

# Buyer Market Power and Exchange Rate Pass-through

Leticia Juarez

Department of Research and  
Chief Economist

DISCUSSION  
PAPER N°  
IDB-DP-1026

# Buyer Market Power and Exchange Rate Pass-through

Leticia Juarez

Inter-American Development Bank

August 2023



<http://www.iadb.org>

Copyright © 2023 Inter-American Development Bank. This work is licensed under a Creative Commons IGO 3.0 Attribution-NonCommercial-NoDerivatives (CC-IGO BY-NC-ND 3.0 IGO) license (<http://creativecommons.org/licenses/by-nc-nd/3.0/igo/legalcode>) and may be reproduced with attribution to the IDB and for any non-commercial purpose. No derivative work is allowed.

Any dispute related to the use of the works of the IDB that cannot be settled amicably shall be submitted to arbitration pursuant to the UNCITRAL rules. The use of the IDB's name for any purpose other than for attribution, and the use of IDB's logo shall be subject to a separate written license agreement between the IDB and the user and is not authorized as part of this CC-IGO license.

Note that link provided above includes additional terms and conditions of the license.

The opinions expressed in this publication are those of the authors and do not necessarily reflect the views of the Inter-American Development Bank, its Board of Directors, or the countries they represent.



## Abstract\*

This paper studies the role of buyer market power in determining the response of international prices to exchange rate changes (i.e., exchange rate pass-through). Using a novel dataset of the universe of Colombian export transactions that links Colombian exporters (sellers) to their foreign importers (buyers), I document three facts: i) most Colombian exports are concentrated in a few foreign buyers in each market, ii) the same seller charges different prices to different buyers in the same product and destination, and iii) Markets with a higher concentration of sales among buyers display lower exchange rate pass-through. Motivated by these stylized facts, I propose an open economy model of oligopsony—a market with large number of sellers and a few buyers—that accounts for buyer market power in international markets and its consequences for price determination in international transactions. The model shows that larger foreign buyers pay a marked-down price, i.e., a price below the marginal product value for the buyer. Most importantly, these markdowns are flexible and play a role when adjusting prices to exchange rate shocks. I derive a model-based equation relating pass-through to buyer size and estimate it on the micro transaction level data for Colombia. I find that after an exchange rate shock, sellers connected to larger buyers face more moderate changes in their prices in the seller currency (i.e., lower exchange rate pass-through) than those connected to small buyers. Pass-through ranges from 1% for firms connected with the largest buyers to 17% for firms connected with the smallest buyers. I use the estimates from the empirical analysis to calibrate the model and propose a counterfactual where buyer market power is eliminated. Under this scenario, sellers' revenues increase; however, the price in seller currency is more responsive to exchange rate shocks.

**JEL classifications:** D43, E31, F31, F41, F42, L1

**Keywords:** Market power, Exchange rate, Oligopsony, Market structure, Markdown, Exchange-rate pass-through

---

\*I am extremely grateful to Javier Cravino, John Leahy, Andrei Levchenko and Pablo Ottonello for their invaluable mentorship, support, and advice. I also want to thank Kayleigh Barnes, David Berger, Nina Buchmann, Brian Ceballos, Kathryn Dominguez, Jan Eeckhout, Kyle Handley, Ezequiel Garcia Lembergman, Caitlin Hegarty, Patrick Kennedy, Dmitry Mukhin, Emir Murathanoglu, Andrés Rodríguez-Clare, Esteban Rossi-Hansberg, Sebastian Sotelo, Linda Tesar, Lucas Zavala and Roman Zarate for very helpful comments and discussions. All errors are my own.

The views expressed here are strictly those of the author and do not necessarily reflect the views of the Inter-American Development Bank, its Board of Directors or the countries they represent. Email: [leticiaj@umich.edu](mailto:leticiaj@umich.edu). Website: <https://leticiajuarez.github.io/>.

# 1 Introduction

Large firms dominate many sectors of the global economy. It has become increasingly clear that this phenomenon has important macroeconomic consequences (Autor et al., 2020; Gutiérrez and Philippon, 2019; De Loecker, Eeckhout and Unger, 2020). In the context of international markets, a vast group of small exporting firms often sell their goods to just a handful of large, multinational buyers. For example, the top one percent of importers account for 83.5% of U.S. imports (Bernard et al., 2018). This raises the question of how the presence of large buyers affects prices and price dynamics in export markets. In particular, when there is an exchange rate shock, do large firms leverage this buyer market power to increase their profits? What are the consequences for smaller connected firms?

This paper studies buyer market power in international markets and its impact on exchange rate pass-through. Exchange-rate pass-through corresponds to the change in international prices in the seller's currency as a response to a change in the exchange rate. I combine a novel transaction-level dataset covering the universe of Colombian exports with an oligopsony model of buyer market power in international trade. The main conclusion is that buyer market power moderates the response of international prices to exchange rate shocks. The main mechanism behind this effect is that large firms have *more* variable markdowns and can use this as a tool to maintain more stable prices. When the Colombian currency appreciates, U.S. buyers absorb the shock by reducing their markdowns. The result is that the prices Colombian exporters receive respond less.

I begin by documenting stylized facts on Colombian export markets. This paper uses data on exports from Colombia to the rest of the world from 2007 to 2020. I exploit the granularity of my data, containing identifiers of buyer, seller, product, destination country, and year in each transaction. Export data are matched to data on bilateral exchange rates for each year and destination country. I define a *market* as a product-destination-year combination. I find that i) sales are concentrated among a few large foreign buyers in each market, ii) a given seller faces different prices for different buyers of the same products and destination country, and iii) markets with a higher concentration of sales among buyers display more moderate changes in market average prices after an exchange rate shock (i.e., lower exchange rate pass-through).

Motivated by these stylized facts, I propose an open economy model of oligopsony that accounts for buyer market power in international markets and illuminates its consequences for price determination in international transactions. In my model, sellers are located in the home country and buyers are in foreign countries. On the supply side, buyers face a nested CES supply curve from sellers. The supply curve is microfounded with a discrete-choice problem, where sellers are price takers and choose which product to produce and which buyer to supply. On the demand side, buyers observe the quantities supplied and choose the price they are willing to pay for a product. Given a finite number of buyers, they act strategically, internalizing their influence on prices. In equilibrium, buyers pay sellers a price marked down from the marginal revenue of the product.

The first theoretical result is that markdowns are increasing in the buyer's market share—that is, larger buyers have greater markdowns. Aggregating the firm-level markdowns across all firms in a market, I find market-level average markdowns are increasing in buyer market concentration. Additionally, markdowns depend on sellers' within-product cross-buyer elasticity of substitution and the cross-product elasticity of substitution. Lower elasticities correspond to greater markdowns. Intuitively, if substitution across buyers and products is costly for sellers, buyers have more market power and higher markdowns.

The second theoretical result is that the price response to exchange rate shocks varies with buyer market share. This is a novel source of exchange rate pass-through dispersion that, to my knowledge, has not been previously studied in the literature. The overall effect is driven by two offsetting mechanisms: a markdown channel and a marginal-revenue channel.

On the one hand, the markdown channel implies that following a change in the exchange rate, buyers adjust their markdowns, keeping prices more stable in the seller's currency. Larger buyers tend to have more variable markdowns and adjust their markdowns more elastically. In response to the stable price, sellers do not substitute away from that buyer.

On the other hand, the marginal-revenue channel implies that, following a change in the exchange rate, a standard price effect induces sellers to change their quantity supplied, which in turn affects marginal revenue. Because sellers have a lower supply elasticity in concentrated markets—intuitively, the costs to finding another buyer are higher for these sellers—larger buyers face smaller changes in marginal revenue. In contrast to the markdown channel, prices in the seller's currency are more volatile.

I then take the model to the data and estimate the exchange rate pass-through elasticity. The richness of the transaction-level data allows me to regress buyer-seller-product prices on the exchange rate and on an interaction between the exchange rate and the buyer market share. The measure of buyer market share is based on my model and corresponds to the share of the sales in a market account to a given buyer. In this way, I differentiate the exchange rate pass-through for larger and smaller buyers. I control by a variety of fixed effects including seller time to account for sellers' marginal cost, and year-product-country fixed effects to isolate the differences between markets, comparing across buyers with different market shares.<sup>1</sup> I find that larger buyers face a lower exchange rate pass-through to prices in the seller's currency, ranging from 1% for the largest buyers to 17% for the smallest ones. Thus, when the currency of the seller's country depreciates, sellers in concentrated markets face attenuated price increases (in the seller's currency) relative to exporters that sell to smaller buyers.

The results thus reveal that the markdown channel is more empirically relevant than the marginal-revenue channel. Intuitively, larger buyers internalize the upward-sloping supply curve and are aware that each additional unit they buy increases the price of every other unit. As a result, buyers strategically purchase fewer units, increasing prices by less than if the seller supply curve were flat. In the event of a depreciation of the seller currency, gains for the large buyer come at the expense of lower prices earned by the seller.

I proceed by quantifying the markdowns for large firms and estimating how they change in response to an exchange rate shock. In the model, two elasticities govern the magnitude of this effect: the cross-product elasticity of supply and the within-product cross-buyer elasticity of supply. I propose an approach that integrates i) empirical estimates of the exchange rate pass-through elasticities, ii) moments from the cross-section of prices, and iii) a simulated method of moments to estimate these elasticities by indirect inference. I find the markdowns for the average firms are around 15% and that they adjust by 3% in response to a 10% exchange rate shock.

Finally, I use the model to simulate a counterfactual economy with no buyer market power. In a perfectly competitive economy, sellers' revenues are higher due to a price effect (i.e., the absence of markdowns) as well as a quantity effect (i.e., they adjust quantities in response to higher prices). However, revenues in the seller currency are more elastic in response to international shocks,

---

<sup>1</sup>Note that even though this might drop the exchange rate coefficient, the coefficient of interest—the one for the interaction term—does not change.

potentially generating greater volatility.

I illustrate my findings with an example. Starbucks, a large U.S. buyer of Colombian coffee, receives a higher markdown (i.e., a price discount) than smaller U.S. firms buying coffee from Colombia. All else equal, Starbucks is thus able to pay lower prices for coffee. Moreover, prices paid by Starbucks in the seller currency (i.e., the COP, Colombian peso) are less responsive to exchange rate shocks. In the aggregate, if the U.S.-Colombia coffee market is dominated by large buyers like Starbucks, the average market price for coffee is also reduced and less responsive to shocks. In a counterfactual world where Starbucks and other large firms did not have such market power, sellers in developing countries would increase their revenues because they would sell at a higher price. However, these sellers would charge prices that respond more to shocks which would bring volatility to their revenues.

This paper contributes to three strands of the literature. First, it contributes to the literature on international pricing response to exchange rate changes (Amiti, Itskhoki and Konings, 2014; Auer and Schoenle, 2016; Burstein and Gopinath, 2014; Gopinath et al., 2020). While most of these papers focused on the seller side, a theoretical contribution of this paper is to introduce a buyer market and a buyer-concentration effect. Empirically, the detailed buyer-seller data I use in this research allow me to quantify the role of buyer-seller relationships in determining the exchange rate pass-through and to quantify the markdown response.

Second, this paper relates to the literature on market power (De Loecker, Eeckhout and Unger, 2020; Atkeson and Burstein, 2008; De Loecker et al., 2016). In particular, a growing body of work on buyer market power in labor markets uses oligopsony and monopsony models to explain why workers' wages are marked down from their marginal products (Berger, Herkenhoff and Mongey, 2022; Azar, Marinescu and Steinbaum, 2019; Lamadon, Mogstad and Setzler, 2022; Felix, 2022). My theoretical approach most closely resembles Berger, Herkenhoff and Mongey (2022) in labor markets in the United States and Zavala (2022) in agricultural value chains in Ecuador. I draw the modeling tools from this literature but apply them to an international-trade setting with buyers having oligopsony power over the sellers. I contribute to this literature by showing the implications of buyer market power for international prices.

Third, I contribute to a nascent literature on buyer-seller links, global value chains, and shock transmissions (Devereux, Dong and Tomlin, 2017; Huneus, 2018; Alviarez et al., 2022; Lim, 2018; Hottman and Monarch, 2020; Dhyne et al., 2021). Because of data availability, most of these papers focus on firm-to-firm transactions in the domestic context, while my paper and a few others (Adão et al., 2022; Bernard et al., 2019) analyze the international markets. I contribute to this literature by documenting the existence of price dispersion for the same seller, product and destination in the international setting. Additionally, I estimate the cross-buyer elasticity of substitution, a key parameter that had not been previously estimated.

The rest of the paper proceeds as follows. Section 2 presents my data and empirical setting together with some key stylized facts on buyer-seller relationships in Colombia and their consequences for exchange rate pass-through. Section 3 presents the model that links buyer market concentration to export prices, yielding a specification for estimating the effect of buyer market power on exchange rate pass-through. Section 4 presents my empirical strategy and its link to my theoretical model. Section 4 also uses the estimates from the empirical part to calibrate the model and estimate key elasticities to quantify the markdown channel. Section 5 proposes a counterfactual scenario with no buyer market power. Section 6 concludes.

## 2 Data

This paper combines buyer-seller transaction data for Colombia in international markets with data on bilateral exchange rate shocks. In this section, I describe the data and present summary statistics relevant for the analysis.

### 2.1 Buyer-Seller Data

One of the challenges of studying buyer market power in international markets is the lack of detailed information on bilateral transactions between buyers and sellers. I use novel data on the universe of cross-border trade transactions between Colombian exporters and foreign firms during 2007–2020.<sup>2</sup> The data come from the Colombian National Directorate of Taxes and Customs (DIAN; Dirección de Impuestos y Aduanas Nacionales de Colombia).<sup>3</sup> For each transaction, DIAN reports the value and quantity shipped (in USD and in COP), the shipment date, the 10-digit Harmonized System (HS10) code of the product traded, the country of destination, the weight, the port through which this transaction occurred and the transportation mode. The key element of the dataset is that I am able to uniquely identify the foreign firm interacting with the Colombian firms and, in this way, I can carry out a buyer-seller analysis.

I combine these administrative microdata with data on bilateral exchange rates from International Financial Statistics of the International Monetary Fund (IMF). In particular, I use the monthly nominal bilateral exchange rate expressed as local currency per USD.

### 2.2 Descriptive Statistics for Colombia

As Colombia is a developing country that hosts thousands of small firms exporting to the rest of the world, it is the ideal setting to study how the characteristics of their buyers affect their prices and how these prices react to shocks. The United States is Colombia's largest trading partner, representing about 41% of the country's exports. In addition, as the COP has depreciated against the USD and other leading currencies several times over the last decades, my data also presents a perfect setting to study the exchange rate pass-through to international prices.

I have information on the universe of Colombian firms exporting to the rest of the world. My data consists of all exports from 50,869 Colombian firms producing 6,941 different HS10-level goods<sup>4</sup> exported to 54 different countries during 2007–2020.

Table 1 summarizes the main descriptive statistics relevant for my analysis. In each year of data, an average of 13,382 sellers trade with 39,028 buyers each year.<sup>5</sup> Each combination of destination and HS10 product includes, on average, 4.55 buyers, suggesting only a few buyers for a large number of sellers. Each of these buyers buys on average 3.68 products from Colombia.

---

<sup>2</sup>In the Appendix, we include robustness checks conducted with data at the transaction level for importing firms.

<sup>3</sup>This dataset was accessed through Datamyne.

<sup>4</sup>Each product is identified with a 10-digit code, which corresponds to the Harmonized Commodity Description and Coding System at the highest level of disaggregation. An example for this could be women's or girls' cotton panties versus knitted or crocheted panties.

<sup>5</sup>Note that these buyers correspond to all possible destinations.



**Table 1: Annual Summary Statistics**

Variable	Mean	SD
# Products	6,941	91
# Sellers	13,382	5,479
# Buyers	39,028	2,914
# Buyers by destination $\times$ product	4.6	23
# Products by buyer	3.7	9

Notes: In this table products are at the 10-digit Harmonized System level. Source: Colombian Customs Data.

## 2.3 Facts

Small sellers in Colombia sell their products to large firms abroad. In this section, I document three stylized facts on the role of these large buyers in Colombian export markets. Together they suggest the existence of substantial buyer market power. Most importantly, they support the idea that buyer market power is relevant not only for price setting in international markets, but also for price adjustments to exchange rate shocks (exchange rate pass-through).

I find that i) most Colombian exports are sold to the largest foreign buyers in each market, ii) sellers price discriminate across buyers in international markets, and iii) the exchange rate pass-through coefficient is negatively correlated with the concentration of buyers in a market. These facts motivate the oligopsony model in Section 3 where buyer market power determines the degree of exchange rate pass-through into international prices.

### Fact I: Most Colombian Exports Are Sold to the Largest Foreign Buyers in Each Market

I explore the well-known dominance by large firms of the markets in my data. I define a market as a destination  $\times$  product  $\times$  year, where a product is at the HS10 level.

First, I identify the top buyers (top 3, top 5, top 10) of exports in each market and calculate how much they contribute to the total value bought in each market. Figure 1, Panel A shows that the value of the exports bought by the top three buyers in each market accounts for 78% percent of exports from Colombia, suggesting the high degree of buyer concentration in Colombia's export market. For example, for the coffee market into the United Stat for a certain year, this would mean Starbucks, Peet's Coffee and Dunkin' Donuts buy most of Colombia's coffee sold to the United States, by value.

Second, I calculate the degree of concentration of sales by using a standard measure of concentration, the Herfindhal-Hirschman Concentration Index (HHI). Before defining this index, I define  $S_{bjkt}$  as Buyer  $b$ 's share of the nominal value of all exports of Product  $j$  to Country  $k$  in period  $t$ .

$$S_{bjkt} = \frac{p_{bjkt}q_{bjkt}}{\sum_b p_{bjkt}q_{bjkt}}$$

I then define the HHI.

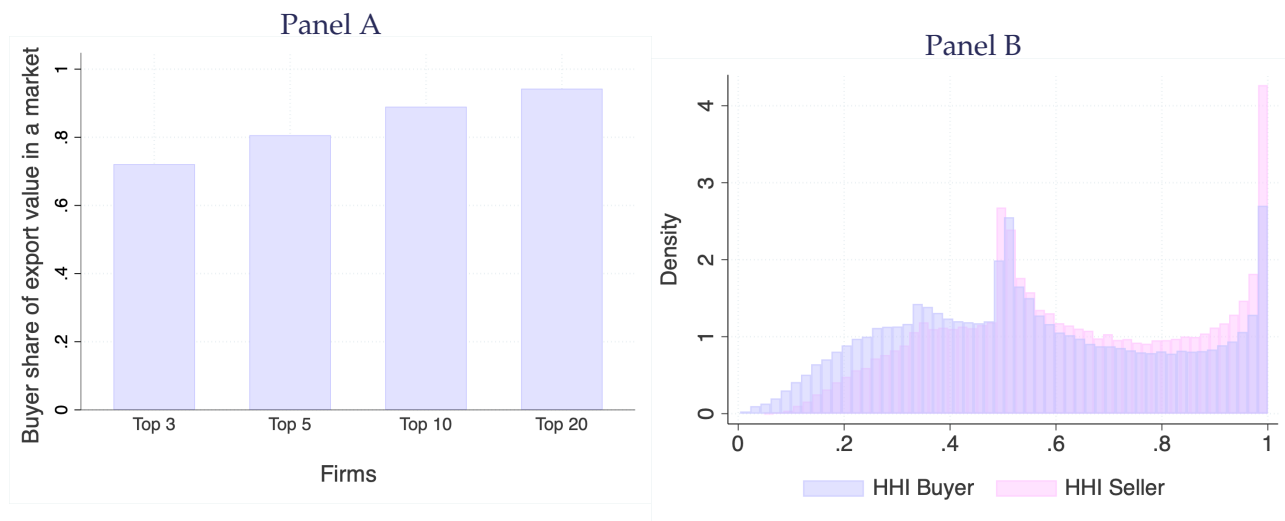
$$HHI_{jkt} = \sum_b S_{bjkt}^2 \quad (2.1)$$

Figure 1, Panel B plots the distribution of the HHI. Note that in a market with only one buyer the HHI

would be 1, while in a market with two buyers where each of them accounts for half of the market share, the HHI is 0.5. The figure shows a considerable number of markets with a high HHI, implying a high degree of concentration of sales among buyers.

I benchmark the observed level of concentration against the HHI for sellers comparing the concentration of buyers in Colombian markets with the concentration of sellers. Figure 1, Panel B indicates the concentration of export flows among buyers is as important as the concentration among sellers, and therefore, it could have important economic implications.

**Figure 1: Buyer Market Concentration**



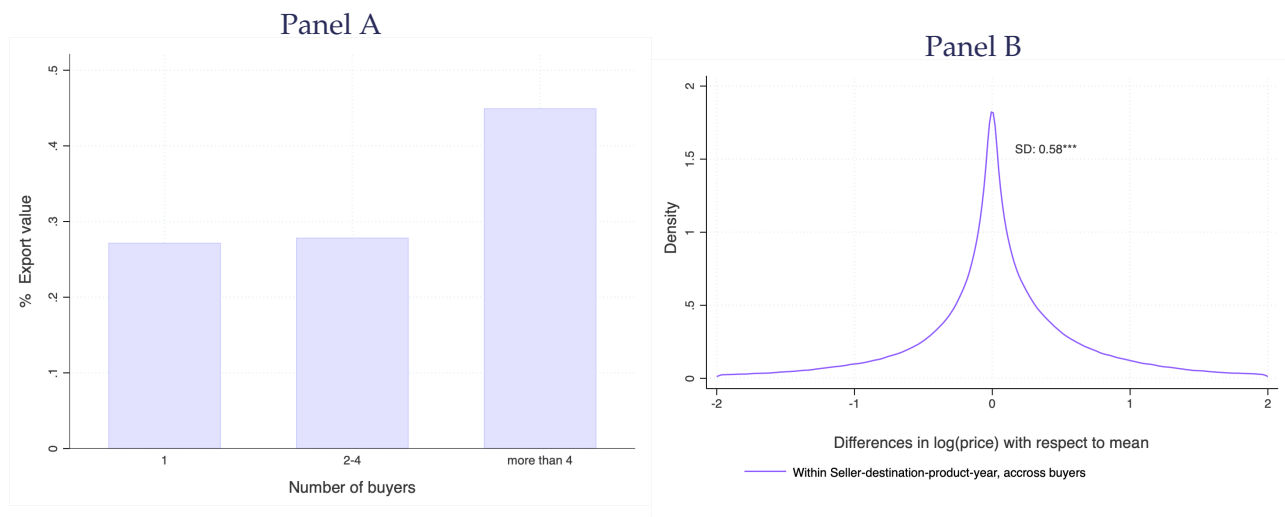
Notes: This figure shows the concentration of Colombian exports among foreign buyers. Panel A shows how much of the export value in a market, where market is defined as destination country  $\times$  HS10 product  $\times$  year, corresponds to the top buyers. Top buyers are ranked by their purchases in the given market. Panel B shows the distribution of the HHI using equation 2.1 for the buyer market share (blue) and the seller market share (pink).

## Fact II: Sellers Price Discriminate Across Buyers in International Markets

I document the existence of multi-buyer firms in a market and that these firms receive different prices for the same product among their buyers.

Figure 2, Panel A shows a significant number of multibuyer firms in Colombian export markets. In my sample, these firms account for roughly 80% of the exports value of the country. To date, no empirical evidence exists on price discrimination for buyers in international markets. I document this new stylized fact for sellers (exporters) in Colombia. As documented in Figure 2, Panel B, the same firm, exporting the same product to the same destination in the same year, receives different prices from different buyers. This is true even controlling for sector  $\times$  destination  $\times$  year fixed effects to compare similar destination markets (i.e., controlling for size of the market, as well as growth of a particular sector). The standard deviation from the mean of prices received by one firm for the same product to the same destination across similar buyers is around 0.58%. This suggests specific buyers have characteristics that considerably affect the price that a firm sets.

**Figure 2:** Export Value Explained by Multibuyer Sellers and Top Buyers and Price Dispersion



Notes: This figure shows characteristics of multibuyer sellers. Panel A highlights that sellers with more than one buyer account for half of the export value on average per market. Panel B illustrates the price dispersion after including product fixed effects, country of destination fixed effects and year fixed effect. The blue line also includes also seller fixed effects. That is, for a given seller, product, year and country of destination, prices have a standard deviation of 0.58%.

### Fact III: Markets with High Concentration of Sales Among Buyers Display Low Exchange Rate Pass-through

I now explore how the concentration of buyers relates to the exchange rate pass-through. I define exchange rate pass-through as how export prices, that is the prices in COP, react to a change in the exchange rate. For every market, destination–product, I run the following regression.

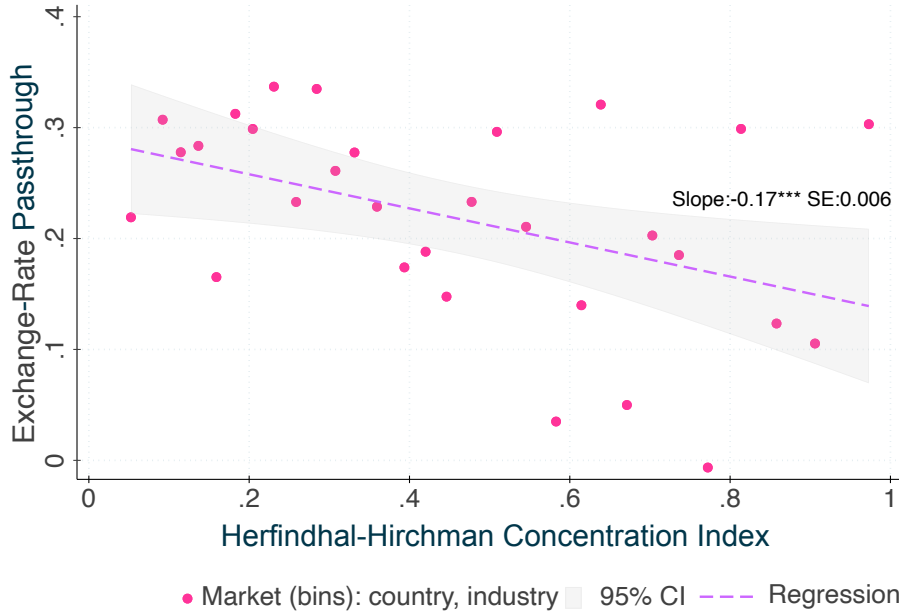
$$\Delta \ln p_t = \underbrace{\psi_{jk}}_{\text{Exchange rate pass-through}} \Delta \ln e_{kt} + \epsilon_t \quad (2.2)$$

where  $p_t$  corresponds to the average price in seller currency (COP) and  $e_k$  is the nominal bilateral exchange rate (local currency per unit of foreign currency).

Figure 3 presents the coefficients of my regression on a bin scatter plot. It shows there is a negative correlation between the exchange rate pass-through and the concentration of buyers. This means that in the event of an exchange rate shock, markets where buyers are more concentrated have fewer changes in prices, in the sellers' currency. This last fact motivates my model in the following section, exploring buyer market power in international markets as the main channel for this effect. Given that buyers are large and have buyer market power, this affects how prices are adjusted.<sup>6</sup>

<sup>6</sup>I have just shown that this relationship holds in the cross section for the different industries. In Section 7.2.6 of the Appendix, I also show this relationship holds in the time series for Colombia.

**Figure 3: Exchange Rate Pass-through and the Concentration Index**



Notes: This figure shows regression 2.2, which accounts for correlations between the exchange rate pass-through coefficient for a given market and the HHI defined as equation 2.1.

### 3 The Model

I develop an oligopsony model in international markets with an infinitely many sellers located in the home country and a few large buyers in each foreign market. This concentration of demand gives the buyers market power and allows them to choose the prices they pay.<sup>7</sup> The concentration of buyers, and hence their market power, differs across and within products. Given these prices, sellers choose which products they produce, and to which buyer they sell. I model the seller’s choice of sector and buyer as a discrete-choice problem, which yields a nested CES supply curve.

The equilibrium price is a function of the relative buyer market share.<sup>8</sup> The shape of this function is determined by two key elasticities, the cross-product supply elasticity and within-product cross-buyer supply elasticity, which govern the heterogeneity of costs in the seller’s choice problem. Intuitively, more heterogeneous sellers’ costs lead to greater consequences of buyers’ market power.

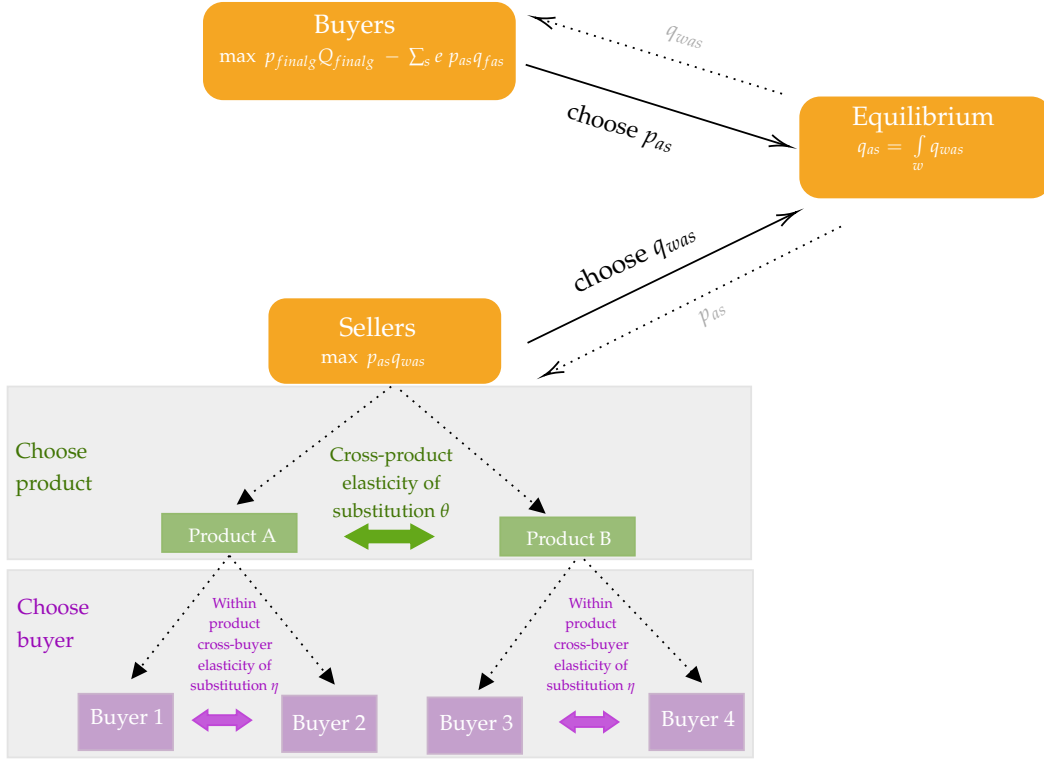
#### 3.1 Timeline and Model Structure

The timeline of the model is as follows: i) productivity shocks are realized, ii) buyers choose the price they want to pay for their inputs, and iii) sellers choose the quantity they are going to supply of each input. I solve this by backward induction, starting with the sellers’ problem then moving to the buyers’ problem. Figure 4 summarizes the model structure with notation explained in the text.

<sup>7</sup>In my baseline model, buyers compete à la Bertrand. However, in Appendix 7.1.5, I additionally solve for Cournot competition.

<sup>8</sup>In this sense, the model also connects to the work of Alvarez et al. (2022).

**Figure 4: Model Structure**



Notes: This figure displays a diagram of the structure of the model. The upper part shows how quantities and prices are determined in equilibrium. The lower part illustrates the seller input supply decision according to the discrete choice framework.

### 3.2 Seller Supply Function

An infinite mass of potential sellers in a home country indexed by  $s \in [0, 1]$  sell their products indexed by  $j \in [1, \dots, M]$  to buyers  $b$  in destination countries  $k$ . Each seller makes two decisions: i) which product to produce and ii) which buyer to supply. This decision will depend on the sellers' initial endowment, some productivity shocks and the prices offered by the buyers.

To begin, each Seller  $s$  has an endowment,  $q_s \sim \psi$ , and can decide to allocate it to the production of any product-buyer combination. As the seller produces more of a product for a buyer, the less he has left of this endowment to use for another product and buyer:  $\sum_{bj} q_{sbj} = q_s$ . Also, sellers with more of the endowment,  $q_s$ , can produce more.

Second, apart from their initial endowment, each Seller  $s$  for Product  $j$  for Buyer  $b$  in Destination  $k$  receives an idiosyncratic productivity drawn iid from a nested Fréchet distribution: he receives an idiosyncratic shock,  $\rho_{sjk}$ , for producing each Product  $j$  (product-specific shock) and an idiosyncratic shock,  $\rho_{sbjk}$ , for supplying each Buyer  $b$  within Product  $j$  (within-product buyer-specific shock). Therefore, the idiosyncratic shocks determine the supply. A higher shock for Buyer  $b$  and Product  $j$  means that the seller can supply more if he chooses that buyer and product. Intuitively,  $\rho_{sjk}$  corresponds to the availability of inputs and technology for the seller to produce Product  $j$ , and  $\rho_{sbjk}$  corresponds to search costs and frictions for the seller to connect with Buyer  $b$  of Product  $j$ .

Third, the sellers observe the prices offered by the different buyers for the different products in each destination and take these prices into account when maximizing their profits. The seller chooses the buyer and product that yields the highest profits for each Destination  $k$ , given the productivity

shocks and the prices set by the buyers.<sup>9</sup>

$$\max_{q_{sbjk}} \sum_{bj} p_{sbjk} q_{sbjk} \rho_{sbjk}^{\frac{1}{\eta}} \rho_{sjk}^{\frac{1}{\theta}} \text{ s.t. } \sum_{bj} q_{sbjk} = q_s,$$

where  $p_{sbk}$  is the price at the destination if it is consumed by Buyer  $b$  in Sector  $s$ . Note that this price varies by Buyer  $b$  since they have market power. As there are no diminishing returns to selling to a given buyer-product in equilibrium each seller will pick just one buyer-product and sell everything to him if there are no ties.

For intuition, consider the problem of a seller who has an initial endowment of  $q_s$  square feet of land to be cultivated. He could use it for growing either coffee or cocoa beans depending on his technology,  $\rho_{sjk}$ . For example, he has a machine more suitable for either of those beans. If he produces coffee, he could sell it to either Starbucks or Peet's Coffee depending on the search costs,  $\rho_{sbjk}$ . For example, he has previously sold to Starbucks and thus has some relationship with them, or he matches better with Starbucks' packaging preference. Finally, the seller will take into account the price offered by those buyers before deciding to sell to any of them. There could be a trade-off between producing lower quantities and higher prices offered by the buyers.

The probability that Seller  $s$  chooses Product  $j$  and Buyer  $b$ ,  $\Pr(sbjk)$ , is independent of his endowment,  $q_s$ . Due to the Frechet distribution of productivity shocks, for a given seller, that is fixing  $q_s$ , the probability of choosing Buyer  $b$  and Product  $j$  is the same as the probability that  $(\Pr(\text{revenue}_{b',j',k} < \text{revenue}_{b,j,k}) \forall b', j' \neq b, j)$ . Following Eaton and Kortum (2002), this probability is then equal to how much of the total production of all sellers goes to each buyer and product. Formally, we define  $\lambda_{bjk}$  as the share (of the total of sellers' production) that is sold to Buyer  $b$  of Product  $j$  in Destination  $k$ :<sup>10</sup>

$$\lambda_{bjk} = \frac{P_{jk}^{1+\theta}}{\underbrace{\sum_{j'k} P_{j'k}^{1+\theta}}_{\Pr(\text{chooses Product } j)}} \frac{P_{bjk}^{1+\eta}}{\underbrace{P_{jk}^{1+\eta}}_{\Pr(\text{chooses Buyer } b|j)}}, \quad (3.1)$$

where  $P_{jk} = B_{jk} \left( \sum_{b' \in j} B_{b'jk} p_{b'jk}^\eta \right)^{\frac{1}{\eta}}$  and  $P_k = \left( \sum_{j'} P_{j'k}^{1+\theta} \right)^{\frac{1}{1+\theta}}$ . I derive this in Appendix 7.1.2.

Aggregating across sellers yields a nested CES upward-sloping supply curve for Buyer  $b$  in Product  $j$ , Country  $k$ :<sup>11</sup>

$$q_{bjk} = \left( \frac{p_{bjk}^\eta}{P_{jk}^\eta} \right) \left( \frac{P_{jk}^\theta}{P_k^\theta} \right) Y \quad (3.2)$$

where  $Y = \sum_{b'j'k'} p_{b'j'k'} q_{b'j'k'}$

<sup>9</sup>Note that there are no costs in this maximization given all the sellers have an endowment. One way some types of costs are included is through the different shocks  $\rho_{sbjk}$  and  $\rho_{sjk}$ , but not input costs.

<sup>10</sup>All destinations here will differ on the exchange rate, and they might also have different elasticities. More details on this are found in Section 3.2.1.

<sup>11</sup>See Appendix 7.1.3 for derivations and intuitions on how prices relative to the price index relate to quantity.

### 3.2.1 Interpreting Elasticities

There are intuitive interpretations of the parameters  $\theta$  and  $\eta$ .<sup>12</sup> First,  $\theta$  governs the correlation of product-specific shocks. This means that the higher  $\theta$ , the more correlated are the seller's productivity draws across sectors. This means that, if the idiosyncratic productivity for the different product is more likely to be similar, the prices of the product will be more relevant to determine the quantity choice. Intuitively,  $\theta$  will be high if the availability of inputs needed for many different sectors and technology is similar so that there is little heterogeneity in productivity. Finally,  $\theta$  is the elasticity of substitution across products in the CES supply function. If  $\theta$  is relatively high, then it is easy to substitute products from the point of view of the seller. Higher substitutability would correspond to higher rates of seller switching between products in a dynamic setting.

Analogously,  $\eta$  governs the correlation of buyer-specific shocks. The higher  $\eta$ , the more correlated are the seller's draws across buyers within a product. Then, since search costs to connect with one buyer or another are similar, the price each buyer offers will be more important. If  $\eta$  is high, then sellers are able to actually connect with many buyers, and there will be low heterogeneity in the cost of finding a buyer.

Following the literature on the topic, we expect  $\eta > \theta$ , which has different interpretations: i) Idiosyncratic cost shocks are more strongly correlated across buyers than across products, ii) there is more heterogeneity in the productivity of producing different products than in the costs of connecting with two different buyers,<sup>13</sup> and iii) sellers are more substitutable within products than across products from the buyer's point of view.

## 3.3 Buyer's Profit Maximization

There is a finite number of buyers in Foreign Country  $k$ . Each buyer purchases her inputs to produce a final good to sell in her home country. A buyer can buy different inputs from different countries.<sup>14</sup> Her production function is CES:

$$Q_{finalg} = \left( \int_{jk} z_b q_{bjk}^{\frac{1-\sigma}{\sigma}} dj k \right)^{\frac{\sigma}{\sigma-1}}, \quad (3.3)$$

where  $z_b \sim O$  is an idiosyncratic productivity term, which is the only source of ex ante heterogeneity across buyers.

Buyers of Product  $j$  exert market power over sellers, which I model as Bertrand competition. When deciding the price to pay, buyers form expectations about how sellers will respond. This means that they internalize the upward-sloping supply curve: each additional unit they purchase increases the price of every other unit. Note that, as I assume that the market structure is oligopsonistic, a buyer can affect the price index  $P_j$ ; however, there is an infinite mass of products such that the buyer cannot affect the aggregate price index  $P$ . Therefore, the problem of Buyer  $b$  that buys Product  $j$  in Country  $k$  consists of choosing the prices they will offer to sellers,  $p_{bjk}$ . Buyers maximize the following profit function subject to a production function, equation 3.3, and the quantity supplied by the seller,

<sup>12</sup>The interpretation of elasticities is inspired by Berger, Herkenhoff and Mongey (2022) and Zavala (2022).

<sup>13</sup>Note that, in the empirical analysis, this condition holds for the same destination and in the same period.

<sup>14</sup>Note that he can also buy the *same* input  $j$  from different countries.

equation 3.2.

$$\max_{p_{bjk}} p_{finalg} Q_{finalg} - \sum_{origin,j} \frac{1}{e_k^{origin}} p_{bjk} q_{bjk} \quad \text{s.t.} \quad Q_{finalg} = \left( \int_{jk} z_{bjk} q_{bjk}^{\frac{1-\sigma}{\sigma}} dj \right)^{\frac{\sigma}{\sigma-1}} \quad \text{and} \quad q_{bjk} = \frac{p_{bjk}^\eta P_{jk}^\theta}{P^\theta} Y \quad (3.4)$$

The first term of the profit function corresponds to the revenue the buyer obtains after selling quantity  $Q_{finalg}$  of the final good he produces at price  $p_{finalg}$ . The domestic price of output is modeled as exogenous.<sup>15</sup> The second term corresponds to the costs paid for the inputs (they buy different products from different countries), all the quantities,  $q_{bjk}$ , bought at prices,  $p_{bjk}$ .

The profit function is expressed in local currency. Buyers sell their final products in the home country, so the revenue term is expressed in local currency. As buyers buy these inputs in international markets (costs term), which means they pay for them in the currency of the producer, I introduce the term  $e_k^{origin}$  that corresponds to the nominal exchange rate to convert the costs to local currency. The subindex  $k$  indicates the country of the buyer, while the superindex *origin* corresponds to the country of the seller.<sup>16</sup> This term is defined as foreign currency per unit of home currency.

The first-order condition (FOC) can be written as

$$p_{bjk} = \underbrace{\frac{1}{\mu_{bjk}}}_{\text{mark down: } \mu_{bjk} > 1} \times \underbrace{MRP_{bjk}}_{\text{marginal revenue product}} \times e_k, \quad (3.5)$$

where markdown  $\mu_{bjk} = 1 + \epsilon_{bjk}^{-1}$  with  $\epsilon_{bjk} = \frac{\partial \ln q_{bjk}}{\partial \ln p_{bjk}}$  is the supply elasticity faced by Buyer  $b$  of Product  $j$  in Destination  $k$ .

Equation 3.5 shows that the price of the input in the producer's currency (seller's currency) depends on the markdown, the exchange rate and the marginal value of the input, that is the value the input adds to the final product. In other words, the buyers, who are the ones that have market power, will pay for an input an amount equal to how much this input adds to their revenues "reduced" in how much market power they have.<sup>17</sup>

Some relevant intuitions can be derived from equation 3.5. First,  $MRP_{bjk}$  is expressed in buyer's currency and the markdown has no unit so, for the price to be in the currency of the seller, I need to multiply by the exchange rate  $e_k$ . If all transactions happened in the domestic market (that is, if there is no difference in currency, so  $e_k = 1$ ), then price is equal to the markdown times the MRP. Second, under perfect competition,  $\frac{1}{\epsilon_{bjk}} = 0$  and the price is equal to the marginal value of the input. When the buyer has market power, he internalizes the upward-sloping supply of inputs,  $\frac{1}{\epsilon_{bjk}} > 0$ , and the input price is "marked down" from the perfectly competitive level. The steeper the supply curve faced by the buyer (higher  $\frac{1}{\epsilon_{bjk}}$ ), the more market power he has, the higher the markdown, and the lower the price, ceteris paribus. Alternatively, the more value the input adds to the final good (higher MRP), the higher the price.<sup>18</sup>

<sup>15</sup>I relax this assumption in Appendix 7.1.11 and assume these buyers charge markups.

<sup>16</sup>Note that we think about our home country as the *only* origin country for the seller as we move forward, so the superindex "origin" is omitted in the rest of the paper, but  $e_k$  refers to the bilateral exchange rate between our home country where the seller is and Country  $k$  where the buyer is.

<sup>17</sup>Note that this is equivalent to Berger, Herkenhoff and Mongey (2022) on labor-market power where the wage is equal to the markdown times the marginal productivity of labor. The intuition is that these buyers avoid purchasing the last few units of a good whose value to them is greater than their marginal cost, just to hold down the price paid for prior units.

<sup>18</sup>I am not assuming constant returns to scale in the marginal revenue of the product. Doing so would be expecting that



### 3.4 Buyer Market Power and Supply Elasticity

The elasticity of supply allows us to better understand how prices are determined. Given Bertrand competition,<sup>19</sup> the elasticity of supply has the following closed form

$$\epsilon_{bjk} = \eta(1 - S_{bjk}) + \theta S_{bjk}, \quad (3.6)$$

where

$$S_{bjk} = \frac{p_{bjk} q_{bjk}}{\sum_b p_{bjk} q_{bjk}} = \frac{p_{bjk}^{\eta+1}}{\sum_{b' \in B} p_{b'jk}^{\eta+1}} \quad (3.7)$$

is the relative size of Buyer  $b$  and Product  $j$  in Destination  $k$ . This variable is key given that together with the elasticities it determines the buyer's market power.

Focusing on equation 3.6, the supply elasticity,  $\epsilon_{bjk}$ , is the weighted average of the elasticity of substitution across products,  $j$ , and across buyers,  $b$ , where the relative size of the buyers governs these weights. Note that the smaller the buyer share, which could relate to a higher level of competition (more buyers per market), the more weight on the substitutability across buyers within a product,  $\eta$ . With many buyers, they exert less influence, and sellers can always switch to other buyers of the same product or input. However, as the number of buyers decreases, the relevance relies on the potential substitution between products,  $\theta$ .

Finally, I arrive at my first theoretical result. Rearranging equation 3.6, and assuming  $\eta > \theta$ , I find the elasticity of supply is decreasing in buyer market share, and so the markdown is increasing in buyer market share. Therefore, larger buyers have larger markdowns.

**Proposition 1** 1. *The markdown of Buyer  $b$  for Product  $j$  in Destination  $k$  is increasing in that buyer's market share in the market:*

$$\mu_{bjk} = \frac{\eta \left( 1 - \frac{p_{bjk}^{\eta+1}}{\sum_{b' \in B} p_{b'jk}^{\eta+1}} \right) + \theta \left( \frac{p_{bjk}^{\eta+1}}{\sum_{a' \in S} p_{a'jk}^{\eta+1}} \right)}{1 + \eta \left( 1 - \frac{p_{bjk}^{\eta+1}}{\sum_{b' \in B} p_{b'jk}^{\eta+1}} \right) + \theta \left( \frac{p_{bjk}^{\eta+1}}{\sum_{b' \in B} p_{b'jk}^{\eta+1}} \right)}; \quad \Gamma_{bjk} = \frac{\partial \mu_{bjk}}{\partial S_{bjk}} < 0.$$

2. *The marginal revenue of product,  $MRP_{bjk}$ , of a Buyer  $b$  in Product  $j$  is increasing in that buyer's market share in the market:*

$$MRP_{bjk} = \frac{\partial \text{revenue}}{\partial q_{bjk}} = p_{bjk} q_{bjk}^{-\frac{1}{\sigma}}; \quad \Theta_{bjk} = \frac{\partial MRP_{bjk}}{\partial S_{bjk}} > 0.$$

**Proof** See Appendix.

each additional unit of different inputs would increase the marginal revenue in the same amount. If there were constant returns to scale in the production function, then  $\frac{\partial MRP_{bjk}}{\partial q_{bjk}}$  would be 0. This would mean the  $MRP_{bjk}$  is not affected by a change in quantities and so also not affected by a change in prices (or exchange rate).

<sup>19</sup>I focus on Bertrand competition and present results under Cournot competition in the Appendix.

### 3.5 Concentration

In this section, I aggregate my previous results at the market level. Aggregating the right-hand side of equation 3.7 across all firms in a local market, weighting each firm by its buyer market share, gives the key relationship between the degree of buyer market power in the inputs market and its concentration level.

**Proposition 2** *Suppose inputs supply follows a nested CES, and buyers compete for sellers à la Bertrand, the average price markdown in market  $s$  is given by*

$$\mu_{jk} = \frac{\overline{MRP}_{jk}}{\bar{p}_{jk}e_k} = 1 + \epsilon^{-1} = 1 + \eta HHI_{sk} + \theta(1 - HHI_{sk}) \quad (3.8)$$

where  $\overline{MRP}_{jk}$  and  $\bar{p}_{jk}$  are Market  $j$ 's (revenue-weighted) average marginal revenue of product of the input and average price, respectively,  $\epsilon_j^{-1}$  is the (revenue weighted) average market supply elasticity, and  $HHI_{jk} = \sum_{b \in \Theta_{jk}} S_{bjk}^2$  is the market's HHI.

*Proof* See Appendix.

After obtaining an equation for equilibrium price and after showing how it depends on the markdown,<sup>20</sup> I can now finally investigate the relationship of the markdowns to price adjustments caused by exchange rate shocks.

### 3.6 Exchange Rate Pass-through

In this section, I investigate the role of buyer market power in determining the export price response to exchange rate shocks (exchange rate pass-through elasticity). I consider a generic exchange rate shock at the country-pair level,  $\Delta e_k$ , our home country and destination Country  $k$ .

By definition, a bilateral exchange rate shock affects the prices and quantities for all exports in the home country. This means that, after an exchange rate shock, when Buyer  $b$  chooses the new price, full efficiency would require considering how the shock affects the prices chosen by all the other buyers of Seller  $s$ .<sup>21</sup> Consistent with my assumption in the buyer profit-maximization problem, I assume that when Buyer  $b$  chooses the new bilateral price, she takes as given both prices and quantities of all other pairs. In other words, this means focusing on the direct effect of the shock on the price,  $p_{bjk}$ .<sup>22</sup> Log-differentiating equation 3.5, and using the result in Proposition 1, I rewrite the log change in price,  $d \ln p_{bjk}$ , as<sup>23</sup>

$$d \ln p_{bjk} = d \ln \mu_{bjk} + d \ln MRP_{bjk} + d \ln e_k. \quad (3.9)$$

<sup>20</sup>In Appendix 7.1.6, I show the relationship between size and price level.

<sup>21</sup>Intuitively, by affecting the price and quantities for other buyer-seller pairs, a given shock may affect the price.  $p_{bjk}$ , through changes in buyer market share. Section 7.1.9 considers how the pass-through formula would change once these indirect effects are considered. The more general pass-through formula can be derived by solving a complex system of equations for each Seller  $s$ .

<sup>22</sup>I validate this assumption in the next section, where I show that the effect of the country-pair-level shock to the bilateral price is unchanged regardless of whether or not the quantities or prices of other buyers in the same Product  $j$  and Destination  $k$  are controlled for in the estimation.

<sup>23</sup>Note that I am dropping the subindex  $s$ , I will assume sellers are homogeneous in the prices they receive from the buyers so I can isolate the buyer effects. In my empirical part, I control for differences in two different sellers connected with the same buyer.

Solving for each term, I derive

$$d\ln\mu_{sbjk} = \frac{d\ln\mu_{bjk}}{d\ln S_{bjk}} \frac{d\ln S_{bjk}}{d\ln p_{bjk}} d\ln p_{bjk} \quad (3.10)$$

$$= Y_{sbjk}(\eta + 1)(1 - S_{bjk}) d\ln p_{bjk} \quad (3.11)$$

$$= \Gamma_{bjk} d\ln p_{bjk}, \quad (3.12)$$

where I have defined  $Y_{sbjk} = -\frac{\partial \ln \mu_{sbjk}}{\partial S_{bjk}} > 0$  as the partial elasticity of bilateral markdowns with respect to the buyer share  $S_{bjk}$  and  $\Gamma_{bjk} = \frac{d\ln \mu_{bjk}}{d\ln p_{bjk}} < 0$ .

$$d\ln MRP_{sbjk} = \frac{d\ln MRP_{sbjk}}{d\ln p_{bjk}} d\ln p_{bjk} \quad (3.13)$$

$$= \frac{-1}{\sigma} (1 - x_{bjk}) \epsilon_{bjk} d\ln p_{bjk} \quad (3.14)$$

$$= \Phi_{bjk} d\ln p_{bjk}, \quad (3.15)$$

where  $\sigma$  is the elasticity of substitution of the CES production function,  $x_{bjk}$  is the expenditure share of Buyer  $b$  from Destination  $k$  on Product  $j$  and  $\epsilon_{bjk}$  is the elasticity of substitution as in equation 3.6.

Substituting equations 3.10–3.13 into 3.9, it is possible to write the log change in the price,  $p_{sbjk}$ , for each Buyer  $b$  in Product  $j$  and Destination  $k$  as a function of the buyer's market share,  $S_{sbjk}$ , and fundamentals. Proposition 3 characterizes the direct component of the pass-through of an exchange rate shock into the price,  $p_{bjk}$ .

**Proposition 3** The pass-through of a bilateral exchange rate shock to the price  $p_{bjk}$  when  $d \ln p_{bjk} = 0, \forall i \neq k$ . is given by:

$$\frac{dp_{bjk}}{de_k} = \frac{1}{1 + \underbrace{\Gamma_{bjk}(\eta, \theta, S_{bjk})}_{\text{Mark down channel}(+)} + \underbrace{\Phi_{bj}(\varphi_j, S_{bjk})}_{\text{Marginal Revenue Channel}(-)}} \quad (3.16)$$

where  $\Gamma_{bjk} = Y_{sbjk}(\eta + 1)(1 - S_{bjk})$  and  $\Phi_{bjk} = \varphi_j \epsilon_{bjk}$ , with  $\varphi_j = \frac{-1}{\sigma}(1 - x_j)$

*Proof* See Appendix.

Equation 3.16 indicates that the pass-through elasticity into prices in a model with buyer market power can be written as a function of the buyer share in the market and the parameter vector  $v = \{\eta, \theta, \varphi\}$ .

### 3.6.1 Aggregate Level

Next, I calculate the average exchange rate pass-through by sector and destination in terms of the HHI.

**Proposition 4** The average exchange rate pass-through is given by:

$$\psi_{jk} = \frac{dp_{jk}}{de_k} = \frac{1}{1 + \underbrace{\tilde{\Gamma}_{jk}(\eta, \theta, HHI_{jk})}_{\text{Mark down channel}(+)} + \underbrace{\tilde{\Phi}_{jk}(\varphi_j, HHI_{jk})}_{\text{Marginal Revenue Channel}(-)}} \quad (3.17)$$

where  $\tilde{\Gamma}_{jk} = \frac{d\mu_{jk}}{de_k}$  and  $\tilde{\Phi}_{bjk} = \frac{d \ln MVP}{d \ln e_k}$

*Proof* See Appendix.

## 3.7 Channels

In this section, I decompose the overall exchange rate pass-through effect into markdown and marginal-revenue channels. From my theoretical model, I derive an expression to quantify each of these channels in the empirical part in Section 4.4.

### 3.7.1 Markdown Channel

The markdown channel is driven by the endogenous response of the buyer's market share to the shock. Following a positive exchange rate shock ( $\uparrow e_k$ , a devaluation of the home country), the buyer reduces her markdown and increases the price in the buyer currency (compensating for the shock and keeping the price more stable in the seller currency) such that the seller does not substitute away from that buyer. In other words, she internalizes the upward-sloping supply curve in equation 3.2: each additional unit she purchases increases the price of every other unit.

The key theoretical result of my model is that, at the firm level, the markdown channel,  $\Gamma_{bjk}$ , is an

increasing function of the buyer market share.<sup>24</sup> Therefore, the markdown channel operates differently for buyers with different market shares: higher market share leads to more variable markdowns. Intuitively, buyers with higher market share, have higher markdowns. They pay a price way below the marginal-revenue product. Given this, they have more *scope* to adjust their markdowns as desired.

To identify the magnitude of this effect, and formally analyze each component present in this channel, I focus on a direct implication of Proposition 2.

### Corollary 1

$$\text{markdown channel} = \frac{\partial \ln \mu_{bjk}}{\partial \ln p_{bjk}} = \frac{d \ln \mu_{bjk}}{d \ln S_{bjk}} \frac{d \ln S_{bjk}}{d \ln p_{bjk}} = \frac{-(\eta + 1)(1 - S_{bjk})S_{bjk}}{\left(\frac{\eta}{\theta - \eta}\right) (\eta + (\theta - \eta)S_{bjk} + 1)}$$

If the cross-product elasticity of substitution is lower than the within-product cross-buyer elasticity,  $\eta > \theta > 1$ , then firms with higher  $S_{bjk}$  have more-variable markdowns.

$$\frac{d \text{markdown channel}}{d S_{bjk}} > 0$$

**Proof** Differentiate equation 3.8 with respect to  $S_{bjk}$ . See Appendix 7.1.14 for details.

To understand the intuition behind the Corollary 1, suppose that the exogenous shock is a positive bilateral exchange rate shock whose variation I introduce in the empirical section. Two conditions must hold for a positive exchange rate shock to increase the markdown of Buyer  $b$  in Product  $j$ , and Country  $k$ , and thereby reduce price paid via buyer market power. First, a positive exchange rate shock (a depreciation) must increase buyer market share. The reason for this is that buyer market share is the only endogenous component of that buyer's markdown. The other two components,  $\eta$  and  $\theta$ , are supply parameters, which by assumption do not change. The source of market power in the international market is sellers' production heterogeneity for products and buyers. Buyers can "exploit" this heterogeneity to pay marked-down prices. The bigger a buyer is relative to her competitors, the more she can mark prices down without sellers easily leaving because there are fewer buyer options nearby and sellers tend to prefer switching in the same product across buyers before switching markets completely. Therefore, the degree of market power in each market, Product–Destination  $jk$ , can only meaningfully change if the relative size of the buyer meaningfully changes. Second, there must be a difference between sellers' key inverse elasticities of substitution (i.e.,  $\theta - \eta$ ). If there is no difference in elasticities, sellers substitute equally between buyers and product. In this scenario, the effect of the exchange rate on buyer market share would be irrelevant for changes in the buyer market power. Such is the case under two of the model's limiting cases: monopsonistic competition (i.e., no gap to induce effects on market power, but because  $\theta - \eta < 0$ , there is still some level of market power), and perfect competition (i.e., no gap to induce effects, and because  $\theta = \eta = 0$  no level of market power either).<sup>25</sup>

<sup>24</sup>Equation 3.10 shows  $\Gamma_{bjk}$  depends on  $S_{bjk}$ , and Appendix 3.7.1 shows the relationship is increasing.

<sup>25</sup>For this section, I borrow some labor-market intuitions from Berger, Herkenhoff and Mongey (2022); Felix (2022).

### 3.7.2 Marginal-Revenue Channel

The marginal-revenue channel captures the price response due to changes in the buyer's average revenue. When the bilateral price increases due to a positive exchange rate shock, a standard supply effect leads the seller to supply more of that variety. Higher supply decreases the average revenue, decreasing the price. Rearranging equation 3.13, I obtain the following expression for the marginal-revenue channel.

$$\frac{d\ln MRP_{sbjk}}{d\ln p_{bjk}} = \frac{-1}{\sigma} (1 - x_{bjk}) \epsilon_{bjk}$$

It can be seen that the marginal-revenue channel depends on i)  $\sigma$ , the parameter for elasticity of substitution in the buyer's CES production function, ii)  $x_{bjk}$ , the share of input  $j$  in the buyer's production costs, and iii) the elasticity of supply.<sup>26</sup> I interpret how each parameter contributes to this channel.

First, the higher the  $\sigma$ , the more substitutability between products in the production function and the less relevant the marginal-revenue channel. In the extreme, if  $\sigma \rightarrow \infty$ , then every input has a close substitute either from another seller in that same country or in another country and there is no differential marginal-revenue effect for larger buyers, because there is no marginal-revenue effect at all.<sup>27</sup>

Second, a higher  $x_{bjk}$  yields a more-relevant product for the buyers' production. If  $x_{bjk} = 1$ , input  $j$  is the only input and the marginal revenue will be constant, where increasing one unit of the input will increase the marginal revenue the same amount. If that were the case, then the buyer's market share would be irrelevant for this channel because, again, this channel would be shut down.

Third, a higher elasticity of supply yields a bigger marginal-revenue channel. Note that this is the only term in the marginal-revenue channel that depends on the buyer market share. This effect differs by buyer market share. As the elasticity of supply is smaller for bigger buyers, the bigger the buyer, the less substantial the revenue (and price) decrease.

---

<sup>26</sup>As shown in equation 3.13, the marginal-revenue channel depends on the buyer's production function because it is related to how the product bought is used for production. In my baseline model, I propose a CES production function, but I solve for alternative specification in Appendix 7.1.13.

<sup>27</sup>If the production function were Cobb Douglas, then  $\sigma = 1$ . This case is explored in the Appendix 7.1.13.

## 4 Estimation

In this section, I use the data on Colombian exporters to test the theoretical model of the effect of exchange rate shocks on international prices. The results confirm the mechanisms proposed by the theory and show the markdown channel dominates. Then, I use indirect inference to estimate the parameters that account for the markdown channel and quantify the effect. Robustness checks for this section are in Appendix 7.2.8.

### 4.1 Exchange Rate Pass-through

Consider a sudden change in the bilateral exchange rate between the home country and Destination  $k$ . Below, I analyze the degree to which the exchange rate shock is passed on to international prices depending on buyer market power. The theoretical pass-through regression equation 3.16 cannot be directly estimated since pass-through  $\psi_{sbjk}$  is not observed in the data. I can, nonetheless, identify the theoretical coefficients in the relationship between pass-through and buyer market share. Therefore, I step back to the decomposition of the log price change in equation 3.9.

#### 4.1.1 Linearization

To estimate the effect of an exchange rate shock on prices for buyers with different market shares, after linearizing on the buyer market share,  $S_{bjk}$ , I calculate a first-order approximation, replace the differential  $d$  with a time difference  $\Delta$  and rearrange to derive Proposition 5.

**Proposition 5** 1. *The first-order approximation to the exchange rate pass-through elasticity into prices in seller currency for Buyer  $b$  in Product  $j$  and Destination  $k$  is given by*

$$\psi^*_{bjk} \approx \mathbb{E} \left[ \frac{\Delta p_{bjk}}{\Delta e_k} \right] = \alpha_{jk} + \beta_{jk} S_{bjk}. \quad (4.1)$$

2. *The first-order approximation to the exchange rate pass-through elasticity into producer currency export prices for Product  $j$  and Destination  $k$  is given by*

$$\psi^*_{jk} \approx \mathbb{E} \left[ \frac{\Delta p_{jk}}{\Delta e_k} \right] = \alpha_{jk} + \beta_{jk} HHI_{jk}, \quad (4.2)$$

where  $HHI_{jk}$  corresponds to the concentration of that sector in that destination.

*Proof* See Appendix.

The pass-through elasticity,  $\psi^*_{bjk}$ , measures the buyer-product-destination price's equilibrium log change relative to the log change in the bilateral exchange rate, averaged across all possible states of the world and economic shocks. Proposition 5 relates firm-level pass-through to buyer market share, which forms a sufficient statistic for cross-sectional variation in pass-through within the product-destination universe. The values of the coefficients in this relationship ( $\alpha_{jk}$  and  $\beta_{jk}$ ) can be estimated in the data.

Furthermore, Proposition 5 provides closed-form expressions for coefficients  $\alpha_{jk}$  and  $\beta_{jk}$ .

Starting from Proposition 5, I arrive at my main empirical specification, where I regress the annual change in the log export price on the change in the log exchange rate, interacted with the buyer market share. Formally, the exchange rate pass-through into seller currency prices to Buyer  $b$ , in Product  $j$  and Destination  $k$  is

$$\Delta p_{s,b,j,k,t} = \underbrace{[\alpha + \beta S_{b,j,k,t-1}]}_{\text{Exchange rate pass through}} \Delta e_{kt} + \underbrace{\tau_{s,j,k} + \tau_{s,t}}_{\text{Fixed Effects}} + \epsilon_{s,b,j,k,t} \quad (4.3)$$

where  $\Delta p_{s,b,j,k,t}$  is the log change in price of Good  $j$  from Seller  $s$  to Buyer  $b$  in Country  $k$  at Time  $t$ ,  $\Delta e_{k,t}$  is the log bilateral exchange rate change (COP seller currency per 1 unit buyer currency—Destination  $k$ ). That is, an increase in  $e_k$  corresponds to the bilateral depreciation of seller currency, COP, relative to the Destination  $k$  buyer currency.  $\tau_{s,j,k}$ ,  $\tau_{s,t}$  are destination-product-seller fixed effect, year-seller fixed effect.<sup>28</sup>

I estimate parameters  $\alpha$  and  $\beta$  with values averaged across seller, product, destination, and period. The regression equation 4.3 is a structural relationship that emerges from the theoretical model, and  $S_{b,j,k,t-1}$  corresponds to my measure of buyer market share defined in equation 7.1.2.<sup>29</sup> Note that  $\alpha + \beta S_{b,j,k,t-1}$  corresponds to the exchange rate pass-through coefficient. That is, if this term is zero, a shock to the exchange rate produces no change in the seller-currency prices (COP), and a proportional change (to the change in the exchange rate) in the buyer currency (rest of the world currency).<sup>30</sup>

The main empirical contribution of this paper corresponds to the coefficient  $\beta$ , which determines how the market share of the buyer affects the exchange rate pass-through. If this coefficient is negative, larger buyers experience a lower change in price in the seller currency in response to exchange rate changes. For example, if Colombia depreciates its currency by 1%, this translates to an  $\alpha + \beta\%$  change for the cases where a buyer is the only buyer in that destination for that product in a given year. However, when there is more than one buyer, the effect of the exchange rate shock is  $\alpha + \beta S_{bjk}\%$ . I summarize the distribution of this variable in my data in the Appendix.

I propose different specifications including the fixed effects indicated by parameters in the theoretical model. First, I include a year-HS-country fixed effect. This fixed effect is meant to isolate the differences between markets and compare across buyers with different market shares. Note that the inclusion of this fixed effect, controlling for market level outcomes, is also consistent with the assumption made in Section 3, in which I state that both the quantities that exporters sell to other Buyers  $b$ , and the prices that other sellers charge to Firm  $b$ , do not change.<sup>31</sup> Second, I include several fixed effects accounting for the seller dimension, such as a year-seller fixed effect to control for shocks to the marginal cost, quality and characteristics of the buyer-seller relationship such as tenure, different products, etc. More robustness checks on this can be found in Appendix 7.2.8.

<sup>28</sup>In the data, I test directly for nonlinearity in this relationship and find no statistically significant evidence.

<sup>29</sup>In the Appendix, I discuss the assumption that  $\Delta e_{k,t}$  is uncorrelated with  $S_{b,j,k,t-1}$  and so the OLS estimates of  $\alpha$  and  $\beta$  from this regression are the theoretical coefficients in the pass-through relationship.

<sup>30</sup>This would correspond to a complete exchange rate pass-through as defined throughout the literature (Amiti, Itskhoki and Konings, 2014; Gopinath et al., 2020).

<sup>31</sup>In particular, for less-saturated versions of the same regression, I also construct specific market-level controls in the data and include them in the regression (e.g., market price index, inflation, GDP).



## 4.2 Firm-Level Main Empirical Findings

In Table 2, I present the results for my benchmark empirical specification, equation 4.3. To explore the underlying mechanisms behind the equilibrium relationship between pass-through and buyer market share, I begin with a simpler specification and build up my benchmark empirical specification, equation 4.3. As the equation includes different sets of fixed effects, we go from the least-saturated regression to the most-demanding fixed effects. Table 2 reports the results. First, in Column (1), I find that, at the annual horizon, the unweighted average exchange rate pass-through elasticity into seller prices in the sample is 0.16, or, equivalently, 0.84 ( $= 1 - 0.16$ ) into destination prices. I include product-destination-specific effects (where industry is defined at the HS 8-digit level) to be consistent with the theory, and year effects to control for common marginal-cost variation. In Column (2), I include an interaction between exchange rates and buyer market share. I show that the simple average coefficient reported in Column (1) masks a considerable amount of heterogeneity, as buyers (for the same seller) with different market share have very different pass-through rates. Buyers with a high market share exhibit a lower exchange rate pass-through into seller-currency export prices. The median buyer in the sample has 13% market share and a pass-through of 14% in the currency of the seller. As the market share increases, the pass-through declines. For example, the pass-through of a buyer with almost no market power (around zero market share) is 17.8%, and a buyer with a 50% market share has only a 5% pass-through.

**Table 2:** Effect of Buyer's Market Share on Exchange Rate Pass-through

	(1)	(2)	(3)	(4)
	$\Delta \ln(\text{Price})$	$\Delta \ln(\text{Price})$	$\Delta \ln(\text{Price})$	$\Delta \ln(\text{Price})$
$\ln(\Delta ER) = \alpha$	0.129* (0.0673)	0.110 (0.132)	0.178** (0.0805)	
$S_{t-1}$		-0.0884*** (0.00981)	-0.106*** (0.0110)	-0.0862*** (0.0119)
$\ln(\Delta ER) \times S_{t-1} = \beta$		-0.332* (0.170)	-0.246* (0.128)	-0.266** (0.122)
Period FE	x			
Country-HS FE		x		
Period-Seller FE	x		x	x
Country-HS-Seller FE	x		x	
Country-HS-Period FE				x
$N$	515834	515834	515834	515834

**Notes:** Results from equation 4.3. The dependent variable corresponds to the log change of prices.  $\Delta ER$  and  $S_{t-1}$  are the bilateral exchange rate and the buyer market share, respectively. Products are defined at the HS10 level. Standard errors are clustered at the country-time level and are shown in parentheses. \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

To better understand the results from my regression, Table 3 shows the number of firms with different levels of exchange rate pass-through and buyer share. The largest buyers have on average between 0% and 5% pass-through, while the smallest buyers have an exchange rate pass-through greater than 20%. These results reflect that the dominant mechanism is the markdown channel: larger firms have lower exchange rate pass-through. That is, given larger buyers have market power, they internalize the upward-sloping supply curve for inputs, which implies that each additional unit they

**Table 3: Firms with Different Levels of Exchange Rate Pass-through**

EPRT	Number of firms	Mean S
$0 < \alpha + \beta S_t < 0.05$	68,548	0.91
$0.05 < \alpha + \beta S_t < 0.10$	57,011	0.66
$0.10 < \alpha + \beta S_t < 0.15$	82,935	0.44
$0.15 < \alpha + \beta S_t < 0.20$	169,764	0.21
$0.20 < \alpha + \beta S_t$	1,144,500	0.02

Notes: The table shows the number of firms and the mean value for buyer market share  $S_t$  for the different categories of exchange rate pass-through coefficients.  $\alpha$  and  $\beta$  correspond to the estimates from Table 2.

buy raises the price of every other unit.<sup>32</sup> As a result, they increase prices by less than if the supply curve they faced were flat. For a given buyer, the higher the market power, the steeper the supply curve faced, and so the lower the pass-through of an exchange rate shock to the seller's price. The intuition behind this is that larger buyers have more market power, which allows them to adjust the markdowns after the exchange rate shock without affecting the price.

### 4.3 Aggregation at the Market Level

In this section, I explore the market level exchange rate pass-through. I start from the theoretical equation 4.2, and obtain the following regression at the market level.

$$\Delta p_{s,k,t} = [\alpha + \beta HHI_{s,k,t}] \Delta e_{kt} + FEs + \epsilon_{s,k,t}, \quad (4.4)$$

where  $\Delta p_{s,k,t}$  is the log change of the average price in a market, destination, year;  $HHI_{s,k,t}$  is the HHI.<sup>33</sup> While calculating the exchange rate pass-through at the market level, I can no longer include seller fixed effects to control for specific seller characteristics, such as the seller market share. Thus, the coefficient of this regression could be reflecting either buyer or seller market power. To address this potential issue, I aggregate the information I have at the seller level and calculate the concentration index for the sellers as well. This allows me to disentangle the effects, and I can account accurately for the effect of buyer market concentration. Results for this regression are shown in Table 4. When exports are more concentrated among a few buyers, the exchange rate pass-through for the average market price is lower. Column (1) shows that, even without controlling for seller HHI, buyer concentration has a significant relationship with exchange rate pass-through. Columns (2), (3), and (4) include information on the distribution of sellers' market share while controlling for period, HS-country and HS-period fixed effects. My preferred specification is Column (4) because it contains the most restrictive fixed effects. It shows that the concentration of the buyers strongly influences the exchange rate pass-through.

<sup>32</sup>This is analogous to a monopoly case where the only seller internalizes the downward-sloping demand curve.

<sup>33</sup>We summarize the distribution of the HHI and the exchange rate pass-through at the market level in the Appendix.

**Table 4:** Effect of Market Concentration on Average Exchange Rate Pass-through

	(1)	(2)	(3)	(4)
	$\Delta \ln(\text{Price})$	$\Delta \ln(\text{Price})$	$\Delta \ln(\text{Price})$	$\Delta \ln(\text{Price})$
$L(\Delta \text{ER}) = \alpha$	0.0624** (0.0274)	-0.0313 (0.0306)	0.120*** (0.0316)	-0.0261 (0.0335)
HHIbuyer	0.00534 (0.00390)	-0.00368 (0.00554)	-0.00928** (0.00448)	-0.00692 (0.00712)
$L(\Delta \text{ER}) \times \text{HHIbuyer} = \beta$	-0.0674** (0.0342)	-0.329*** (0.0507)	-0.338*** (0.0360)	-0.284*** (0.0602)
HHIseller		0.0131** (0.00596)	0.0167*** (0.00470)	0.0148** (0.00738)
$L(\Delta \text{ER}) \times \text{HHIseller}$		0.380*** (0.0548)	0.212*** (0.0418)	0.356*** (0.0637)
HS FE	x	x		
Country FE	x	x		
Period FE	x	x	x	
HS–Country FE			x	x
HS–Period FE				x
N	153807	153807	153807	153807

*Notes:* The table shows results for equation 4.4. HHIbuyer and HHIseller correspond to the HHI for sales concentrations among buyers and sellers, respectively. They are calculated by using equation 2.1 with the market share of the buyers and sellers. Standard errors are clustered at the country-time level and are shown in parentheses. \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

## 4.4 Estimation of the Markdown Channel

In the model, two key elasticities govern market power and thus the magnitude of the markdown channel: the elasticity of substitution across products,  $\theta$ , and the elasticity of substitution within product, across buyers,  $\eta$ . In this section, I describe an approach which integrates i) new empirical estimates using bilateral exchange rate shocks (see Section 4.2) and ii) new moments from the cross-section, into iii) a simulated method of moments routine in which all unknown parameters are estimated jointly.

### 4.4.1 Challenges for Estimation

Equation 3.16 shows that the pass-through term,  $\frac{dp_{sbjk}}{de_k}$  is a function of three parameters— $\eta$ ,  $\theta$ ,  $\varphi$ —and  $S_{bjk}$ . Once we linearize on buyer market shares,  $S_{bjk}$ , I have two coefficients (equation 4.1) which I obtain from running the regression in the data. The sizes of the coefficients  $\beta$  and  $\alpha$  are informative on the magnitudes of the elasticities  $\theta$  and  $\eta$ . However, I cannot disentangle them from the effect of the marginal revenue,  $\varphi$ . This is a well-known issue in the markup literature (De Loecker and Warzynski, 2012), which is usually addressed by estimating the production function and backing out market power.<sup>34</sup> Instead, I combine the elasticities from the empirical part with moments from

<sup>34</sup>Another typical problem for the estimation of the elasticity of supply (and so the markdown) is that, when firms behave strategically, the structural elasticity cannot be measured using how prices respond to a well-identified shock. The structural elasticity is a partial equilibrium concept answering the counterfactual: how much do firms change supply, holding their

the cross-section and use the structure of the model to estimate  $\eta$  and  $\theta$  directly, along with other parameters.

#### 4.4.2 Indirect Inference

I recover the parameters of the model through indirect inference implemented as simulated method of moments (SMM). I estimate all parameters jointly, but outline the estimation procedure separately for each group of parameters. Appendix 7.3.1 provides further details.<sup>35</sup>

**Estimates for  $\eta$  and  $\theta$**  To estimate  $\eta$  and  $\theta$ , I proceed in three steps: (1) Estimate equation 4.1 in the actual data. (2) Simulate equation 4.1 in the model. (3) Pick  $\eta$  and  $\theta$  so that the coefficients  $\alpha$  and  $\beta$  from the model match their counterparts in the data. I estimate equation 4.1 in the actual data already in Section 4.2 and obtain  $\hat{\alpha}$  and  $\hat{\beta}$ . To simulate equation 4.1, I use the following procedure. First, I draw the productivity of each buyer from an exogenous distribution.<sup>36</sup> For each guess of  $\eta$  and  $\theta$ , I solve the model. Next, I shock the prices by drawing from the distribution of bilateral exchange rate shocks. I solve the model again to create a simulated panel, treating the outcomes across these two model economies as panel data. The resulting exchange rate pass-through coefficients, denoted  $\beta(\eta, \theta)$  and  $\alpha(\eta, \theta)$ , are functions of  $\eta$  and  $\theta$ . I pick  $\eta$  and  $\theta$  so that the pass-through coefficients estimated from the simulated data match the coefficients I estimated from the actual data (coefficients from Table 2) such that

$$(\hat{\eta}, \hat{\theta}) = \operatorname{argmin}_{\eta, \theta} \{ \|\hat{\alpha} - \alpha(\eta, \theta)\| + \|\hat{\beta} - \beta(\eta, \theta)\| \}.$$

**Estimate for  $\varphi_j$**  I take advantage of the data available for Colombia and use cross-sectional moments to estimate parameters that govern the marginal-revenue product. Holding  $\eta$  and  $\theta$  fixed, I normalize on one of the buyers in each market and calculate the relative prices. I use these values to estimate a term that contains  $x_j$  and  $\sigma$  together.

$$\frac{p_{sbjk}}{p_{sb'jk}} = \frac{p_{finalgood}}{p_{finalgood}} \left( \frac{x_{b'jk}}{x_{bjk}} \right)^\sigma \frac{e_k}{e_k}$$

**External Parameters:  $\epsilon_k, z_b$  and Others** I assume that (log) buyers' productivity,  $\log z_b$  and log changes in exchange rate shocks,  $\Delta e_k$ , follow normal distributions.

$$\log z \sim N(\mu_z, \sigma_z^2) \text{ and } \ln \Delta e_k \sim N(\mu_e, \sigma_e^2)$$

For buyer productivity, I choose  $(\mu_z, \sigma_z^2)$  such that it matches the distribution of buyers' market shares. For bilateral exchange rate shocks, I choose  $(\mu_e, \sigma_e^2)$  to match the distribution of log changes in bilateral exchange rate in the data. For buyer productivity, I choose  $(\mu_z, \sigma_z^2)$  equal to (0,1). Finally, the numbers of products and buyers are also chosen to match the data from Colombia.

---

competitors'  $q_{sbjk}$  constant. The reduced-form elasticity includes all other firms' responses.

<sup>35</sup>I follow a top-down approach related to Berger, Herkenhoff and Mongey (2022) and Zavala (2022).

<sup>36</sup>This is needed to have nonsymmetric buyer market shares.

### 4.4.3 Parameter Estimates

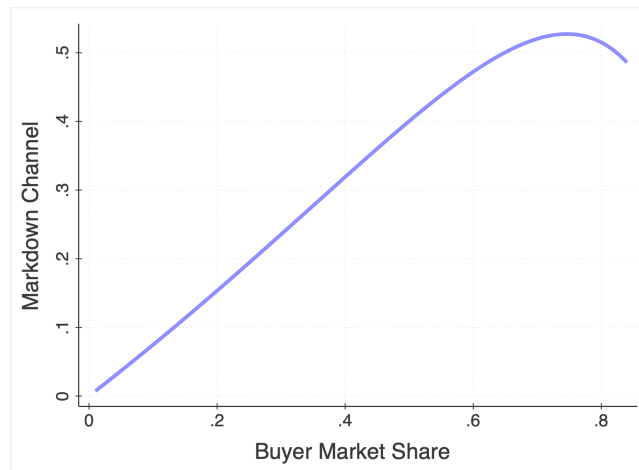
**Table 5:** Summary of Parameters

Parameter	Description	Value	Moment	Model	Data
<b>A. Assigned</b>					
$N$	Number of products	6,983			
$M_j$	Number of buyers per product	17			
$\mu_{e_k}$	Mean of $\ln ER$ changes	0.03			
$\sigma_{e_k}^2$	SD of $\ln ER$ changes	0.1			
<b>B. Estimates</b>					
$\theta$	Across-product substitutability	1.11	Baseline pass-through $\hat{\alpha}$	0.181	0.175
$\eta$	Across-buyer substitutability	4.23	Interaction buyer share $\hat{\beta}$	-0.243	-0.241
$\sigma$	Input substitutability	0.3	Relative price level	0.012	0.013
$z$	Productivity shifter	0.05	Average firm size	0.21	0.23

### 4.4.4 Quantifying the Markdown Channel

After obtaining the estimates for  $\eta$  and  $\theta$  and using the corresponding  $S_{bjk}$  in my data, I calculate the implied markdowns faced by Colombian exporters. I find the average markdown to be 26%. Then, using the structural equation from the model, I quantify the markdown channel. Figure 5 shows the markdown channel is bigger for buyer with larger market shares, once I plug in the estimates for the elasticities.

**Figure 5:** Markdown Channel and ERPT varies with size



Notes: Figure plots buyer market share on the x-axis and changes in the markdowns (or the markdown channel) on the y-axis. Buyer market share is defined as the share of the market, defined as destination country x product x year, purchased by a given buyer.

## 5 Counterfactual: Eliminating Buyer Market Power

To explore the aggregate implications of buyer market power for the sellers in Colombia, I propose a counterfactual eliminating buyer market power. Moving from an oligopsony structure to perfect competition with no strategic interactions implies changes in the level of revenues, but also in the volatility of these revenues.

### 5.1 Level Effect

Under perfect competition, buyers still face upward-sloping supply curves, whose shapes are determined by the cross-product elasticities of substitution ( $\eta$ ) and within-product cross-buyer elasticity of substitution ( $\theta$ ). However, they do not internalize their influence over the price. Rather, they perceive a perfectly elastic supply curve ( $\epsilon_{bjk} = \infty$ ). Input prices are no longer marked down from their marginal-revenue product. The change in the sellers' revenues can be decomposed into two effects: a quantity effect and a price effect. To quantify these effects, I first simulate the model with and without market power. The total impact of buyer market power is the log difference in sellers' revenues between the two scenarios:

$$\begin{aligned} \text{Total Effect} &= \log \sum_{sbjk} p_{sbjk}^{PerfComp} q_{sbjk}^{PerfComp} - \log \sum_{sbjk} p_{sbjk}^{Olig} q_{sbjk}^{Olig} \\ &= \underbrace{\ln \sum_{sbjk} p_{sbjk}^{PerfComp} q_{sbjk}^{Olig} - \log \sum_{sbjk} p_{sbjk}^{Olig} q_{sbjk}^{Olig}}_{\text{Price Effect}} + \underbrace{\ln \sum_{sbjk} p_{sbjk}^{Olig} q_{sbjk}^{PerfComp} - \log \sum_{sbjk} p_{sbjk}^{Olig} q_{sbjk}^{Olig}}_{\text{Quantity Effect}}. \end{aligned}$$

#### 5.1.1 Price Effect

The price effect corresponds to the increase in price when removing markdowns; sellers earn higher revenues for supplying the same product to the same buyer. This effect can be thought of as a redistribution from buyers to sellers. To measure this effect, I calculate sellers' revenue using quantities from the oligopsony model-baseline and prices from the perfect-competition counterfactual.

#### 5.1.2 Quantity Effect

The quantity effect corresponds to efficiency gains. In the model, sellers trade off the price of a given buyer and a given product with their idiosyncratic shock for producing that product and supplying that buyer. This leads to misallocation: Some sellers do not produce the product in which they are most productive, simply because its price index is too low. Conditional on a product, some sellers do not supply the buyers with lower information frictions to connect with them, simply because their prices are too low. Once buyer market power is removed, the tradeoff lessens and allows sellers to produce the product they are most productive on and supply their buyer with lower search costs/frictions. To measure this effect, I calculate sellers' revenue using prices from the oligopsony-model baseline and quantities from the perfect competition counterfactual. I find that sellers' revenues would be 31.1% higher in the absence of market power. Redistribution from buyers to sellers increases income by 24% and efficiency gains would increase sellers' revenues by 7%.<sup>37</sup>

<sup>37</sup> Although all farmers gain from perfect competition, the gains are not equally shared: increases are higher for markets with higher baseline level of buyer market concentration.

## 5.2 Effect on $\Delta$ in Revenues with Exchange Rate Shocks

In the rest of this section, I quantify the welfare effects of buyer market power by comparing the volatility of the revenues faced by the sellers in an oligopsony structure to those in perfect competition.

To this end, consider a single consumer, a seller in the home country, whose income is equal to the revenues  $y_t$  obtained from exporting their products. Revenues from exports are the only source of income such that  $c_t = y_t$ . At the same time, revenues in each period follow a random walk:

$$Y_t = Y_{t-1}e^{\mu}e^{-1/2\sigma^2}\epsilon_t,$$

where  $\ln(\epsilon_t)$  is a normally distributed random variable with mean 0 and variance  $\sigma^2$ . Under these assumptions  $E(e^{-(1/2)\sigma^2}\epsilon_t) = 1$ . Preferences on such consumption paths are assumed to be

$$\mathbb{E} \left[ \sum_{t=0}^{\infty} \beta^t \frac{((1+\lambda)C_t^{PerfComp})^{1-\gamma}}{1-\gamma} \right],$$

where  $\beta$  is a subjective discount rate,  $\gamma$  is the coefficient of risk aversion, and the expectation is taken with respect to the distribution of shocks  $\epsilon_t$ .

I compare the utility difference for a seller in an oligopsony structure with one in perfect competition. An extremely risk-averse consumer would prefer the case in oligopsonistic competition. I quantify this utility difference by multiplying the perfect competition path by a constant factor  $1 + \lambda$  in all dates and states, choosing  $\lambda$  so the seller is indifferent between the oligopsony and the compensated perfect-competition path. Therefore,  $\lambda$  is chosen to solve

$$\mathbb{E} \left[ \sum_{t=0}^{\infty} \beta^t \frac{((1+\lambda)C_t^{PerfComp})^{(1-\gamma)}}{1-\gamma} \right] = \mathbb{E} \left[ \sum_{t=0}^{\infty} \frac{\beta^t}{1-\gamma} C_t^{Olig(1-\gamma)} \right].$$

Canceling, taking logs and collecting terms gives

$$\lambda \approx \frac{1}{2}\gamma(\sigma_{PerfComp}^2 - \sigma_{Olig}^2).$$

Note that the compensation parameter  $\lambda$ —the welfare gain from eliminating volatility from buyer market power—depends on three terms: the risk-aversion parameter  $\gamma$ , the amount of risk present in each case  $\sigma_{PerfComp}^2$ , and  $\sigma_{PerfComp}^2$ . The last two terms correspond to variance of the  $\epsilon_t$  for each case.

To estimate  $\lambda$ , estimates of these parameters are needed. As both scenarios have a different variance for their change in revenues, I use the results from the empirical section to estimate this where the variance of the income is

$$\text{var}[\Delta Y_t] = (\hat{\alpha} + \hat{\beta}S_{bjkt})^2 \text{var}[\Delta e_{kt}].$$

I plug in  $S_{bjkt} = 0$  for the perfect competition case, and I assign  $S_{bjkt} = 1$  to the oligopsony case, obtaining 0.0008 and 0.000003, respectively. Seeing this agent as a representative seller in a developing country, I use estimates of the coefficient of risk aversion,  $\gamma$ . In macroeconomics and finance, this coefficient ranges from 1 (lowest risk aversion) to 5 (highest risk aversion). I pick a coefficient of 1 and calculate  $\lambda$ :

$$\lambda \approx 0.0004$$

From the literature, these welfare losses of a monetary-policy regime are low, but they are on the order of magnitude of Lucas (2003). Comparing this lambda with Lucas (2003) (0.0005), I can conclude buyer market power accounts for 80% of the costs of welfare related to eliminating the whole business cycle in the U.S. when evaluating the volatility of sellers' income in Colombia.

Taking into account both effects, the level effect for the price and the effect related to the volatility of the revenues, we can explain why the mentioned parameters (i.e., the elasticities, risk premium, utility function, etc.) matter in understanding how sellers are affected by buyer market power in international markets.

## 6 Conclusion

This paper studies buyer market power in international markets and its impact on the exchange rate pass-through. I combine a novel transaction-level dataset covering the universe of Colombian exports that crucially contains information on the identity of the foreign buyer for the period 2007–2020 with an oligopsony model of buyer market power in international trade. The main conclusion is that buyer market power is relevant in determining the exchange rate pass-through.

Theoretically, buyer market power has implications for price determination and for how these prices react to exchange rates. First, buyers with higher market share have a higher markdown, and so a lower price, all else equal. Second, buyer market power has consequences for the exchange rate pass-through. The overall effect is driven by two offsetting mechanisms: a markdown channel and a marginal-revenue channel.

My empirical strategy focuses on estimating the Colombian exports' pass-through elasticity to the rest of the world. At the firm level, my findings suggest that bigger buyers pay lower prices, and have a lower exchange rate pass-through to sellers' currency, ranging from 1% for the largest to 17% for the smallest buyers. The mechanism behind this is that large buyers' greater market power leads to *more* variable markdowns. At the market level, in markets where buyers are more concentrated, prices have higher markdowns and exchange rate pass-through in seller currency is lower.

Finally, I calibrate the model and obtain key elasticities that allow me to simulate a counterfactual scenario where buyers have no market power. Under this scenario, sellers receive higher prices but their revenues are more responsive to exchange rate shocks. In this setting, seller currency devaluations are much common than appreciations. On balance, sellers are less likely to benefit from reduced volatility than to be disadvantaged by attenuated revenue gains during depreciation episodes.

This paper has important policy implications for sellers from developing countries who sell their products to large firms. Even though when selling to a large firm they might receive marked-down prices, these prices are more stable during exchange rate shocks. Countries in Latin America frequently have devaluations, so this mechanism prevents them from suffering a harsher consequence of the shock. On the other hand, multinationals abroad might find it less appealing to connect with small sellers.

In recent decades, concentration of sales in large, multinational firms has been increasing, raising many questions for future research. At the firm level, future work could focus on exploring which kinds of buyers are the best investment for small sellers in developing countries in the long run. At the same time, which markets contribute more to the growth of these small firms. Relevant policy questions at the market level remain unanswered. First, how does the market structure in terms of concentration of two different countries affect when they engage in trade? Second, how does that market structure affect the propagation of shocks.



## References

- Adão, Rodrigo, Paul Carrillo, Arnaud Costinot, Dave Donaldson, and Dina Pomeranz.** 2022. "Imports, Exports, and Earnings Inequality: Measures of Exposure and Estimates of Incidence." *Quarterly Journal of Economics*, 137(3): 1553–1614. <https://doi.org/10.1093/qje/qjac012>.
- Alviarez, Vanessa, Michele Fioretti, Ken Kikkawa, and Monica Morlacco.** 2022. "Two-sided market power in firm-to-firm trade." Inter-American Development Bank. <https://doi.org/10.18235/0003493>.
- Amiti, Mary, Oleg Itskhoki, and Jozef Konings.** 2014. "Importers, Exporters, and Exchange Rate Disconnect." *American Economic Review*, 104(7): 1942–78.
- Antras, Pol, Teresa C Fort, and Felix Tintelnot.** 2017. "The Margins of Global Sourcing: Theory and Evidence from US Firms." *American Economic Review*, 107(9): 2514–64.
- Atkeson, Andrew, and Ariel Burstein.** 2008. "Pricing-to-Market, Trade Costs, and International Relative Prices." *American Economic Review*, 98(5): 1998–2031.
- Auer, Raphael A, and Raphael S Schoenle.** 2016. "Market Structure and Exchange Rate Pass-Through." *Journal of International Economics*, 98: 60–77.
- Autor, David, David Dorn, Lawrence F Katz, Christina Patterson, and John Van Reenen.** 2020. "The Fall of the Labor Share and the Rise of Superstar Firms." *Quarterly Journal of Economics*, 135(2): 645–709.
- Azar, José, Ioana Marinescu, and Marshall Steinbaum.** 2019. "Measuring Labor Market Power Two Ways." In *AEA Papers and Proceedings*. Vol. 109, 317–21. American Economics Association.
- Barro, Robert J.** 1977. "Long-Term Contracting, Sticky Prices, and Monetary Policy." *Journal of Monetary Economics*, 3(3): 305–16.
- Berger, David W, Kyle F Herkenhoff, and Simon Mongey.** 2022. "Labor Market Power." *American Economic Review*, 112(4): 1147–1193. <https://doi.org/10.1257/aer.20191521>.
- Bernard, Andrew B, Emmanuel Dhyne, Glenn Magerman, Kalina Manova, and Andreas Moxnes.** 2019. "The Origins of Firm Heterogeneity: A Production Network Approach." National Bureau of Economic Research. Working Paper 25441. [https://www.nber.org/system/files/working\\_papers/w25441/w25441.pdf](https://www.nber.org/system/files/working_papers/w25441/w25441.pdf).
- Bernard, Andrew B, J Bradford Jensen, Stephen J Redding, and Peter K Schott.** 2007. "Firms in International Trade." *Journal of Economic Perspectives*, 21(3): 105–30.
- Bernard, Andrew B, J Bradford Jensen, Stephen J Redding, and Peter K Schott.** 2018. "Global Firms." *Journal of Economic Literature*, 56(2): 565–619.
- Bresnahan, Timothy F.** 1989. "Empirical Studies of Industries with Market Power." *Handbook of Industrial Organization*, 2: 1011–57.
- Burstein, Ariel, and Gita Gopinath.** 2014. "International Prices and Exchange Rates." In *Handbook of International Economics*. Vol. 4, 391–451. Elsevier.
- Carlton, D. W.** 1991. "A Theory of Allocation and Its Implications for Marketing and Industrial Structure: Why Rationing Is Efficient." *Journal of Law and Economics*, 34(2): 231–62.
- De Loecker, Jan, and Frederic Warzynski.** 2012. "Markups and Firm-Level Export Status." *American Economic Review*, 102(6): 2437–71.

- De Loecker, Jan, Jan Eeckhout, and Gabriel Unger.** 2020. "The Rise of Market Power and the Macroeconomic Implications." *Quarterly Journal of Economics*, 135(2): 561–644.
- De Loecker, Jan, Pinelopi K Goldberg, Amit K Khandelwal, and Nina Pavcnik.** 2016. "Prices, Markups, and Trade Reform." *Econometrica*, 84(2): 445–510.
- Devereux, Michael B, Wei Dong, and Ben Tomlin.** 2017. "Importers and Exporters in Exchange Rate Pass-Through and Currency Invoicing." *Journal of International Economics*, 105: 187–204.
- Dhyne, Emmanuel, Ayumu Ken Kikkawa, Magne Mogstad, and Felix Tintelnot.** 2021. "Trade and Domestic Production Networks." *Review of Economic Studies*, 88(2): 643–68.
- Eaton, Jonathan, and Samuel Kortum.** 2002. "Technology, Geography, and Trade." *Econometrica*, 70(5): 1741–79.
- Eggertsson, Gauti B, Jacob A Robbins, and Ella Getz Wold.** 2021. "Kaldor and Piketty's Facts: The Rise of Monopoly Power in the United States." *Journal of Monetary Economics*, 124: S19–S38.
- Felix, Mayara.** 2022. "Trade, Labor Market Concentration, and Wages." Massachusetts Institute of Technology. Job Market Paper.
- Gopinath, Gita, Emine Boz, Camila Casas, Federico J Díez, Pierre-Olivier Gourinchas, and Mikkel Plagborg-Møller.** 2020. "Dominant Currency Paradigm." *American Economic Review*, 110(3): 677–719.
- Gutiérrez, Germán, and Thomas Philippon.** 2019. "Fading Stars." In *AEA Papers and Proceedings*. Vol. 109, 312–16. American Economics Association.
- Heise, Sebastian.** 2019. "Firm-to-Firm Relationships and the Pass-Through of Shocks: Theory and Evidence." Federal Reserve Board of New York. Staff Report Number 896.
- Hottman, Colin J, and Ryan Monarch.** 2020. "A Matter of Taste: Estimating Import Price Inflation across US Income Groups." *Journal of International Economics*, 127: Article 103382. <https://doi.org/10.1016/j.jinteco.2020.103382>.
- Huneus, Federico.** 2018. "Production Network Dynamics and the Propagation of Shocks." PhD diss. Princeton University, Princeton, NJ.
- Lamadon, Thibaut, Magne Mogstad, and Bradley Setzler.** 2022. "Imperfect Competition, Compensating Differentials, and Rent Sharing in the US Labor Market." *American Economic Review*, 112(1): 169–212.
- Lim, Kevin.** 2018. "Endogenous Production Networks and the Business Cycle." Working Paper.
- Lucas, Robert E.** 2003. "Macroeconomic Priorities." *American economic review*, 93(1): 1–14.
- Morlacco, Monica.** 2019. "Market Power in Input Markets: Theory and Evidence from French Manufacturing." Toulouse School of Economics.
- Zavala, Lucas.** 2022. "Unfair Trade? Monopsony Power in Agricultural Value Chains." The World Bank.

## 7 Appendix

### 7.1 Appendix: Theoretical Model

#### 7.1.1 Supply Side: Frechet Shocks

We assume that the shock is drawn from a nested Frechet distribution. Then,

$$H(\vec{\rho}) = \exp \left[ - \sum_s B_s \left( \sum_a B_{sb} \rho_{sb}^{-\eta} \right)^{\frac{\theta}{\eta}} \right], \text{ with } \theta < \eta,$$

The seller chooses the buyer that is going to yield the maximum profits. I will do this for Firm  $a$  in Sector  $s$ . The density function of choosing Firm  $a$  and Sector  $s$  is:

$$H_{sb}(\vec{\rho}) = -\theta \tilde{P}_s^{\theta-\eta} B_{sb} \rho_{sb}^{-\eta-1} \exp \left( - \left( \sum_{s'} \tilde{P}_{s'}^\theta \right) \right) d\rho_{sb}$$

where  $\tilde{P}_{s'} = B_{s'} \left( \sum_{a' \in S'} B_{b'j'} \rho_{b'j'}^{-\eta} \right)^{\frac{1}{\eta}}$ . In the rest of the paper, I will simplify  $\beta_{bj}$  and  $\beta_j$  to 1.

#### 7.1.2 Supply Side: Share

We need to integrate two things, first the probability of choosing Buyer  $b$  and Product  $j$ , and second the total quantities. For a given seller, that is fixing  $q_s$ , the probability of choosing Firm  $b$  and Product  $j$  is the same

as the probability that  $\rho_{b'j'} \leq \frac{p_{sb}}{p_{b'j'}} \rho_{sb} = \frac{p_{sb}}{p_{b'j'}} \rho$ .<sup>38</sup> Then<sup>39</sup>

$$\begin{aligned}
\lambda_{bj} &= P(\rho_{b'j'} \leq \frac{p_{bj}}{p_{b'j'}} \rho_{bj}) \\
&= \int_0^\infty \exp \left( - \underbrace{\left( \sum_{j'} B_{j'} \left( \sum_{b' \in j'} B_{b'j'} \left( \frac{p_{bj}}{p_{b'j'}} \right)^{-\eta} \rho^{-\eta} \right)^{\frac{\theta}{\eta}} \right)}_{\Pr(\rho_{b'j'} \leq \frac{p_{bj}}{p_{b'j'}})} \right) \underbrace{dH_{bj}(\rho)}_{\text{density of } \rho_{bj}} \\
&= \int_0^\infty \rho^{-\eta-1} \theta B_j B_{bj} \left( \sum_{b' \in S} B_{b'j'} \left( \frac{p_{sb}}{p_{b'j'}} \right)^{-\eta} \rho^{-\eta} \right)^{\frac{\theta-\eta}{\eta}} \exp \left( - \left( \sum_{s'} B_{s'} \left( \sum_{a' \in j'} B_{a'j'} \left( \frac{p_{bj}}{p_{b'j'}} \right)^{-\eta} \rho^{-\eta} \right)^{\frac{\theta}{\eta}} \right) \right) d\rho \\
&= \int_0^\infty \rho^{-\eta-1} \theta B_j B_{bj} p_{bj}^{\eta-\theta} \left( \sum_{b' \in M} B_{b'j'} p_{b'j'}^\eta \rho^{-\eta} \right)^{\frac{\theta-\eta}{\eta}} \exp \left( -\rho^{-\theta} p_{bj}^{-\theta} \left( \sum_{j'} B_{j'} \left( \sum_{b' \in j'} B_{b'j'} p_{b'j'}^\eta \right)^{\frac{\theta}{\eta}} \right) \right) d\rho \\
&= \int_0^\infty \theta P_j^{\theta-\eta} B_{bj} p_{bj}^{\eta-\theta} \rho^{-\theta-1} \exp \left( -\rho^{-\theta} p_{bj}^{-\theta} \left( \sum_{j'} P_{j'}^\theta \right) \right) d\rho \\
&= \underbrace{\frac{P_j^\theta}{\sum_{j'} P_{j'}^\theta}}_{\Pr(f \text{ chooses product } j)} \underbrace{\frac{B_{bj} p_{bj}^\eta}{P_j^\eta}}_{\Pr(\text{seller chooses buyer } b|j)} \underbrace{\int_0^\infty -\exp(-u) du}_{=1}
\end{aligned}$$

This expression has an intuitive interpretation: conditional on choosing Product  $j$ , the probability of choosing Buyer  $b$ ,

$\Pr(b|j)$  depends on how large the price of Buyer  $b$  (numerator) is relative to the price index of Product  $j$  (denominator), which is a CES aggregate of prices across buyers within a sector. The unconditional probability of choosing Product  $j$ ,  $\Pr(j)$ , then depends on how large the price index of Sector  $s$  (numerator) is relative to the overall price index (denominator), which is a CES aggregate of price indexes across sectors. As the elasticities increase, the price becomes more important in determining whether a seller chooses Buyer  $b$ , conditional on choosing Product  $j$ . This means, the easier it is to switch from product to product, the more relevant the price ratio is. So we get that the **share of seller's s production that is consumed by Buyer b and Product j** is:

$$\lambda_{sb} = \frac{P_j^\theta}{\sum_{j'} P_{j'}^\theta} \frac{B_{bj} p_{bj}^\eta}{P_j^\eta}$$

where  $P_j = B_j \left( \sum_{b' \in B} B_{b'j} p_{b'j}^\eta \right)^{\frac{1}{\eta}}$ .

### 7.1.3 Supply Curve: Choice of Quantity

Aggregating across sellers yields a nested CES supply curve for Buyer  $b$  in Product  $j$ . We know that

$$p_{bj} q_{bj} = \lambda_{bj} P Q$$

<sup>38</sup>This means that the revenue is higher in Buyer  $b$  and Product  $j$ .

<sup>39</sup>This is the probability that the shock is higher than any other shock. Specifically by looking at the equations we can see it is the probability that  $e_{sb}$  is higher than another shock (cdf of  $e$  on point  $\frac{p_{sb}}{p_{b'j'}} \rho$ ) throughout the whole distribution of shocks  $e$  (integral part). Also,  $\lambda = \int_0^\infty H_{sb}(\rho, \frac{p_{sb}}{p_{b'j'}} \rho, \dots)$ .

The expected quantity supplied by Seller  $w$  to Buyer  $a$  in Sector  $s$  is

$$q_{sbj} = q_s \times \Pr(sbj)$$

Integrating over sellers yields the total quantity in Product  $j$  supplied to Buyer  $b$ :

$$\begin{aligned} q_{sbjk} &= \int_0^1 \Pr(sbjk) q_s dR \\ &= \int_0^1 \frac{p_{bjk}^{1+\eta}}{\sum_b P_{bjk}^{1+\eta}} \frac{(\sum_b P_{bjk}^{1+\eta})^{\frac{1+\theta}{1+\eta}}}{\sum_{j'} (\sum_{a's} P_{a's}^\eta)^{\frac{1+\theta}{1+\eta}}} q_s dR \\ &= \frac{p_{sb}^\eta}{\sum_a P_{sb}^\eta} \frac{\sum_a (p_{sb}^\eta)^{\frac{\theta}{\eta}}}{\sum_{s'} (\sum_{a's} P_{a's}^\eta)^{\frac{\theta}{\eta}}} \underbrace{\int_0^1 p_{sb} q_s dR}_Y \end{aligned}$$

Multiplying both sides by  $p_{sb}$  and summing across sectors and buyers, we have  $Y = \sum_{sb} p_{sb} q_{sb}$ , so that  $Y$  is total spending by buyers on sectors. So, the quantity supplied to Buyer  $a$  of Product  $x$  in Sector  $s$  is:

$$q_{bjk} = \left( \frac{p_{bj}^\eta}{P_j^\eta} \right) \left( \frac{P_j^\theta}{P^\theta} \right) Y \quad (7.1)$$

where  $P = (\sum_{s'} P_{s'}^\theta)^{\frac{1}{\theta}}$ .

#### 7.1.4 Supply Side: Seller Production Function Instead of Endowment

The quantity a seller with productivity  $q_s$  and idiosyncratic shocks  $\rho_{sjk}, \rho_{sbjk}$  could sell<sup>40</sup> of Product  $j$  to Buyer  $b$ , is then determined by their productivity and the idiosyncratic shocks:

$$q_{sbjk} = \rho_{sbjk}^{\frac{1}{\eta}} \rho_{sjk}^{\frac{1}{\theta}} q_s \quad (7.2)$$

where  $q_s$  is a function of labor and does not depend of  $b$ . This would mean the seller uses labor to produce and wages adjust where it is no longer profitable to keep on producing. Therefore, the production is bounded. An example could be  $q_s = L_{sjk}$  and bringing profits for the seller:  $p_{sjk} L_{sjk} - w L_{bjk}$  and (perfect competition  $w = p$ ?)  $q_s$  is seller specific as can be shown in Appendix 7.1.2, if the production function is seller specific then, for a given seller the probability of choosing Firm  $b$  and Product  $j$  does not depend on the production function. Therefore, the quantity supplied in equilibrium relative to other buyers and products would be the same as in the baseline model.

#### 7.1.5 Demand Curve: Choice of Price

##### Bertrand Competition

$$\pi_{bj} = p_{finalg} Q_{finalg} - \sum_j \frac{1}{e} p_{bj} q_{bj} \quad \text{s.t.} \quad Q_{finalg} = \left( \int_s q_{bj}^{\frac{1-\gamma}{\gamma}} ds \right)^{\frac{\gamma}{\gamma-1}} \quad \text{and} \quad q_{bj} = \frac{p_{bj}^{\eta-1}}{P_j^{\eta-1}} \frac{P_j^{\theta-1}}{P^{\theta-1}} Y \quad (7.3)$$

<sup>40</sup>Note that this is not the actual quantity sold, but the quantity that a seller could sell at most to a Buyer  $a$  in Sector  $s$ , if they choose to supply Buyer  $a$  in Sector  $s$ .

The FOC imply that:

$$\begin{aligned}
[p_{bj}] : \frac{\partial(\text{revenue})}{\partial q_{bj}} \frac{\partial q_{bj}}{\partial p_{bj}} - \frac{1}{e} \left[ q_{bj} + p_{as} \frac{\partial q_{bj}}{\partial p_{bj}} \right] &= 0 \\
\frac{\partial(\text{revenue})}{\partial q_{bj}} - \frac{1}{e} \left[ q_{bj} \frac{\partial p_{bj}}{\partial q_{bj}} + p_{as} \right] &= 0 \\
\frac{\partial(\text{revenue})}{\partial q_{bj}} - \frac{1}{e} \left[ p_{bj} \frac{q_{bj}}{p_{bj}} \frac{\partial p_{bj}}{\partial q_{bj}} + p_{as} \right] &= 0 \\
\frac{\partial(\text{revenue})}{\partial q_{bj}} - \frac{1}{e} p_{bj} \left[ \frac{1}{\epsilon} + 1 \right] &= 0 \\
\underbrace{\text{MRP}_{bj}}_{\text{Marginal Revenue of Product } s} - \frac{1}{e} p_{bj} \frac{1 + \epsilon_{bj}}{\epsilon_{bj}} &= 0
\end{aligned}$$

where  $\epsilon_{bj}$  is the supply elasticity. Then, we get that

$$p_{bj} = \frac{\epsilon_{bj}}{1 + \epsilon_{bj}} e \text{MRP}_{bj} \quad (7.4)$$

## Cournot Competition

$$\pi_{bj} = p_{finalg} Q_{finalg} - \sum_s \frac{1}{e} p_{bj} q_{bj} \quad \text{s.t.} \quad Q_{finalg} = \left( \int_j q_{bj}^{\frac{1-\gamma}{\gamma}} dj \right)^{\frac{\gamma}{\gamma-1}} \quad \text{and} \quad q_{bj} = \frac{p_{bj}^{\eta-1}}{P_j^{\eta-1}} \frac{P_j^{\theta-1}}{P^{\theta-1}} Y \quad (7.5)$$

The FOC imply that:

$$\begin{aligned}
[q_{bj}] \frac{\partial p_{bj} q_{bj}}{\partial q_{bj}} - \frac{1}{e} \left[ \frac{\partial p_{bj}}{\partial q_{bj}} q_{bj} + p_{bj} \right] &= 0 \\
MVP(e) - \frac{1}{e} p_{bj} \left[ \frac{\partial p_{bj}}{\partial q_{bj}} \frac{q_{bj}}{p_{bj}} + 1 \right] &= 0 \\
p_{bj} \left[ \frac{1}{\epsilon} + 1 \right] &= \frac{MVP(e)}{\frac{1}{e}} \\
p_{bj} &= \frac{\epsilon}{1 + \epsilon} e \text{MRP}_{bj}
\end{aligned}$$

### 7.1.6 Buyer Size and Level Price

In this section I explore the relationship in the data between the size of the buyer and the price. For doing so, I run the following regression:

$$\ln(\text{price}_{sbjkt}) = \xi BS_{bjkt} + FE_{sjkt} + X_{kt} + \epsilon_{sbjkt} \quad (7.6)$$

where  $\ln(\text{price}_{sbjkt})$  is the price of Product  $j$ , Seller  $s$  charges to Buyer  $b$  at Destination  $k$  in period  $t$  and  $X_{k,t}$  are control variables at the country and time level. To represent this relationship, I plot the bin scatter of the demeaned variables, as well as the fitted line. The slope of this line is the main coefficient of the regression ( $\xi$ ). Figure 6 Panel A shows that the price of the same product, sold to the same destination in a given year is increasing in the buyer's size. This is true, even controlling for destination and time-specific variables. The reason for this is that even though the markdowns for firms with higher market shares are larger, the marginal-revenue product for larger firms is also larger. Therefore, large firms are willing to pay higher prices.<sup>41</sup>

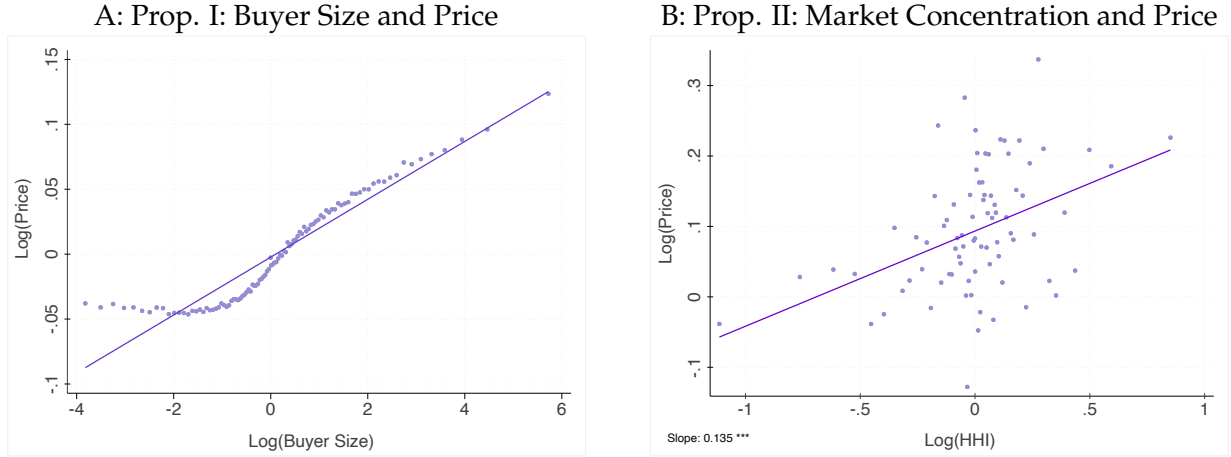
<sup>41</sup>Note that this result is analogous to Berger, Herkenhoff and Mongey (2022), where large firms pay higher wages.

Then, I turn to the market-level predictions of the model. I aggregate equation 7.6 at the market level such that price in a market can be expressed as a weighted average of prices for a given product in a given destination where the weights correspond to the buyers' market share. I obtain the average price of a product for a destination for a given year as a function of the concentration of the market, expressed as the market's HHI,  $HHI_{kt} = \sum_{b=1}^B S_{bjkt}^2$ .<sup>42</sup>

$$\ln(\text{price}_{jkt}) = \zeta HHI_{jkt} + FE_{jkt} + X_{kt} + \epsilon_{jkt} \quad (7.7)$$

Figure 6 Panel B shows the correlation between the market price of a product and the concentration of buyers in that given market. It can be noted how for a bigger concentration of buyers, prices tend to be lower in that market.<sup>43</sup>

**Figure 6**



### 7.1.7 Elasticity of Supply

We are missing what is the value of  $\epsilon_{bj}$ . For this, we can go back to the quantity supplied and calculate it:

$$q_{bj} = \frac{p_{bj}^{\eta-1} P_s^\theta}{P_s^\eta P^\theta} Y$$

$$\epsilon = \frac{\partial q}{\partial p} \frac{p}{q} = \left[ (\eta - 1) \frac{p_{bj}^\eta P_s^\theta Q}{p_{bj} P_s^\eta P^\theta} + (\theta - \eta) \frac{P_s^{\theta-\eta} p_{bj}^{\eta-1} Q}{P_s P^\theta} \right] \frac{p_{bj}}{q_{bj}}$$

$$\epsilon = \left[ (\eta - 1) \frac{q_{bj}}{p_{bj}} + (\theta - \eta) \frac{q_{bj}}{P_s} \right] \frac{p_{bj}}{q_{bj}}$$

$$\epsilon = (\eta - 1) + (\theta - \eta) \frac{p_{bj}}{P_s}$$

$$\epsilon_{bj} = \frac{d \ln q_{bj}}{d \ln p_{bj}} = (\eta - 1) \left( 1 - \left( \frac{p_{bj}^{\eta-1}}{\sum_{a' \in s} p_{a's}^{\eta-1}} \right) \right) + (\theta - 1) \left( \frac{p_{bj}^{\eta-1}}{\sum_{a' \in s} p_{a's}^{\eta-1}} \right)$$

$$\epsilon_{bj} = (\eta - 1) (1 - \text{Share}) + (\theta - 1) (\text{Share})$$

$$p_{bj} = \frac{1}{\frac{1}{\epsilon_{bj}} + 1} eMVP_j$$

<sup>42</sup>See the Appendix for proof.

<sup>43</sup>Given the potential endogeneity in this regression, as mentioned in Bresnahan (1989), in the Appendix, I use an IV equal to how big is the buyer in other markets to estimate this relationship. Results hold.

### 7.1.8 Pass-through

The starting point for this analysis is the optimal price setting equation, which we rewrite including now a destination index  $k$ :

$$p_{ask} = \frac{\epsilon_{ask}}{1 + \epsilon_{ask}} eMVP_{ask}$$

Rewriting this equation as the sum of logs. We assume that the mark-up depends on the price charged by the exporting firm relative to the aggregate industry price level in the destination country  $d$ :

$$\ln p_{asd} = \ln \mu_{asd} + \ln MVP_{asd} + \ln e_d$$

So log-differentiating, we have that the log change in price  $\Delta p_{asd}$  can be approximated as

$$\Delta \ln p_{asd} = \Delta \ln \mu_{asd} + \Delta \ln MVP_{asd} + \Delta \ln e_d \quad (7.8)$$

We assume that the mark-down depends on the price charge by the seller from country  $d$  relative to the (log) aggregate industry price level in the origin country  $d$ ,  $p_{sb}$ . That is,  $\mu_{asd} = \mu_{asd}(p_d - p)$ . Then we get expression:

$$\Delta p_{asd} = Y_{asd}(\Delta p_{asd} - \Delta p_{sd}) + mvp_q \Delta q_{asd} + \alpha_{asd} \Delta e_d$$

where  $Y_{asd} = -\frac{\mu_{asd}}{(p_d - p)}$  is the elasticity of the mark-up with respect to the relative price (constant markdowns, this = 0),  $mvp_q = \frac{\partial mvp(\dots)}{\partial q}$  is the elasticity of the marginal value with respect to output (assumed common across firms), and  $\alpha = \frac{\partial mvp(\dots)}{\partial e_d}$  is the partial-elasticity of the marginal value (expressed in destination country's currency) to the exchange rate. We assume  $\frac{\partial mvp(\dots)}{\partial w} = 0$ . Log demand is given by  $q_{asd} = q(p_{asd} - p_s) + \Delta q_d$  where  $q_d$  denotes the log of the aggregate quantities/demand in country  $n$ . Log-differentiating,

$$\Delta q_d = -\epsilon_d(\Delta p_{asd} - \Delta p_d) + \Delta q_d$$

where  $\epsilon_d = -\frac{\partial q(\dots)}{\partial p_d} > 0$  is the price elasticity of **supply**. Combining these two equations and collecting terms we get:

$$\Delta p_{asd} = \frac{1}{1 + Y_{asd} + \phi_{asd}} [-\alpha \Delta e_d + (Y_{asd} + \phi_{asd}) \Delta p_{asd} + mvp_q \Delta q_d]$$

where  $\phi_d = mvp_q \epsilon_d > 0$  is the partial elasticity of mvp with respect to the relative price. **Going back to (7.8) and solving for each term:**

- Consider first the markdown term:

$$d \ln \mu_{bjk} = \Gamma_{bjk} d \ln p_{bjk}$$

with  $\Gamma_{bjk} = -\frac{\partial \ln \mu_{bjk}}{\partial p_{bjk}} > 0$  as the partial elasticity of bilateral markdowns with respect to the price,  $p_{bjk}$ .

Note that  $\frac{\partial \ln \mu_{bjk}}{\partial BS_{bjk}} > 0$  is negative, because higher buyer share, lower elasticity, lower markdown.

$$\begin{aligned} \Gamma_{bjk} &= -\frac{d \ln \mu_{bjk}}{d \ln p_{bjk}} \\ &= -\frac{d \ln \mu_{bjk}}{d \ln S_{bjk}} \times \frac{d \ln S_{bjk}}{d \ln p_{bjk}} \end{aligned}$$

where  $\epsilon_{asd}$  is the price elasticity of supply.

and



$$S_{bjk} = \frac{p_{bjk}^{\eta-1}}{\sum_x p_{bjk}^{1-\eta}}$$

$$\ln(S_{bjk}) = \ln(p_{bjk}^{1-\eta}) + \ln\left(\sum_s p_{sb}^{1-\eta}\right)$$

$$d\ln S_{bjk} = 1 - \eta \frac{dp_{bjk}}{p_{bjk}} - 1 - \eta \frac{1}{\sum_s p_{bjk}^{\eta-1}} \frac{p_{bjk}^{\eta-1}}{p_{bjk}} dp_{bjk}$$

$$d\ln(S_{bjk}) = 1 - \eta d\ln p_{bjk} - 1 - \eta) S_{bjk} d\ln p_{bjk}$$

$$d\ln S_{bjk} = [1 - \eta - 1 - \eta) S] d\ln p_{bjk}$$

$$d\ln S_{bjk} = 1 - \eta(1 - S_{bjk}) d\ln p_{bjk}$$

$$d\ln S_{bjk} = 1 - \eta d\ln(p_{bjk}) - 1 - \eta$$

$$d\ln \mu = Y_{sbjk}(\eta + 1)(1 - S_{bjk}) d\ln p_{bjk} \quad (7.9)$$

$$d\ln \mu = \Gamma_{bjk} d\ln p_{bjk}$$

where

$$\Gamma_{bjk} = -\frac{d\ln \mu_{bjk}}{d\ln p_{bjk}} = \frac{S_{bjk}}{\left(\frac{\eta}{\theta-\eta} + S_{bjk}\right)\left(1 + \frac{\theta-\eta}{\eta+1} S_{bjk}\right)} > 0$$

- Consider the second term:

$$MVP = \frac{\partial revenues}{\partial q_{bjk}}$$

$$\frac{d\ln MVP_{bjk}}{d\ln p_{bjk}} = \frac{d\ln MVP_{bjk}}{d\ln q_{bjk}} \frac{d\ln q_{bjk}}{d\ln p_{bjk}}$$

$$\frac{d\ln MVP_{bjk}}{d\ln p_{bjk}} = \frac{dMVP}{dq_{bjk}} \frac{q_{bjk}}{MVP_{bjk}} \epsilon_{bjk}$$

$$\frac{d\ln MVP_{bjk}}{d\ln p_{bjk}} = (\alpha_j - 1) \frac{MVP_{bjk}}{q_{bjk}} \frac{q_{bjk}}{MVP_{bjk}} \epsilon_{bjk}$$

$$\frac{d\ln MVP_{bjk}}{d\ln p_{bjk}} = (\alpha_j - 1) \epsilon_{bjk}$$

So, given a change in bilateral exchange rate  $d\ln e_d$ , as in [Burstein and Gopinath \(2014\)](#) there is a direct and indirect effect.

The direct component of the exchange rate pass-through is:

$$\frac{d \ln p_{sbj}}{d \ln e_d} = \frac{1}{\underbrace{1 - Y_{bjk}(1 - \eta_{bjk})(1 - S_{bjk})}_{\text{Markdownchannel}} - \underbrace{(\alpha_j - 1)\epsilon_{bjk}}_{\text{ValueChannel}}}$$

Taking into account that  $d; n p_{sbj}$  is in USD we can change this equation into COP using the following:

$$d \ln p_{sbj}^{\text{dollars}} = d \ln p_{asd}^{\text{pesos}} - d \ln e$$

And so we get:

$$\frac{d \ln p_{sbjk}}{d \ln e_d} = 1 - \frac{1}{\underbrace{1 - Y_{bjk}(1 - \eta)(1 - S_{bjk})}_{\text{Markdownchannel}} - \underbrace{(\alpha_j - 1)\epsilon_{bjk}}_{\text{ValueChannel}}}$$

where  $Y_{bjk} = \frac{d \ln \mu_{bjk}}{d \ln S_{bjk}}$

### 7.1.9 Path Through: General Case

Log-differentiating equation 3.5, I get that the log change in price,  $d \ln p_{sbj}$ , can be written as:

$$d \ln p_{sbjk} = d \ln \mu_{bjk} + d \ln MVP_{sbjk} + d \ln e_k \quad (7.10)$$

Consider first the markdown term:

$$d \ln \mu_{bjk} = \Gamma_{bjk} d \ln p_{bjk}$$

with  $\Gamma_{bjk} = -\frac{\partial \ln \mu_{bjk}}{\partial p_{bjk}} > 0$  as the partial elasticity of bilateral markdowns with respect to the price,  $p_{bjk}$ .

$$\begin{aligned} \Gamma_{bjk} &= -\frac{d \ln \mu_{bjk}}{d \ln p_{bjk}} \\ &= -\frac{d \ln \mu_{bjk}}{d \ln S_{bjk}} \times \frac{d \ln S_{bjk}}{d \ln p_{bjk}} \end{aligned}$$

Solving for the first term:  $\frac{d \ln \mu_{bjk}}{d \ln S_{bjk}}$

$$\begin{aligned} \mu_{bjk} &= \frac{1}{1 + \frac{1}{\epsilon_{bjk}}} \\ \frac{d \ln \mu_{bjk}}{d \ln S_{bjk}} &= \frac{\theta(1 - S_{bjk})}{\frac{1}{S_{bjk}} + \frac{\theta - \eta}{\eta + 1}} \\ &= Y_{bjk} < 0 \text{ (by prop II)} \end{aligned}$$

Solving for the second term:

$$\begin{aligned}
S_{bjk} &= \frac{p_{bjk}^{\eta+1}}{\sum_x p_{bjk}^{1+\eta}} \\
\ln S_{bjk} &= \ln p_{bjk}^{1+\eta} + \ln\left(\sum_s p_{bjk}^{1+\eta}\right) \\
d\ln S_{bjk} &= (1+\eta) \frac{dp_{bjk}}{p_{bjk}} - (1+\eta) \frac{1}{\sum_s p_{bjk}^{\eta+1}} \frac{p_{bjk}^{\eta+1}}{p_{bjk}} dp_{bjk} - \sum_{z \neq b} (1+\eta) \frac{p_{zjk}}{\sum_b p_{bjk}^{1+\eta}} \frac{p_{zjk}^{1+\eta}}{p_{zjk}} \frac{dp_{zjk}}{dp_{bjk}} dp_{bjk} \frac{p_{bjk}}{p_{bjk}} \\
d\ln S_{bjk} &= (1+\eta) d\ln p_{bjk} - (1+\eta) S_{bjk} d\ln p_{bjk} - (1+\eta) \sum_z S_{zjk} \frac{p_{bjk}}{p_{zjk}} \frac{dp_{zjk}}{dp_{bjk}} d\ln p_{bjk} \\
d\ln S_{bjk} &= (1+\eta) \left(1 - S_{bjk} - \sum_z S_{zjk} \frac{d\ln p_{zjk}}{d\ln p_{bjk}}\right) d\ln p_{bjk}
\end{aligned}$$

Finally,

$$d\ln \mu_{bjk} = Y_{sbjk} (\eta_{bjk} + 1) \left(1 - S_{bjk} - \underbrace{\sum_z S_{zjk} \frac{d\ln p_{zjk}}{d\ln p_{bjk}}}_{\text{Indirect}}\right) d\ln p_{bjk} \quad (7.11)$$

$$\frac{d\ln \mu_{bjk}}{d\ln p_{bjk}} = \underbrace{\Gamma_{bjk}^*}_{\text{Direct}}$$

### 7.1.10 Proof of Proposition 3: Log Linearization and First-Order Approximation

$$\begin{aligned}
p_{bjk} &= \mu_{bjk} e_k MVP_{bjk} \\
\ln p_{bjk} &= \ln \mu_{bjk} + \ln e_k + \ln MVP_{bjk} \\
d\ln p_{bjk} &= \frac{d\ln \mu_{bjk}}{d\ln S_{bjk}} \frac{d\ln S_{bjk}}{d\ln p_{bjk}} d\ln p_{bjk} + d\ln e_k + (1-\alpha) \epsilon_{bjk} d\ln p_{bjk}
\end{aligned}$$

Starting from the pass-through equation:

$$\begin{aligned}
d\ln p_{sbj} &= \frac{1}{1 + \underbrace{\Gamma_{bjk}}_{\text{Mark down channel}} + \underbrace{\Phi_{bjk}}_{\text{Marginal Revenue Channel}}} d\ln e_d \\
d\ln p_{bjk} &= \frac{1}{1 - \frac{d\ln \mu_{bjk}}{d\ln S_{bjk}} (1+\eta) (1 - S_{bjk}) + (1-\alpha_j) \epsilon_{bjk}} de_k, \text{ where } Y = \frac{d\ln \mu_{bjk}}{d\ln p_{bjk}}
\end{aligned}$$

Doing a first-order approximation in  $S_{sbjk}$  and dividing by  $d\ln e_d$ :

$$\frac{d\ln p_{sbjk}}{d\ln e_d} \approx \frac{1}{1 + \bar{Y}_{bjk} (1-\eta) (1 - \bar{S}_{bjk}) + (1-\alpha_j) \bar{\epsilon}} + \frac{\left. \frac{\partial Y_{bjk}}{\partial S_{sbjk}} \right|_{\bar{S}_{bjk}} \cdot (1+\eta) (1 - \bar{S}_{bjk}) - \bar{Y}_d (1+\eta) \cdot \left. \frac{\partial \epsilon_{bjk}}{\partial S_{bjk}} \right|_{\bar{S}_{bjk}} (1-\alpha_j)}{[1 + \bar{Y}_{bjk} (1-\eta) (1 - \bar{S}_{bjk}) + (1-\alpha_j) \bar{\epsilon}]^2} (S_{bjk} - \bar{S}_{bjk})$$

Separating terms multiplied by  $BS$  and  $\bar{BS}$ :

$$\frac{d \ln p_{axsd}}{d \ln e_d} \approx \left[ \frac{1}{1 + \bar{Y}_{bjk}(1 - \eta)(1 - \bar{S}_{bjk}) + (1 - \alpha_j)\bar{\epsilon}} - \frac{\frac{\partial Y_d}{\partial S_{bjk}} \Big|_{\bar{S}_{bjk}} \cdot (1 + \eta)(1 - \bar{S}_{bjk}) - \bar{Y}_d(1 + \eta) \cdot \frac{\partial \epsilon_{bjk}}{\partial S_{bjk}} \Big|_{\bar{S}_{bjk}} (1 - \alpha_j)}{[1 + \bar{Y}_{bjk}(1 - \eta)(1 - \bar{S}_{bjk}) + (1 - \alpha_j)\bar{\epsilon}]^2} \right] \cdot \bar{S}_{bjk} \\ + \left[ \frac{\frac{\partial Y_d}{\partial S_{bjk}} \Big|_{\bar{S}_{bjk}} \cdot (1 + \eta)(1 - \bar{S}_{bjk}) - \bar{Y}_d(1 + \eta) \cdot \frac{\partial \epsilon_{bjk}}{\partial S_{bjk}} \Big|_{\bar{S}_{bjk}} (1 - \alpha_j)}{[1 + \bar{Y}_{bjk}(1 - \eta)(1 - \bar{S}_{bjk}) + (1 - \alpha_j)\bar{\epsilon}]^2} \right] \cdot S_{bjk}$$

Getting together the terms with  $\frac{\Delta \ln p_{axsd}}{\Delta \ln e_d}$  and taking common factor of terms with  $BS$  and  $\bar{BS}$ :

$$\frac{d \ln p_{bjk}}{d \ln e_d} \approx \alpha_{bjk} + \beta_{bjk} S_{bjk}$$

where:

$$\alpha_{bjk} = \left[ \frac{1}{1 + \bar{Y}_{bjk}(1 - \eta)(1 - \bar{S}_{bjk}) + (1 - \alpha_j)\bar{\epsilon}} + \frac{\frac{\partial Y_d}{\partial S_{bjk}} \Big|_{\bar{S}_{bjk}} \cdot (1 + \eta)(1 - \bar{S}_{bjk}) - \bar{Y}_d(1 + \eta) \cdot \frac{\partial \epsilon_{bjk}}{\partial S_{bjk}} \Big|_{\bar{S}_{bjk}} (1 - \alpha_j)}{[1 + \bar{Y}_{bjk}(1 - \eta)(1 - \bar{S}_{bjk}) + (1 - \alpha_j)\bar{\epsilon}]^2} \right]$$

$$\beta_{bjk} = \left[ \frac{\frac{\partial Y_d}{\partial S_{bjk}} \Big|_{\bar{S}_{bjk}} \cdot (1 + \eta)(1 - \bar{S}_{bjk}) - \bar{Y}_d(1 + \eta) \cdot \frac{\partial \epsilon_{bjk}}{\partial S_{bjk}} \Big|_{\bar{S}_{bjk}} (1 - \alpha_j)}{[1 + \bar{Y}_{bjk}(1 - \eta)(1 - \bar{S}_{bjk}) + (1 - \alpha_j)\bar{\epsilon}]^2} \right]$$

→  $\beta$  is the coefficient of interest

### 7.1.11 Monopolistic Competition for Final Good

Adding a demand function assuming that the aggregate income of the final consumers is given. In particular, assume that the demand for the buyers takes the following form:

$$x = X(r/R)^{-\sigma}$$

$$r = Bx^{\frac{-1}{\sigma}}$$

where  $x$  is quantity and  $r$  is price to final consumers and  $XR$  is the total income of final consumers. We are going to take these variables as given. Then, the total revenue of the firm is given by:

$$TR = px = Bx^{\frac{-1}{\sigma}} x = Bx^{\frac{\sigma-1}{\sigma}},$$

where  $B$  is a constant that is given, just assume that it is equal to 1. Using the production function we get:

$$TR_{bk} = B \left( q_{bjk}^\alpha \right)^{\frac{\sigma-1}{\sigma}}$$

Then the marginal revenue is given by:

$$MR_{bjk} = \alpha \left( \frac{\sigma-1}{\sigma} \right) q_{bjk}^{\frac{-\alpha}{\sigma}}$$

The only difference with our previous expression is that it is multiplied by the markup assuming some value for  $\sigma$  and adjust the exponent.

### 7.1.12 Demand Curve: Choice of Price

#### Bertrand Competition—One Product Only

$$\pi_{bj} = p_{finalg} Q_{finalg} - \frac{1}{e} p_{bj} q_{bj} \quad \text{s.t.} \quad Q_{finalg} = q_{bjk}^\sigma \quad \text{and} \quad q_{bj} = \frac{p_{bj}^\eta P_s^{\theta-1}}{P_s^{\eta-1} p^{\theta-1}} Y \quad (7.12)$$

The FOC imply that:

$$\begin{aligned} [p_{bj}] : \quad & \frac{\partial(\text{revenue})}{\partial q_{bj}} \frac{\partial q_{bj}}{\partial p_{bj}} - \frac{1}{e} \left[ q_{bj} + p_{bj} \frac{\partial q_{bj}}{\partial p_{bj}} \right] = 0 \\ & \frac{\partial(\text{revenue})}{\partial q_{bj}} - \frac{1}{e} \left[ q_{bj} \frac{\partial p_{bj}}{\partial q_{bj}} + p_{bj} \right] = 0 \\ & \frac{\partial(\text{revenue})}{\partial q_{bj}} - \frac{1}{e} \left[ p_{bj} \frac{q_{bj}}{p_{bj}} \frac{\partial p_{bj}}{\partial q_{bj}} + p_{bj} \right] = 0 \\ & \frac{\partial(\text{revenue})}{\partial q_{bj}} - \frac{1}{e} p_{bj} \left[ \frac{1}{\epsilon} + 1 \right] = 0 \\ & \underbrace{MVP_s}_{\text{Marginal Value of Product s}} - \frac{1}{e} p_{bj} \frac{1 + \epsilon_{bj}}{\epsilon_{bj}} = 0 \end{aligned}$$

where  $\epsilon_{bj}$  is the supply elasticity to Firm  $a$ . Then, we get that

$$p_{sbj} = \frac{\epsilon_{bj}}{1 + \epsilon_{bj}} e MRP_s \quad (7.13)$$

#### Bertrand Competition—Only Colombia

$$\pi_{bj} = p_{finalg} Q_{finalg} - \sum_j \frac{1}{e_k} p_{bjk} q_{bjk} \quad \text{s.t.} \quad Q_{finalg} = \prod_j z_b q_{bjk}^{\sigma_j} \quad \text{and} \quad q_{bjk} = \frac{p_{bjk}^\eta P_{jk}^\theta}{P_{jk}^\eta p^\theta} Y \quad (7.14)$$

The FOC imply that:

$$\begin{aligned} [p_{bj}] : \quad & \frac{\partial(\text{revenue})}{\partial q_{bjk}} \frac{\partial q_{bjk}}{\partial p_{bjk}} - \frac{1}{e_k} \left[ q_{bjk} + p_{bjk} \frac{\partial q_{bjk}}{\partial p_{bjk}} + p_{bak} \frac{\partial q_{bak}}{\partial p_{bjk}} + \frac{\partial p_{bak}}{\partial p_{bjk}} q_{bak} \right] = 0 \\ & p_{sbj} = \frac{1}{1 + \epsilon_{bjk}^{-1}} e_k MRP_s \end{aligned} \quad (7.15)$$

#### Bertrand Competition—Only One Input per Country

$$\pi_{bj} = p_{finalg} Q_{finalg} - \sum_{origin} \frac{1}{e_k} p_{bjk} q_{bjk} \quad \text{s.t.} \quad Q_{finalg} = \prod_j z_b q_{bjk}^{\sigma_{origin}} \quad \text{and} \quad q_{bjk} = \frac{p_{bjk}^\eta P_{jk}^\theta}{P_{jk}^\eta p^\theta} Y \quad (7.16)$$

Origin= Colombia, Ecuador, France

The FOC imply that:

$$[p_{bj}] : \frac{\partial(\text{revenue})}{\partial q_{bj}} \frac{\partial q_{bjk}}{\partial p_{bjk}} - \frac{1}{e_k^{\text{Colombia}}} \left[ q_{bj} + p_{bjk} \frac{\partial q_{bj}}{\partial p_{bj}} \right] + \frac{1}{e_k^{\text{France}}} \left[ \underbrace{\frac{\partial p_{bak}}{\partial p_{bjk}} q_{bak}}_0 + \underbrace{p_{bak} \frac{\partial q_{bak}}{\partial p_{bjk}}}_0 \right] = 0$$

$$p_{sbj} = \frac{1}{1 + \epsilon_{bjk}^{-1}} e_k^{\text{Colombia}} MRP_s \quad (7.17)$$

### 7.1.13 Marginal Revenue Effect

#### One Good

$$Q_{\text{finalgood}} = \left( \frac{q_{bjk}}{\sigma_j} \right)^{\sigma_j}$$

If the price charged by the buyer does not change:

$$MRP = \frac{\partial \text{revenues}}{\partial q_{bjk}} = \sigma \frac{Q_{\text{finalgood}}}{q_{bjk}}$$

$$\frac{d \ln MRP_{bjk}}{d \ln p_{bjk}} = \frac{d \ln MRP_{bjk}}{d \ln q_{bjk}} \frac{d \ln q_{bjk}}{d \ln p_{bjk}}$$

$$\frac{d \ln MRP_{bjk}}{d \ln p_{bjk}} = \frac{d MRP}{d q_{bjk}} \frac{q_{bjk}}{MRP_{bjk}} \epsilon_{bjk}$$

$$\frac{d \ln MVP_{bjk}}{d \ln p_{bjk}} = (\sigma_j - 1) \epsilon_{bjk}$$

#### Cobb-Douglas

$$Q_{\text{finalgood}} = \prod_j \left( \frac{q_{bjk}}{\sigma_j} \right)^{\sigma_j}$$

If the price charge by the buyer does not change:

$$MRP = \frac{\partial \text{revenues}}{\partial q_{bjk}} = \sigma \frac{Q_{\text{finalgood}}}{q_{bjk}}$$

$$\frac{d \ln MRP_{bjk}}{d \ln p_{bjk}} = \frac{\partial MRP}{\partial p_{bjk}} \frac{p_{bjk}}{MRP}$$

$$\frac{d \ln MRP_{bjk}}{d \ln p_{bjk}} = \left[ -\frac{Q_{\text{finalgood}}}{q_{bjk}^2} \frac{\partial q_{bjk}}{\partial p_{bjk}} + \frac{\partial Q_{\text{finalgood}}}{\partial q_{bjk}} \frac{\partial q_{bjk}}{\partial p_{bjk}} \frac{1}{q_{bjk}} + \sum_{j' \neq j} \frac{\partial Q_{\text{finalgood}}}{\partial q_{bj'k}} \frac{\partial q_{bj'k}}{\partial p_{bjk}} \frac{1}{q_{bjk}} \right] \frac{p_{bjk}}{MRP}$$

$$\frac{d\ln MRP_{bjk}}{d\ln p_{bjk}} = -\frac{\sigma}{\sigma} \epsilon_{bjk} + \sigma \epsilon_{bjk} + \sum_{j' \neq j} \frac{\partial Q_{finalgood}}{\partial q_{bj'k}} \frac{\partial q_{bj'k}}{\partial p_{bjk}} \frac{1}{q_{bjk}} \frac{p_{bjk}}{MRP}$$

$$\frac{d\ln MRP_{bjk}}{d\ln p_{bjk}} = \epsilon_{bjk}(\sigma - 1) + \sum_{j' \neq j} \frac{\partial Q_{finalgood}}{\partial q_{bj'k}} \frac{\partial q_{bj'k}}{\partial p_{bjk}} \frac{1}{q_{bjk}} \frac{p_{bjk}}{MRP} < 0$$

**CES** With a CES production function we have that:

$$Q_b = \left( \sum_j q_{bs}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}$$

Then we get that:

$$MVP_{bs} \propto \left( \frac{Q_b}{q_{bs}} \right) \left( \frac{q_{bs}^{\frac{\sigma-1}{\sigma}}}{\left( \sum_s q_{bs}^{\frac{\sigma-1}{\sigma}} \right)} \right) = x_{bs} \frac{Q_b}{q_{bs}}$$

where  $x_{bs}$  is the expenditure share of Buyer  $b$  on Seller  $s$ .<sup>44</sup> Totally differentiating in logs we get:

$$d\ln MVP_{bs} = d\ln x_{bs} + d\ln Q_b - \frac{d\ln q_{bs}}{d\ln p_{bs}}$$

We get that

$$d\ln x_{bs} = \frac{\sigma-1}{\sigma} d\ln q_{bs} - \frac{\sigma-1}{\sigma} x_{bs} d\ln q_{bs} = \frac{\sigma-1}{\sigma} (1 - x_{bs}) \frac{d\ln q_{bs}}{d\ln p_{bs}}$$

Similarly:

$$d\ln Q_b = x_{bs} \frac{d\ln q_{bs}}{d\ln p_{bs}}$$

Replacing this in the previous equation we get:

$$d\ln MVP_{bs} = \left( \frac{\sigma-1}{\sigma} - 1 \right) (1 - x_{bs}) \frac{d\ln q_{bs}}{d\ln p_{bs}} = \frac{-1}{\sigma} (1 - x_{bs}) \frac{d\ln q_{bs}}{d\ln p_{bs}}$$

$$\frac{d\ln MVP_{bs}}{d\ln p_{bs}} = \frac{-1}{\sigma} (1 - x_{bs}) \epsilon_{bs}$$

### 7.1.14 Increasing Relationship between Markdown Channel and Buyer Size

Start with the markdown equation:  $\mu_{bjk} = 1 + \epsilon_{bjk}^{-1}$  where  $\epsilon_{bjk} = \eta + (\theta - \eta) S_{bjk}$

$$\text{markdown channel} = \frac{\partial \ln \mu_{bjk}}{\partial \ln p_{bjk}} = \frac{\partial \mu_{bjk}}{\partial S_{bjk}} \frac{\partial S_{bjk}}{\partial p_{bjk}} \frac{p_{bjk}}{\mu_{bjk}}$$

$$\frac{d\mu_{bjk}}{dS_{bjk}} = -[\eta + (\theta - \eta) S_{bjk}]^{-1} (\theta - \eta)$$

$$\text{markdown channel} = \frac{\partial \ln \mu_{bjk}}{\partial \ln p_{bjk}} = \frac{-(\eta + 1)(1 - S_{bjk}) S_{bjk}}{\left( \frac{\eta}{\theta - \eta} \right) (\eta + (\theta - \eta) S_{bjk} + 1)}$$

<sup>44</sup>Note that this  $s$  could be also product.

Note that for values  $\eta > \theta > 1$

$$\frac{\text{markdown channel}}{dS_{bjk}} > 0$$

### 7.1.15 HHI and Markdowns

In this equation,  $\kappa$  is the effect of an exogenous shock on the payroll Herfindhal. To derive the expression, plug in  $\mu_{jkt} = 1 + \epsilon_{jkt}^{-1}$  and differentiate:

$$\begin{aligned} \kappa &= \frac{d\mu_{jkt}}{dX} = \frac{d(1 + \epsilon_{jkt}^{-1})}{dX} \\ &= \left[ \frac{d(1 + \epsilon_{jkt}^{-1})}{dHHI_{jkt}} \frac{dHHI_{jkt}}{dX} \right] \\ &= \left[ \frac{d(1 + \epsilon_{jkt}^{-1})}{dHHI_{jkt}} \kappa_t \right] \\ &= \left( \frac{1}{\theta} - \frac{1}{\eta} \right) \kappa_t \end{aligned}$$

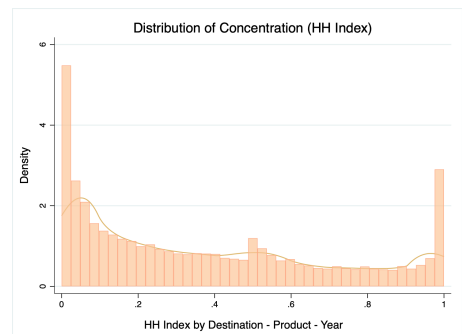
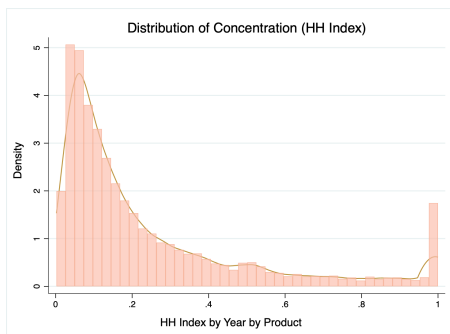
I then compute the standard errors for  $\kappa_t$  under the assumption that the effect on concentration and the input supply parameters are independent. It follows that:

$$\begin{aligned} \text{var}(\kappa_t) &= \text{var} \left[ \left( \frac{1}{\theta} - \frac{1}{\eta} \right) \kappa_t \right] \\ &= \text{var} \left[ \left( \frac{1}{\theta} - \frac{1}{\eta} \right)^2 \right] \mathbb{E}[\kappa_t^2] - \left[ \mathbb{E} \left( \frac{1}{\theta} - \frac{1}{\eta} \right) \right]^2 [\mathbb{E}(\kappa_t)]^2 \\ &= \text{var} \left[ \left( \frac{1}{\theta} - \frac{1}{\eta} \right) + \left[ \mathbb{E} \left( \frac{1}{\theta} - \frac{1}{\eta} \right) \right]^2 \right] [\text{var}(\kappa_t) + [\mathbb{E}(\kappa_t)]^2] - \left[ \frac{1}{\theta} - \frac{1}{\eta} \right]^2 [\mathbb{E}(\kappa_t)]^2 \end{aligned}$$

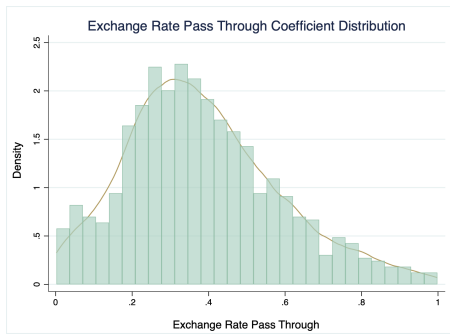
whose components can all be plugged in using sample estimates.

## 7.2 Appendix: Empirical Part

### 7.2.1 Variables Distribution







## 7.2.2 HS10 examples

**Structure of HTS Codes**  
 [ HTS Code example ]  
**0902.10.1015**

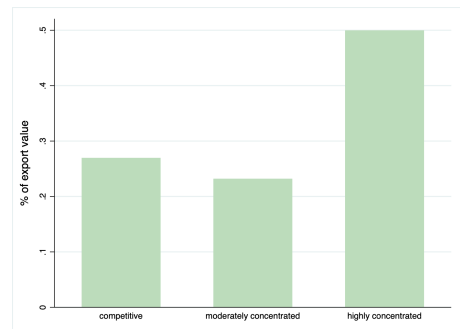
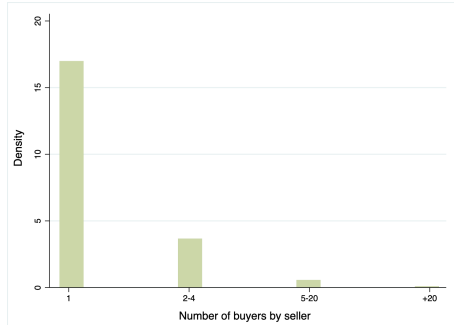
Meaning of the numbers	Article Description
<b>09</b> Chapter	Coffee, Tea, Mate and Spices
<b>0902</b> Heading	Tea, whether or not flavored
<b>0902.10</b> (HS Code) Sub Heading	Green tea (not fermented) in immediate packings of a content not exceeding 3 kg
<b>0902.10.10</b> Subheading (Determines Duty)	Flavored
<b>0902.10.1015</b> Statistical Suffix (Further Definition and Makeup)	Certified Organic

Commodity Code	Description
2204 10	✓ Sparkling wine
2204 1011	✓ With a protected designation of origin (PDO)
2204 1011 00	<a href="#">Champagne</a>
2204 1013 00	<a href="#">Cava</a>
2204 1015 00	<a href="#">Prosecco</a>
2204 1091 00	<a href="#">Asti spumante</a>
2204 1093 00	<a href="#">Other</a>
2204 1094 00	<a href="#">With a protected geographical indication (PGI)</a>
2204 1096 00	<a href="#">Other varietal wines</a>
2204 1098 00	<a href="#">Other</a>

## 7.2.3 Buyers and Sales Concentration

The two figures below show characteristics of the export markets in Colombia. Figure 7.2.3 shows that in the majority of the cases a seller only supplies to one buyer. Figure 7.2.3 shows that for the biggest part of the export value, markets are highly concentrated.

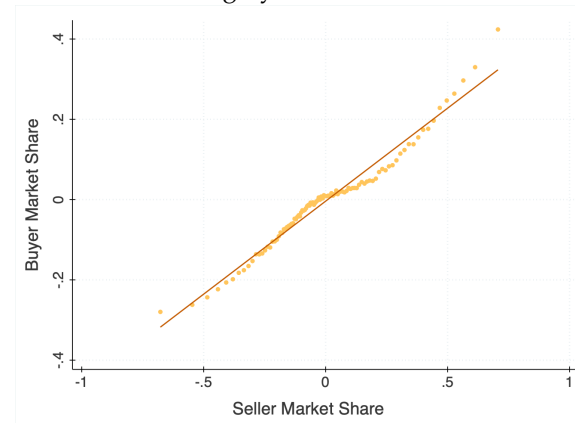
Export value explained by multi-buyers



## 7.2.4 Assortative Matching

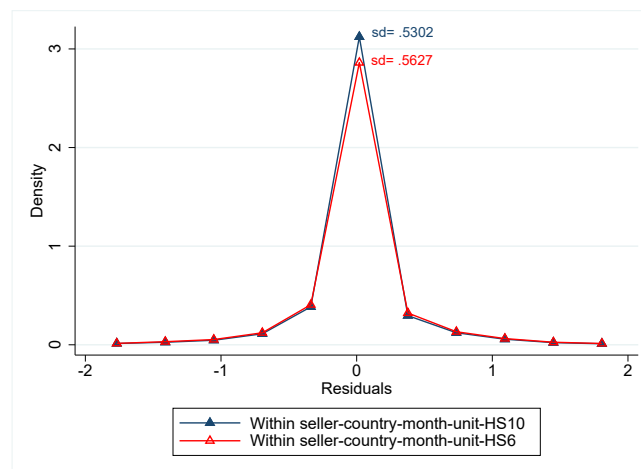
The figures below show that it is more likely large buyers buy from larger sellers and that highly concentrated

markets in terms of buyers are also highly concentrated in terms of sellers.



## 7.2.5 Price Dispersion: Monthly

One could think that, as the exchange rate is very volatile, then the price differences found could be attributed to different exchange rates instead of the same seller discriminating among buyers. To check for this, I check price dispersion at the month level. It can be observed that price discrimination even happens at the price level.



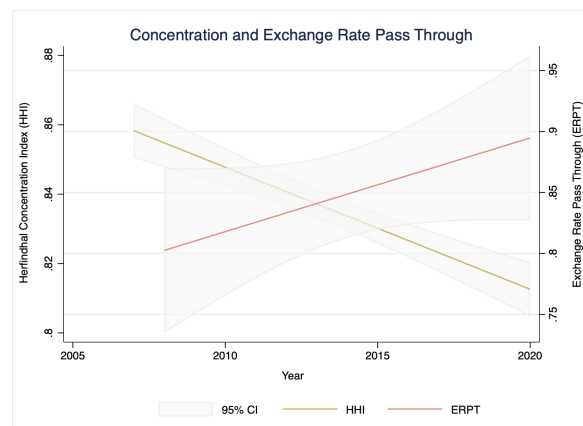
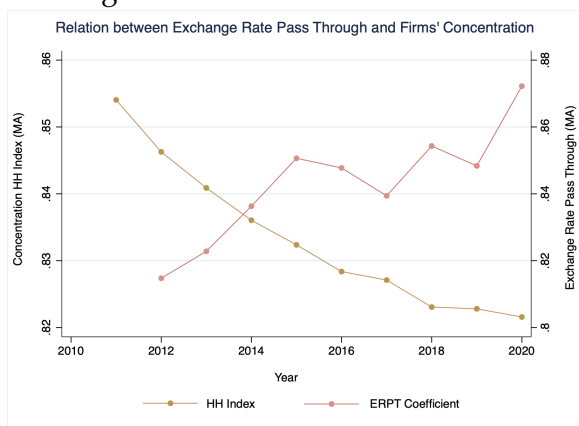
	Products	Products with different prices	%
HS6	3654	2299	62,9
HS10	4889	2811	57,5

The standard deviation of  $\ln(\text{price})$  within seller-country-month-unit-HS10 is 0.5302. At the HS6 level, it is 0.5627.

### 7.2.6 Colombia Time Series

I find a relationship between the concentration of sales in buyers and the exchange rate pass-through. The figures below show how this correlation holds in the time series for Colombia

2008–2020.



### 7.2.7 Mechanism: Consistency with Seller Side Results

In this section, I detailed how my paper is consistent with the existent literature on sellers' power in a monopolistic competition environment. In the presence of seller market power, sellers charge a markup above their marginal cost. In the presence of a cost shock (an exchange rate shock would work in the same way), firms with higher market share internalize this shock (Atkeson and Burstein, 2008; Amiti, Itskhoki and Konings, 2014). In other words, firms that have more market power, that is, charging higher markups, adjust their markup in order to keep prices more stable in the currency of the buyer. They keep quantities more stable by keeping prices more stable. This corresponds to a more incomplete pass-through for sellers with higher market share.

In the presence of buyer market power, the mechanism works analogously, although it brings about the opposite outcome. Buyers that have more market power, that is, buyers who charge a lower markdown, adjust their markdowns more in order to keep prices more stable in the currency of the seller. This in turn, cause prices to be less stable in the currency of the buyer and results in a more complete pass-through. The underlying mechanism here happens because, as the buyer faces a supply curve, to keep quantities more stable, he needs to let the prices they accept change more.

### 7.2.8 Robustness: Seller Market Power

In the theoretical appendix I propose an alternative theoretical model that takes into account the power of the seller. In this section, I include a variable in the baseline regressions that will allow us to isolate the buyer market power effect from the seller side. It can be shown that estimates are still significant and have the expected sign.

	(1)	(2)	(3)
	$\Delta \ln(\text{Prices})$	$\Delta \ln(\text{Prices})$	$\Delta \ln(\text{Prices})$
$L(\Delta ER)$	0.203*** (0.0691)	0.0637** (0.0259)	0.0970*** (0.0261)
$S_{t-1}$	-0.0613*** (0.00848)	-0.0358*** (0.00499)	-0.0373*** (0.00559)
$L(\Delta ER) \times S_{t-1}$	-0.240** (0.113)	-0.153*** (0.0557)	-0.404*** (0.0547)
$Seller\ Size_{t-1}$		-0.0227*** (0.00432)	-0.0171*** (0.00461)
$L(\Delta ER) \times Seller\ Size_{t-1}$		0.0784 (0.0480)	0.0736 (0.0449)
Country–HS–Seller FE	x		
Period–Seller FE	x		
HS–Period FE		x	
Country FE		x	
Country–HS FE			x
Year FE			x
N	484804	510893	511830

Standard errors in parentheses

\*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

## 7.2.9 Robustness: Length of Contracts and Volatility Unrelated to Exchange Rate Shocks

Barro (1977) and Carlton (1991) argue that buyer-seller prices could be less responsive to shocks due to the use of contracts which specify fixed prices for a period of time. Given the existence of long-term relationships might be more likely to use either implicit or explicit contracts, they could exhibit lower pass-through of shocks (Heise, 2019). importer-exporter-product (HS10) triplets in the data. In this section, I will examine the potential connection between relationship length and size of the buyer. This could potentially bias (upward) the estimators if the length of the relationship implies lower pass-through. Table 6 shows different specifications that aim to control for the length of the relationship in my baseline regression. Column (1) adds buyer–seller fixed effects, and Columns (2)–(3) include two different measures of relationship length: length of a relationship in the triplet buyer-seller-HS10 and length of a buyer-seller relationship. I include these two measures given that it could be the case firms, that are already trading in other products are more likely to have fixed contracts.

**Table 6**

	(1)	(2)	(3)
	$\Delta \text{Log(Prices)}$	$\Delta \text{Log(Prices)}$	$\Delta \text{Log(PricesBS)}$
IERchange	-0.125 (0.170)	0.231** (0.113)	0.268** (0.115)
lagbuyersize1	-0.180*** (0.0181)	-0.0897*** (0.0109)	-0.0863*** (0.0106)
IERchange $\times$ lagbuyersize1	0.00648 (0.186)	-0.324** (0.127)	-0.312** (0.128)
ltenureany		0.0222** (0.0101)	
IERchange $\times$ ltenureany		-0.000628 (0.0674)	
ltenurehs			0.00627 (0.0123)
IERchange $\times$ ltenurehs			-0.0373 (0.0774)
Seller - Buyer FE	x		
Seller - period FE	x	x	x
Dest - HS - Seller FE	x	x	x
N	273577	385461	385461

Standard errors in parentheses

\*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

In all the cases, even though the fact that longer relationships have less change in prices in the buyer currency, they do not seem to be explaining the mechanism this paper proposes.

### 7.2.10 Robustness: Prices in USD

In this section, I report the same regressions as before, the only difference being that the dependent variable corresponds to the price in USD. In my dataset, information is reported in both USD and COP. Although it is expected the variable corresponding to COP is a more accurate measure, given it is directly the profit received by Colombian sellers after the transaction is reported in customs.

	(1)	(2)	(3)	(4)	(5)
	$\Delta \text{Log(Prices)}$	$\Delta \text{Log(Prices)}$	$\Delta \text{Log(Prices)}$	$\Delta \text{Log(Prices)}$	$\Delta \text{Log(Prices)}$
L( $\Delta$ ER)	0.103*** (0.022)	0.137*** (0.023)	0.094*** (0.022)	0.172*** (0.066)	-
$BS_{t-1}$		-0.022*** (0.003)	-0.024*** (0.004)	-0.038*** (0.006)	-0.019*** (0.003)
L( $\Delta$ ER) $\times$ $BS_{t-1}$		-0.106*** (0.037)	-0.076** (0.038)	-0.156* (0.081)	-0.179*** (0.049)
HS-Year FE	x	x			
HS-Year-Sell FE			x	x	
Country FE	x	x	x	x	
Buyer FE				x	
HS-Year-Country FE					x
N	325404	325404	325404	325404	325404

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

### 7.2.11 Robustness: Dominant Currency Paradigm

In this section, I replicate my findings following the data cleaning and specification of [Gopinath et al. \(2020\)](#). First, I restrict the data to the manufacturing sector, using the HS codes proposed in the paper. Second, I start as a benchmark specification with [Gopinath et al. \(2020\)](#)'s main regression, that is, including only destination-industry-seller. The relevant difference with my specification is that in their study they do not include time fixed effects. The reason for this is their variable of interest (the USD-to-COP exchange rate) is at the year level.

It can be shown how when including the time fixed effects, the coefficient changes and becomes smaller but still significant, and the sign does not change.

	(1)	(2)	(3)
	$\Delta \text{Log(Price)}$	$\Delta \text{Log(Price)}$	$\Delta \text{Log(Price)}$
$L(\Delta \text{ER}) = \alpha$	0.887*** (0.284)	0.464*** (0.162)	0.108* (0.0601)
$BS_{t-1}$		-0.0170 (0.0103)	-0.0330*** (0.00934)
$L(\Delta \text{ER}) \times BS_{t-1} = \beta$		-0.395** (0.196)	-0.149** (0.0721)
Country-HS-Seller	x	x	x
HS - Period FE			
HS - Period - Seller FE			x
Year FE		x	
N	165100	170796	163463

Standard errors are clustered at the country-time level and are shown in parentheses \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

### 7.2.12 Robustness: Devaluations versus Appreciation

In this section I estimate the different effects for the case where there is a devaluation vs appreciation. As shown in Table 7, I find the effects are stronger for devaluations. One caveat about this effect, is that my sample does not contain a lot of appreciation events of a relevant magnitude for COP. Potentially the reason why I find almost no effect for appreciation is the appreciation events are insignificant and reversed shortly after they occur.

## 7.3 Decreasing Market Concentration

The existence of large firms, especially large buyers, has been a growing concern for policymakers, given their macroeconomic effects ([De Loecker, Eeckhout and Unger, 2020](#); [Eggertsson, Robbins and Wold, 2021](#)). These consequences become even more relevant in international markets, given there are not only a small number of high-performance players ([Bernard et al., 2007](#); [Morlacco, 2019](#)), but also high entry costs that create barriers to competition ([Antras, Fort and Tintelnot, 2017](#)). In this section, I study the quantitative implications of a reduction of the concentration of buyers. I use my estimated coefficients to calculate the average exchange rate pass-through in a market. I start from the firm-level expression for the pass-through:

$$\frac{d \ln p_{sbjk}}{d \ln e_k} = \alpha + \beta S_{jbk}$$

**Table 7: Positive or Negative  $\Delta$  ER**

	(1) $\Delta \ln(\text{Prices})$ <i>Devaluation</i>	(2) $\Delta \ln(\text{Prices})$ <i>Appreciation</i>
$L(\Delta ER)$	0.493*** (0.153)	0.260 (0.162)
$S_{t-1}$	-0.0832*** (0.0226)	-0.0160 (0.0191)
$L(\Delta ER) \times S_{t-1}$	-0.686*** (0.237)	0.129 (0.187)
HS-period FE	x	x
Dest-HS-Seller FE	x	x
N	274927	179037

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

Plugging in for the estimated coefficients,  $\hat{\alpha}$ ,  $\hat{\beta}$  and each firm's buyer size, I obtain a firm-level exchange rate pass-through which I then aggregate to the market level, using weights  $\omega$

$$\sum_{b'} w_{b'} \frac{d \ln p_{sbjk}}{d \ln e_k} = \hat{\alpha} + \hat{\beta} \sum_{b'} w_{b'} S_{jk}$$

Note that when I use the weight equal to the buyer shares, this leads to the following expression with the HHI:

$$\sum_{b'} S_{jb'k} \frac{d \ln p_{sbjk}}{d \ln e_k} = \hat{\alpha} + \hat{\beta} HHI_{jk}$$

Table 8 shows the exchange rate pass-through for scenarios with different concentrations compared to the actual concentration in Colombia, Column (2). Comparing to these benchmark values, I propose three other scenarios: a) a merger between the two biggest firm (in terms of buyer share) in every market, which means an increase in concentration, Column (1); b) leaving fixed the number of buyers in each market and assigning a symmetric share of sales to each buyer, Column (3); and c) assigning the same number of buyers to each market (the median number of buyers across all markets with a symmetric distribution of sales among them, column(4). For each case, I present two sets of results corresponding to different weight matrices. The first line corresponds to the case where the weights are the share of the buyer. The second line corresponds to having weights equal to the trade flow share the buyer has in the year, and the exchange rate pass-through at the country-year level. Results

**Table 8: Average Exchange Rate Pass-through**

$\omega$	Merger	Benchmark	Symmetric shares Different #
Buyer share	0.04%	<b>20.50%</b>	24.10%
Trade flow	0.02%	<b>15.20%</b>	22.30%

show that for cases with mergers, that is, when market concentration increases, the exchange rate pass-through decreases. For all other cases, when concentration is decreased the exchange rate pass-through increases.

### 7.3.1 Estimation

**Set Up the Model** Let's simulate the economy in the baseline equilibrium assuming that you know  $\mu_A$  and  $\sigma_A$  from the log normal distribution and an initial vector  $Y$ .

- Simulate a random vector of productivities  $z$  from the log normal distribution.
- Start the algorithm with an initial vector of  $p$ 's. For example  $p = 1$
- Solve for the quantities using the supply function:

$$q_{bjk} = \left( \frac{p_{bjk}^\eta}{P_{jk}^\eta} \right) \left( \frac{P_{jk}^\theta}{P_k^\theta} \right) Y$$

- Solve for the markdown using the elasticity function.
- Solve for the new vector of  $p'$
- Update the vector of  $p$ 's and  $Y$ :

$$p^r = \nu p^{r-1} + (1 - \nu) p'$$

$$Y^r = \sum_{b'j'k'} p_{b'j'k'}^{r-1} q_{b'j'k'}^{r-1}$$

- Repeat the algorithm until the maximum difference between  $p^r$  and  $p^{r-1}$  and  $Y^r$  and  $Y^{r-1}$  is lower than a tolerance factor.