661;0.540]
ρ_{d33}	β	0.5	0.2	0.498	0.470	[0.571;0.440]
ρ_{d34}	β	0.5	0.2	0.396	0.396	[0.439;0.357]
ρ_{d35}	β	0.5	0.2	0.284	0.302	[0.329;0.225]
ρ_{d36}	β	0.5	0.2	0.633	0.632	[0.667;0.597]
ρ_{d37}	β	0.5	0.2	0.654	0.659	[0.698;0.623]
ρ_{d38}	β	0.5	0.2	0.323	0.304	[0.358;0.280]
ρ_{d39}	β	0.5	0.2	0.533	0.541	[0.568;0.494]
ρ_{d40}	β	0.5	0.2	0.615	0.601	[0.671;0.573]
ρ_{d41}	β	0.5	0.2	0.691	0.681	[0.726;0.647]
ρ_{d42}	β	0.5	0.2	0.294	0.297	[0.350;0.219]
ρ_{d43}	β	0.5	0.2	0.344	0.353	[0.385;0.292]
ρ_{d44}	β	0.5	0.2	0.716	0.721	[0.745;0.687]
ρ_{d45}	β	0.5	0.2	0.260	0.204	[0.343;0.174]
ρ_{d46}	β	0.5	0.2	0.316	0.330	[0.347;0.282]
ρ_{d47}	β	0.5	0.2	0.695	0.687	[0.753;0.638]
ρ_{d48}	β	0.5	0.2	0.907	0.929	[0.954;0.863]
ρ_{d49}	β	0.5	0.2	0.461	0.462	[0.505;0.417]
ρ_{d50}	β	0.5	0.2	0.292	0.310	[0.327;0.265]
ρ_{d51}	β	0.5	0.2	0.943	0.959	[0.980;0.914]
ρ_{d52}	β	0.5	0.2	0.629	0.641	[0.674;0.591]
ρ_{d53}	β	0.5	0.2	0.510	0.507	[0.554;0.469]
ρ_{d54}	β	0.5	0.2	0.357	0.373	[0.391;0.326]
ρ_{d55}	β	0.5	0.2	0.527	0.553	[0.574;0.466]
ρ_{d56}	β	0.5	0.2	0.317	0.287	[0.383;0.231]
ρ_{d57}	β	0.5	0.2	0.223	0.216	[0.245;0.199]
ρ_{d58}	β	0.5	0.2	0.664	0.669	[0.697;0.637]
ρ_{d59}	β	0.5	0.2	0.546	0.536	[0.585;0.511]
ρ_{d60}	β	0.5	0.2	0.309	0.317	[0.348;0.262]
ρ_{d61}	β	0.5	0.2	0.505	0.526	[0.543;0.469]
ρ_{d62}	β	0.5	0.2	0.807	0.822	[0.877;0.747]
ρ_{d63}	β	0.5	0.2	0.224	0.225	[0.274;0.170]
ρ_{d64}	β	0.5	0.2	0.557	0.560	[0.616;0.486]
ρ_{d65}	β	0.5	0.2	0.260	0.270	[0.330;0.209]
ρ_{d66}	β	0.5	0.2	0.502	0.557	[0.544;0.451]
ρ_{d67}	β	0.5	0.2	0.583	0.573	[0.616;0.537]
ρ_{d68}	β	0.5	0.2	0.553	0.540	[0.586;0.509]
ρ_{d69}	β	0.5	0.2	0.521	0.489	[0.567;0.475]
ρ_{d70}	β	0.5	0.2	0.777	0.801	[0.840;0.735]
ρ_{d71}	β	0.5	0.2	0.427	0.441	[0.480;0.365]
ρ_{d72}	β	0.5	0.2	0.835	0.837	[0.897;0.793]
ρ_{d73}	β	0.5	0.2	0.448	0.459	[0.498;0.389]
ρ_{d74}	β	0.5	0.2	0.121	0.118	[0.164;0.073]
ρ_{d75}	β	0.5	0.2	0.407	0.401	[0.462;0.366]
ρ_{d76}	β	0.5	0.2	0.688	0.674	[0.738;0.638]
ρ_{d77}	β	0.5	0.2	0.894	0.873	[0.929;0.862]
ρ_{d78}	β	0.5	0.2	0.286	0.312	[0.355;0.245]
ρ_{d79}	β	0.5	0.2	0.030	0.034	[0.048;0.010]

Table A.12: Prior and Posteriors - Std Error of Sectoral Mark-up Shocks $\forall i \in \{M, F\}$

Parameter	Prior			Posterior		
	Distribution	Prior Mean	S.D	Posterior Mean	Posterior Mode	CI
$\sigma_{\nu_{i1}}$	Inv Γ	0.2	2	0.083	0.079	[0.108;0.054]
$\sigma_{\nu_{i2}}$	Inv Γ	0.2	2	0.072	0.066	[0.098;0.054]
$\sigma_{\nu_{i3}}$	Inv Γ	0.2	2	0.066	0.068	[0.081;0.044]
$\sigma_{\nu_{i4}}$	Inv Γ	0.2	2	0.327	0.333	[0.369;0.294]
$\sigma_{\nu_{i5}}$	Inv Γ	0.2	2	3.173	3.228	[3.230;3.122]
$\sigma_{\nu_{i6}}$	Inv Γ	0.2	2	2.896	2.927	[2.949;2.835]
$\sigma_{\nu_{i7}}$	Inv Γ	0.2	2	4.856	4.852	[4.920;4.783]
$\sigma_{\nu_{i8}}$	Inv Γ	0.2	2	0.236	0.255	[0.299;0.183]
$\sigma_{\nu_{i9}}$	Inv Γ	0.2	2	0.107	0.123	[0.147;0.062]
$\sigma_{\nu_{i10}}$	Inv Γ	0.2	2	0.413	0.386	[0.444;0.377]
$\sigma_{\nu_{i11}}$	Inv Γ	0.2	2	1.264	1.279	[1.298;1.233]
$\sigma_{\nu_{i12}}$	Inv Γ	0.2	2	1.968	1.947	[2.050;1.912]
$\sigma_{\nu_{i13}}$	Inv Γ	0.2	2	1.413	1.464	[1.451;1.371]
$\sigma_{\nu_{i14}}$	Inv Γ	0.2	2	2.054	2.074	[2.099;2.012]
$\sigma_{\nu_{i15}}$	Inv Γ	0.2	2	2.183	2.186	[2.218;2.126]
$\sigma_{\nu_{i16}}$	Inv Γ	0.2	2	0.379	0.393	[0.425;0.323]
$\sigma_{\nu_{i17}}$	Inv Γ	0.2	2	5.404	5.429	[5.474;5.347]
$\sigma_{\nu_{i18}}$	Inv Γ	0.2	2	4.810	4.849	[4.885;4.723]
$\sigma_{\nu_{i19}}$	Inv Γ	0.2	2	0.530	0.541	[0.566;0.485]
$\sigma_{\nu_{i20}}$	Inv Γ	0.2	2	0.243	0.225	[0.286;0.177]
$\sigma_{\nu_{i21}}$	Inv Γ	0.2	2	0.082	0.084	[0.104;0.056]
$\sigma_{\nu_{i22}}$	Inv Γ	0.2	2	0.090	0.065	[0.110;0.066]
$\sigma_{\nu_{i23}}$	Inv Γ	0.2	2	0.164	0.174	[0.189;0.129]
$\sigma_{\nu_{i24}}$	Inv Γ	0.2	2	0.149	0.189	[0.204;0.102]
$\sigma_{\nu_{i25}}$	Inv Γ	0.2	2	0.257	0.277	[0.310;0.197]
$\sigma_{\nu_{i26}}$	Inv Γ	0.2	2	0.325	0.321	[0.350;0.297]
$\sigma_{\nu_{i27}}$	Inv Γ	0.2	2	0.165	0.154	[0.192;0.132]
$\sigma_{\nu_{i28}}$	Inv Γ	0.2	2	0.073	0.065	[0.094;0.050]
$\sigma_{\nu_{i29}}$	Inv Γ	0.2	2	0.082	0.066	[0.117;0.050]
$\sigma_{\nu_{i30}}$	Inv Γ	0.2	2	1.597	1.646	[1.650;1.554]
$\sigma_{\nu_{i31}}$	Inv Γ	0.2	2	1.479	1.498	[1.538;1.416]
$\sigma_{\nu_{i32}}$	Inv Γ	0.2	2	1.146	1.179	[1.188;1.089]
$\sigma_{\nu_{i33}}$	Inv Γ	0.2	2	1.713	1.720	[1.761;1.620]
$\sigma_{\nu_{i34}}$	Inv Γ	0.2	2	5.133	5.163	[5.196;5.054]
$\sigma_{\nu_{i35}}$	Inv Γ	0.2	2	2.767	2.822	[2.819;2.716]
$\sigma_{\nu_{i36}}$	Inv Γ	0.2	2	8.799	8.853	[8.904;8.683]
$\sigma_{\nu_{i37}}$	Inv Γ	0.2	2	3.831	3.866	[3.915;3.758]
$\sigma_{\nu_{i38}}$	Inv Γ	0.2	2	5.297	5.351	[5.359;5.234]
$\sigma_{\nu_{i39}}$	Inv Γ	0.2	2	4.473	4.541	[4.540;4.391]
$\sigma_{\nu_{i40}}$	Inv Γ	0.2	2	3.728	3.760	[3.774;3.676]
$\sigma_{\nu_{i41}}$	Inv Γ	0.2	2	3.096	3.107	[3.163;3.035]
$\sigma_{\nu_{i42}}$	Inv Γ	0.2	2	2.964	2.996	[3.024;2.903]
$\sigma_{\nu_{i43}}$	Inv Γ	0.2	2	2.013	2.004	[2.066;1.960]
$\sigma_{\nu_{i44}}$	Inv Γ	0.2	2	4.138	4.186	[4.237;4.063]
$\sigma_{\nu_{i45}}$	Inv Γ	0.2	2	1.557	1.573	[1.604;1.518]
$\sigma_{\nu_{i46}}$	Inv Γ	0.2	2	1.493	1.559	[1.572;1.440]
$\sigma_{\nu_{i47}}$	Inv Γ	0.2	2	2.545	2.567	[2.583;2.511]
$\sigma_{\nu_{i48}}$	Inv Γ	0.2	2	0.860	0.915	[0.898;0.795]
$\sigma_{\nu_{i49}}$	Inv Γ	0.2	2	1.894	1.947	[1.961;1.848]
$\sigma_{\nu_{i50}}$	Inv Γ	0.2	2	1.290	1.304	[1.326;1.256]
$\sigma_{\nu_{i51}}$	Inv Γ	0.2	2	1.342	1.357	[1.382;1.305]
$\sigma_{\nu_{i52}}$	Inv Γ	0.2	2	2.836	2.828	[2.889;2.787]
$\sigma_{\nu_{i53}}$	Inv Γ	0.2	2	4.116	4.157	[4.207;4.051]
$\sigma_{\nu_{i54}}$	Inv Γ	0.2	2	1.394	1.415	[1.448;1.352]
$\sigma_{\nu_{i55}}$	Inv Γ	0.2	2	0.847	0.849	[0.873;0.822]
$\sigma_{\nu_{i56}}$	Inv Γ	0.2	2	1.595	1.612	[1.646;1.547]
$\sigma_{\nu_{i57}}$	Inv Γ	0.2	2	1.564	1.566	[1.604;1.520]
$\sigma_{\nu_{i58}}$	Inv Γ	0.2	2	2.035	2.054	[2.074;2.001]
$\sigma_{\nu_{i59}}$	Inv Γ	0.2	2	2.178	2.190	[2.244;2.123]
$\sigma_{\nu_{i60}}$	Inv Γ	0.2	2	1.870	1.896	[1.928;1.829]
$\sigma_{\nu_{i61}}$	Inv Γ	0.2	2	1.763	1.777	[1.814;1.712]
$\sigma_{\nu_{i62}}$	Inv Γ	0.2	2	1.551	1.580	[1.637;1.502]
$\sigma_{\nu_{i63}}$	Inv Γ	0.2	2	1.220	1.229	[1.267;1.182]
$\sigma_{\nu_{i64}}$	Inv Γ	0.2	2	2.590	2.604	[2.630;2.548]
$\sigma_{\nu_{i65}}$	Inv Γ	0.2	2	0.858	0.865	[0.911;0.801]
$\sigma_{\nu_{i66}}$	Inv Γ	0.2	2	3.420	3.500	[3.468;3.377]
$\sigma_{\nu_{i67}}$	Inv Γ	0.2	2	1.899	1.917	[1.942;1.858]
$\sigma_{\nu_{i68}}$	Inv Γ	0.2	2	1.024	1.028	[1.066;0.984]
$\sigma_{\nu_{i69}}$	Inv Γ	0.2	2	0.770	0.793	[0.812;0.714]
$\sigma_{\nu_{i70}}$	Inv Γ	0.2	2	0.656	0.653	[0.695;0.620]
$\sigma_{\nu_{i71}}$	Inv Γ	0.2	2	0.737	0.757	[0.779;0.684]
$\sigma_{\nu_{i72}}$	Inv Γ	0.2	2	1.422	1.428	[1.455;1.390]
$\sigma_{\nu_{i73}}$	Inv Γ	0.2	2	0.893	0.905	[0.929;0.841]
$\sigma_{\nu_{i74}}$	Inv Γ	0.2	2	0.062	0.058	[0.080;0.042]
$\sigma_{\nu_{i75}}$	Inv Γ	0.2	2	0.206	0.246	[0.265;0.159]
$\sigma_{\nu_{i76}}$	Inv Γ	0.2	2	0.366	0.364	[0.401;0.325]
$\sigma_{\nu_{i77}}$	Inv Γ	0.2	2	0.370	0.358	[0.416;0.324]
$\sigma_{\nu_{i78}}$	Inv Γ	0.2	2	0.259	0.295	[0.293;0.224]
$\sigma_{\nu_{i79}}$	Inv Γ	0.2	2	0.090	0.101	[0.117;0.059]

Table A.13: Prior and Posteriors - Shock Persistence of Sectoral Mark-up Shocks $\forall i \in \{M, F\}$

Parameter	Prior			Posterior		
	Distribution	Prior Mean	S.D	Posterior Mean	Posterior Mode	CI
$\rho_{\nu_{i1}}$	β	0.5	0.2	0.200	0.160	[0.251;0.141]
$\rho_{\nu_{i2}}$	β	0.5	0.2	0.380	0.359	[0.409;0.354]
$\rho_{\nu_{i3}}$	β	0.5	0.2	0.532	0.516	[0.591;0.457]
$\rho_{\nu_{i4}}$	β	0.5	0.2	0.216	0.227	[0.250;0.185]
$\rho_{\nu_{i5}}$	β	0.5	0.2	0.027	0.013	[0.052;0.004]
$\rho_{\nu_{i6}}$	β	0.5	0.2	0.015	0.016	[0.024;0.003]
$\rho_{\nu_{i7}}$	β	0.5	0.2	0.004	0.003	[0.007;0.001]
$\rho_{\nu_{i8}}$	β	0.5	0.2	0.329	0.347	[0.380;0.269]
$\rho_{\nu_{i9}}$	β	0.5	0.2	0.689	0.684	[0.733;0.645]
$\rho_{\nu_{i10}}$	β	0.5	0.2	0.782	0.815	[0.825;0.749]
$\rho_{\nu_{i11}}$	β	0.5	0.2	0.476	0.477	[0.512;0.424]
$\rho_{\nu_{i12}}$	β	0.5	0.2	0.103	0.115	[0.138;0.070]
$\rho_{\nu_{i13}}$	β	0.5	0.2	0.414	0.403	[0.452;0.357]
$\rho_{\nu_{i14}}$	β	0.5	0.2	0.253	0.257	[0.287;0.209]
$\rho_{\nu_{i15}}$	β	0.5	0.2	0.140	0.172	[0.166;0.105]
$\rho_{\nu_{i16}}$	β	0.5	0.2	0.322	0.312	[0.371;0.248]
$\rho_{\nu_{i17}}$	β	0.5	0.2	0.701	0.757	[0.744;0.671]
$\rho_{\nu_{i18}}$	β	0.5	0.2	0.970	0.981	[0.990;0.955]
$\rho_{\nu_{i19}}$	β	0.5	0.2	0.284	0.261	[0.325;0.235]
$\rho_{\nu_{i20}}$	β	0.5	0.2	0.406	0.399	[0.448;0.362]
$\rho_{\nu_{i21}}$	β	0.5	0.2	0.335	0.330	[0.385;0.286]
$\rho_{\nu_{i22}}$	β	0.5	0.2	0.429	0.416	[0.511;0.364]
$\rho_{\nu_{i23}}$	β	0.5	0.2	0.289	0.265	[0.329;0.249]
$\rho_{\nu_{i24}}$	β	0.5	0.2	0.432	0.473	[0.461;0.407]
$\rho_{\nu_{i25}}$	β	0.5	0.2	0.263	0.278	[0.298;0.224]
$\rho_{\nu_{i26}}$	β	0.5	0.2	0.684	0.674	[0.757;0.610]
$\rho_{\nu_{i27}}$	β	0.5	0.2	0.273	0.262	[0.307;0.215]
$\rho_{\nu_{i28}}$	β	0.5	0.2	0.571	0.597	[0.609;0.528]
$\rho_{\nu_{i29}}$	β	0.5	0.2	0.442	0.406	[0.529;0.386]
$\rho_{\nu_{i30}}$	β	0.5	0.2	0.171	0.184	[0.211;0.127]
$\rho_{\nu_{i31}}$	β	0.5	0.2	0.543	0.522	[0.588;0.486]
$\rho_{\nu_{i32}}$	β	0.5	0.2	0.427	0.413	[0.460;0.390]
$\rho_{\nu_{i33}}$	β	0.5	0.2	0.173	0.163	[0.218;0.134]
$\rho_{\nu_{i34}}$	β	0.5	0.2	0.977	0.987	[0.994;0.959]
$\rho_{\nu_{i35}}$	β	0.5	0.2	0.613	0.637	[0.646;0.569]
$\rho_{\nu_{i36}}$	β	0.5	0.2	0.988	0.991	[0.996;0.980]
$\rho_{\nu_{i37}}$	β	0.5	0.2	0.192	0.182	[0.218;0.163]
$\rho_{\nu_{i38}}$	β	0.5	0.2	0.071	0.090	[0.099;0.045]
$\rho_{\nu_{i39}}$	β	0.5	0.2	0.843	0.861	[0.878;0.814]
$\rho_{\nu_{i40}}$	β	0.5	0.2	0.300	0.276	[0.346;0.263]
$\rho_{\nu_{i41}}$	β	0.5	0.2	0.037	0.045	[0.060;0.008]
$\rho_{\nu_{i42}}$	β	0.5	0.2	0.567	0.592	[0.611;0.518]
$\rho_{\nu_{i43}}$	β	0.5	0.2	0.548	0.528	[0.578;0.522]
$\rho_{\nu_{i44}}$	β	0.5	0.2	0.873	0.890	[0.905;0.837]
$\rho_{\nu_{i45}}$	β	0.5	0.2	0.449	0.439	[0.502;0.407]
$\rho_{\nu_{i46}}$	β	0.5	0.2	0.681	0.661	[0.727;0.619]
$\rho_{\nu_{i47}}$	β	0.5	0.2	0.375	0.406	[0.413;0.344]
$\rho_{\nu_{i48}}$	β	0.5	0.2	0.524	0.519	[0.561;0.483]
$\rho_{\nu_{i49}}$	β	0.5	0.2	0.134	0.147	[0.200;0.046]
$\rho_{\nu_{i50}}$	β	0.5	0.2	0.267	0.247	[0.303;0.221]
$\rho_{\nu_{i51}}$	β	0.5	0.2	0.773	0.793	[0.810;0.738]
$\rho_{\nu_{i52}}$	β	0.5	0.2	0.049	0.042	[0.089;0.014]
$\rho_{\nu_{i53}}$	β	0.5	0.2	0.926	0.985	[0.962;0.883]
$\rho_{\nu_{i54}}$	β	0.5	0.2	0.803	0.819	[0.827;0.773]
$\rho_{\nu_{i55}}$	β	0.5	0.2	0.563	0.563	[0.604;0.528]
$\rho_{\nu_{i56}}$	β	0.5	0.2	0.438	0.414	[0.463;0.409]
$\rho_{\nu_{i57}}$	β	0.5	0.2	0.287	0.287	[0.326;0.247]
$\rho_{\nu_{i58}}$	β	0.5	0.2	0.687	0.665	[0.724;0.657]
$\rho_{\nu_{i59}}$	β	0.5	0.2	0.020	0.016	[0.034;0.002]
$\rho_{\nu_{i60}}$	β	0.5	0.2	0.786	0.811	[0.845;0.751]
$\rho_{\nu_{i61}}$	β	0.5	0.2	0.955	0.965	[0.980;0.928]
$\rho_{\nu_{i62}}$	β	0.5	0.2	0.451	0.451	[0.512;0.406]
$\rho_{\nu_{i63}}$	β	0.5	0.2	0.245	0.228	[0.300;0.178]
$\rho_{\nu_{i64}}$	β	0.5	0.2	0.106	0.089	[0.132;0.056]
$\rho_{\nu_{i65}}$	β	0.5	0.2	0.816	0.848	[0.858;0.763]
$\rho_{\nu_{i66}}$	β	0.5	0.2	0.145	0.129	[0.192;0.104]
$\rho_{\nu_{i67}}$	β	0.5	0.2	0.120	0.130	[0.150;0.089]
$\rho_{\nu_{i68}}$	β	0.5	0.2	0.583	0.533	[0.626;0.551]
$\rho_{\nu_{i69}}$	β	0.5	0.2	0.617	0.605	[0.653;0.592]
$\rho_{\nu_{i70}}$	β	0.5	0.2	0.701	0.690	[0.744;0.661]
$\rho_{\nu_{i71}}$	β	0.5	0.2	0.519	0.536	[0.580;0.476]
$\rho_{\nu_{i72}}$	β	0.5	0.2	0.308	0.335	[0.337;0.274]
$\rho_{\nu_{i73}}$	β	0.5	0.2	0.520	0.516	[0.586;0.461]
$\rho_{\nu_{i74}}$	β	0.5	0.2	0.392	0.386	[0.417;0.372]
$\rho_{\nu_{i75}}$	β	0.5	0.2	0.686	0.666	[0.734;0.646]
$\rho_{\nu_{i76}}$	β	0.5	0.2	0.339	0.323	[0.377;0.309]
$\rho_{\nu_{i77}}$	β	0.5	0.2	0.638	0.588	[0.693;0.590]
$\rho_{\nu_{i78}}$	β	0.5	0.2	0.686	0.708	[0.747;0.638]
$\rho_{\nu_{i79}}$	β	0.5	0.2	0.434	0.457	[0.476;0.390]