# Decomposing the (In)Sensitivity of CPI to Exchange Rates

Marco Errico*

Click here for most recent version

November 16, 2022

**Abstract**

I study the relative importance of domestic frictions and border price insensitivity for the response of domestic consumer prices (CPI) to exchange rate fluctuations. Using firm and transaction-level data from Chile, I estimate that the presence of domestic frictions — distribution costs, variable markups and nominal rigidities — reduce the responsiveness of domestic CPI to exchange rate fluctuations by 60% relatively to an economy that abstract away from it. These frictions are quantitatively more important than the insensitivity of border prices. The presence of domestic frictions also matters for the channels of CPI sensitivity: contrary to prior work, most of the sensitivity arises from the change in the price of imported consumption goods. This channel is more important than the costs arising from imported inputs in the production of domestic goods. The reason is that domestic frictions dampen the price sensitivity of domestically produced goods relatively more. Furthermore, the sensitivity varies across products because of the heterogeneity in domestic frictions, import exposure, and consumption shares. The heterogeneity matters for the overall (in)sensitivity as domestic products with higher import exposure face larger frictions and have lower consumption shares. Ignoring the heterogeneity identifies the wrong products from which most of the sensitivity arises, with implications for monetary policy targeting in open economy and redistribution dynamics.

*Keywords:* Exchange Rates, Pass-Through, Import Exposure, Variable Markups, Input-Output Linkages.
*JEL:* F14, F31, D57, E31, L10, F40.

*Department of Economics, Boston College. Contact: marco.errico@bc.edu.
I am grateful to Jaromir Nosal, Rosen Valchev, Danial Lashkari and Jim Anderson for the priceless support and continuous guidance. I thank my discussant Joaquim Blaum and Andrea Ariu, Marco Brianti, Carter Bryson, Pietro Dall'Ara, Tarek Hassan, Gregor Jarosch, Matteo Maggiori, Diego Perez, Alexander Richter, Matthew Rognlie, Martin Rotemberg, Giacomo Rubbini, Paul Sarkis and Robert Staiger for insightful conversations and comments. I also thank all participants at the Dissertation Workshop, BC International Trade Seminar, BC Macro Lunch and the 2022 BC-BU GLMM for their feedback. All errors are my own. The paper previously circulated with the title "Impact of Import Relationships on Inflation Dynamics".

# 1 Introduction

The relationship between domestic prices (Consumer Price Index, CPI) and exchange rates is a central question in international economics, with implications from optimal monetary policy in open economy to domestic redistribution dynamics.[1] Figure 1 documents that, on average, CPI changes by 0.76% after a 10% exchange rate change in Chile between 2009 and 2019. Thus, exchange rate changes are only partially transmitted to domestic prices, in line with the extensive evidence documenting that CPI responds weakly to exchange rate fluctuations (Goldberg and Campa, 2010; Gopinath, 2015). In order to rationalize the weak response of CPI, the literature has focused on the low sensitivity of the border price of imported goods with respect to exchange rate fluctuations.[2] In other words, the common assumption is that domestic prices do not change because the price of imported goods is not influenced by exchange rate fluctuations. However, back-of-the-envelope calculations show that the low sensitivity of border prices imply a sensitivity of domestic prices much higher than the estimated one.[3]

In this paper, I provide extensive empirical results to document that the insensitivity of domestic prices emerges mainly because of the existence of several domestic frictions, instead of border price insensitivity. I start by developing a framework to quantify what the sensitivity of CPI to exchange rates is expected to be, given the existence of insensitivity in border prices and domestic frictions (Goldberg and Campa, 2010). CPI is sensitive to exchange rate fluctuations because of the consumption of imported goods (direct exposure), the use of imported intermediate inputs in the production of domestic goods and the presence of domestic input-output linkages (indirect exposure). The model aims at capturing the role that domestic frictions — distribution costs, variable markups and nominal rigidities — have in the domestic transmission of exchange rate fluctuations to CPI. I compare the importance of domestic frictions to the effect of border price insensitivity, which is taken as given.

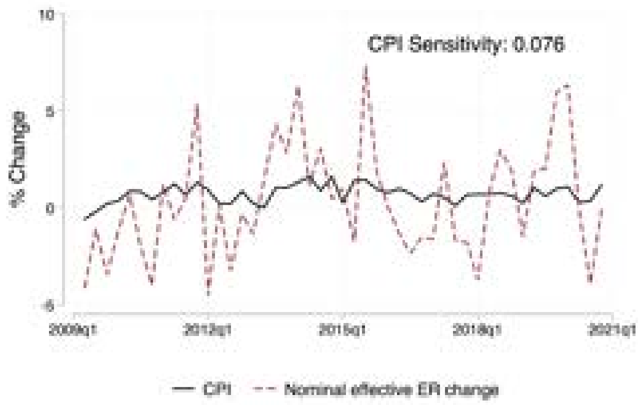
The presence of domestic frictions introduces a wedge between the border price of imports and producers' costs, on one side, and the domestic retail price, on the other, dampening the response of the latter to exchange rate changes and making CPI less sen-

[1] One fundamental aspect for monetary policy trade-offs in open economy is which inflation rate is relevant to policymakers, which, in turn, depends on the exchange rate pass-through into domestic prices (Mishkin, 2008; Benigno and Benigno, 2003; Corsetti et al., 2010). Similarly, exchange rate fluctuations influence domestic redistribution dynamics as firms and consumers use different mixes of domestic and imported products (Cravino and Levchenko, 2017a; Jaravel, 2021). Moreover, understanding relationship between CPI and exchange rates, and the factors influencing it has broad implications for the transmission of international shocks, international business cycle comovements and external imbalances (Corsetti et al., 2008; Backus and Smith, 1993).

[2] See Burstein and Gopinath (2014) for a survey.

[3] For the case of Chile, the estimated incomplete exchange rate pass-through into border prices is about 0.75. Knowing that the share of imported final consumption is 15% and the share of imported intermediate inputs in total production costs is 25%, the sensitivity of domestic prices should be around 0.27, much higher than the 0.076 reported in Figure 1.

Figure 1: Estimated CPI Sensitivity to Exchange Rates




The figure plots the relationship between the change in domestic CPI (black, solid line) and the trade-weighted measure of nominal exchange rate (red, dashed line). Inflation and exchange rate data are sourced from IMF and Datastream, respectively. Trade shares are computed from the universe of import transactions from 2009 to 2020. The coefficient reported is the contemporaneous CPI sensitivity estimated from Equation (26) in Appendix C.

sitive. Distribution costs, i.e. transportation, insurance and wholesaling costs represent a substantial component of retail prices (Goldberg and Campa, 2010; Burstein et al., 2003). This reduces the exposure of CPI to exchange rates by reducing the weight of import border prices and domestic producers' cost in CPI. Similarly, the presence of variable markups and nominal rigidities in the domestic economy creates additional wedges between the change in domestic producers' costs following an exchange rate change and the retail price of domestic goods (Klenow and Willis, 2016; Nakamura and Steinsson, 2008). The pass-through rate of marginal cost changes is incomplete because of variable markups. In other words, domestic firms do not fully adjust their price to changes in their own cost because they absorb part of the cost change in their own margins by modifying the markup they charge. Moreover, the price of domestic goods is sticky because domestic firms face nominal rigidities in the spirit of Calvo.

I leverage several, highly disaggregated data sources from Chile to discipline the rich structure of the model and gauge the role of each domestic frictions relative to border price insensitivity. I construct a granular, product-level (180×180) input-output table for the Chilean economy to measure the channels through which exchange rate fluctuations are transmitted to CPI. The input-output table allows me to account for direct and indirect exposure to imports and to capture the transmission of exchange rate changes through the domestic network (Basu, 1994; Rubbo, 2020). I calibrate each domestic friction using micro-level data, allowing me to account for their heterogeneity at the product level. Specifically, I compute distribution costs for each product from the input-output table, differentiating according to their origin (domestic vs imported) and use (intermediate vs final consumption). I estimate markups using state-of-the-art production function estimation methods and firm-level data from Chile to calibrate variable markups and markup elasticities at the sectoral level. Similarly, I calibrate nominal rigidities using micro-level estimates of price adjustment frequencies from Chile. Lastly, I use the universe of import transaction data to calibrate, in reduced form, the exchange rate pass-through into border prices and its heterogeneity across products due to importers' heterogeneity.

The calibrated model including both border price insensitivity and domestic frictions matches the untargeted estimated sensitivity of domestic prices to exchange rate fluctuations (Figure 1). Combining domestic frictions and border price insensitivity allows to explain the insensitivity of CPI with respect to exchange rates documented in Figure 1 in its entirety. This supports the importance of accounting for domestic frictions, the relevance of the modelling choices and the validity of the calibration strategy, providing a benchmark for future empirical studies on CPI sensitivity to exchange rates.

I find that domestic frictions are more important than the insensitivity of border prices in explaining the insensitivity of domestic prices to exchange rates, Figure 1. Relative to an economy where exchange rate changes are passed entirely into import and domestic prices, the presence of domestic frictions reduces the sensitivity of CPI with respect to exchange rates by 60%. On the contrary, accounting for border price insensitivity reduces CPI sensitivity by 40%. Thus, by dampening the domestic transmission of exchange rate fluctuations, the insensitivity of domestic prices emerges mainly because of the existence of several domestic frictions. Moreover, each individual friction substantially contributes to the overall insensitivity of domestic prices. Distribution costs, variable markups and nominal rigidities reduce the sensitivity of CPI by approximately 35%, 20% and 15%, respectively, suggesting the importance of jointly modelling these frictions.

I gauge the implications for domestic prices quantifying the relative importance of domestic frictions and insensitivity of border prices during the depreciation of the Chilean peso triggered by the *"Estallido Social"* in 2019.[4] Following the 10% depreciation of the Chilean peso between 2019Q3 and 2020Q1, the price of imported goods rose, fueling higher domestic inflation. Through the lens of the calibrated model, the presence of domestic friction insulated domestic inflation, reducing the domestic inflation rate by 50% (0.6 p.p. lower at the quarterly level), twice as much as the contribution of border price insensitivity (0.3 p.p. lower).

Accounting for domestic frictions provides novel insights also on the dominant channel for the sensitivity of CPI to exchange rate fluctuations. In contrast to previous literature, I find that the presence of domestic friction implies that the dominant channel for the sensitivity of CPI is through the presence of imported goods in the final consumption basket, also known as direct exposure. This is in contrast to previous quantification exercises showing that direct exposure is as relevant as indirect exposure, where the latter

[4] The "Estallido Social " (social outburst) refers to a series of massive and severe riots in Chile between October 2019 and March 2020. The riots triggered a major devaluation of the Chilean peso against all major currencies until the Central Bank of Chile intervention in late November.

instead arises from the use of imported intermediate inputs in the production of domestic goods (Goldberg and Campa, 2010).[5] The conflicting evidence can be rationalized by the presence of domestic frictions. Domestic frictions not only reduce the sensitivity of all prices, but make the price of domestically produced goods relatively more insensitive than the price of imported goods. One of the reasons is that domestic frictions dampen the spillover effects of the domestic input-output network, reducing the role of indirect import exposure.

Calibrating the model at product-level unveils a rich heterogeneity in the sensitivity to exchange rates across products, with implications for inflation targeting and redistribution. The sensitivity varies across products because of the heterogeneity in domestic frictions, import exposure, consumption shares, and border price sensitivity. These different sources of heterogeneity matter for the overall (in)sensitivity as domestic products with higher import exposure in production face larger distribution costs, larger real rigidities and have lower consumption shares. Moreover, the identity of the products transmitting the exchange rate fluctuations the most varies when I take into account different subsets of frictions. Ignoring any friction or their heterogeneity has implications for inflation targeting and redistribution: optimal policy requires knowing what products are contributing the most and therefore what prices to target (Pasten et al., 2020; Rubbo, 2020). Similarly, consumers and firms are differentially exposed to exchange rate fluctuations since they use different mixes of imported and domestic goods (Jaravel, 2021).

Incomplete pass-through into border price explains part of the low sensitivity of CPI to exchange rate fluctuations and part of its quantitative role arises because of importers' heterogeneity. I show that importers' heterogeneity in terms of age, size and market power, and presence of trade relationships matters for the sensitivity of border and domestic prices. Specifically, I measure these dimensions with a measure of importers' experience and find that importers with longer experience have larger market shares and face a lower pass-through rate of exchange rate fluctuations into border prices. Importers' heterogeneity reduces CPI sensitivity by 20%. Moreover, the rise in importers' experience accounts for 40% of the decline in CPI sensitivity to exchange rates over the period 2009-2019 (Campa and Goldberg, 2005; Camatte et al., 2021; Georgiadis et al., 2020).

**Prior Work:** This paper is related to several strands of literature. First, it contributes to the literature studying the low sensitivity of domestic inflation to exchange rate fluctuations. Goldberg and Campa (2010) quantify CPI sensitivity accounting for the effects of import exposure and distribution costs for a set of OECD economies, and document that the main channel for CPI sensitivity is through the costs arising from imported input used in goods production (indirect exposure), as opposed to imported final consumption

[5] Goldberg and Campa (2010) focuses on a group of OECD economies. Chile's exposure to imports is quantitatively similar to the average exposure of OECD countries.

(direct exposure). In my analysis, I extend their framework to include a more accurate and comprehensive characterization of the domestic economy and its (heterogeneous) frictions. By accounting for domestic frictions, the main channel for CPI sensitivity changes as imported goods directly consumed are more important than imported input use in goods production. Burstein et al. (2003) and Corsetti and Dedola (2005) also show that distribution costs dampen the response of import and consumer prices to exchange rate changes, but fall short in combining them with other leading frictions or accounting for their heterogeneity and interactions.

My work is connected to the vast literature studying the incomplete pass-through rate into border prices and its determinants.[6] Gopinath and Itskhoki (2011) show that both nominal and real rigidities are necessary to quantitatively account for the response of border prices to exchange rates. I complement their work by showing that the effects of these frictions are not limited to border prices but are relevant also for the response of domestic price to exchange rates. In addition, I document that incomplete pass-through into border prices is not the main driver of the low sensitivity of domestic prices, as domestic frictions account for 60% of the insensitivity of CPI.

Prior work focuses on the firm-level determinants of incomplete pass-through into border prices, such as firm size and market share (Berman et al., 2012; Atkeson and Burstein, 2008), imported inputs (Amiti et al., 2014), strategic complementarities (Amiti et al., 2019), product quality (Chen and Juvenal, 2016) and bargaining and buyer market power (Drozd and Nosal, 2012; Heise, 2019; Alviarez et al., 2021; Errico, 2022).[7] I contribute to this literature by quantifying the aggregate relevance of micro-level determinants of heterogeneous pass-through rates, as I account for the heterogeneity in border price pass-through due to importers' experience.

My work is related to the literature that focuses on production networks, heterogeneity in frictions and propagation of shocks.[8] Rubbo (2020) and Pasten et al. (2020) show, in closed economy, that heterogeneity in price rigidity is key for the transmission of monetary shocks, whereas I focus on different heterogeneous domestic frictions, their interactions and their role for the transmission of exchange rate changes. Dhyne et al. (2021) quantify the propagation of foreign demand shocks using domestic firm-to-firm transactions. Using Chilean data, Huneeus (2018) focuses on the effects of foreign demand shocks in a model with endogenous network. Relative to these papers, I combine input-output tables and product-level frictions to describe the domestic economy and study the transmission of exchange rate changes into domestic prices. Di Giovanni et al. (2017), Cravino and Levchenko (2017b) and Di Giovanni and Levchenko (2010) study the role

[6] See Burstein and Gopinath (2014) and Goldberg and Hellerstein (2008) for recent surveys.

[7] Other related papers are Neiman (2010), which focuses on the effect of intra-firm and arm-length relationships, and Gopinath et al. (2010) and Chen et al. (2022), that study the effect of invoicing choices on pass-through.

[8] See Carvalho and Tahbaz-Salehi (2019) for a recent survey.

of multinational firms and international input-output linkages for the transmission of productivity and inflation shocks across borders. My analysis complements theirs in focusing on the domestic transmission of exchange rate changes.

Finally, my paper is related to the literature documenting a long-run decline in domestic price sensitivity to exchange rate fluctuations. Auer et al. (2019), Camatte et al. (2021) and Georgiadis et al. (2020) use aggregate global input-output table to show that CPI sensitivity to exchange rates decreases as global value chain (GVC) participation and trade openness rise. My work is complementary to theirs as I use micro-level data to quantify the aggregate effects of importers' experience, which relate to prolonged participation in international markets and GVC. Consistent with the literature, I find that a substantial part of the long-run decline can be explained by rising importers' experience.[9]

The rest of the paper is structured as follows. In Section 2, I present my modelling approach, beginning with a price aggregator and then presenting the model of pass-through, with particular attention to the role of leading domestic frictions. Section 3 discusses the calibration strategy of the model in detail and Section 4 presents the main results on the decomposition of the (in)sensitivity of domestic prices to exchange rates. Section 5 concludes.

# 2 A Model of Exchange Rate Pass-Through into CPI

In this section, I derive a set of measurement equations for the pass-through of exchange rate fluctuations into domestic prices (CPI) to decompose the role that domestic forces and border price response play for the sensitivity of CPI.

The focus of the modelling approach is characterizing the domestic transmission of exchange rate fluctuations. I describe a theoretical framework that formalizes the domestic channels and frictions influencing the domestic transmission of exchange rate fluctuations into the CPI. I account for incomplete and heterogeneous pass-through into border prices, but I abstracts away from any micro-foundation and directly disciplined it using import transaction data.

I propose a parsimonious, one-period, partial-equilibrium, multi-product framework in the spirit of Goldberg and Campa (2010). I combine and extend several elements that affect the domestic transmission of (exchange rate) shocks previously studied in the literature, such as distribution costs (Burstein et al., 2003; Corsetti and Dedola, 2005), variable markups (Goldberg and Verboven, 2001), imported inputs in the production of domestic

[9] The quantitative importance of importers' experience and GVC participation is of relevance also for the missing inflation puzzle: Heise et al. (2022) show that global factors, like imported products and import competition, account for part of the growing disconnect between domestic inflation and unemployment.

products (Goldberg and Campa, 2010) and roundabout production (Basu, 1994), and nominal rigidities (Gopinath and Itskhoki, 2011). The model allows to outline the key components influencing the sensitivity of domestic prices to exchange rate fluctuations, linking the behavior of border prices to the dynamics of domestic CPI, and perform an accurate calibration exercise to quantitatively assess their individual role.

## 2.1 Set up

The section introduces the assumptions about preferences, production, and frictions. I then derive a measurement equation for the pass-through rate of exchange rate fluctuations into domestic inflation.

**Price Aggregator.** The preferences of the domestic representative household are given by

$$W(C, L) = U(C) - V(L), \tag{1}$$

where $C$ and $L$ represent the household's final consumption and total labor supply, respectively.[10] I assume domestic households consume N sectoral goods $i \in \{1, \cdot, N\}$.[11] Specifically, the final consumption basket of the household, $C$, is given by a homogeneous of degree one consumption aggregator $\mathcal{C}$ of the individual sectoral goods, $C = \mathcal{C}(c_1, \cdot, c_N)$. The household's utility maximization problem is subject to a standard budget constraint given by:

$$PC \equiv \sum_{i=1}^{N} p_i c_i \leqslant wL + \sum_{i=1}^{n_D} \int_0^1 \pi_{ik} dk, \tag{2}$$

where $P$ is the nominal price index of the final consumption bundle; $wL$ is the labor income; and the last term captures the dividends from owning the domestic firms.

I assume that $C$ takes the form of a Cobb-Douglas aggregator as follows:

$$C(c_1, \cdot, c_N) = \prod_{i=1}^{N} \left(\frac{c_i}{\beta_i}\right)^{\beta_i}, \qquad \text{with } \sum_{i=1}^{N} \beta_i = 1 \tag{3}$$

where $c_i$ is the amount of good $i$ consumed and the constants $\beta_i \geqslant 0$ capture the share of each good in the household's final consumption.

The utility-based final consumption price index, which is the model-implied measure of CPI, is then given by:

$$P(p_1, \cdot, p_n) = \prod_{i=1}^{N} p_i^{\beta_i}, \tag{4}$$

where $p_i$ is the retail price of the good of industry $i$.

10 Typical regularity conditions are imposed on $U$ and $V$: strictly increasing, twice differentiable, and $U'' < 0$, $V'' > 0$ and the Inada conditions are satisfied.

11 I use $i$ to indicate both the good and the industry that produces the good.

Therefore, the pass-through of exchange rates into CPI (the elasticity of CPI to changes in nominal exchange rates, $e$), $\eta^{P,e}$, is given by:

$$\eta^{P,e} \equiv \frac{d \log P}{d \log e} = \boldsymbol{\beta} \times \boldsymbol{\eta}^{\mathbf{p},e}, \tag{5}$$

where $\boldsymbol{\beta}$ refers to the $N \times 1$ vector of expenditure shares, $(\beta_1, \cdot, \beta_N)$, and $\boldsymbol{\eta}^{\mathbf{p},e}$ to the $N \times 1$ vector of price elasticities, $(\eta^{p_1,e}, \cdot, \eta^{p_N,e})^T$.

The pass-through of exchange rate movements into CPI is a weighted average of the pass-through rates into the prices all goods consumed in the final consumption basket. Given the Cobb-Douglas specification in Equation (3), the relative weights correspond to the expenditure shares in total consumption, $\beta_i = \frac{p_i c_i}{PC}$.

I assume that a subset $n_F$ ($n_D = N - n_F$) of sectoral goods are imported (produced domestically).[12] In this way, I can disentangle the effects of direct and indirect import exposure. The former refers to the presence of imported final consumption goods, while the latter accounts for the use of imported intermediate inputs in the production of domestic goods. Highlighting this decomposition, Equation (5) can be rewritten as:

$$\eta^{P,e} = \boldsymbol{\beta} \times \boldsymbol{\eta}^{\mathbf{p},e} = \underbrace{\boldsymbol{\beta}^D \times \boldsymbol{\eta}^{\mathbf{p}^D,e}}_{\substack{\text{Indirect exposure} \\ \text{(Imported Intermediate Inputs)}}} + \underbrace{\boldsymbol{\beta}^F \times \boldsymbol{\eta}^{\mathbf{p}^F,e}}_{\substack{\text{Direct exposure} \\ \text{(Imported Final Consumption)}}}, \tag{6}$$

where $\eta^{\mathbf{p}^D,e}$ ($\eta^{\mathbf{p}^D,e}$) is the vector of pass-through rates into the retail price of a domestically (imported) sectoral goods.

In the following paragraphs, I first characterize the sensitivity of domestically produced goods, $\eta^{\mathbf{p}^D,e}$ in Equation (6), by introducing several elements that influence the transmission of exchange rate fluctuations. I then elaborate further on the sensitivity of imported goods, $\eta^{\mathbf{p}^D,e}$.

**Production and Price Elasticity of Domestic Goods, $\eta^{\mathbf{p}^D,e}$.** I assume that each domestic sectoral good, $i \in n_D$, is produced by a local competitive distributor by aggregating a mass of sectoral varieties, La'O and Tahbaz-Salehi (2022). In turn, sectoral varieties are produced by a continuum of domestic monopolistically competitive firms, indexed by $k \in [0, 1]$.

The competitive distributor of industry $i \in n_D$ aggregates the mass of differentiated varieties into an homogeneous sectoral good, $y_i$, using an homothetic Kimball aggregator, Kimball (1995):

$$\sum_k A_i \mathcal{K}_i \left( \frac{y_{ik}}{y_i} \right) = 1, \tag{7}$$

where $y_{ik}$ is the consumption of variety $k$ in industry $i$, and $A_i$ is a demand shifter;

[12] I label a sectoral good $i \in n_F$ ($i \in n_D$) as "imported" ("domestic").

$\mathcal{K}(\cdot)$ is such that $\mathcal{K}(\cdot) > 0$, $\mathcal{K}'(\cdot) > 0$, $\mathcal{K}''(\cdot) < 0$ and $\mathcal{K}(1) = 1$. The distributor's VES technology represents the demand schedule that monopolistically competitive firms face. In the quantitative analysis in Section 3, I adopt the common Klenow and Willis (2016) formulation for the Kimball aggregator. In this case, Marshall's weak second law is satisfied and implies that, as firms lower their prices, their demand becomes more inelastic and their markup increases. Thus, larger monopolistically competitive firms will have higher markups, higher markup elasticity and lower pass through rate of cost shocks (Burstein et al., 2003; Kimball, 1995).

The distributor sells the homogeneous sectoral good $y_i$ incurring in distribution costs. Distribution costs represent the per-unit service inputs required to bring the homogeneous industry goods to consumers and firms, e.g. transportation, wholesales and retail services, marketing, etc (Burstein et al., 2003; Corsetti and Dedola, 2005). I follow Burstein et al. (2003) and assume that distribution services are combined with one unit of sectoral homogeneous good using a Cobb-Douglas technology and that distribution services are produced using only labor. Thus, the retail price of good $i$, $p_i$, is:

$$p_i = \widetilde{p_i}^{1-\phi_i} w^{\phi_i} \qquad \text{with } \phi \leqslant 1, \tag{8}$$

where $\widetilde{p_i}$ is the price of the aggregate homogeneous good $i$ and $\phi_i$ the cost share of distribution services in the retail price of good $i$. I assume that distribution costs are heterogeneous across industries, as denoted by the $i$-specific weights in the production technology.

The monopolistically-competitive firms within each domestic industry $i \in n_D$ are symmetric and use a common constant return to scale production function. Domestic and imported sectoral goods can be used as inputs in the production of domestic varieties, together with labor. Indirect exposure arises from both the direct use of imported inputs and the presence of domestic input-output linkages.[13] The production function of firm $k$ is given by:

$$y_{i,k} = F_i(l_{i,k}, x_{i1,k}, \cdot, x_{iN,k}), \tag{9}$$

where $y_{i,k}$ is firm $k$'s output, $l_{i,k}$ is the labor input and $x_{ij,k}$ is the amount of good $j$ used as input by firm $k$ in sector $i$. I assume that firms employ the same Cobb-Douglas technology:

$$y_{i,k} = F_i(l_{i,k}, x_{i1,k}, \cdot, x_{iN,k}) = \zeta_i l_{i,k}^{\alpha_{i,l}} \prod_{j=1}^{N} x_{ij,k}^{\alpha_{i,j}} \qquad \text{with } \alpha_{i,l} + \sum_{j=1}^{N} \alpha_{i,j} = 1. \tag{10}$$

[13] In other words, a firm's production cost is directly exposed to imported intermediate inputs when the firm is directly using imported inputs in production. However, the firm is potentially exposed even when it does not use any imported input. This happens through the links to other domestic firms that make use of imported inputs. The latter is captured by domestic input-output linkages.

I assume that $\alpha_{i,l} > 0$, i.e. that labor is an essential input for the production of all varieties, in the sense that $F_i(0, x_{i1,k}, \cdot, x_{iN,k}) = 0$. $\alpha_{i,j}$ denotes the share of good $j$ in industry $i$'s production technology.[14] $\zeta_i$ is a sector-specific normalization constant.

Given the assumption on the distributor's aggregating technology, monopolistically competitive producers charge a variable markup over the marginal cost:

$$\widetilde{p_{ik}} = \mu_i mc_i \qquad \text{with } mc_i = w^{\alpha_{i,l}} \prod_{j=1}^{N} p_j^{\alpha_{i,j}}, \tag{11}$$

where $\widetilde{p_{ik}}$ is the price paid by the distributor for variety $k$, $\mu_i$ is the markup charged and the expression for the marginal cost, $mc$, comes from the specific production function assumed in Equation (10). The markup charged by monopolistically competitive firms increases in firm sales and becomes more sensitive to cost shocks, which implies a lower pass through rate.

I assume that monopolistically competitive producers are subject to Calvo-style nominal rigidities: a fraction $\delta_i$ of firms in each sector $i$ can adjust prices to changes in sectoral marginal costs $d \log \text{mc}_i$. I consider a one-period framework, Rubbo (2020). The timing is as follow: before the world begins, firms set prices based on their marginal cost, Equation (11); then the exchange rate change is realized; because of price rigidities, firms are allowed to adjust their price after observing the realized change in their marginal cost with probability $\delta_i$; the world ends after production and consumption take place.

I now derive an expression for a change in the retail price of a domestic sectoral good following a change in exchange rate, which feeds into domestic prices through imported intermediate inputs and input-output linkages. I focus on the direct effect of exchange rate, Burstein and Gopinath (2014): I consider a partial-equilibrium response of domestic prices, not accounting for changes in the wage rate or the response of firms to changes in sectoral price indices.

A change in the price of domestic goods $i \in n_D$, $\pi_i^D$, is:

$$\pi_i^D \equiv d\log p_i^D = \underbrace{(1-\phi_i)}_{\text{Distribution Costs}} \quad \underbrace{\delta_i}_{\text{Nominal rigidities}} \quad \frac{1}{\underbrace{1+\Gamma_i}_{\text{Real rigidities}}} \quad d\log mc_i \tag{12}$$

$$\underbrace{d\log mc_i}_{\text{Change in mc}} = \underbrace{\sum_{j=1}^{n_D} \alpha_{i,j}\pi_j^D}_{\substack{\text{Exposure } via \\ \text{IO linkages}}} + \underbrace{\sum_{j'=1}^{n_F} \alpha_{i,j'}\pi_{j'}^F (d\log e)}_{\text{Import Exposure}}. \tag{13}$$

A change in the retail price of a domestic good, $\pi^D$, follows a change in the marginal cost

[14] I assume that $\alpha_{i,j} \geqslant 0$ or, in other words, that industry $i$ may rely on the goods produced by other (domestic or imported) industries as intermediate inputs.

- last term in Equation (12). The latter, in turn, originates from a change in input prices, Equation (13). The second summation captures the change in the price of imported inputs ($\pi^F$) while the first summation represents the change in the price of domestically sourced inputs. Crucially, the former depends directly on the (log) exchange rate change, $d \log \varepsilon$. The latter instead captures the indirect effects that exchange rate changes have through the domestic production network and the indirect exposure to imported inputs. Notice that the relevant input prices are the retail prices set by the distributors, which include distribution services.

A change in marginal cost is not passed completely into the retail price of domestic goods because of the presence of several frictions in the economy. Equation (12) shows that the change in marginal cost is attenuated by the presence of distribution costs, variable markups and nominal rigidities. The presence of nominal rigidities allows only a fraction $\delta_i$ of firms to change prices, i.e. those firms touched by the Calvo fairy.

Even if the firm is able to adjust its price, real rigidities due to variable markups make firms reluctant to change their price relative to other firms' prices. The presence of variable markups allows firms to incompletely pass the change in marginal cost into prices by adjusting its markups and partially absorbing the change in costs. The pass-through rate inversely depends on how much the markup is sensitive, i.e. on the markup elasticity $\Gamma_i = \frac{\partial \mu_i}{\partial p_i} > 0$: the more the markup is sensitive, the lower the pass-through of cost shocks to prices. The ratio $\frac{1}{1+\Gamma_i} < 1$ in Equation (12) formally captures the incomplete pass-through due to variable markups.

Lastly, the presence of distribution costs in Equation (8) reduces the sensitivity of retail prices to changes in the production cost as the latter accounts only for a share $1 - \phi_i$ of the retail price. By reducing the sensitivity of prices to changes in marginal costs, these frictions ultimately dampen the transmission of exchange rate fluctuations.

Because of round-about production and input-output linkage, domestic prices can change because of indirect exposure. Let $\pi^D = (\pi_1, \cdot, \pi_{n_D})^T$ be the $n_D \times 1$ vector of domestic price changes. Combining Equations (13) and (12) and rearranging, the vector of changes in domestic prices becomes:

$$\pi^D = \underbrace{(I - \Phi\Delta\Gamma S_d)^{-1}}_{\substack{\text{Adjusted} \\ \text{Leontief Inverse}}} \underbrace{\Phi}_{\substack{\text{Matrix of} \\ (1-\phi_i)}} \underbrace{\Delta}_{\substack{\text{Matrix of} \\ \delta_i}} \underbrace{\Gamma}_{\substack{\text{Matrix of} \\ \frac{1}{1+\Gamma_i}}} \underbrace{S_m}_{\substack{\text{Imported intermediate} \\ \text{input shares}}} \pi^F(d \log e). \tag{14}$$

A change in the price of foreign inputs, $\pi^F = (\pi_1, \cdot, \pi_{n_F})^T$, is transmitted to domestic prices through the shares of imported intermediate inputs, captured by the matrix $S_m$.[15] However, the resulting change in marginal costs is attenuated by the presence of distribution costs, variable markups and nominal rigidities, captured respectively by the diagonal

[15] In other words, the matrix $S_m$ collects all the input shares $\alpha_{i,j}$ where $j \in n_F$.

matrices Φ, Δ and Γ. Lastly, the first term represents the Adjusted Leontief Inverse matrix, that captures the effects of domestic round-about production. Namely, the matrix quantifies the amplifying effect of domestic input-output linkages on the transmission of cost changes. The Leontief matrix $(I - S_d)^{-1}$, with $S_d$ being the input-output matrix of domestic input shares, captures the total expenditure of sector $i$ on good $j$.[16] The adjusted matrix accounts for the fact that marginal cost changes are not fully passed into prices because of the presence of domestic frictions, ultimately capturing the effective total elasticity.

It follows immediately that the price elasticity of domestic goods in Equation (6), $\boldsymbol{\eta}^{\mathbf{p}^D,e}$, is:

$$\boldsymbol{\eta}^{\mathbf{p}^D,e} = \underbrace{(I - \Phi\Delta\Gamma S_d)^{-1}\,\Phi\Delta\Gamma}_{\substack{\text{Domestic network} \\ \text{\& frictions}}} \times \underbrace{S_m}_{\text{Import Exposure}} \times \underbrace{\boldsymbol{\eta}^{\mathbf{p}^F,e}}_{\substack{\text{Elasticity of} \\ \text{imported inputs}}}, \tag{15}$$

where $\boldsymbol{\eta}^{\mathbf{p}^F,e}$ is the vector of price elasticities of imported goods. Equation (15) shows that the sensitivity of domestic goods to exchange rate fluctuations depends not only on how the retail price of imported goods reacts to exchange rate fluctuations ($\boldsymbol{\eta}^{\mathbf{p}^F,e}$) and how much domestic production is directly exposed to imported inputs ($S_m$), but also on the features (frictions and network) of the domestic economy.

**Price Elasticity of Imported Goods, $\eta^{\mathbf{p}^F,e}$.** The sensitivity of CPI to exchange rates depends directly on how the price of imported good changes after an exchange rate shock, $\eta^{\mathbf{p}^F,e}$, as part of the final consumption bundle is imported from abroad (direct exposure). Similarly, CPI indirect exposure also depends on $\eta^{\mathbf{p}^F,e}$ as imported inputs are used in the production of domestic goods.

I specify the sensitivity of the retail price of imported goods, $\eta^{\mathbf{p}^F,e}$, assuming that imported goods are produced abroad and purchased by a local distributor, which combines imported goods with local distribution services and determines the retail price of imported goods, $p_i$. I also assume that the domestic economy is small (small open economy assumption) and rule out international input-output linkages. In this case, changes in domestic prices do not affect the foreign production costs of imported goods.

As in Equation (8), the retail price of imported goods is given by:

$$p_i = (\widetilde{p}_i(e))^{1-\phi_i}\, w^{\phi_i} \qquad \text{with } \phi_i \leqslant 1, \tag{16}$$

where $i \in n_F$ and $\widetilde{p}_i$ is the border price of the imported good, which is determined by the foreign producer and depends on the exchange rate.

Given the specific focus on the role of domestic frictions and domestic transmission, I abstract away from any micro-foundation of the production process of imported goods

16 Similarly to $S_m$, $S_d$ captures all the input shares $\alpha_{i,j}$ where $i, j$ are both domestic products.

and discipline directly how border prices react to exchange rate fluctuations. I assume that the pass-through rate of exchange rate fluctuations into border prices is incomplete, i.e. $\Psi_i = \frac{\partial \log \widetilde{p}_i}{\partial \log e} < 1$, consistently with extensive evidence (Burstein and Gopinath, 2014; Gopinath, 2015). In the quantitative analysis, I use the universe of import transactions to discipline the behavior of border prices at the product level in a reduced form.

Following the same reasoning for domestic prices, the change in the retail price of imported goods following an exchange rate shock, $d \log e$, is:

$$\pi_i^F \equiv d \log p_i^F = \underbrace{(1 - \phi_i)}_{\text{Distribution Costs}} \quad \underbrace{\Psi_i}_{\substack{\text{Heterogeneous} \\ \text{Border Pass-Through}}} \quad d \log e,$$

where $\Psi_i$ captures the incomplete pass-through rate into border prices. It follows that the price elasticity of imported goods appearing in Equations (6) and (15) is:

$$\eta^{p^F, e} = \underbrace{\Phi}_{\substack{\text{Matrix of} \\ (1-\phi_i)}} \quad \underbrace{\Psi}_{\substack{\text{Matrix of Heterogeneous} \\ \text{Border Pass-Through}}} \quad . \tag{17}$$

The sensitivity of imported good retail prices decreases the larger is the share of distribution services included ($\phi_i$), and the lower is the sensitivity of border prices ($\Psi_i$). In Section 3, I calibrate the sensitivity of border prices at the product level, $\Psi_i$, using import transaction data and leveraging heterogeneity across importers. In this regard, I assume that $\Psi_i$ depends on importers' characteristics such as importers' size and experience since a large literature points to the role of customer accumulation, buyer market power and firm-to-firm trade relationships on pricing and pass-through dynamics (Atkeson and Burstein, 2008; Berman et al., 2012; Drozd and Nosal, 2012; Alviarez et al., 2021; Heise, 2019; Errico, 2022).

The sensitivity of the retail price of imported goods, $\eta^{p^F, e}$ in Equation (17), together with (6) and (15), fully characterizes all elements determining the transmission of exchange rate fluctuations into CPI. The three measurement equations jointly provide a decomposition of the major forces impacting the sensitivity of domestic prices. Section 3 shows how to calibrate in detail each component.

**Discussion of Model Assumptions.** I close this section with a discussion on the assumptions and caveats made in the description of the domestic economy and the sensitivity of CPI to exchange rate changes.

I derive the pass-through of exchange rate into CPI, Equation (5), focusing on the direct effect of exchange rates into prices (Burstein and Gopinath, 2014). In other words, I abstract away from the effect of exchange rate changes on domestic wages, sectoral prices and quantities. While such partial-equilibrium assumption is a simplification, most of the exchange rate fluctuations at quarterly level are relatively small and changes in aggregate variables like wages are likely to occur in response to larger devaluations or over long horizons. Thus, the quantitative analysis in Section 4 can be interpreted as a short-run quantification. Moreover, general equilibrium dynamics require additional structure in terms of wage determination and taking a stance on the dynamics of exchange rates and sectoral prices for a careful characterization of the dynamics of domestic prices in the presence of Calvo rigidities.

The second key assumption is that the production and consumption specifications are Cobb-Douglas. The main implication for the analysis carried out in here is that expenditure switching forces are low as relative consumption and input shares remain constant.[17] This is consistent with the short-run analysis on the effects of exchange rate fluctuations carried out in the paper. Expenditure switching forces are likely to occur in response to larger devaluations or over long horizons. Values of the elasticity of substitution in the range of 1-2 are chosen to describe aggregate import demand in the macroeconomic real business cycle literature, Ruhl et al. (2008). Low values of the elasticity of substitution are appropriate as relative price shocks due to exchange rate fluctuations are transitory and, thus, demand-side responses are likely to be limited.[18] Moreover, the product categories in the input-output tables are relatively aggregated compared to the standard disaggregation levels in trade data, making substitution across products relatively low.[19]

A key assumption is the reduced form treatment of the exchange rate pass-through into border prices. The reason is twofold: on one side, the aim and focus of the model are the description of domestic frictions and forces influencing the transmission of exchange rate fluctuations; on the other hand, the richness of the data available allows to directly and carefully disciplining the behavior of border prices. The main implications of accounting for incomplete pass-through into border price in a reduced form is the assumption of separability between the interactions with domestic and with foreign suppliers. In other words, there are no strategic interactions between domestic and foreign suppliers.

Lastly, I take a stance on how the leading domestic frictions included are micro-founded. I followed Burstein et al. (2003) in modelling distribution costs. Compared to Corsetti and Dedola (2005), which use additive distribution costs, the qualitative implica-

[17] In addition to sales reallocation, non-linearities and second-order effects can be relevant in an frictional production network like the one considered here (Hulten, 1978; Baqaee and Farhi, 2020). Exploring these elements in a general equilibrium setting is left for future research.

[18] In the international real business cycle literature, matching the terms of trade volatility and the negative relationship between terms of trade and trade balance generally require low values of the trade elasticity, Hillberry and Hummels (2013).

[19] Reinert and Roland-Holst (1992) show that trade elasticities are particularly low across manufacturing sectors in the US, ranging between 0.25 to 3.5. More disaggregated data like those used in the international trade literature estimate a much larger trade elasticity, between 4 and 15, Hillberry and Hummels (2013).

tions on pass-through are the same but the calibration is immediate as the shares $\phi_i$s can be computed directly from the input-output tables. I also assume that distribution services are paid in labor and the distribution sector is competitive. The former implies that the share does not react to exchange rate changes, given the focus on the direct effects of exchange rates into prices. The latter implies that distributors do not charge markups, abstracting from double marginalization and additional incomplete pass-through due to variable markups.[20] Similarly, the micro-foundation of variable markups nominal rigidities follows standard choices in the macro and international economics literature and are compatible with the data available. Notice that abstracting away from nominal rigidities makes the effect of variable markups vanish because monopolistically competitive firms are symmetric. If nominal rigidities are absent, the change in price is identical for all firms. Thus, relative prices do not change and the effect of variable markups disappears.[21]

# 3 Calibration

A detailed calibration of the domestic economy is one of the goals and contributions of this paper. The measurement equations (15), (17) and (5) testify how different channels and frictions determine the sensitivity of CPI to exchange rates. Each element (distributions margins, variable markups and nominal rigidities, trade exposure and the granularity of the production network, and incomplete border pass-through rates) and their heterogeneity across products are carefully disciplined using a variety of micro-level data. The key ingredients are the 2013 "make" and "use" tables from the Central Bank of Chile, data from the survey of manufacturing from 2000 to 2007 (ENIA, *Encuesta Nacional Industrial Anual*) compiled by the Chilean National Statistical Agency (INE, *Instituto National de Estadisticas*), and the universe of Chilean import transactions from 2009 to 2019 from the Chilean Customs Agency (*Aduanas*).[22]

I now discuss in details the data and the strategy I use to calibrate each element of the main measurement equations and additional information is provided in Appendix A. In the following Section, I show how a granular representation of the domestic economy and heterogeneity in frictions are key to accurately gauge the transmission of exchange rate fluctuations into domestic prices. This suggest that the strategy and the data I use

20 Goldberg and Campa (2010) provide a raw estimate of the sensitivity of distribution services to exchange rate. They show that distribution margin slightly decreases following an exchange rate depreciation. However, an accurate product level calibration is difficult due to data limitations. The estimated effect of distribution costs can be considered as an upper bound.

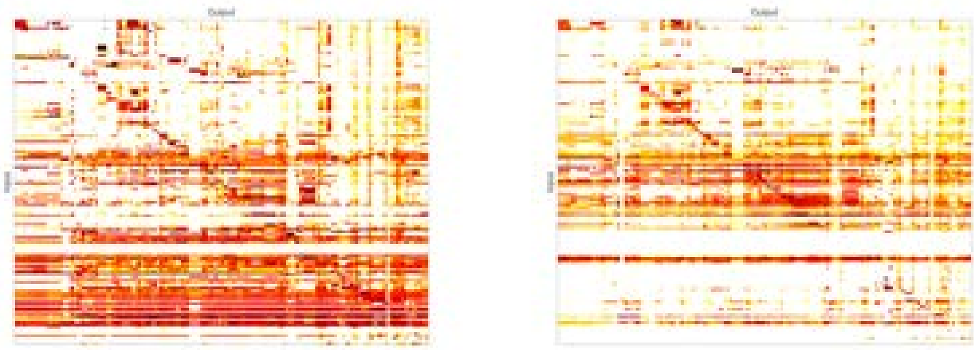
21 Departing from the symmetric firms case implies that firm-level pass-through depends on the covariance between markup elasticity and the cost shock, Amiti et al. (2019). Expanding the analysis to introduce within sector heterogeneity across firms requires additional firm-level data to discipline the covariance, representing a valuable venue for the future.

22 I also use additional macroeconomic variables such as inflation rates, sectoral deflators, GDP growth rates, exchange rates from IMF, OECD or Central Bank of Chile.

can provide the basis for future calibrations and quantitative analyses.

**Domestic Network: $S_m$, $S_d$ and $\beta$.** I construct the input-output matrices for the Chilean economy combining the 2013 "make" and "use" tables provided by the the Central Bank of Chile. The tables consist of two basic national accounting tables: the "make" table shows the production of commodities by industry while the "use" table shows the use of commodities by intermediate and final users. The Central Bank of Chile also provides information on international flows, allowing the construction of international make (for imports) and use (for exports) tables. The tables are very disaggregated and include 180 products and 110 industries.[23]

Figure 2: Domestic and International Leotief Matrices



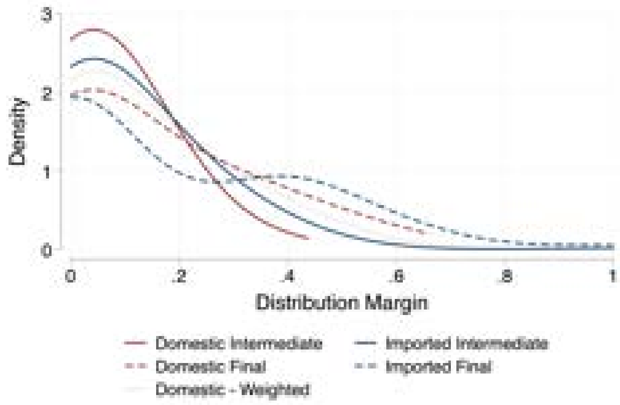
The left (right) panel plots the domestic (international) input-output matrix of the Chilean economy in 2013. The matrices are computed using the make and use table under the industry technology assumption. Each row (column) represents an input (output). The intensity of the coloring shows how much one product is used as input in the production of other products: the darker (lighter) the color, the higher the input share. Log input shares smaller than -10 are censored.

I combine the make and use tables under the industry technology assumption to construct a (180×180) product-by-product input-output matrix.[24] Each matrix quantifies how much of each product (row) is used in the production of other products (column). I also use the input-output tables to compute the share of each product in final consumption. This allows me to calibrate the $S_m$ and $S_d$ matrices and the vector $\boldsymbol{\beta}$. Figure 2 reports the domestic and international input-output tables, $S_d$ and (left) $S_m$ (right) respectively, where a more intense color refers to a higher share of a certain input in the production of a given product. Importantly, domestic network is highly sparse and trade exposure is heterogeneous across products. Both elements play an important role in shaping the response of aggregate variables, Pasten et al. (2020).

23 As a comparison, commonly used input-output tables as the WIOD or the OECD tables have around 30 to 40 industries. Pasten et al. (2020) shows that the granularity of the input-output table plays a central role in the quantification of the real effects of monetary policy, as less granular input-output tables tend to underestimate its effects.

24 Appendix A.2 provides details on the technical assumptions for the construction of the IO matrices.

Figure 3: Density of Distribution Margins




The figure plots the density distribution of the distribution margins across products. The distribution margins are computed according to Equation (18). I differentiate products depending: on their use, final vs intermediate use (solid vs dashed lines, respectively); on their origin, imported vs domestically produced (blue vs red lines, respectively). The dotted line shows the density distribution of the expenditure-weighted average of the distribution margin for final and intermediate domestic products.

**Distribution margins: Φ.** The distribution margin is computed as the ratio of the value of trade and transport margins to the value of total supply of that product at purchasers' prices:

$$\phi_i \equiv \frac{\text{Retail + wholesale + Transportation costs}}{\text{Value at purchaser prices}} \equiv \frac{\text{Value at purchaser prices - value at basic prices}}{\text{Value at purchaser prices}}. \tag{18}$$

Following Goldberg and Campa (2010), I use the input-output matrices for the Chilean economy to compute the value of trade and transport margins as the difference between the cost of supply (basic price) and the purchaser price.[25] The richness of the data allows me to compute not only heterogeneous margins across products but also across use (final vs intermediate consumption) and origin (imported vs domestic). In the model in Section 2, the price of domestic goods is the same independently of their use, final consumption vs intermediate input. Therefore, it is not possible to use the corresponding distribution margins. For each domestic product, I calibrate the common distribution margin as the expenditure-weighted average of the distribution margin for final and intermediate use. The same issue does not arise for imported products.

Figure 3 and Table 8 in Appendix A.2 report the density distribution for different class of products (domestic vs imported, intermediate vs final). On one hand, domestically produced products tend to have lower distribution margins compared to imported goods, consistent with the fact that internationally sourced goods are subject to larger transportation costs. On the other hand, intermediate goods also tend to have lower

[25] The Central Bank of Chile provides the make and use tables both at basic and purchaser prices. The latter is defined as the cost of supply plus retail, wholesale, transportation costs, and net taxes.

distribution margins. This suggests that lower pass-through due to distribution costs potentially arises at the end of the production chain, when products reach final consumers.

**Markup elasticity: $\Gamma$.** I use the Annual National Industrial Survey (ENIA) from 2000 to 2007 to estimate markup elasticities at the 3-digit industry level.[26] The theoretical model in Section 2 assumes a Kimball VES technology. For the main quantitative exercise, I further specify Equation (7) assuming that the Kimball aggregator takes the form of a Klenow and Willis (2016) aggregator. I follow Gopinath et al. (2010) and Amiti et al. (2019) and calibrate the steady-state value of the markup elasticity:

$$\Gamma_i = \frac{\epsilon_i}{\sigma_i - 1}, \tag{19}$$

where the markup elasticity depends on two parameters, the industry-specific elasticity of demand, $\sigma_i$, and the super-elasticity of demand, $\epsilon_i$.[27]

For each industry, I calibrate the elasticity of demand to match the revenue-weighted average estimated markup, $\bar{\mu}_i$, $\sigma_i = \frac{\bar{\mu}_i}{\bar{\mu}_i - 1}$. ENIA provides information on sales, inputs expenditures, employment and wage bill, investment, industry code (ISIC rev 3), for approximately 5000 plants per year with more than 10 employees. I estimate production functions and firm-level markups using state-of-the-art techniques and best practices, Levinsohn and Petrin (2003), Ackerberg et al. (2015) and De Loecker and Warzynski (2012). As robustness, I consider alternative measures of markups: I estimate markups using different definitions of variable input (cost of good sold vs labor only) and using the alternative cost share approach (Autor et al., 2020; De Loecker et al., 2016). Appendix A.3 provides additional details on the estimation of production function and markups.

I follow Edmond et al. (2018) in estimating the super-elasticity parameter $\epsilon$ using the within-industry relationship between markups and market shares implied by the Klenow and Willis (2016) specification:

$$\frac{1}{\mu_{ik}} + \log\left(1 - \frac{1}{\mu_{ik}}\right) = a_i + b_i \log \texttt{share}_{ik}, \qquad b_i = \frac{\epsilon_i}{\sigma_i}, \tag{20}$$

where $\texttt{share}_{ik}$ is the market share of firm $k$ in industry $i$. I estimate the slope coefficient $b_i$ for each industry introducing firm and year fixed effects. Fixed effects are meant to control for unobserved productivity and quality (Edmond et al., 2018; Errico and

[26] I match the estimated 3-digit industry level parameters with the product classification in the IO tables. It is possible that the same estimated markup elasticity is used for more than one product. For missing products, mostly in services, I use the estimated aggregate markup elasticity.

[27] The markup elasticity of variety $k$ in industry $i$ takes the form of $\Gamma_{ik} = \frac{\epsilon_i}{\sigma_i - 1 + \epsilon_i \log\left(\frac{\widetilde{p_{ik}}}{\widetilde{p_i}}\right)}$, with $\widetilde{p_{ik}}$ and $\widetilde{p_i}$ being the price of variety $k$ and the industry price index, respectively. Both Gopinath et al. (2010) and Amiti et al. (2019) calibrate it under the assumption that $\widetilde{p_{ik}} = \widetilde{p_i}$. Under this assumption, the markup elasticity can be interpreted as the steady-state markup elasticity, Gopinath et al. (2010), or the markup elasticity for an average firm, Amiti et al. (2019).

Table 1: Markup and Markup Elasticity

| | Markup | | | | Implied Parameters | | |
|---|---|---|---|---|---|---|---|
| | Mean | Median | StD | Weighted Mean | $\sigma$ | $\epsilon$ | $\Gamma$ |
| Food Beverages and Tobacco | 1.343 | 1.302 | 0.226 | 1.415 | 4.098 | 2.281 | 0.479 |
| Textile and Apparel | 1.274 | 1.262 | 0.186 | 1.301 | 4.266 | 1.672 | 0.498 |
| Wood Paper and Printing | 1.289 | 1.257 | 0.201 | 1.377 | 3.643 | 1.712 | 0.646 |
| Petroleoum and Chemical Products | 1.392 | 1.275 | 0.410 | 1.420 | 3.521 | 1.139 | 0.434 |
| Plastic Rubber and Construction | 1.292 | 1.262 | 0.209 | 1.391 | 3.930 | 2.546 | 0.578 |
| Fabricated Metal | 1.165 | 1.101 | 0.263 | 1.295 | 4.939 | 0.810 | 0.226 |
| Machinery and Equipment | 1.201 | 1.177 | 0.188 | 1.152 | 8.122 | 1.595 | 0.380 |
| Motor Vehicle | 1.088 | 1.119 | 0.265 | 1.047 | 13.18 | 7.582 | 0.486 |
| Forniture | 1.244 | 1.227 | 0.172 | 1.275 | 4.641 | 2.283 | 0.627 |
| Aggregate | 1.274 | 1.237 | 0.247 | 1.408 | 3.453 | 1.093 | 0.446 |

The table reports summary statistics of the estimated markups aggregated at the 2-digit sectoral level. Weighted-mean reports the average markup weighted by revenue. Markups are estimated using the survey of manufacturing (ENIA) from 2000 to 2007 and state-of-the-art production function estimation, Ackerberg et al. (2015) and De Loecker and Warzynski (2012). The table reports also the average implied demand elasticity ($\sigma$), super-elasticity ($\epsilon$) and markup elasticity ($\Gamma$). Demand elasticity is calibrated to match the estimated revenue-weighted average markup. I follow Edmond et al. (2018) to estimate the demand super-elasticity leveraging the within-industry relationship between markups and market shares implied by the Klenow and Willis (2016) specification. Markup elasticity is defined as in Equation (19). Appendix A provides additional information on data and empirical specifications.

Lashkari, 2022). I retrieve the superelasticity, $\epsilon_i$, given the estimated demand elasticity.

Table 1 reports the estimated sectoral parameters (markup elasticity, demand elasticity and superelasticity) and summary statistics of the sectoral markup distributions. Estimated average and median markups are reasonable and in line with previous results from Chile, Levinsohn and Petrin (2003) and Garcia-Marin et al. (2019).[28] Importantly, the implied steady-state markup elasticities are in the range of values previously used in the literature and show substantial heterogeneity across sectors.[29] Moreover, markups and the implied parameters are very similar independently of the markup estimation approach or variable input used.

**Calvo probability: $\Delta$.** Due to lack of disaggregated domestic pricing data, I calibrate a common probability of price adjustment (Calvo parameter), $\delta$, across all products.[30] I set the average monthly frequency of price adjustment to 30%, following the micro-level estimates of Aruoba et al. (2022) from confidential daily transaction data from the

[28] Figure 15 in Appendix A.3 plots the distribution of markups across firms for each industry.

[29] Gopinath et al. (2010) vary the super-elasticity $\epsilon$ between $[0, 8]$, implying a $\Gamma$ varying between $[0, 2]$, given a $\sigma = 5$. Consistent with the the chosen Kimball specification, the right panel of Figure 16 in Appendix A.3 shows that the positive relationship between average markup and markup elasticity holds also across industries. The left panel of Figure 16 in Appendix A.3 shows that there is no relationship between the average markups and the estimated superelasticity across industries.

[30] As shown in the following Section, heterogeneity in frictions is key in determining which products are the most important contributors to the transmission of exchange rate fluctuations. At this stage, the role of price rigidities cannot be fully explored and is left to future research.

Chilean Tax Authority.[31] This implies an average quarterly probability of adjustment of 65%, with an average duration of about 2.8 months.

**Pass-through into Border Prices: $\Psi$.** Differently from domestic frictions, the model of exchange rate pass-through in Section 2 captures the role of (heterogeneous) incomplete pass-through into border prices in a reduced form, *via* $\Psi_i$. I use transaction-level import data from the Chilean Custom Agency (*Aduanas*) and follow previous work to discipline directly the pass-through into border prices, accounting for importers' heterogeneity.

Specifically, $\Psi_i$ is disciplined at the product level accounting for the heterogeneity due to importers' experience. The aim is to capture the role that firm level determinants such age, size, market power and the presence of trade relationships have in shaping the pass-through rate of exchange rates into border prices. Alviarez et al. (2021), Juarez (2022) and Errico (2022) show that importers exert market power on their supplier and pay a markdown on the price they pay. This gives room to adjust the markdown following an exchange rate changes, keeping prices stable and lowering the exchange rate pass-through. Similarly, Dasgupta and Stiglitz (1988) and Heise (2019) show that relationship capital is accumulated as trade relationships grow older, influencing pricing and pass-through behavior. Moreover, an extensive literature on exporters' dynamics points to the role of market share, size and productivity in influencing pass-through rate into export prices (Atkeson and Burstein, 2008; Alessandria, 2009; Berman et al., 2012; Drozd and Nosal, 2012; Amiti et al., 2014). I document that importers with longer experience have larger market shares and face a lower pass-through rate into border prices.[32] I calibrate $\Psi$ combining this empirical evidence.

The universe of import transactions provided by the Chilean Customs Agency includes, for each import transaction, standard information such as the importer's unique identifier (*importer*), the 8-digit HS product code (*product*), the date of the transaction, the country of origin (*origin*), the FOB and CIF values, the quantity shipped. I use data from 2009 to 2019; additional information on cleaning and summary statistics are reported in Appendix A.1.

I measure importers' experience constructing a measure of importing tenure at firm-product-origin level. I define the tenure of an importer-product-origin triplet as the number of quarters the importer has been consecutively importing a certain HS8 product from a given origin.[33] Importers with longer tenure are firms that have been consistently

[31] The frequency of price adjustment is slightly higher compared to the estimated value of $\approx 20\% - 25\%$ for the US, Nakamura and Steinsson (2008) and Pasten et al. (2020).

[32] Errico (2022) rationalizes this findings with through an open economy model of oligopsony that delivers consistent qualitative predictions. As importers grow older and larger, they gain experience in foreign markets which allows to exert stronger market power on their foreign supplier.

[33] As robustness, in Appendix B, I relax this definition of tenure and consider the number of quarters the importer has been importing a given product, dropping the consecutive requirement. I also consider the cumulative imported quantity for each firm-product-origin triplet.

engaging in importing activities for longer periods of time.

Table 7 in Appendix A.1 provides information on the distribution of importing tenure and the number of observations along different dimensions. Import flows are dispersed across firms, products and countries of origin, in line with previous literature (Eaton et al., 2021; Piveteau, 2021). The median importing firm records four flows per quarter, concentrated in one product or a couple of countries of origin. The second half of the table shows that the sparsity appears also along the time dimension. Importing is not a long-lasting activity as the median importing tenure across firm-product-origin triplets is one quarter. These statistics provide an overview of the prevalence of short import spells, and this is true using both definitions of tenure.

**Fact I: Responsiveness of Border Prices.** I augment a standard exchange rate pass-through regression to quantify the effect of importing tenure on the transmission of exchange rate fluctuations into border price (Heise, 2019; Errico, 2022). Let $f$ index an importing firm, $p$ an HS8 product category, $o$ the country of origin, and $t$ the quarter. The pass-through is estimated at quarterly frequency to be consistent with the Calvo probability $\Delta$, also calibrated at the quarterly level. The baseline specification is:

$$\Delta \log p_{fpot} = \beta_1 \Delta \log e_{ot} + \beta_2 \log \text{Tenure}_{fpot} \times \Delta \log e_{ot} + \beta_3 X_{fpot} + \eta_{fop} + \nu_t + \varepsilon_{fpot}, \quad (21)$$

where $\Delta \log p_{fpot}$ is the price change of product $po$ imported by firm $f$ between quarter $t$ and $t-1$, and $\Delta \log e_{ot}$ is the change in the Chilean peso-country $o$ exchange rate between quarter $t$ and $t-1$. $\text{Tenure}_{fpot}$ is the importing tenure at quarter $t$, defined as described in the previous section. In the main specification, I use the log of tenure to reduce the impact of the positive skewness in the distribution of tenure. I include time fixed effects and importer-product-origin fixed effects, meaning that the effect of importing tenure on the pass-through of exchange rate fluctuations, $\beta_2$, is estimated using the variation within the same import relationship over time.

$X_{fpot}$ is a set of controls that includes the average size of the importer-product-origin triplet and an index of competitor price change. The former is used to control for differences in size and productivity, as larger firms may exhibit lower pass-through rates because of their size or stronger pricing to market behavior, Amiti et al. (2014) and Berman et al. (2012). The latter controls for strategic complementarities across importers. Following Amiti et al. (2019), I construct an index of competitor price change as a weighted average of the price changes of all other importers of the same product $p$:

$$\Delta \log p_{-ft} = \sum_{j \in F_p} \frac{S_{jt}}{1 - S_{ft}} \Delta \log p_{jt}, \quad (22)$$

where $F_p$ refers to the set of importers purchasing product $p$ from any origin. The shares

$S_{jt}$ are defined for each product $p$ across all origins in terms of quantity. Given the potential endogeneity in the change of competitors' prices, I instrument the competitor price changes with movements in the bilateral exchange rates. As in standard pass-through regression, I control for the inflation rate in the origin country to control for changes in the production cost, Burstein and Gopinath (2014) and Goldberg and Campa (2010).[34]

Table 2: Effect of Importing Tenure on ERPT into Border Prices

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| $\Delta \log e$ | 0.2546 | 0.2711 | 0.3376 | 0.3880 | 0.3868 |
| | (0.098) | (0.109) | (0.116) | (0.115) | (0.115) |
| Log Tenure X $\Delta \log e$ | | | -0.0408 | -0.0342 | -0.0350 |
| | | | (0.013) | (0.012) | (0.013) |
| Average Size X $\Delta \log e$ | | | | -0.0096 | -0.0092 |
| | | | | (0.003) | (0.004) |
| Strategic $\Delta \log p_{-f}$ | | | | | 0.2718 |
| | | | | | (0.313) |
| Time | Yes | Yes | Yes | Yes | Yes |
| Importer X Product X Country | No | Yes | Yes | Yes | Yes |
| Observations | 2,568,634 | 2,368,422 | 2,368,422 | 2,368,422 | 2,365,619 |

Coefficients for terms in levels (log tenure, average size and inflation of origin country) and left and right censorship dummies are omitted. Standard errors clustered at country level. Tenure is defined as the number of quarters the importer has been consecutively importing a Product X Origin pair. Average size is defined as log average quantity traded at the Importer X Product X Origin level. Strategic is constructed according Equation (22).

Table 2 presents the estimates of the key coefficients of interest. Column (1) reports the estimated exchange rate pass-through rate from a standard regression, with no controls except for time fixed effects. The magnitude is comparable to Heise (2019) but falls short relative to standard estimates in the literature, which does not control for time fixed effects.[35] Using within importer-product-origin variation, Column (3) shows that each additional quarter in importing tenure reduces the sensitivity of border price. The estimated effect implies that an increase in importing tenure from the bottom quartile (25th percentile) to the top quartile (75th percentile), approximately 3-4 years difference

[34] The macroeconomic variables used in the empirical analysis, such as inflation rates and exchange rates, are obtained from additional sources like the IMF, the OECD or the Central Bank of Chile.

[35] The average estimated magnitude in the literature is around 0.75 (Amiti et al., 2014; Gopinath et al., 2020). The discrepancy with the literature is explained by the presence of time fixed effect in the main specification in Equation (21). Table 10 in Appendix A.4 shows that removing time fixed effect provides an estimated pass-through rate of approximately 0.75, depending on the type of variation used, in line with the previous estimates from the literature. In addition, the specification without time fixed effects - Table 10 in Appendix A.4 - estimates a higher effect of importing tenure on the exchange rate pass-through than the one reported in Table 2. For this reason, the effects of heterogeneous border price pass-through in Section 4 should be considered as a conservative lower bound.

in 2019, reduces the pass-through rate by approximately 5-6%, a substantial drop. Column (4) and (5) introduce additional controls. The qualitative and quantitative effect of importing tenure on pass-through is unaltered. In line with previous results in the literature, own average size reduces pass-through rates, Amiti et al. (2014). Similarly, the index of competitor price change shows the presence of strategic complementarity among importers.[36]

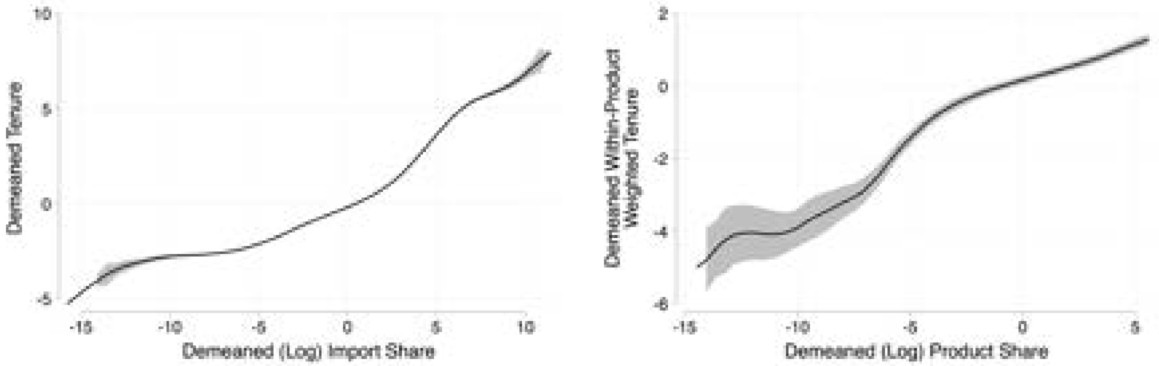
In Table 11 Appendix B, I analyze the sensitivity of the results in Table 2. In the first column, I run the baseline specification in Equation (21) using the preferred definition of tenure in levels. I show that results are quantitatively similar, and, as expected, a larger implied pass-through for lower values of tenure. In the second and third columns, I run the baseline specification in Equation (21) using alternative measures of importing tenure. I replace my conservative measure of tenure with the number of quarters since the first time the firm imported a specific HS8 product-country of origin pair. Alternatively, I use the cumulative quantity traded up to that quarter within each importer-product-origin triplet. Both measures have the same qualitative effects on the pass-through of exchange rate shocks. In the fourth column, I identify the effect of tenure on pass-through using the variation coming from different importing experience across different origins, within a firm-product pair. I use a combination of origin-product and firm-product fixed effects to substitute for the firm-product-origin fixed effects. Also in this case, the qualitative effect of importing tenure on pass-through is preserved. The remaining columns examine the sensitivity of my results with respect to the set of controls used in Equation (21). I run the baseline regression using different measures to control for the heterogeneity in firm size. I replace the average quantity of the importer-product-origin triplet and use the size of the importer computed as the total quantity traded across all product-origin pairs throughout the entire dataset or the quantity traded in each given quarter at the importer-product-origin level. Lastly, I construct alternative competitor price indices to control for strategic complementarities. I reconstruct the index in Equation (22) where the shares are computed using transaction values, rather than quantities. In addition, I use a more conservative definition of competitor and redefine the set of competitors of each importer at the product-origin, $F_{po}$, which includes all importers purchasing product $p$ from origin $o$. In all these cases, I find similar results to the baseline specification.

**Fact II: Market Share.** Figure 4 shows non-parametrically that, at each point in time, products that are imported more intensively are also those where firms have, on average, longer importing tenure. The left panel uses the whole sample, defining tenure and market shares at the firm-product-origin-quarter level. The right panel aggregates the data, defining a product category at the 3-digit SITC level. In the latter, for each

[36] Amiti et al. (2019) show that strategic complementarities are significant only for larger firms. This could explain why the average effect of strategic complementarities in Table 2 is not significant.

product, I compute the expenditure-weighted average tenure across all firms importing in that product category. Similarly, market shares now refer to the overall market share of the product category. Independently of the level of aggregation, I demean all variables at the quarter level to avoid the mechanical increase in tenure as time passes and make it comparable over time.

Figure 4: Relationship Market Share - Importing Tenure

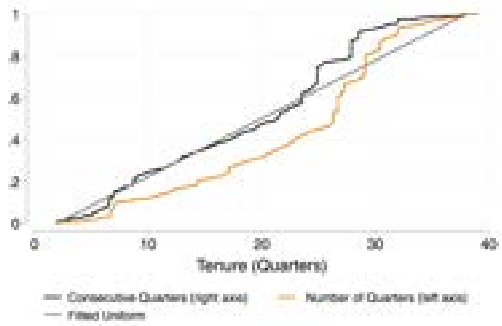



The left panel plots the non-parametric relationship between the (log) market share and the tenure in the whole sample. Market shares and tenure are defined at the firm-product-origin-quarter level. Products are defined at the 8-digit level. Variables are demeaned at the quarter-firm level. The right panel plots the non-parametric relationship between the (log) market share of a product and the expenditure-weighted average tenure across all firms importing that product. Products are defined at the 3-digit SITC level. Share and average tenure are computed at the quarterly level. Variables are demeaned at the quarter level. The panels show the 99% confidence intervals.

Figures 17 in Appendix B shows that the positive relationship between market shares and tenure is robust to different measures of tenure, variations and subsamples. Panel a) uses the less conservative measure of importing tenure, which is defined as the number of quarters since the first time the firm imported a specific HS8 product-origin pair. In panel b) and c), I demean the variables at the quarter and quarter-firm-product level, respectively. Finally, panel d) uses only the second half of the sample to avoid possible mechanical increases in average tenure. Similarly, aggregating tenure and market shares at the product level, Figure 18 shows that the relationship is robust to i) the measure of tenure used (panel a); the aggregation weighting (panel b uses simple averages across firm-origin pairs); the subsample considered (panel c uses the second half of the sample only); the aggregation level (panel d aggregates at the 5-digit level). In all these cases, I find similar results to the baseline relationship documented in Figure 4.

**Disciplining $\Psi$.** I combine the empirical facts documented above to discipline the heterogeneous sensitivity of border prices, $\Psi_i$. Fact I and II imply that imported products with higher market shares are also those with lower exchange rate pass-through rates into border prices because importers with longer importing tenure are relatively more active.

Figure 5: Cross-product Distribution of Tenure




The figure plots the cumulative distribution of average importing tenure at the product level. I consider 5-digit SITC product categories. The average importing tenure for each product is computed as the expenditure-weighted average tenure across all firm-origin pairs. The black (orange) line plots the most preferred (alternative) definition of importing tenure, as defined in Table 7 in Appendix A.1. The solid gray line represents a uniform distribution over the range of importing tenure. The figure uses data from 2019 only.

I calibrate a baseline incomplete pass-through rate to be 0.75. The value is estimated using the Customs data and the regression in Equation (21) after dropping the time fixed effects. The estimated magnitude is in line with previous estimates from the literature and reported in Table 10 in Appendix A.4. This value represents the exchange rate pass-through into border price of a product that exhibits zero importing tenure.

I calibrate heterogeneous pass-through rates across imported products using the estimates on the effect of importing tenure on the pass-through of exchange rate fluctuations (Fact I - Table 2). Figure 5 shows that, in 2019, the preferred measure of importing tenure aggregated at the 5-digit product level ranges between 1 a 40 quarters.[37] Given the estimated effect of importing tenure, this implies an heterogeneous pass-through ranging between 0.6 and 0.75.[38] Figure 5 shows that the cumulative distribution of importing tenure across 5-digit products closely resembles a uniform distribution. Thus, I evenly distribute product-level pass-through rates in the rage $[0.6, 0.75]$.[39]

I leverage the positive relationship between market share and importing tenure (Fact II - Figure 4) to allocate the heterogeneous pass-through rates across imported products. Imported products with larger market shares are those with higher average importing tenure and, therefore, with lower pass-through.

37 My analysis focuses on the effect of tenure on pass-through across products, not dynamically. I choose the distribution of importing tenure in 2019 interpreting it as the stationary distribution of importing tenure across products. In addition, choosing 2019 makes the quantification of the event study - the 2019 "*Estallido Social*" - more accurate.

38 In order not to underestimate the effects of high levels of importing tenure, I use the estimated coefficient for the effect of tenure in level, column (1) in Table 11, rather than in logs (Table 2). This implies that the lowest pass-through rate is $0.75 - 0.0038 \times 40 \approx 0.75 - 0.15 = 0.6$. Using the coefficients in logs delivers a slightly higher lower bound.

39 The cumulative distribution is very close to a uniform distribution except for very high value of importing tenure. Assuming a uniform distribution slightly overestimates the effect of products with high tenure.

In Section 2, I assume that sectoral goods are used for both final consumption and as intermediate inputs. The same price elasticity applies to both direct exposure (final consumption) in Equation (6) and indirect exposure (intermediate inputs) in Equation (15). In the empirical quantification, the imported sectoral goods used both as final consumption and intermediate inputs are considered separately, calibrating two different pass-through rates depending on their use.

# 4 Empirical Results

I quantify the importance of domestic frictions and border price dynamics for the sensitivity and insensitivity of domestic prices to exchange rate fluctuations.

I show that domestic frictions are quantitatively more relevant than border price sensitivity in explaining the insensitivity of domestic prices. Moreover, I find that all domestic frictions are individually relevant for the low responsiveness of domestic prices. I quantify the relevance of domestic frictions and incomplete border price pass-through during the sharp depreciation of the Chilean peso following the "*Estallido Social*" event in 2019, showing that the former (latter) insulated domestic prices reducing inflation by 0.6 (0.3) p.p. at quarterly level.

Similarly, domestic frictions determine the sources of sensitivity of domestic prices. Contrary to previous results in the literature, I find that most of the CPI sensitivity arises through changes in the price of imported final goods (direct exposure) because domestic frictions dampen relative more the response of domestically produced goods. Moreover, the interaction between the heterogeneity in frictions, import exposure and consumption share influences the overall response of CPI and the contribution of individual products.

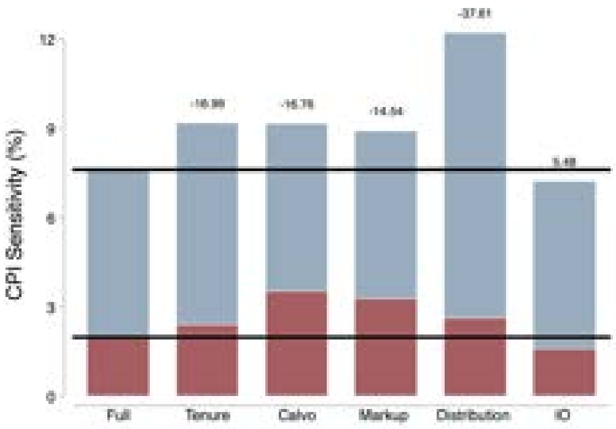
The low sensitivity of border prices still plays a substantial role in explaining the low sensitivity of CPI to exchange rate fluctuations, even after accounting for domestic frictions. Using back-of-the-envelope calculation and my estimates from Section 3, I quantify the aggregate effects of micro-level determinants of exchange rate pass-through into border prices. I show that the increase in average importing tenure from 2009 to 2019 can account for 40% of the decline in the aggregate sensitivity of domestic prices to exchange rate fluctuations.

I conclude discussing what these results imply for inflation targeting and monetary policy in open economy, and future modelling and calibration exercises.

## 4.1 Role of Individual Mechanisms

I now present the first quantitative result: all mechanisms operating in Equations (15) and (17) but the presence of domestic input-output linkages are quantitatively relevant in shaping the response of domestic prices to exchange rate fluctuations.

Figure 6: Role of Individual Mechanisms




The figure plots the CPI sensitivity to a one percent depreciation in the exchange rate for different cases. The first bar (Full) refers to the fully calibrated model which includes incomplete and heterogeneous pass-through, input-output linkages and all domestic frictions (distribution costs, variable markups and nominal rigidities). All the other bars refer to an economy that abstracts away from one element at the time. For instance, the bar "Calvo" represents a fully calibrated model that omits the role of nominal rigidities. I scale all the numbers by 100. Notice that all scenarios use the same input and consumption shares to be as comparable as possible. The red (blue) part of each bar accounts for the part of sensitivity arising from indirect (direct) exposure as defined in Equation (6). The horizontal lines refer to the Full model implied sensitivities. The numbers on top of each bar represents the difference between the fully calibrated model and each alternative scenario.

I proceed by studying the response of domestic prices and CPI to a positive change in the exchange rate (depreciation of the Chilean peso). The baseline economy is a fully calibrated economy in which all mechanisms - distribution costs, variable markups and nominal rigidities, domestic input-output linkages and heterogeneous border price sensitivities - are active at the same time. I then assess the importance of each individual mechanism shutting down one mechanism at the time and quantifying the response of domestic CPI when abstracting away from it.

Each mechanism considered ($\Psi, \Delta, \Gamma$ and $\Phi$) substantially dampen the response of domestic prices after a depreciation. Figure 6 reports the sensitivity of domestic CPI in the fully calibrated (Full) and in the five different economies in which one mechanism is shut down. Abstracting away from distribution costs implies the larger departure from the full model as domestic CPI is 37% less responsive. Variable markups and nominal rigidities equally insulate domestic CPI from exchange rate fluctuations, respectively 17% and 15% lower. Distribution costs play a larger role than variable markups and nominal rigidities because they affect the retail price of both imported and domestically produced goods, while variable markups and nominal rigidities influence only the latter. Domestic prices in the Full model are 17% less responsive than in an economy that abstracts away from heterogeneous border price sensitivity and experienced importers (Tenure). The quantitative relevance of importing tenure shows the importance of adjusting import exposure for the presence of experienced importers, as the latter influence the sensitivity of import price.

Lastly, the presence of domestic input-output linkages increases CPI sensitivity as shocks are propagated through the domestic network by round-about linkages, but the effect is negligible. Figure 6 shows that the amplification mechanism increases CPI response by 5% only. The amplifying role is dampened by the presence of multiple frictions in the domestic network and has key implications for the sources of CPI sensitivity, as explored in Section 4.5.

## 4.2 Decomposing CPI Insensitivity

How sensitivity is CPI in a frictionless world where all costs shocks are passed entirely into prices? Answering this question gives us a benchmark to understand how insensitive is domestic CPI to exchange rate fluctuations and provide additional information on the relative importance of domestic frictions and border price insensitivity.

I again proceed by quantifying the response of CPI to a one percent depreciation of the exchange rate across different scenarios. I calibrate six different cases in which I add one channel at a time to develop step-wise intuition. Table 3 lists the different combinations of pass-through into import prices and domestic frictions I study. The benchmark economy is a frictionless economy (i.e. no distribution costs, variable markups and nominal rigidities) that includes input-output linkages and in which the pass-through rate into border prices is complete. On the contrary, Case V considers a fully calibrated economy that includes all frictions, input-output linkages and in which the pass-through rate into border prices is incomplete and heterogeneous.

Figure 7 shows that the fully calibrated model predicts a CPI sensitivity extremely close to the estimate for the period from 2009 to 2019 while a frictionless benchmark economy largely overestimates it. The full model implies a sensitivity that falls in the range of estimated sensitivities for Chile, supporting the validity of the measurement equation in Section 2 and showing that its simplicity is not coming at the expenses of quantitative performance. The implied sensitivity in the benchmark economy is four times larger than the estimated one (29.3% vs 7.62%). As expected, abstracting away from all elements that dampen the transmission of costs shocks increases the sensitivity of domestic prices.

Figure 7 shows that most of the insensitivity of CPI is due to domestic factors, i.e. mechanisms that do not operate on border prices. Including homogeneous incomplete pass-through rate into import prices reduces the sensitivity of domestic prices by 25% (22/29.3). Accounting for heterogeneity in border price sensitivity further reduces domestic price sensitivity by another 18%, 18.2/22. However, the effect on border prices falls short in matching the estimated CPI sensitivity as less than 50% of the gap between

Table 3: Overview of Calibration Cases

| | Pass-through into Import Prices | | Domestic Frictions | | | |
|---|---|---|---|---|---|---|
| | Average $\Psi$ | Heterogeneous $\Psi$ (Tenure) | $\Phi$ | $\Gamma$ | $\Delta$ | IO Linkages |
| Benchmark | Complete | | | | | ✓ |
| Case I | Incomplete | | | | | ✓ |
| Case II | Incomplete | ✓ | | | | ✓ |
| Case III | Incomplete | ✓ | ✓ | | | ✓ |
| Case IV | Incomplete | ✓ | ✓ | ✓ | | ✓ |
| Case V (”Full”) | Incomplete | ✓ | ✓ | ✓ | ✓ | ✓ |

The table details the assumptions on pass-through into border prices, importing tenure, domestic frictions and input-output linkages for the different cases considered in the calibration. Notice that all scenarios use the same input and consumption shares.

the estimated value and the benchmark economy is closed. Applying the same reasoning to the domestic frictions considered — distribution costs, variable markups and nominal rigidities — reduces domestic price sensitivity by approximately 35%, 25% and 17%, respectively.[40] All together, domestic frictions are quantitatively more relevant in dampening the sensitivity of CPI than incomplete pass-through to border prices. This shows how the response of border prices and the presence of domestic frictions need to go hand in hand to fully characterize the response of domestic CPI to exchange rate fluctuations.

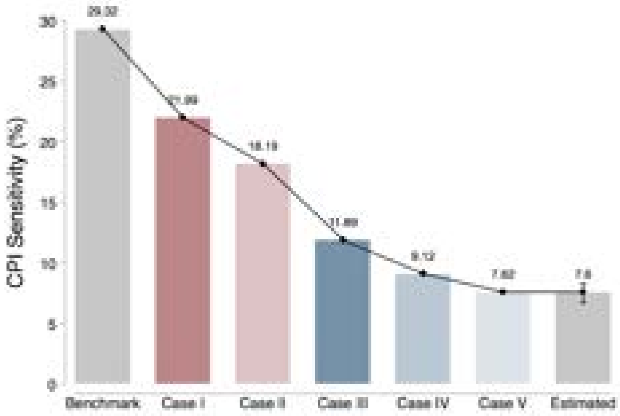
### 4.3 Direct vs Indirect Exposure and Input-Output Linkages

In contrast with previous work, Figure 6 documents that, in the fully calibrated economy and across all the scenarios considered, the bulk of the CPI response to a depreciation shock comes from the direct exposure of CPI to exchange rates, Equation (6). Direct exposure, i.e. imported final consumption (blue area in Figure 6), accounts for approximately 75% of the overall sensitivity in the fully calibrated case even though imported consumption represents only 15% of the total final consumption basket.[41] This results is at odds with previous work, that tends to assign the same importance to direct and indirect exposure (Goldberg and Campa, 2010; Burstein et al., 2003; Gopinath, 2015). I now investigate the conflicting results on the role of direct and indirect exposure and argue that standard quantification exercises tend to overestimate the contribution of imported intermediate inputs because they abstract away from a careful calibration of

[40] Figure 7 also provides additional evidence on the relative importance of each individual mechanism considered. Consistently with Figure 6, all channels considered contribute substantially to the overall aggregate insensitivity of domestic prices and the relative importance is qualitatively the same. In Appendix C, I show that the specific order does not changes the qualitative predictions of the relative importance of each mechanism.

[41] In comparison, imported inputs in the production of domestic goods account for 25% of total inputs.

Figure 7: Decomposing CPI Sensitivity




The figure plots the aggregate CPI sensitivity to a one percent depreciation in the exchange rate for different cases. See Table 3 for a description of the different cases. I scale all the numbers by 100. The last column, "Estimated", reports the estimated CPI sensitivity to exchange rate estimated at the quarterly level from 2009 to 2019 (also scaled by 100). The bands refer to the range of estimated CPI sensitivity across different specifications in terms of lags and controls. Appendix C provides additional details on the estimation.

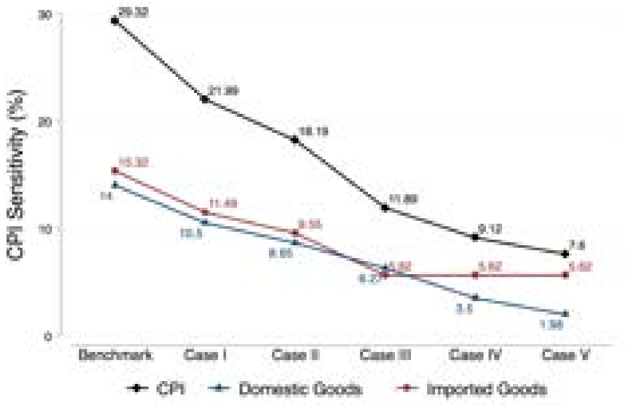
(heterogeneous) domestic frictions. In doing so, I also explore the role of input-output linkages as determinant of indirect exposure.

The importance of direct exposure is usually overestimated by the omission of domestic frictions that mainly alter the response of domestically produced goods. Figure 8 shows that, as more domestic frictions are considered, not only CPI becomes less sensitive to exchange rate fluctuations, but the sensitivity of CPI is increasingly driven by imported final consumption goods ("direct exposure"). In a frictionless economy ("Benchmark"), direct and indirect import exposure equally contribute to the overall price change. Introducing (heterogeneous) incomplete pass through into border prices does not alter the relative importance of the two types of exposure. However, the relative importance changes when domestic frictions are introduced (Case IV and V) as they influence only the sensitivity of domestically produced goods. Standard practices do not account for the presence of domestic frictions, and quantify direct exposure in frameworks comparable to the frictionless economy case ("Benchmark").

Indirect exposure originates also from the domestic input-output production network. Even though a domestically produced good does not make direct use of imported intermediate inputs, the domestic inputs used in its production could be exposed to imports. Figure 6 shows that the contribution of roundabout production is actually modest, as abstracting away from input-output linkages reduces CPI sensitivity to exchange rate by only 5%. The presence of domestic frictions and the centrality of import exposure are key to understand the small role of input-output linkages.

As more frictions are included in the domestic economy, the amplification generated by the presence of input-output linkages shrinks (Basu, 1994; Pasten et al., 2020). The

Figure 8: Decomposing Aggregate CPI Sensitivity




The figure plots the aggregate CPI sensitivity to a one percent depreciation in the exchange rate and its decomposition into imported final consumption (”Imported”), i.e. direct exposure, and domestic final consumption (”Domestic”), i.e. indirect exposure, for different cases. See Table 3 for a description of the different cases. I scale all the numbers by 100.

left panel of Figure 9 compares the sensitivity of domestic prices in the case of roundabout production (x-axis) and without roundabout production (y-axis). I show that the median change in domestic prices in each quartile of the distribution is higher when roundabout production is considered as shocks are amplified through the network (Acemoglu et al., 2016). However, propagation diminishes as frictions are introduced in the economy. The intuition is that domestic frictions reduce price responsiveness and, thus, downstream propagation at any point in the network (Carvalho and Tahbaz-Salehi, 2019).[42]

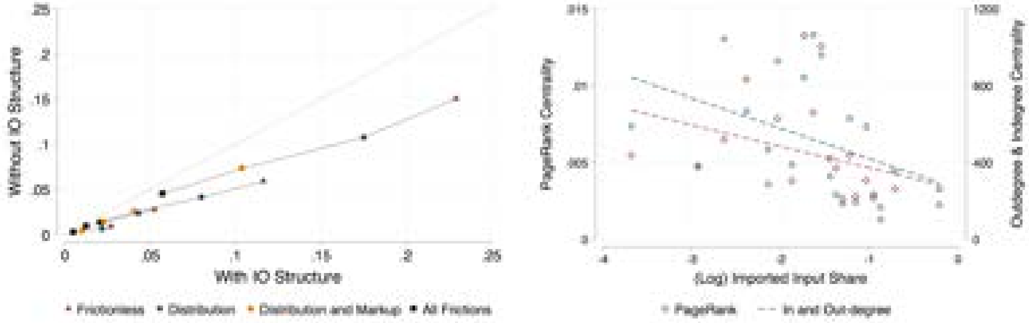
Moreover, the right panel of Figure 9 shows that imported inputs are not central in the production network of domestic goods. I measure the centrality of a product in the domestic input-output network using both the PageRank centrality measure and the average between the In-degree and Out-degree measures. Centrality measures are used to assess the relative importance of each node in networks.[43] Products that are more central rely relatively less on imported inputs, therefore reducing amplification forces.

These results suggest that evaluating the role of import exposure for the transmission of exchange rate fluctuations to domestic prices requires both incorporating domestic frictions and detailed production networks. Common practice in calibrating aggregate models is to compute import exposure as the sum of direct and indirect exposure, where

[42] The (adjusted) Leontief inverse matrix captures direct and indirect downstream propagation. Abstracting away from domestic frictions implies using the Leontief inverse matrix rather than the adjusted one in Equation (15), where the former implies a stronger amplification.

[43] In-degree (out-degree) centrality counts the number of ties directed to (from) the node, quantifying the relevance of a node in the immediate vicinity. As standard practice I take the average of the two. PageRank centrality is a variant of eigenvector centrality, which weights the linked nodes by their centrality. In my sample, the two measures are highly correlated (65%). In both cases, edges are weighted according to the input shares forming the input-output tables (see Appendix A.2). No frictions are considered in the weighting. Figure 25 in Appendix C graphically represents the production network, the centrality and import intensity of each node.

Figure 9: Role of IO network




The left panel compares the evolution of the price of domestic products in an economy that includes input-output linkages (x-axis) to the evolution in an economy that abstracts away from input-output linkages (y-axis), as more domestic frictions are considered. Each series plots the median price change in each quartile of the distribution. I consider the following scenarios: "Frictionless" refers to the absence of domestic frictions; "Distribution" includes only distribution margins; "Distribution and markups" includes both distribution and variable markups; "All Frictions" includes distribution, variable markups and Calvo frictions. In all scenario, pass-through into import prices is incomplete and heterogeneous due to importing tenure. The dotted line shows the 45 degree line. Table 12 in Appendix C reports the CPI sensitivity for all scenarios considered in the presence of and abstracting away from input-output linkages. It also reports the decomposition between direct (imported final consumption) and indirect exposure (imported intermediate inputs). The right panel shows the relationship between the centrality of a product in the domestic production network and the share of imported inputs in its production. I consider the PageRank centrality measure (left axis) and the average of the in-degree and out-degree measures (right axis). Centrality is measured weighting the edges according to the input-output linkages. The share of imported inputs is computed over total costs from the IO tables. The dashed line shows a linear fit. Table 15 in Appendix C reports the corresponding coefficient. Section 3 and Appendix A provide additional details on the IO tables.

the latter is commonly computed from dense input-output tables (Burstein et al., 2003; Gopinath, 2015; Pasten et al., 2020). However, omitting domestic frictions results in overestimating the role of indirect exposure and, thus, CPI sensitivity.

## 4.4 The 2019 "*Estallido Social*".

The "*Estallido Social*" (social outburst) refers to a series of massive and severe riots originated in Chile between October 2019 and March 2020. From the perspective of my analysis, the riots triggered a major devaluation of the Chilean peso against all major currencies and make the event a natural laboratory to study the effects of domestic frictions on domestic prices.

Figure 22 in Appendix C documents the timing and the evolution of the shock using the Google index for protests: riots do not constitute an expected event and is short-lived.[44] Following the social outburst, the Chilean peso sharply depreciates with respect

[44] The protests started in the capital, Santiago, on October 6 after subway fares rose by 4%. The increase in subway fares was the trigger of the protests, but high costs of living and socio-economic inequality represent the deeper roots of the social outburst. The riots quickly escalated and spread across the entire country, though with different levels of intensity (Aruoba et al., 2022). https://www.bloomberg.com/news/articles/2021-07-06/investors-look-abroad-amid-political-tensions-chile-market-chat

to all major foreign currencies. Political and social tensions increase uncertainty and risk, putting pressure on the value of the Chilean peso. The three-month depreciation rate of the Chilean rate peaks at 12% in mid November, right before the Central Bank of Chile intervention on the currency market to stabilize the value of the currency.[45]

I use the model to gauge the response of domestic prices to the sharp depreciation triggered by the shock, assessing the insulating effect of domestic frictions and border price insensitivity. I first quantify the implied rise in domestic prices following the depreciation of the Chilean peso using the fully calibrated economy. I compare the prediction from the fully calibrated model to two counterfactual scenarios: one economy that includes only domestic frictions; another economy that accounts for incomplete border price pass-through only. I consider three different scenarios in measuring the quarterly depreciation rate of the Chilean peso (column (1) in Table 4). In the most conservative scenario, I consider the average quarterly depreciation in the last quarter of 2019 with respect to the third quarter of the same year, which is 5.6% ("*Average*"). Alternatively, I consider the peak depreciation rate during the last quarter of 2019, which is about 12% ("*Peak*"). Finally, to account for lagged response of the exchange rate and domestic prices, I consider also the cumulative depreciation of the Chilean peso over the 2019Q4-2020Q1 period with respect to the third quarter of 2019 ("*Cumulative*").

Domestic frictions insulate domestic prices more than the insensitivity of border prices during the depreciation of the Chilean peso. The fully calibrated model predicts an increase in domestic prices which accounts for about 30% to 90% of the actual inflation rate in Chile during the time period considered, depending on the scenario (column 2 and column 3).[46] In the "*Average*" scenario, a counterfactual economy with incomplete and heterogeneous pass-through into border prices but without domestic frictions (columns 4 and 5) predicts the inflation rate to be 0.6 p.p. higher (approximately 50% higher) than the actual inflation rate, a sizeable difference at the quarterly level. Domestic inflation is 0.3 p.p. higher (approximately 25%) in an economy with domestic frictions but complete pass-through into border prices (columns 6 and 7), half as much as the effects of domestic frictions. As expected, domestic inflation have stronger insulating effects than incomplete pass-through into border prices. This confirms the importance of both border prices dynamics and domestic transmission for the response of domestic prices to exchange rate changes.

45 The Central Bank of Chile used around $24bn in open market operations in the period between 2019Q3 and 2020Q1.

46 These numbers are sensible considering that the average quarterly inflation in the previous 4 quarters was 0.5%. Additional inflationary forces in the economy can explain the remaining part.

Table 4: "*Estallido Social*" and Counterfactual

| | | | Full | W/out Domestic Frictions | | Complete Border Price PT | |
|---|---|---|---|---|---|---|---|
| | Depreciation | Actual $\pi$ | Imported $\pi$ | $\widehat{\pi}$ | % Change | $\widehat{\pi}$ | % Change |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Average | 5.61 | 1.02 | 0.43 | 1.61 | 58.2 | 1.28 | 25.3 |
| Peak | 11.8 | 1.02 | 0.90 | 2.27 | 122.9 | 1.56 | 53.4 |
| Cumulative | 10.8 | 2.32 | 0.82 | 3.46 | 49.3 | 2.82 | 21.4 |

The table reports back-of-the-envelope calculations on the relative importance of domestic frictions and incomplete border price pass-through on domestic inflation during the 2019 "*Estallido Social*" in Chile. Each row corresponds to a different scenario in terms of Chilean peso depreciation rate. Column 1 shows the depreciation rate corresponding to each scenario. Column 2 reports the actual quarterly inflation rate (in %) corresponding to each scenario. Column (3) quantifies the implied inflation (in %) following the depreciation of the Chilean peso using the fully calibrated model. Column 4 (6) quantifies the counterfactual domestic inflation (in %) in an economy that includes incomplete pass-through into border prices (domestic frictions) and abstracts away from domestic frictions (incomplete pass-through into border prices). Column 5 (7) quantifies the percentage difference between the counterfactual inflation rate in column 4 (6) relative to the actual inflation rate in column 2.

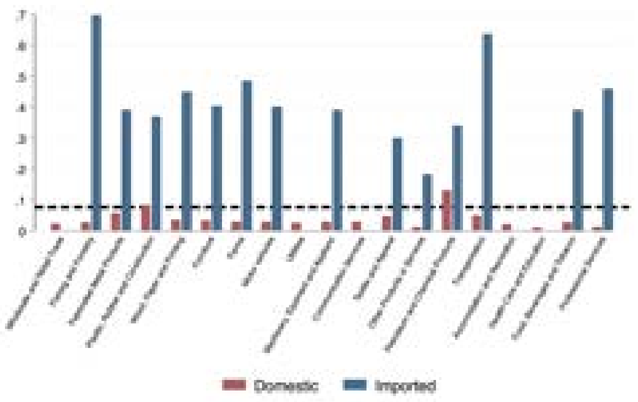
## 4.5 Heterogeneity across Products and Identity Effects

Focusing on the cumulative effects masquerades substantial heterogeneity across products. Moreover, the interactions of different dimensions of heterogeneity, such as heterogeneity in domestic frictions, import exposure and consumption share, play a crucial role for both the aggregate response and the relative contribution of different products to the CPI response.

Figure 10 graphically illustrates substantial heterogeneity in the sectoral response to the common exchange rate depreciation shock in the fully calibrated economy. Crucially, imported final goods are more sensitivity than domestically produced goods, consistent with the fact that direct exposure accounts for the bulk of the sensitivity of CPI. Moreover, within each category - domestic and imported goods - sectoral goods exhibit very different patterns in terms of sensitivity. For instance, among domestically produced goods, accommodation and service sectors are insensitive to exchange rates compared to the chemical and rubber sectors, as the latter are more exposed to imported inputs.

Figure 11 documents that not only the presence of frictions, but also their heterogeneity, is relevant to understand the low sensitivity of domestically produced goods. The left (right) panel shows a positive correlation between the share of imported inputs in production and the markup elasticity (distribution costs). The heterogeneity in frictions and their positive correlation with imported inputs make the role of frictions even more relevant for the overall response of CPI: the dampening effects are stronger for those products that are more relevant for the transmission of exchange rate fluctuations. Similarly, Figure 26 in Appendix C shows that ignoring heterogeneous consumption shares

Figure 10: Sectoral Heterogeneity




The figure plots sensitivity of prices across different 2-digit industries. Price sensitivity is computed in the fully calibrated model. I distinguish between imported final consumption (blue bars) and domestic final consumption (red bars). For each sectors, I compute the expenditure-weighted average sensitivity across products. Sectors are in ascending order (left to right) in terms of consumption shares. The dashed line presents the sensitivity of CPI.

matters for aggregate sensitivity (Chen et al., 2022). Domestic products that have larger consumption shares are also those that are less sensitive to imports and, thus, to exchange rate fluctuations.

The identity of the most relevant products for the overall sensitivity changes when different dimensions of heterogeneity are considered. The heterogeneity in sensitivity across domestically produced goods arises because of the heterogeneity in the exposure to imported inputs, domestic frictions and border price sensitivity. Interacting different dimensions of heterogeneity translates into different relative contributions across products. Figure 12 shows how the ranking of the products contributing the most to the overall CPI sensitivity changes depending on the frictions considered.[47] Compared to the fully calibrated model, shutting off one dimension of heterogeneity can substantially alter the ranking across products. The effect is pronounced i) when omitting distribution costs and ii) for imported final consumption (right panel). Table 14 in Appendix C shows that the changes in ranking are not correlated across scenarios, suggesting that different dimensions of heterogeneity impact each product in different ways.[48]

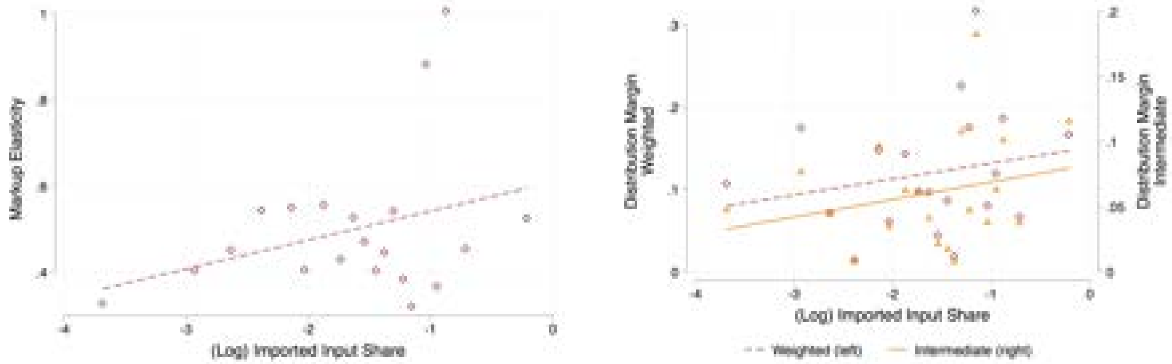
## 4.6 Heterogeneous Pass-through into Border Prices

While domestic frictions are important for the (in)sensitivity of domestic prices, incomplete pass-through into border prices still plays a substantial role in explaining the

[47] I consider the scenarios of Figure 4.1, by shutting down one element at the time between distribution cost, variable markups and nominal rigidities, IO linkages and heterogeneous border price sensitivity.

[48] Table 15 in Appendix C shows that centrality and individual frictions (variable markups and distribution costs) do not mutually exclude each other and have comparable correlations with import exposure, suggesting that jointly accounting for all these elements is key to quantify CPI sensitivity.

Figure 11: Import Exposure and Friction Heterogeneity




The left panel plots the relationship between the share of imported inputs in production and the markup elasticity for the set of domestically produced goods. The share of imported inputs is computed as the ratio between the total expenditure on all imported goods used in production and the total costs of production. The right panel plots the relationship between the share of imported inputs in production and the distribution margin for the set of domestically produced goods. The distribution margin is computed for domestic intermediate inputs only or as a weighted average between domestic intermediate inputs and final consumption goods. The dashed lines show linear fit. Table 15 in Appendix C reports the corresponding coefficients. Section 3 and Appendix A provide additional details on how import shares, distribution margins and markup elasticities are computed. Log imported input shares smaller than -10 are dropped.

low sensitivity of CPI to exchange rate fluctuations. In this section, I extend the analysis on the role of heterogeneous pass-through into border prices and show that the rise in average importing tenure accounts for 40% of the decline in domestic price sensitivity over the period 2009-2019.

A growing literature documents a decline in the sensitivity of domestic prices to exchange rate fluctuations across several advanced economies since the late 1980s. Several papers consider the rise of global value chains and the stability of international trade relationships as possible explanations for the decline in exchange rate pass-through (Campa and Goldberg, 2005; Camatte et al., 2021; Georgiadis et al., 2020). The effect of importing tenure on exchange-rate pass-through into border and domestic prices points in the same direction.[49]

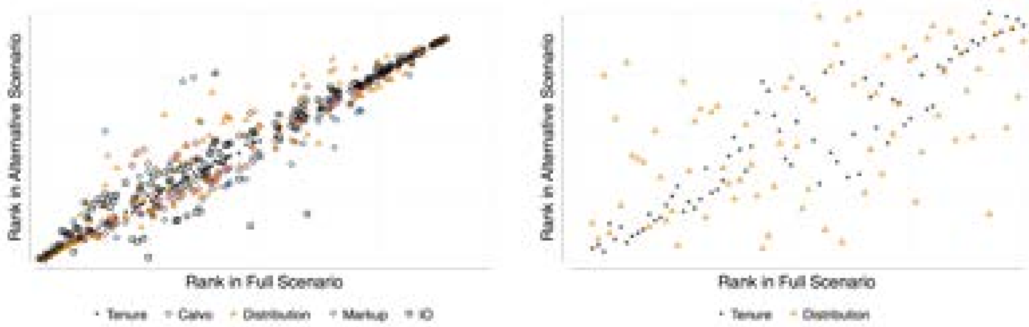
I find that the sensitivity of domestic prices to exchange rate changes decreases in Chile, complementing the recent evidence from advanced economies (Camatte et al., 2021). The dash line in Figure 13 plots the estimated trend from 2007 to 2020 using a 5-year rolling window. The pass-through into CPI decreases by 50% relative to 2009.[50]

Using back-of-the-envelope calculations based on my estimates, I compute the con-

[49] Figure 6 shows that CPI is 16% less sensitive in a fully calibrated economy compared to an economy that abstracts away from the effects of importing tenure. Table 13 in Appendix shows that its contribution is quantitatively similar across multiple combinations of alternative frictions.

[50] Figure 21 in Appendix C shows that the decline is just part of a long-run negative trend started in the 70s. CPI sensitivity to exchange rates is initially around 0.35%, and reaches a value of 0.07-0.1% in the last decade. I estimate a trend because exchange rate pass-through rates at quarterly level are particularly noisy. Appendix C provides additional details on the estimation.

Figure 12: Ranking of Products




The figure compares the ranking of the products contributing the most to the overall CPI sensitivity in the fully calibrated model (x-axis) to the ranking in an alternative scenario (y-axis). For domestically produced goods (left panel), I consider the following alternative scenarios: a fully calibrated economy that omits, one at the time, the role of the heterogeneity in border price sensitivity, nominal rigidities, distribution costs, variable markups, and input-output linkages. For imported goods (right panel), I consider the following alternative scenarios: a fully calibrated economy that omits, one at the time, the role of the heterogeneity in border price sensitivity, and distribution costs.

tribution of the rise of importing tenure to the decline in CPI sensitivity. Relative to the beginning of 2009, when importing tenure is normalized to one quarter, Figure 23 in Appendix C shows that the expenditure-weighted average importing tenure increased to 18 quarters. I quantify the change in CPI sensitivity driven by the increase in importing tenure using the estimated effect of importing tenure on border prices (Table 2) and the fact that omitting importing tenure increases CPI sensitivity by approximately 20%.[51] Figure 13 shows that the counterfactual trend in CPI sensitivity (solid line) decreases 40% less relative to the estimated one.[52] This confirms the importance of micro-level determinants of border price pass-through and their evolution in explaining aggregate dynamics like the trend in domestic price sensitivity to exchange rates.[53]

## 4.7 Taking Stock and Policy Implications

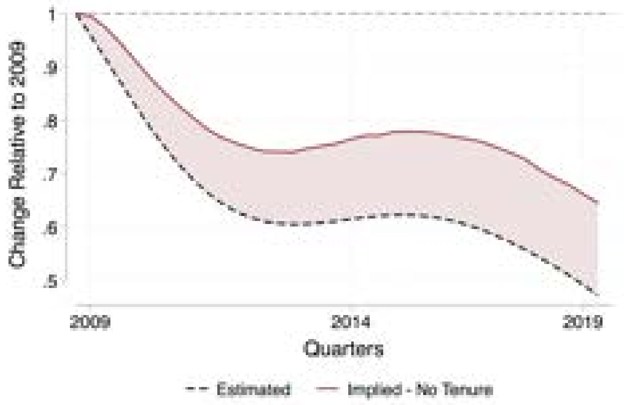
My empirical analysis establishes a number of important facts. Taken together, these results show that accurately accounting for the role of domestic frictions is key to understand both the insensitivity and the sensitivity of domestic prices to exchange rate

[51] A tenure of 18 quarters implies a pass-through rate into import price 0.10 lower ($\log(18) \times 0.035$), given the estimates in Table 2. I then multiply it by 20% to get the effect on domestic prices, which is approximately 0.025%. CPI sensitivity declines from 0.117% to 0.055%. Omitting the role of tenure, the end point is 0.0755%, approximately 35% higher.

[52] As robustness, Figure 24 in Appendix C shows the counterfactual trends using different measures of tenure and different estimates for the marginal effect of tenure on border price pass-through rate. The counterfactual trend decreases at least 20% less than the estimated one.

[53] The rise in average importing tenure and, more generally, international market participation in the period starting from 2009 could be driven by the formation of new international relationship following the Great Trade collapse in 2008, Heise (2019). Expanding the analysis to include the years of the Great Recession and/or around Covid with a focus on business-cycle dynamics is an interesting avenue for future work (Di Giovanni et al., 2022; Antràs, 2020).

Figure 13: Trend in ERPT and Contribution of Tenure




The figure plots the estimated trend in CPI sensitivity to exchange rates (dash line) and the counterfactual trend in CPI sensitivity to exchange rates abstracting away from the rise in importing tenure. The trend is estimated using a polynomial approximation of the series of estimated exchange rate pass-through rates into CPI. Exchange rate pass-through rates are estimated using a 5-year rolling window from 2007 to 2020 at the quarterly level. Appendix C provides additional details on the estimation. The counterfactual trend is computed subtracting the effect due to the rise in the average importing tenure, documented in Figure 23 in Appendix C. The effect of importing tenure is computed multiplying tenure by its effect on the pass-through into border prices (Table 21) and scaled by its contribution to domestic price sensitivity (Table 13).

fluctuations. Moreover, heterogeneity in friction and import exposure is essential to determine which sectors are the most important contributors to the (in)sensitivity of domestic prices. I now elaborate on the broad policy implications of the results presented as domestic price sensitivity to exchange rates is key for the transmission of international shocks, monetary policy and domestic redistribution dynamics.

One fundamental aspect for monetary policy trade-offs in open economy is which inflation rate is relevant to policymakers, that, in turn, depends on the exchange rate pass-through (ERPT). On one hand, ERPT is related to inflation stabilization in open economy, exchange rate misalignment and the so-called "fear of floating" (Calvo and Reinhart, 2002). Incomplete ERPT partially insulates domestic prices to exchange rate fluctuations, reducing the cost of floating and volatile exchange rates. On the other hand, ERPT is also related to the transmission and the absorption of shocks, and terms of trade imbalances. Incomplete ERPT limits expenditure switching forces, trade and capital adjustments, reducing the effectiveness of exchange rates as shock absorber and policy instrument. The inflation rate central banks should target crucially depends on the degree of exchange rate pass-through into domestic prices: PPI (CPI) targeting is optimal in case of low (high) pass-through rates of exchange rate fluctuations (Corsetti et al., 2010; Chen et al., 2022). Abstracting away from domestic friction implies a substantially higher sensitivity of domestic prices and, thus, a potentially different optimal monetary policy target in open economy.

Moreover, exchange rate fluctuations are transmitted heterogeneously to domestic products. Policymakers should weight different components of domestic inflation depending on their frictions and exposure, not necessarily coinciding with CPI weights, resembling the closed-economy long-standing inflation targeting debate (Bernanke and Woodford, 2005). The heterogeneous sensitivity is also relevant for the transmission of international shocks and domestic redistribution dynamics: domestic households and firms might be differentially exposed to exchange rate changes depending on the consumption and input mixes used (Cravino and Levchenko, 2017a; Jaravel, 2021).

Lastly, the role of importers' characteristics showcases that micro-level determinants of heterogeneous incomplete pass-through into border prices matter for aggregate dynamics and long-run trends. These findings suggest that, in a globalized and interdependent economy, it is important to learn about micro-level forces that influence the transmission of shocks across borders and how they interact with aggregate dynamics and policy conduct (Di Giovanni and Levchenko, 2010; Heise et al., 2022).

# 5 Conclusion

In this paper, I have explored the role of domestic frictions for the (in)sensitivity of domestic prices to exchange rate fluctuations. I find that domestic frictions such as distribution costs, variable markups and nominal rigidities account for 60% of the overall insensitivity of domestic CPI, relatively more than incomplete pass-through into border prices. The presence of domestic frictions impacts also the channels of domestic price sensitivity: contrary to previous literature, most of the sensitivity arises from direct exposure (imported final consumption) because domestic frictions dampens relatively more the response of domestically produced goods (indirect exposure).

The extensive use of micro-level data allows to quantifies a rich heterogeneity in sensitivity across products, originating from the interaction of heterogeneous domestic frictions, direct and indirect exposures and incomplete pass-through rates. Importantly, the identity of the products contributing the most to the transmission of exchange rate fluctuations depends on the subset of heterogeneity considered. This testifies the importance of jointly accounting for the frictions and mechanisms included in the analysis. In this regard, the model and the calibration strategy used can guide future research on the relationship between domestic prices and exchange rates.

# References

Acemoglu, D., U. Akcigit, and W. Kerr (2016). Networks and the macroeconomy: An empirical exploration. *Nber macroeconomics annual 30*(1), 273–335.

Ackerberg, D. A., K. Caves, and G. Frazer (2015). Identification properties of recent production function estimators. *Econometrica 83*(6), 2411–2451.

Alessandria, G. (2009). Consumer search, price dispersion, and international relative price fluctuations. *International Economic Review 50*(3), 803–829.

Alviarez, V., M. Fioretti, K. Kikkawa, and M. Morlacco (2021). Two-sided market power in firm-to-firm trade. Technical report, Working Paper No. IDB-DP-884, Department of Research and Chief Economist.

Amiti, M., O. Itskhoki, and J. Konings (2014). Importers, exporters, and exchange rate disconnect. *American Economic Review 104*(7), 1942–78.

Amiti, M., O. Itskhoki, and J. Konings (2019). International shocks, variable markups, and domestic prices. *The Review of Economic Studies 86*(6), 2356–2402.

Antràs, P. (2020). De-globalisation? global value chains in the post-covid-19 age. Technical report, National Bureau of Economic Research.

Aruoba, S. B., A. Fernández, D. Guzmán, E. Pastén, and F. Saffie (2022). Pricing under distress.

Atkeson, A. and A. Burstein (2008). Pricing-to-market, trade costs, and international relative prices. *American Economic Review 98*(5), 1998–2031.

Auer, R. A., A. A. Levchenko, and P. Sauré (2019). International inflation spillovers through input linkages. *Review of Economics and Statistics 101*(3), 507–521.

Autor, D., D. Dorn, L. F. Katz, C. Patterson, and J. Van Reenen (2020). The fall of the labor share and the rise of superstar firms. *The Quarterly Journal of Economics 135*(2), 645–709.

Backus, D. K. and G. W. Smith (1993). Consumption and real exchange rates in dynamic economies with non-traded goods. *Journal of International Economics 35*(3-4), 297–316.

Baqaee, D. R. and E. Farhi (2020). Productivity and misallocation in general equilibrium. *The Quarterly Journal of Economics 135*(1), 105–163.

Basu, S. (1994). Intermediate goods and business cycles: Implications for productivity and welfare.

Benigno, G. and P. Benigno (2003). Price stability in open economies. *The Review of Economic Studies 70*(4), 743–764.

Berman, N., P. Martin, and T. Mayer (2012). How do different exporters react to exchange rate changes? *The Quarterly Journal of Economics 127*(1), 437–492.

Bernanke, B. S. and M. Woodford (2005). *The inflation-targeting debate*, Volume 32. University of Chicago Press.

Burstein, A. and G. Gopinath (2014). International prices and exchange rates. In *Handbook of international economics*, Volume 4, pp. 391–451. Elsevier.

Burstein, A. T., J. C. Neves, and S. Rebelo (2003). Distribution costs and real exchange rate dynamics during exchange-rate-based stabilizations. *Journal of monetary Economics 50*(6), 1189–1214.

Calvo, G. A. and C. M. Reinhart (2002). Fear of floating. *The Quarterly journal of economics 117*(2), 379–408.

Camatte, H., G. Daudin, V. Faubert, A. Lalliard, and C. Rifflart (2021). Global value chains and the transmission of exchange rate shocks to consumer prices.

Campa, J. M. and L. S. Goldberg (2005). Exchange rate pass-through into import prices. *Review of Economics and Statistics 87*(4), 679–690.

Carvalho, V. M. and A. Tahbaz-Salehi (2019). Production networks: A primer. *Annual Review of Economics 11*, 635–663.

Chen, N., W. Chung, and D. Novy (2022). Vehicle currency pricing and exchange rate pass-through. *Journal of the European Economic Association 20*(1), 312–351.

Chen, N. and L. Juvenal (2016). Quality, trade, and exchange rate pass-through. *Journal of International Economics 100*, 61–80.

Chen, S., M. B. Devereux, K. Shi, and J. Xu (2022). Consumption heterogeneity and monetary policy in an open economy. Technical report, National Bureau of Economic Research.

Corsetti, G. and L. Dedola (2005). A macroeconomic model of international price discrimination. *Journal of International Economics 67*(1), 129–155.

Corsetti, G., L. Dedola, and S. Leduc (2008). International risk sharing and the transmission of productivity shocks. *The Review of Economic Studies 75*(2), 443–473.

Corsetti, G., L. Dedola, and S. Leduc (2010). Optimal monetary policy in open economies. In *Handbook of monetary economics*, Volume 3, pp. 861–933. Elsevier.

Cravino, J. and A. A. Levchenko (2017a). The distributional consequences of large devaluations. *American Economic Review 107*(11), 3477–3509.

Cravino, J. and A. A. Levchenko (2017b). Multinational firms and international business cycle transmission. *The Quarterly Journal of Economics 132*(2), 921–962.

Dasgupta, P. and J. Stiglitz (1988). Learning-by-doing, market structure and industrial and trade policies. *Oxford Economic Papers 40*(2), 246–268.

De Loecker, J., J. Eeckhout, and G. Unger (2020). The rise of market power and the macroeconomic implications. *The Quarterly Journal of Economics 135*(2), 561–644.

De Loecker, J., P. K. Goldberg, A. K. Khandelwal, and N. Pavcnik (2016). Prices, markups, and trade reform. *Econometrica 84*(2), 445–510.

De Loecker, J. and F. Warzynski (2012). Markups and firm-level export status. *American economic review 102*(6), 2437–71.

Dhyne, E., A. K. Kikkawa, M. Mogstad, and F. Tintelnot (2021). Trade and domestic production networks. *The Review of Economic Studies 88*(2), 643–668.

Di Giovanni, J., Kalemli-Ozcan, A. Silva, and M. A. Yildirim (2022). Global supply chain pressures, international trade, and inflation. Technical report, National Bureau of Economic Research.

Di Giovanni, J. and A. A. Levchenko (2010). Putting the parts together: trade, vertical linkages, and business cycle comovement. *American Economic Journal: Macroeconomics 2*(2), 95–124.

Di Giovanni, J., A. A. Levchenko, and I. Mejean (2017). Large firms and international business cycle comovement. *American Economic Review 107*(5), 598–602.

Drozd, L. A. and J. B. Nosal (2012). Understanding international prices: Customers as capital. *American Economic Review 102*(1), 364–95.

Eaton, J., M. Eslava, D. Jinkins, C. J. Krizan, and J. R. Tybout (2021). A search and learning model of export dynamics. Technical report, National Bureau of Economic Research.

Edmond, C., V. Midrigan, and D. Y. Xu (2018). How costly are markups? Technical report, National Bureau of Economic Research.

Errico, M. (2022). Importer's dynamics and exchange rate pass-through.

Errico, M. and D. Lashkari (2022). The quality of us imports and the consumption gains from globalization.

Garcia-Marin, A., S. Justel, and T. Schmidt-Eisenlohr (2019). Trade credit, markups, and relationships.

Georgiadis, G., J. Gräb, and M. Khalil (2020). Global value chain participation and exchange rate pass-through. *Available at SSRN 3767294*.

Goldberg, L. S. and J. M. Campa (2010). The sensitivity of the cpi to exchange rates: Distribution margins, imported inputs, and trade exposure. *The Review of Economics and Statistics 92*(2), 392–407.

Goldberg, P. K. and R. Hellerstein (2008). A structural approach to explaining incomplete exchange-rate pass-through and pricing-to-market. *American Economic Review 98*(2), 423–29.

Goldberg, P. K. and F. Verboven (2001). The evolution of price dispersion in the european car market. *The Review of Economic Studies 68*(4), 811–848.

Gopinath, G. (2015). The international price system. Technical report, National Bureau of Economic Research.

Gopinath, G., E. Boz, C. Casas, F. J. Díez, P.-O. Gourinchas, and M. Plagborg-Møller (2020). Dominant currency paradigm. *American Economic Review 110*(3), 677–719.

Gopinath, G. and O. Itskhoki (2011). In search of real rigidities. *NBER Macroeconomics Annual 25*(1), 261–310.

Gopinath, G., O. Itskhoki, and R. Rigobon (2010). Currency choice and exchange rate pass-through. *American Economic Review 100*(1), 304–36.

Heise, S. (2019). Firm-to-firm relationships and the pass-through of shocks: Theory and evidence. *FRB of New York Staff Report* (896).

Heise, S., F. Karahan, and A. Şahin (2022). The missing inflation puzzle: The role of the wage-price pass-through. *Journal of Money, Credit and Banking 54*(S1), 7–51.

Hillberry, R. and D. Hummels (2013). Trade elasticity parameters for a computable general equilibrium model. In *Handbook of computable general equilibrium modeling*, Volume 1, pp. 1213–1269. Elsevier.

Hulten, C. R. (1978). Growth accounting with intermediate inputs. *The Review of Economic Studies 45*(3), 511–518.

Huneeus, F. (2018). Production network dynamics and the propagation of shocks. *Graduate thesis, Princeton University, Princeton, NJ*.

Jaravel, X. (2021). Inflation inequality: Measurement, causes, and policy implications. *Annual Review of Economics 13*, 599–629.

Juarez, L. (2022). Buyer market power and exchange rate pass-through.

Kaplan, S. B. A. H. G. and P. Zoch (2020). Some unpleasant markup arithmetic: Production function elasticities and their estimation from production data.

Kimball, M. S. (1995). The quantitative analytics of the basic neomonetarist model.

Klenow, P. J. and J. L. Willis (2016). Real rigidities and nominal price changes. *Economica 83*(331), 443–472.

La'O, J. and A. Tahbaz-Salehi (2022). Optimal monetary policy in production networks. *Econometrica 90*(3), 1295–1336.

Levinsohn, J. and A. Petrin (2003). Estimating production functions using inputs to control for unobservables. *The review of economic studies 70*(2), 317–341.

Mahajan, S. (2018). *Handbook on Supply and Use Tables and Input Output-Tables with Extensions and Applications*. United Nations Publications, Department of Economic and Social Affairs, Statistics Division.

Miller, R. E. and P. D. Blair (2009). *Input-output analysis: foundations and extensions*. Cambridge university press.

Mishkin, F. S. (2008). Exchange rate pass-through and monetary policy. Technical report, National Bureau of Economic Research.

Nakamura, E. and J. Steinsson (2008). Five facts about prices: A reevaluation of menu cost models. *The Quarterly Journal of Economics 123*(4), 1415–1464.

Neiman, B. (2010). Stickiness, synchronization, and passthrough in intrafirm trade prices. *Journal of Monetary Economics 57*(3), 295–308.

Pasten, E., R. Schoenle, and M. Weber (2020). The propagation of monetary policy shocks in a heterogeneous production economy. *Journal of Monetary Economics 116*, 1–22.

Piveteau, P. (2021). An empirical dynamic model of trade with consumer accumulation. *American Economic Journal: Microeconomics 13*(4), 23–63.

Reinert, K. A. and D. W. Roland-Holst (1992). Armington elasticities for united states manufacturing sectors. *Journal of Policy Modeling 14*(5), 631–639.

Rubbo, E. (2020). Networks, phillips curves, and monetary policy. *manuscript, Harvard University*.

Ruhl, K. J. et al. (2008). The international elasticity puzzle.

# Appendix

# A Data and Calibration

## A.1 Chilean Customs Data and Importing Tenure

For each import transaction, the Chilean Customs dataset includes standard information such as the importer's unique identifier (*importer*), the 8-digit HS product code (*product*), the date of the transaction, the country of origin (*origin*), the FOB and CIF values, the quantity shipped, etc. Data are available from 2009 to 2020. I compute prices as unit values by dividing the shipment value by the quantity shipped. To improve the reliability of the data, I trim the dataset by dropping observations whose price changes are above (below) the 99th (1st) percentile. Additional data cleaning entails the removal of all transactions with missing information, e.g. quantity, value, etc. I aggregate all transactions at the importer-origin-product-quarterly level, by summing over values and quantities. Table 6 provides summary statistics of the main variables and Table 5 reports information on industry and origin composition of the data.

Table 5: Summary Statistics - Breakdown by Industry and Origin

| | Numbers of Transactions (%) | Import Value (%) |
|---|---|---|
| **Industry (SITC):** | | |
| Food & Animals | 3.871 | 8.238 |
| Beverages, Tobacco | 0.291 | 0.613 |
| Crude Materials | 1.589 | 2.392 |
| Mineral fuels | 0.503 | 24.34 |
| Animal & Vegetable Oils | 0.192 | 0.524 |
| Chemicals | 11.55 | 13.23 |
| Manufactured Goods | 18.57 | 9.466 |
| Machinery | 36.52 | 33.02 |
| Mix Manufacturing | 26.91 | 8.160 |
| **Country:** | | |
| China | 14.02 | 6.208 |
| USA | 25.01 | 30.00 |
| EU15 | 25.41 | 17.41 |
| Other Americas | 18.42 | 25.03 |
| Others | 17.14 | 21.35 |

The table reports the breakdown by industry (2-digit SITC level) and country of origin of the cleaned universe of import transactions from the Chilean Customs, 2009-2019. The breakdown is computed in terms of i) number of transactions and ii) import values.

Table 6: Description of the Data - Customs

| | Whole Sample | | | | |
|---|---|---|---|---|---|
| | Mean | Median | StD | p5 | p95 |
| Importers | 41,186 | . | . | . | . |
| Products | 7,518 | . | . | . | . |
| Origin Countries | 168 | . | . | . | . |
| Products per importer | 10.66 | 3 | 27.28 | 1 | 43 |
| Origins per importer | 2.227 | 1 | 2.931 | 1 | 7 |
| Unit value (USD/quantity) | 1,732.7 | 21.35 | 76,930.6 | 0.934 | 1,569.2 |
| % $\Delta$ log unit value | 0.446 | 0.417 | 0.690 | -116.6 | 118.1 |
| Transaction value (USD) | 130,817.5 | 7,214.3 | 2,659,917.9 | 239.5 | 286,991.7 |
| Observations (N) | 3,044,931 | . | . | . | . |

The table reports summary statistics of the cleaned universe of import transactions from the Chilean Customs, 2009-2019. Transaction values and unit values are defined in USD.

Table 7: Summary Statistics - Importing Tenure

| | p5 | p25 | Median | p75 | p95 | Mean | N |
|---|---|---|---|---|---|---|---|
| **Observation:** | | | | | | | |
| Importer X Time | 1 | 1 | 4 | 11 | 44 | 11.8 | 965,043 |
| Importer X Product X Time | 1 | 1 | 1 | 1 | 2 | 1.19 | 9,524,237 |
| Importer X Country X Time | 1 | 1 | 2 | 5 | 18 | 4.94 | 2,299,882 |
| **Tenure:** | | | | | | | |
| Main | 1 | 1 | 1 | 2 | 6 | 1.99 | 2,391,689 |
| Alternative | 1 | 1 | 1 | 3 | 13 | 3.26 | 2,391,689 |

The table reports summary statistics on the distribution of the number of observations along different dimension (importer, time, product and country) from the cleaned universe of import transactions from the Chilean Customs, 2009-2019. The table reports summary statistics on importing tenure, defined as: i) the number of quarters the importer has been consecutively importing a Product X Origin pair (main); ii) the number of quarters the importer has been importing a Product X Origin pair (alternative).

## A.2 Construction of IO Matrix and Distribution Costs

I construct the input-output matrix for the Chilean economy combining the 2013 ”make” and ”use” tables provided by the the Central Bank of Chile (*Banco Central de Chile*).[54] I combine the make and use tables to construct a product-by-product input-output matrix that quantifies how much of each product is used in the production of other products. I choose to construct a product-by-product matrix, rather than an industry-by-industry, to leverage the larger product dimension of the make and use tables.

I follow standard best practice in Mahajan (2018) and Miller and Blair (2009) in constructing the input-output table under the industry technology assumption. Consider

[54] The most recent version of the tables provided by the Central Bank of Chile is from 2013. Data are available at the following website: https://si3.bcentral.cl/estadisticas/Principal1/Excel/CCNN/cdr/excel.html.

the product-by-industry make matrix, $V^T$, and the product-by-industry use matrices of domestic and imported products $U_d$ and $U_m$, respectively. Define $g^T$ the row vector of industry output, i.e. the column sum of $V^T$. I construct the product-mix matrix $C$,

$$C = V^T \left[\texttt{diag}(g^T)\right]^{-1},$$

that collects the share of each product in the output of an industry. Under the industry technology assumption, each industry has its own specific way of production, irrespective of its product mix.[55] I obtain the domestic and international Leontief matrices by multiplying the product-mix matrix $C$ to the use matrices $U_d$ and $U_m$:

$$S_d = U_d C^T \qquad S_m = U_m C^T,$$

where $S_d$ and $S_m$ represent the domestic and international product-by-product Leontief matrices, respectively. The left (right) panel of Figure 2 plots the domestic (international) Leontief matrix. As expected, the matrices are highly sparse given the granularity of the product classification used.

## A.3 Markup Elasticity

In this section, I provide additional information on how markup elasticities are estimated and calibrated. In the main text, I assume that the Kimball aggregator in Equation (7) takes the form of a Klenow and Willis (2016) aggregator. In this case, the firm-level markup elasticity depends on two parameters, the industry-specific elasticity of demand, $\sigma_i$, and the super-elasticity of demand, $\epsilon_i$, as follows:

$$\Gamma_{ik} = \frac{\epsilon_i}{\sigma_i - 1 + \epsilon_i \log\left(\frac{\widetilde{p_{ik}}}{\widetilde{p_i}}\right)}. \tag{23}$$

I follow Gopinath et al. (2010) and Amiti et al. (2019) and calibrate the steady-state elasticity of markups, assuming $\widetilde{p_{ik}} = \widetilde{p_i}$.[56] I calibrate the demand elasticity parameter $\sigma$ to match the average, steady-state markup. I then follow Edmond et al. (2018) in estimating the superelasticity parameter $\epsilon$ using the firm-level relationship between markups and market shares implied by the Klenow and Willis (2016) function form of Equation (7).

I now provide details on how I estimate markups and markup elasticities to calibrate the model in Section 2.

55 Compared to the most common alternative assumption (product technology assumption), the key advantage of the industry technology assumption is that negative elements in the input-output table cannot arise.

56 Under the condition $\widetilde{p_{ik}} = \widetilde{p_i}$, Equation (23) can be interpreted as the markup elasticity for an average firm (Amiti et al., 2019) or at the steady-state markup elasticity (Gopinath et al., 2010).

Table 8: Distribution Margins - Summary Statistics

| | Intermediate Goods | | Final Goods | |
|---|---|---|---|---|
| | Domestic | Imported | Domestic | Imported |
| Farms | 0.0701 | 0.0778 | 0.258 | 0.183 |
| Fishing and Forestry | 0.0135 | 0.000166 | 0.113 | 0.0224 |
| Oil, Coal and Gas Extraction | 0.0000500 | 0.0236 | 0 | 0 |
| Mining | 0.000593 | 0.0216 | 0 | 0 |
| Food, Beverages and Tobacco | 0.0896 | 0.207 | 0.265 | 0.366 |
| Textile and Apparel | 0.128 | 0.248 | 0.342 | 0.529 |
| Wood, Paper and Printing | 0.103 | 0.142 | 0.181 | 0.257 |
| Petroleum and Chemical Products | 0.150 | 0.172 | 0.307 | 0.386 |
| Plastic Rubber and Construction | 0.0580 | 0.146 | 0.146 | 0.401 |
| Fabricated Metal Products | 0.0577 | 0.133 | 0.0309 | 0.0809 |
| Machinery and Equipment | 0.0918 | 0.194 | 0.134 | 0.336 |
| Motor Vehicles | 0.0335 | 0.0988 | 0.0744 | 0.333 |
| Furniture | 0.112 | 0.225 | 0.312 | 0.369 |
| Utilities | 0.0310 | 0.000800 | 0.106 | 0 |
| Construction | 0.00269 | 0 | 0 | 0 |
| Wholesale and Retail Trade | 0.00384 | 0.00180 | 0.0229 | 0 |
| Transportation | 0.0107 | 0.00803 | 0.0183 | 0 |
| Health Care and Education | 0.00190 | 0 | 0.0250 | 0 |
| Accomodation and Recreation | 0.0381 | 0.0216 | 0.0894 | 0 |
| Professional Services | 0.0208 | 0.0157 | 0.0525 | 0.0226 |
| Communication | 0.0451 | 0.0153 | 0.149 | 0 |
| Other Products or Services | 0.0908 | 0.0701 | 0.0391 | 0.118 |

The table reports the average distribution margin for each (2-digit) industry. I distinguish across products depending on their use, final vs intermediate use, and on their origin, imported vs domestically produced.

**ENIA Data:** I use the Annual National Industrial Survey (ENIA) from 2000 to 2007, that provides information for approximately 5000 plants per year with more than 10 employees. It reports detailed information on sales, inputs expenditures, employment and wage bill, investment, industry code (ISIC rev 3). I consider the following variables: `REMPAG` as wage bill; `EMPTOT` and `THHANO` as total number of employees and total hours worked, respectively; `VSTK` as capital stock; `FABVAL` as production value; `VBPB` as gross production value and `VA` as value added; the sum of `TCOVAL` and `MTMPVAL` as total material expenditure; `ELECONS` as electricity consumption in MW. Table 9 presents a few basic summary statistics for the leading variables used in the analysis.

I drop firms that have zero or negative employees, wage bill, production, material expenditure or electricity usage, and capital stock. I also drop observations for which i) the gross value of production is lower than the total value added; ii) the wage bill is larger than the total value added. To obtain a real measure of the main nominal variables, I use deflators provided by the Central Bank of Chile or the National Statistical Agency (*INE*). Production value is deflated using industry-specific deflators; the value of capital

Table 9: Description of the Data - ENIA

| | Mean | p25 | Median | p75 |
|---|---|---|---|---|
| Sales | 5,666,147 | 151,802 | 407,989 | 1,607,334 |
| Wage Bill | 438,828.1 | 37,268 | 88,067 | 279,700 |
| Material Expenditure | 3,067,797 | 74,545 | 209,090 | 866,560 |
| Capital Stock | 3,001,394 | 31,636 | 130,379 | 620,612 |
| Electricity Used (MW) | 3,520.978 | 27 | 77 | 357 |
| Observations | 31,027 | | | |

The table reports summary statistics of the cleaned ENIA dataset from 2000 to 2007. All variables but electricity consumption are in millions of Chilean pesos.

stock is deflated by the investment good deflator; wage bill is deflated by the domestic CPI and material expenditure by industry-specific producer price indices.

**Markup estimation & $\sigma_i$:** I use production function estimation to estimate markups at the three-digit ISIC industry level following state-of-the-art techniques and best practices, Levinsohn and Petrin (2003), Ackerberg et al. (2015) and De Loecker and Warzynski (2012).

As specified in the theoretical model in Section 2, I estimate a Cobb-Douglas production function of the form:

$$\log y_{ik} = \beta_i^k \log k_{ik} + \beta_i^l \log l_{ik} + \beta_i^x \log x_{ik} + \omega_{ik} + \xi_{ik} \tag{24}$$

where $y_{ik}$, $k_{ik}$, $l_{ik}$, $x_{ik}$, $\omega_{ik}$ and $\xi_{ik}$ represent quantity sold, capital stock, labor, materials, log productivity and the error term, respectively. I follow the control function literature, Levinsohn and Petrin (2003) and Ackerberg et al. (2015), to tackle the endogeneity challenge due to unobserved time-varying firm-level productivity $\omega_{ik}$ and consistently estimate the production function in Equation (24).

I treat capital as a dynamic input that faces adjustment costs. I use the consumption of electricity in megawatts as proxy variable. I favor a composite variable of the cost of goods sold as benchmark measure for variable input. I construct this variable summing the total cost of labor (wage bill) to the total expenditure in materials.[57]

Given the estimated output elasticities, markups are constructed following De Loecker and Warzynski (2012); hence, firm-level markups are given by:

$$\mu_{ik} = \widehat{\beta_i^{\texttt{Cost}}} \frac{\texttt{Sales}_{ik}}{\texttt{Cost}_{ik}} \tag{25}$$

[57] Using this measure as variable input implicitly imposes an additional assumption in the estimation, as it assumes that labor and materials are perfectly substitutable, De Loecker et al. (2020). As robustness, in the section below, I relax this assumption, treating labor costs and materials separately and using the former to estimate markups. Markups and markup elasticities are highly correlated to the one I obtain from my preferred specification.

where $\texttt{Cost}_{ik}$ is the sum of wage bill and material expenditure and $\beta_i^{\texttt{Cost}}$ is the associated output elasticity estimated from Equation (24). For each industry, I calibrate the industry-specific demand elasticity using the estimated revenue-weighted average markup $\bar{\mu_i}$, $\sigma_i = \frac{\bar{\mu_i}}{\bar{\mu_i}-1}$.

**Estimating Kimball Super-elasticity $\epsilon_i$:** The Klenow and Willis (2016) functional form of the Kimball aggregator implies the following within-industry relationship between markups and market shares, up to a constant:

$$\frac{1}{\mu_{ik}} + \log\left(1 - \frac{1}{\mu_{ik}}\right) = a_i + b_i \log \texttt{share}_{ik}, \qquad b_i = \frac{\epsilon_i}{\sigma_i},$$

where $\texttt{share}_{ik}$ is the market share of firm $k$ in industry $i$. I estimate the slope coefficient $b_i$ for each industry introducing firm and year fixed effects. I can then retrieve the sectoral super-elasticities $\epsilon_i$ given the estimated demand elasticity $\sigma_i$.

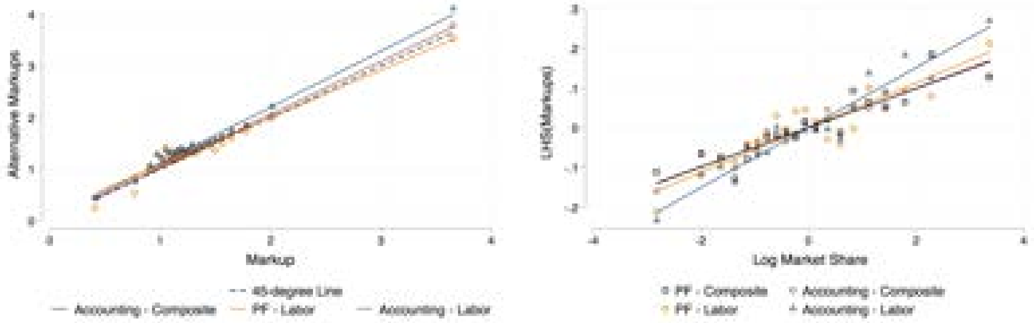
**Robustness:** It is well known that standard production data, as those used here, report revenues and expenditures rather than physical units. The standard practise of deflating using sectoral indices can introduce an additional bias due to unobserved firm-specific input price variation, De Loecker et al. (2016).[58] Moreover, recent work by Kaplan and Zoch (2020) shows that it is not possible to consistently estimate output elasticities when only revenue data is available in the presence of variable markups.

To assess the robustness of the estimates from my preferred specification, I compute markups using the simple alternative cost share approach (Autor et al., 2020; De Loecker et al., 2016). Under constant return to scale, the output elasticity of each input is equal to the share of that input in total costs. I assume that the output elasticity is common to all firms within each industry and I calibrate it to the median input share in each industry. I also relax the assumption of a composite variable input used in my preferred specification. I re-estimate markups and markup elasticities treating labor and materials separately using both the production function and the cost share approaches.

The left panel of Figure 14 plots the alternative estimates of markups against the markups obtained from the preferred specification. The right panel of Figure 14 shows the relationship in Equation (20) between (log) market share and markups, using the whole sample and controlling for year and industry fixed effects. Overall, these additional estimates show qualitative and quantitative patterns that are similar to the benchmark specification. Markup distributions are very similar, independently of the approach or variable input used. Similarly, the estimated super-elasticities (the slope coefficient on the right panel of Figure 14) are very close.

[58] Without more detailed data on output prices and quantities, it is not possible to implement the control function approach proposed by De Loecker et al. (2016) to tackle the input price bias.

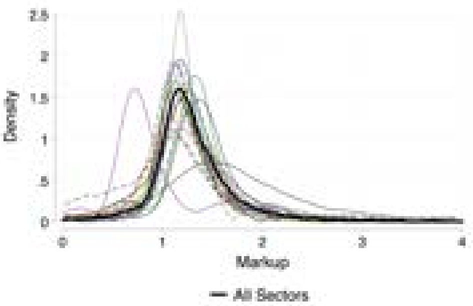
Figure 14: Comparison with Alternative Markup Estimates




The left panel plots the relationship between the preferred measure of markups (x-axis) and the alternative measures of markups estimated as robustness (y-axis). The preferred measure of markups is estimated using production function estimation and a composite measure of cost of goods sold as variable input. Alternative measures of markups include: i) estimates using production function estimation and labor as variable input ("PF - Labor"); ii) estimates using the cost share approach and a composite measure of cost of goods sold as variable input ("Accounting - Composite"); iii) estimates using the cost share approach and labor as variable input ("Accounting - Labor"). The right panel shows the relationship between the log market share of a firm and the left-hand-side of Equation (20), $\frac{1}{\mu_{ik}} + \log\left(1 - \frac{1}{\mu_{ik}}\right)$, where $\mu_{ik}$ is the firm-level markup. I consider both the preferred measure of markups ("PF - Composite") and the alternative measures estimated as robustness ("PF - Labor", "Accounting - Composite" and "Accounting - Labor"). I use the whole sample and include both year and industry fixed effects.

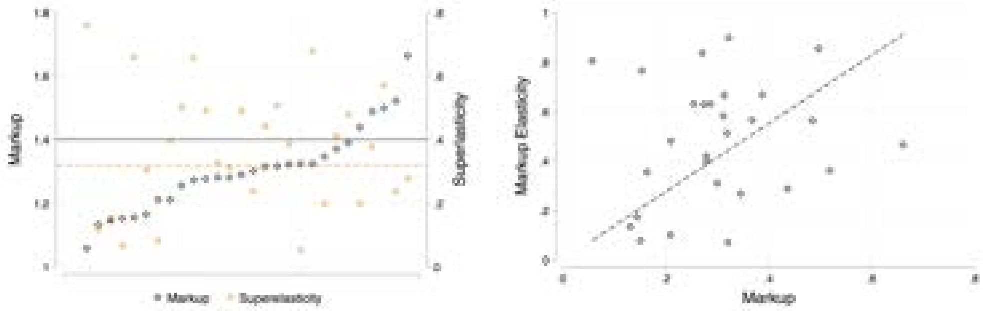
### A.3.1 Additional tables and figures

Figure 15: Markup Distributions




The figure plots the distribution of estimated markups for each 3-digit ISIC industry. The thick solid black line represents the aggregate distribution pooling all industries together. Markups are estimated using the preferred specification, i.e. production function estimation and a composite measure of cost of goods sold as variable input.

Figure 16: Markup Elasticity and Super-elasticity




In the left panel I rank each 3-digit ISIC industry by the estimated revenue-weighted average markup. For each industry I plot the estimated revenue-weighted average markup and the corresponding estimated demand super-elasticity, $\epsilon_i$. The solid horizontal line shows the aggregate revenue-weighted average markup in the whole sample. The right panel shows the relationship between the estimated revenue-weighted average markup (x-axis) and the implied markup elasticity at the 3-digit ISIC industry level. The dashed line shows a linear fit through the implied markup elasticities. Markups are estimated using the preferred specification, i.e. production function estimation and a composite measure of cost of goods sold as variable input. Markup elasticity is defined according to Equation (19), where $\sigma_i$ is calibrated using the revenue-weighted average markup and $\epsilon_i$ is estimated using Equation (20).

## A.4 Pass-through $\Psi(T)$

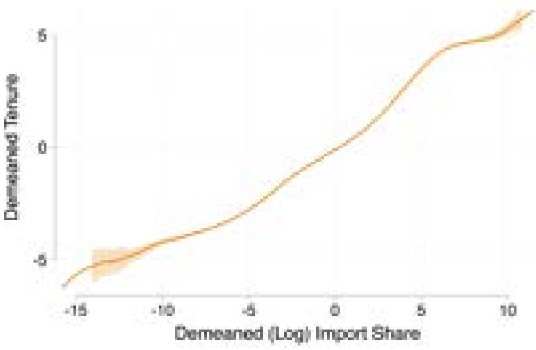
Table 10: Estimated Average Pass-through

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| $\Delta \log e$ | 0.7149 | 0.8324 | 0.7759 | 0.7092 | 0.8118 | 0.7641 |
| | (0.107) | (0.105) | (0.103) | (0.111) | (0.107) | (0.105) |
| Log Tenure X $\Delta \log e$ | | -0.0816 | | | -0.0727 | |
| | | (0.014) | | | (0.015) | |
| Tenure X $\Delta \log e$ | | | -0.0109 | | | -0.0100 |
| | | | (0.002) | | | (0.002) |
| Importer X Product X Country | Yes | Yes | Yes | | | |
| Importer X Product | | | | Yes | Yes | Yes |
| Product X Country | | | | Yes | Yes | Yes |
| Observations | 2,368,422 | 2,368,422 | 2,368,422 | 2,413,107 | 2,413,107 | 2,413,107 |

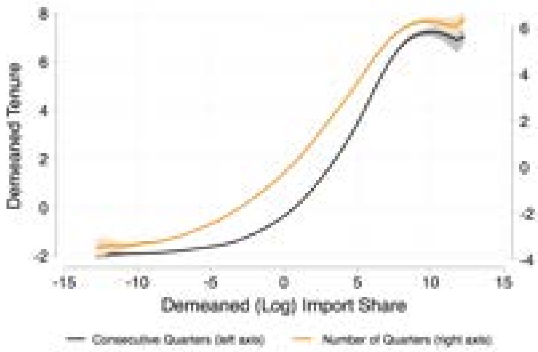
The table reports the estimated coefficients from the specification in Equation (21) without the set of controls included, $X$, and time fixed effects, $\nu_t$. Columns (1) and (4) do not control for the effect of importing tenure. Columns (2) and (5) ( (3) and (6) ) control for the interaction between exchange rate change and the log (level) of importing tenure. Columns (1), (2) and (3) ( (4), (5) and (6) ) include Import X Product X Country (Importer X Product and Product X Country) fixed effects. Coefficients for variables in level (log importing tenure, importing tenure and inflation of origin country) and left and right censorship dummies are omitted. Standard errors clustered at country level. Importing tenure is defined as the number of quarters the importer has been consecutively importing a Product X Origin pair.

# B Importing Tenure: Robustness

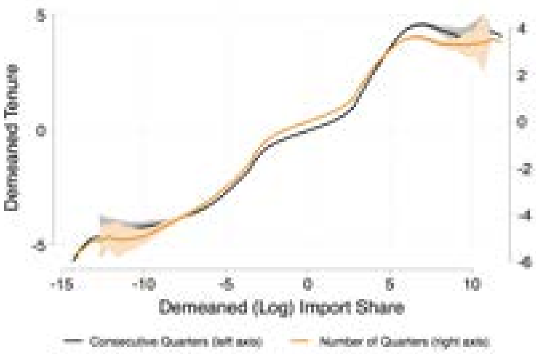
Figure 17: Heterogeneity in Tenure - Robustness



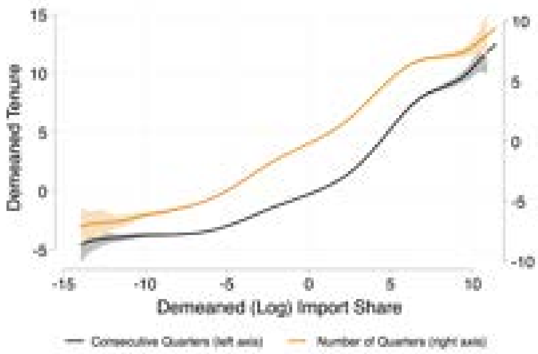

(a) Alternative measure of tenure




(b) Demeaning at quarter level



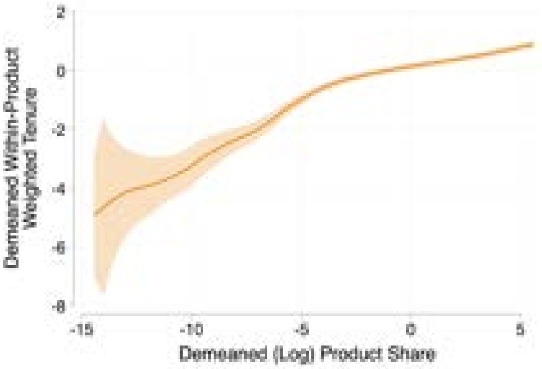

(c) Demeaning at quarter-firm-sector level



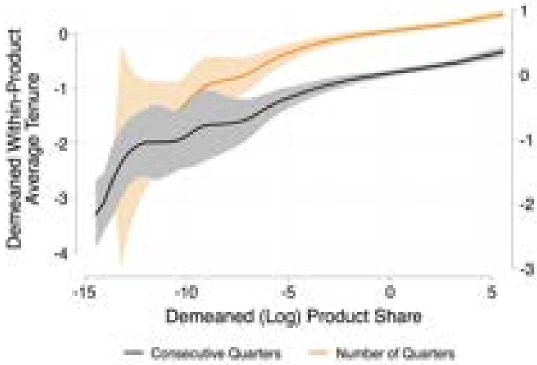

(d) Second half of the sample

All figures plot the non-parametric relationship between the (log) import share and importing tenure in the whole sample. Share and tenure are computed at the quarterly level. Import shares and tenure are defined at the firm-product-origin-quarter level, with product defined at the 8-digit level. Variables are demeaned to avoid mechanical increase in tenure due to time passing and make it comparable over time. Panel a) uses the alternative definition of tenure, the number of quarters a firm is importing the same product-origin pair (dropping the consecutive requirement of the main definition). Panel b) uses both definitions of tenure but demeans variables at the quarterly level only. Similarly, panel c) plots the variables demeaned at the quarterly-firm-sector level, where sector is defined at the 3-digit level. Finally panel d) shows the relationship between the (log) import share and tenure in the second half of the sample, using both definitions of tenure. In all panels, I report the 99% confidence intervals.

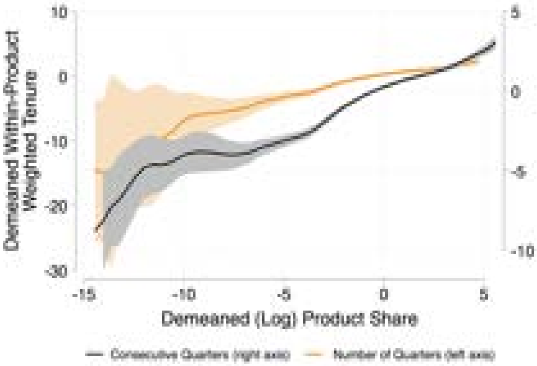
Figure 18: Heterogeneity in Tenure at Product Level - Robustness



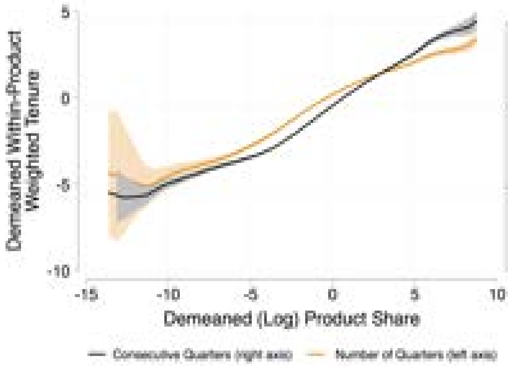

(a) Alternative measure of tenure




(b) Average tenure




(c) Second half of the sample




(d) 5-digit classification

All figures plot the non-parametric, cross-sectional relationship between the (log) import share of a product and the average tenure across all firms importing that product. Share and average tenure are computed at the quarterly level. Variables are demeaned to avoid mechanical increase in tenure due to time passing and make it comparable over time. Panel a) computes the expenditure-weighted tenure using the alternative definition of tenure, the number of quarters a firm is importing the same product-origin pair (dropping the consecutive requirement of the main definition). Panel b) computes the average tenure, considering both the main (left) and the alternative (right) definition of tenure. Panel c) plots the relationship between the (log) import share of a product and the expenditure-weighted average tenure across all firms importing that product using only the second half of the sample. Finally panel d) defines products at the 5-digit level. In all panels, I report the 99% confidence intervals.

Table 11: Pass-through Robustness

| | Level | Alternative Tenure | | Alternative FEs | Alternative Own Size | | Alternative Strategic | |
|---|---|---|---|---|---|---|---|---|
| | | Cum Quarters | Cum Sales | | Trans Value | Importer Size | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| $\Delta \log e$ | 0.3591 | 0.4100 | 0.3359 | 0.3734 | 0.3383 | 0.3906 | 0.3904 | 0.4168 |
| | (0.110) | (0.127) | (0.106) | (0.122) | (0.115) | (0.125) | (0.115) | (0.125) |
| Log Tenure X $\Delta \log e$ | | -0.0334 | -0.0154 | -0.0305 | -0.0409 | -0.0391 | -0.0348 | -0.0357 |
| | | (0.020) | (0.007) | (0.014) | (0.014) | (0.015) | (0.012) | (0.013) |
| Tenure X $\Delta \log e$ | - 0.00375 | | | | | | | |
| | (0.0017) | | | | | | | |
| Size X $\Delta \log e$ | -0.0097 | -0.0104 | -0.0102 | -0.0093 | -0.5117 | -0.0032 | -0.0097 | -0.0109 |
| | (0.003) | (0.004) | (0.004) | (0.003) | (0.146) | (0.008) | (0.003) | (0.004) |
| Strategic $\Delta p_i$ | 0.2664 | 0.2524 | 0.2871 | 0.3001 | 0.2950 | 0.3019 | -0.0980 | -0.3127 |
| | (0.312) | (0.312) | (0.317) | (0.271) | (0.303) | (0.295) | (0.112) | (0.130) |
| Time | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Importer X Product X Country | Yes | Yes | Yes | | Yes | Yes | Yes | Yes |
| Importer X Product | | | | Yes | | | | |
| Product X Country | | | | Yes | | | | |
| Observations | 2,365,619 | 2,365,619 | 2,365,619 | 2,410,260 | 2,365,619 | 2,365,619 | 2,365,619 | 2,314,387 |

Coefficients for terms in levels (log tenure, tenure, average size and inflation of origin country) and left and right censorship dummies are omitted. Standard errors clustered at country level. All columns re-runs the baseline specification in Equation (21) using different controls. Column (1) reports the main specification from column (5) in Table 2 using tenure in levels, instead of log. Column (2) is estimated using an alternative definition of tenure, the number of quarters a firm is importing the same product-origin pair (dropping the consecutive requirement of the main definition). Column (3) defines tenure as the cumulative sum of sales at the product-origin pair. Column (4) uses Product X Origin and Product X Importer fixed effects. Column (5) controls for the actual value of the transaction in the quarter, as alternative measure of own-size. Similarly column (6) uses the size of the importer defined as the sum of the all imports across products and origins. Column (7) computes the index of competitor price change using expenditure weights. Finally, column (8) specifies the index of competitor price change at the Product X Origin level.

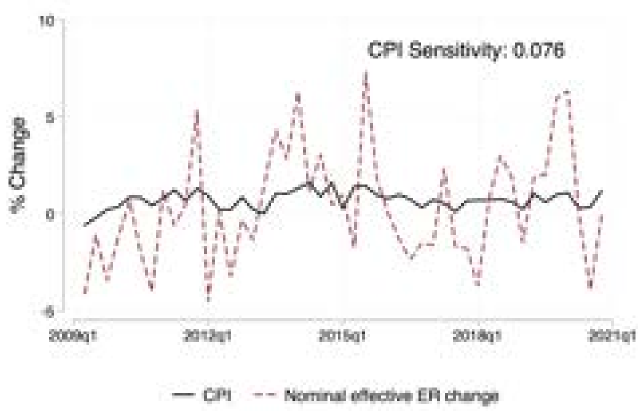
# C Additional Figures and Tables

**Estimating average CPI sensitivity:** I estimate the aggregate CPI sensitivity for the period 2009-2020 at the quarterly level using the following specification:

$$\Delta \log CPI_t = \sum_{\tau=0}^{6} \beta_\tau \Delta \log e_{t-\tau} + \sum_{\tau=0}^{6} \gamma_\tau \pi_{t-\tau} + \varepsilon_t, \tag{26}$$

where $CPI$ is the Chilean consumer price index at the quarterly level; $e$ is the trade-weighted nominal exchange rate between the Chilean peso and the exporting country's currency; $\pi$ is the trade-weighted inflation rate in the exporting country as proxy for trading partners' costs (Campa and Goldberg, 2005; Burstein and Gopinath, 2014). I include up to 6 lags to control for gradual adjustments and auto-correlation in inflation and exchange rates. Inflation and exchange rate data are sourced from IMF and Datastream, respectively. Figure 19 shows the relationship between the change in domestic prices (CPI) and the trade-weighted measure of nominal exchange rate. The estimated contemporaneous, short-run CPI sensitivity from Equation (26) is 7.6%, in line with estimates from the literature (Goldberg and Campa, 2010). The coefficient is robust to the number of lags included and to the inclusion of lagged domestic CPI as additional control.

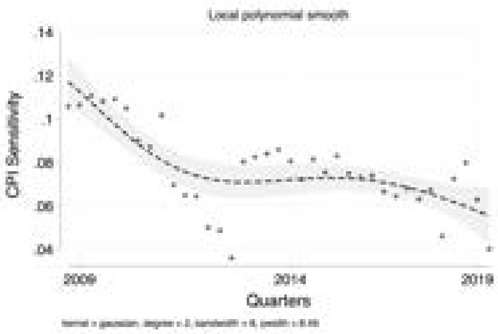
Figure 19: Estimated CPI Sensitivity




The figure plots the relationship between the change in domestic prices (CPI) and the trade-weighted measure of nominal exchange rate. Inflation and exchange rate data are sourced from IMF and Datastream, respectively. Trade shares are computed from the universe of import transactions from 2009 to 2020. The coefficient reported is the contemporaneous CPI sensitivity estimated from Equation (26) in Appendix C.

**Estimating CPI trends:** I estimate the trend in aggregate short-run CPI sensitivity over the period 2009-2020 using the regression in Equation (26) with a rolling time window of five years (20 quarters). I extend the sample to the beginning of 2007 so that the mid-point of the initial window is approximately 2009. Differently from Equation (26), I include lags up to one year as the number of data points in each window is reduced. I then estimate the trend using a polynomial approximation given that the CPI sensitivity is moderately noisy at quarterly level. Figure 20 plots the estimated CPI sensitivities and the corresponding downward trend.

Figure 20: Trend in CPI Sensitivity




The figure plots the estimated trend in short-run CPI sensitivity for Chile over the period from the late 2007 to 2020s. I use a 20-quarter rolling time window and plot the estimated trend at the midpoint of the window. CPI sensitivity is estimated at the quarterly level using regression in Equation (26). Appendix C provides additional details on the data and estimation. The trend is computed using a Gaussian polynomial approximation with bandwidth 8 and degree two. Shaded area plot the 95% confidence intervals.

Figure 21 plots the trend in short-run CPI sensitivity over the period from the late 1970s to 2020 using a rolling time window of ten years (40 quarters). Given the longer horizon considered, I augment the regression in Equation (26) to also control for the growth rate in real GDP of the importing country, Chile, and its lagged values (Campa and Goldberg, 2005):

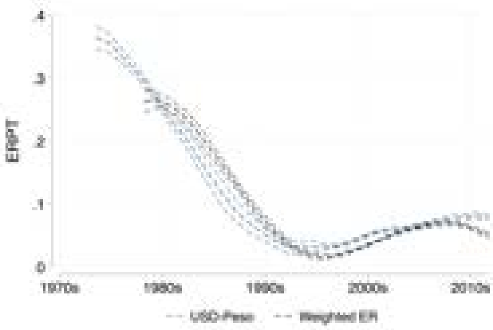
$$\Delta \log CPI_t = \sum_{\tau=0}^{6} \beta_\tau \Delta \log e_{t-\tau} + \sum_{\tau=0}^{6} \gamma_\tau \pi_{t-\tau} + \sum_{\tau=0}^{6} \eta_\tau \Delta \text{GDP}_{t-\tau} + \varepsilon_t. \tag{27}$$

In this case, the trade-weighted nominal exchange rate is downloaded directly from the IMF (series "NEU" from International Financial Statistics). I use the real effective exchange rate in combination to the nominal effective exchange rate from the IMF ("REU" and "NEU" respectively) to compute a trade-weighted measure of exporters' costs.[59] As robustness, I consider the bilateral USD-CLP exchange rate and the US inflation rate as proxy for exporters' costs.[60] I again estimate the trend using a polynomial approximation given that the CPI sensitivity is moderately noisy at quarterly level. Figure 21 shows that sensitivity decreased since the late 1970s and the pattern is robust to the exchange rate series considered.

59 I follow Campa and Goldberg (2005) and construct the proxy for exporters' cost, $\pi$, taking advantage of both the real and nominal exchange rate series. I compute $\pi = NEER \times CPI/REER$, where CPI is the measure of domestic prices in Chile.

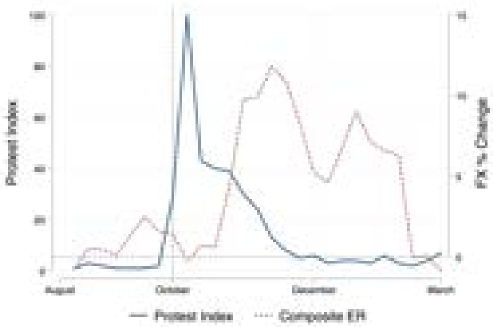
60 Using these alternative series allows to extend the period of analysis back to 1975.

Figure 21: Long-Run Trend in CPI Sensitivity



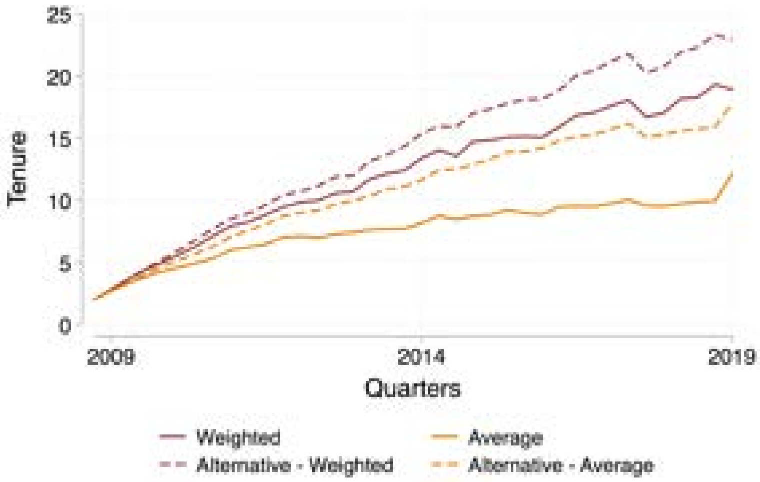

The figure plots the estimated long-run trend in short-run CPI sensitivity for Chile over the period from the late 1970s to 2020s. I use a 40-quarter rolling time window and plot the estimated trend at the midpoint of the window. CPI sensitivity is estimated at the quarterly level using regression in Equation (27). I use a trade-weighted exchange rate and exporters' costs series from the IMF International Financial Statistics ("Weighted ER"). As robustness, I also consider the bilateral USD-CLP exchange rate and the US inflation rate as cost proxy ("USD-Peso"). The trend is computed using an Epanechnikov polynomial approximation with bandwidth 15 and degree one. Dashed lines plot the 95% confidence intervals.

Figure 22: Riot Index and Exchange Rate Dynamics



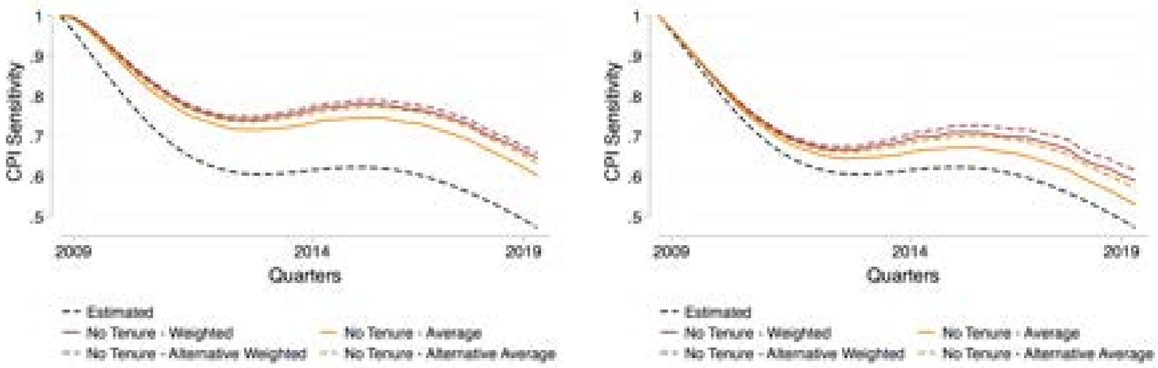

The figure plots, on the left axis, the daily Google search index for protests ("protestas" in Spanish) in Chile. The value is normalized so that the maximum over the time period considered is set equal to 100. On the right axis, I plot the weekly 3-month depreciation rate of the Chilean peso against a composite index of foreign currencies. The composite index of foreign currency is sourced from the Central Bank of Chile and is constructed as a trade-weighted average of bilateral exchange rates.

Figure 23: Trends in Tenure




The figure plots the trend in average tenure from 2009 to 2019 from the universe of import transactions. Solid lines use the main definition of tenure, i.e. the number of consecutive quarters a firm is importing the same product-country pair. Dashed lines ("Alternative") use the less conservative measure of tenure, the number of quarters a firm is importing the same product-country pair (dropping the consecutive requirement of the main definition). Red lines compute average tenure as the expenditure-weighted average tenure across all importer-product-origin triples. Orange lines compute average tenure as a simple average across importer-product-origin triples.

Figure 24: Trends in Tenure & CPI Sensitivity




The left panel plots the counterfactual trends in CPI sensitivity using different definitions of average tenure. The measure of average tenure are described in Figure 23. The trends are computed using the estimated effect of importing tenure from Table 2 (i.e. in logs). The right panel plots the counterfactual trends in CPI sensitivity using the same definitions of average tenure used in the left panel. Differently from the left panel, the trends are computed using the estimated effect of tenure from column (1) in Table 11 (i.e. in levels). In both panels the black, dash line plots the trend in CPI sensitivity to exchange rate estimated as explained in Appendix C.

Table 12: CPI Sensitivity w/out IO linkages

| | Tenure Heterogeneity | | No Tenure Heterogeneity | |
|---|---|---|---|---|
| | IO | w/out IO | IO | w/out IO |
| | (1) | (2) | (3) | (4) |
| **Frictionless:** | | | | |
| Domestic | 8.65 | 4.69 | 10.5 | 5.67 |
| Imported | 9.55 | 9.55 | 11.5 | 11.5 |
| Total | 18.2 | 14.2 | 22.0 | 17.2 |
| **Distribution Only:** | | | | |
| Domestic | 6.27 | 3.59 | 7.63 | 4.35 |
| Imported | 5.62 | 5.62 | 6.76 | 6.76 |
| Total | 11.9 | 9.21 | 14.4 | 11.1 |
| **Distribution & Markups:** | | | | |
| Domestic | 3.50 | 2.43 | 4.26 | 2.95 |
| Imported | 5.62 | 5.62 | 6.76 | 6.76 |
| Total | 9.12 | 8.05 | 11.0 | 9.71 |
| **All Frictions:** | | | | |
| Domestic | 1.98 | 1.58 | 2.40 | 1.92 |
| Imported | 5.62 | 5.62 | 6.76 | 6.76 |
| Total | 7.60 | 7.20 | 9.17 | 8.68 |

The table reports the implied aggregate CPI sensitivity to exchange rates ("Total") and its decomposition into imported final consumption ("Imported"), i.e. direct exposure, and domestic final consumption ("Domestic"), i.e. indirect exposure. I consider four different scenarios in terms of domestic frictions (distribution margin, markup elasticity, and Calvo rigidity). From top to bottom, I consider a domestic economy with: no frictions; distribution costs only; distribution costs and markup elasticity; all frictions together. In all scenarios, pass-through into import prices is incomplete. Columns (1) and (2) (columns (3) and (4)) include (omit) heterogeneous pass-through rate due to importing tenure. Columns (1) and (3) (columns (2) and (4)) include (omit) input-output linkages.

Table 13: On the Role of Importing Tenure

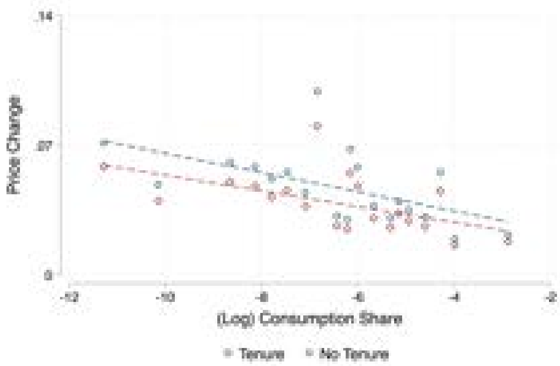
| | Tenure Heterogeneity | No Tenure Heterogeneity |
|---|---|---|
| Frictionless | 18.2 | 22.0 |
| Distribution only | 11.9 | 14.4 |
| Distribution & Markups | 9.12 | 11.0 |
| All Frictions | 7.60 | 9.17 |

The table compares the CPI sensitivity computed in the presence of importing tenure or omitting it across different scenarios. In the presence of importing tenure, the pass-through rate into import price is incomplete and heterogeneous. When abstracting away from importing tenure, the pass-through rate into import price is incomplete but homogeneous. I consider the following scenarios: "Frictionless", referring to a domestic economy with no frictions (i.e. no distribution costs, markup elasticity or Calvo rigidities); "Distribution only" consider a domestic economy with only distribution costs; "Distribution and Markups" refers to an economy including both distribution costs and markup elasticity; "All frictions" considers all domestic frictions together. I consider input-output linkages in all scenarios.

Figure 25: Network Centrality and Import Intensity

The figure shows the relationship between import intensity in production and network centrality across domestically produced goods. I plot the domestic production network of the Chilean economy in 2013 as described by the input-output matrix. Each node represents one of the 180 products making part of the economy. The size of each node is proportional to the centrality of the product in the domestic network: the more central the product is, the larger the node. The top panel uses the PageRank centrality measure while the bottom panel uses the average between the in-degree and out-degree centrality measures. Both measures are computed weighting the edges according to the input-output linkages. The coloring of the nodes depends on the import intensity in the production of that good. Import intensity of a product is computed as the share of imported intermediate inputs over total costs. Warmer colors refer to higher import intensity. Appendix A.2 provides additional details on the construction of the domestic input-output matrix.

Figure 26: Consumption Share and Price Change




The figure plots the relationship between the share of each domestic good in the final consumption basket and the change in price due to a depreciation of the exchange rate. The change in price is computed in the fully calibrated model. The dashed line plots a linear fit. Table 15 in Appendix C reports the corresponding coefficient. Section 3 and Appendix A provide additional details on how consumption shares are computed.

Table 14: Identify Effect and Correlation across Rankings

| | Tenure | Calvo | Markups | Distribution | IO |
|---|---|---|---|---|---|
| Tenure | 1 | | | | |
| Calvo | -0.062 | 1 | | | |
| Markups | 0.12 | 0.029 | 1 | | |
| Distribution | 0.16 | -0.074 | -0.17 | 1 | |
| IO | 0.13 | $-0.78^{\star}$ | -0.0078 | 0.15 | 1 |

The table reports the correlation coefficients between the change in the ranking of the products contributing the most to the overall CPI sensitivity with respect to the fully calibrated model across different scenarios. I consider the change in ranking of the products contributing the most to the overall CPI sensitivity between the fully calibrated model and an alternative scenario. I consider the following alternative scenarios: a fully calibrated economy that omits, one at the time, the role of importing tenure, nominal rigidities, distribution costs, real rigidities, and input-output linkages. I then compute the correlation between changes in ranking across scenarios. All values are not significant except for the correlation between the Calvo and input-output linkages scenarios.

Table 15: Import Exposure and Friction Heterogeneity

| | Imported Input Share | | | | | | | | Δ Domestic Price |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| PageRank Centrality | -3.680 | | | | -3.071 | -3.253 | -0.147 | -0.156 | |
| | (1.54) | | | | (1.54) | (1.56) | (0.074) | (0.075) | |
| Distribution Margin - Intermediate | | 0.363 | | | 0.323 | | 0.150 | | |
| | | (0.16) | | | (0.16) | | (0.074) | | |
| Distribution Margin - Weighted | | | 0.122 | | | 0.0971 | | 0.0846 | |
| | | | (0.086) | | | (0.085) | | (0.074) | |
| Markup Elasticity | | | | 0.0555 | 0.0519 | 0.0507 | 0.110 | 0.107 | |
| | | | | (0.035) | (0.035) | (0.035) | (0.073) | (0.074) | |
| Final Consumption Share | | | | | | | | | -0.475 |
| | | | | | | | | | (0.20) |
| Constant | 0.270 | 0.228 | 0.235 | 0.222 | 0.221 | 0.231 | -6.35e-17 | -6.38e-17 | 0.0424 |
| | (0.016) | (0.016) | (0.017) | (0.022) | (0.026) | (0.026) | (0.073) | (0.073) | (0.0028) |
| *N* | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 |

Columns (1) to (4) report the correlation coefficients between the share of imported intermediate inputs and product level characteristics in the whole sample of domestically produced goods. The share of imported intermediate inputs is computed as the share of imported intermediate inputs used in production over total costs. I consider the following characteristics: the PageRank centrality of the product in the domestic network, column (1); the distribution margin of the product, computed considering only intermediate inputs or as a weighted average between intermediate and final goods (column (2) and (3), respectively); the markup elasticity of the product, column (4). PageRank centrality is computed weighting the edges according to the input-output linkages. Appendix A provides additional information on how distribution margins and markup elasticities are computed. Column (5) regresses the PageRank centrality measure, the markup elasticity and the distribution margin for intermediate goods all together on the share of imported intermediate inputs. Similarly, column (6) uses the weighted measure of distribution costs. Column (7) and (8) run the regressions in column (5) and (6), respectively, after standardizing all the variables. Finally, column (9) reports the correlation coefficient between the change in domestic prices after a depreciation in the exchange rate and the final consumption share in the whole sample of domestically produced goods. The change in domestic prices is computed in the fully calibrated model.