COUNTERVAILING POWER OF FIRMS IN INTERNATIONAL TRADE*

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Abstract

This paper disentangles the effects of seller's and buyer's market power in firm-to-firm trade. I incorporate oligopoly, oligopsony, and bilateral bargaining in a trade model, in which buyers and sellers differ in productivity, bargaining ability, and preferences. These market structures predict differential patterns of price variation across buyers. Testing these predictions, I find, in most markets, price variation is consistent with oligopolistic price discrimination. More productive buyers pay lower mark-ups because of their better outside options, rather than scale economies, oligopsony power, or bargaining abilities. Consequently, more productive buyers have higher gains from trade and cost shocks' pass-through into prices.

JEL codes: F10, F11, F14, F23, L11, L13

Key words: price discrimination, oligopoly, oligopsony, bargaining, buyer size, countervailing power, imported inputs

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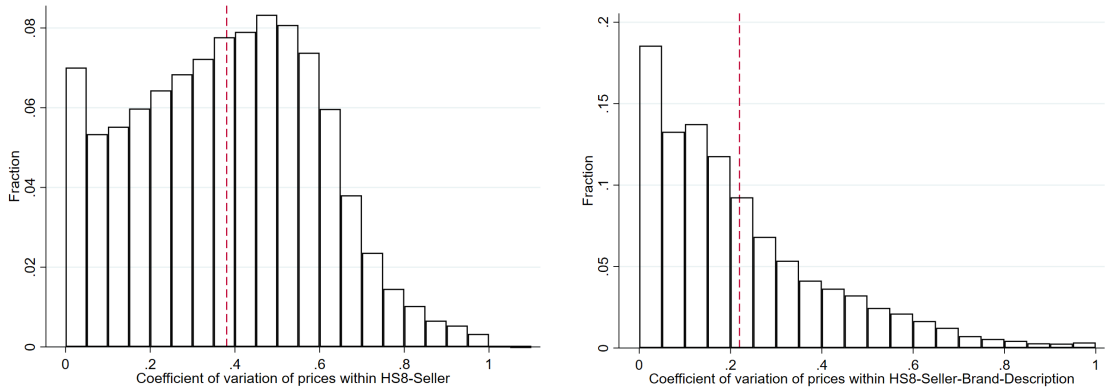
1 Introduction

In the face of new and more granular firm-level data, a recurring finding is that different buyers pay different prices for the same product of the same seller: a violation of the Law of One Price. Since as early as Robinson (1933), economists in many fields have studied market imperfections that could explain this. Industrial organization economists have explained price variation with seller's market power to price discriminate across buyers that have differing willingness to pay (Borenstein and Rose, 1994; Shepard, 1991; McManus, 2007; Gerardi and Shapiro, 2009). Labor economists, on the other hand, often explain variation in wages, or the price of labor, with differences in buyer's market power across employers (Falch, 2010; Staiger et al., 2010; Ransom and Sims, 2010; Dube et al., 2020). In international markets that are dominated by firm-to-firm transactions, both seller's and buyer's market power can result in price variation. Distinguishing between seller's and buyer's market power in firm-to-firm trade is important because they have different implications for welfare, gains from trade, and shock propagation (Varian, 1985; Katz, 1987; Edmond et al., 2015; Berger et al., 2019; Amiti et al., 2019).

In this paper, I disentangle the role of seller's and buyer's market power in price variation across buyers of the same product in a variety of international markets. I use a universe of firm-to-firm import transactions in Paraguayan customs data uniquely suited for this exercise. First, for each imported product, the data records its seller, brand name, country of origin, per-unit weight and detailed commercial description, which I use to account for product quality in price variation. Second, for each import transaction, it identifies individual buyer and seller, which I use to separate buyer's and seller's market power. Third, this data covers a large number of product markets, which I use to document differences in market-power mechanisms behind price variation across market structures.

I find that a large share of within-seller price variation across buyers in narrow product categories remains unexplained by differences in detailed product characteristics. Figure 1a illustrates this by first defining a product with its 8-digit Harmonized System's code (HS8), as standard in the literature, and plotting a density plot of coefficients of variation of prices within HS8-Seller. The average coefficient of variation of prices within these categories is equal to 38%. Fontaine et al. (2020) document a



(a) Price variation across buyers within HS8-Seller

(b) Price variation across buyers within HS8-Seller-Brand-Description

Notes: Coefficient of variations are calculated for each product category (HS8-Unit-Seller-Year or HS8-Unit-Seller-Brand-Description-Year) by dividing standard deviation of unit values but their mean. Unit values 3 times larger and 3 times smaller than the median in each category were excluded, as in Fontaine et al. (2020). Vertical lines show average coefficients across all categories.

Figure 1. Within-Seller Price Variation Across Buyers in Narrow Product Categories

similarly large variation of prices in transactions of French exporters and attribute it entirely to seller's price discrimination. However, differences in product characteristics in HS8 product categories can also explain this within-seller price variation. Figure 1b shows that accounting for product's brand and detailed characteristics available in Paraguayan customs data reduces the average coefficient of variation of prices within-seller to 22%. This confirms an uncontested finding in international trade that different importers choose different product qualities in narrow product categories (Kugler and Verhoogen, 2012; Feenstra and Romalis, 2014; Bastos et al., 2018; Blaum et al., 2019). However, accounting for detailed product characteristics does not entirely eliminate the observed within-seller price variation across buyers.

I show that within-seller price variation across buyers, conditional on product quality, contains valuable information about an industry's market structure. I develop a model of trade, which embeds a range of imperfectly competitive market structures – oligopoly, oligopsony, and bilateral bargaining – in a standard international trade environment. A market structure determines which party sets the price in a firm-to-firm transaction: seller, buyer, or both. Both buyers and sellers can differ in their own

exogenous productivities, preferences for each other, and bargaining abilities – in case of bilateral bargaining. This model demonstrates that different market structures and different sources of firm heterogeneity imply different patterns of within-seller price variation across buyers.

Under oligopoly, a seller can price discriminate across buyers differing in their observed characteristics. Buyers with higher preferences for the seller have higher demand for the seller's product and are charged higher mark-ups. More productive buyers have higher demand for the seller's product but are charged lower mark-ups because of their better outside options. Hence, under oligopoly, larger buyers can pay higher or lower prices depending on the mechanism of price discrimination. Under oligopsony, more productive buyers have higher marginal revenue product, purchase more from the seller and pay higher prices following seller's upward sloping supply curve. Hence, under oligopsony, larger buyers pay higher prices, despite receiving larger mark-downs from a competitive price. Under bilateral bargaining, buyers with higher bargaining abilities negotiate lower mark-ups and then buy more from the seller. Hence, in a bilateral bargaining framework, larger buyers pay lower prices, because these are buyers with higher bargaining abilities.

I test these differential predictions in each imported goods' market using theoretically consistent observable measures of the buyer characteristics in Paraguayan customs data. I find that, in most markets, price variation is most consistent with the two mechanisms of oligopolistic price discrimination. First, sellers charge higher prices to buyers with a larger share of their expenditures spent on the seller's product. This is in line with oligopolistic pricing in Atkeson and Burstein (2008) and implies price discrimination based on buyers' preferences for the seller, as in Kikkawa et al. (2019). Second, conditional on the buyer's expenditure share spent on the seller's product, sellers charge lower prices to buyers purchasing larger quantities of the product. By ruling out alternative hypotheses, I show that this is consistent with more productive buyers getting lower prices by utilizing better outside options.

One competing hypothesis is that sellers charge lower prices to their larger buyers because of the economies of scale. In that case, entry of sellers would affect prices of all buyers of the seller equally without changing the extent of price variation. In contrast, I find that the number of sellers on the market affects the extent of within-seller price

variation across buyers. While monopolists do not vary their prices, in competitive markets, sellers charge even lower prices to their larger buyers when faced with more competition. This is consistent with competing sellers playing the role of buyers' outside options, as in Ellison and Snyder (2010). Without seller competition, prices do not vary as no buyers have outside options. But larger buyers get increasingly lower prices as their outside options improve with the number of sellers on the market.

Another competing hypothesis is that sellers charge lower prices to buyers with better bargaining abilities, who then purchase more from the seller (as in Alviarez et al. (2021a)). In that case, input prices are solely determined by buyers' exogenously fixed bargaining abilities and should not be affected by buyers' sales in the output markets. In contrast, I find that, buyers with larger export sales pay lower prices for the same input to the same supplier. This is in line with the effect of firm's sales in its output market on its outside options in the inputs markets. Firms with larger sales in the output market can have more input suppliers and use them as outside options to get lower input prices from each supplier.

This paper makes several contributions to multiple areas of research in economics. First, it develops a methodology that researchers can use to identify an industry's market structure from observable patterns of price variation across buyers and over time. This methodology relies on theoretically consistent measures of buyer characteristics that have differential effects on prices across the market structures. It distinguishes seller's market power to price discriminate under oligopoly (in Kikkawa et al. (2019), Huang et al. (2021)) from buyer's oligopsony power (in Morlacco (2019), Macedoni and Tyazhelnikov (2019)) and bargaining abilities (in Alviarez et al. (2021a)).

Second, this paper provides first large-scale evidence of buyer's ability to affect prices through outside options in international markets. This mechanism was initially proposed and documented in individual domestic markets in industrial organization literature (Katz, 1987; Inderst and Valletti, 2009; Ellison and Snyder, 2010; Dafny, 2010; Grennan, 2013; Grennan and Swanson, 2018). I show that it arises mostly in markets with horizontal price discrimination and seller competition. It implies that better outside options of more productive firms in inputs markets exacerbate their exogenous productivity advantage and can explain large differences in firms' performance (Bernard et al., 2012; Hottman et al., 2016; Van Reenen, 2018).

Third, this paper uncovers new sources of gains from trade that arise due to buyers' ability to countervail the market power of sellers with their outside options. I show that although exporting encourages firms to upgrade their input suppliers and input quality (Lileeva and Trefler, 2010; Bustos, 2011; Kugler and Verhoogen, 2012; Bastos et al., 2018), it also results in lower input prices from their existing suppliers, conditional on quality. This effect occurs because higher export sales encourage firms to add more input suppliers and the threat of competition makes their existing suppliers lower their prices. Seller competition can be also induced by trade liberalization in inputs markets. I show that more productive input buyers gain more from input-trade liberalization, as they experience a larger reduction in their input prices due to sellers' competition.[1] This is a novel channel through which firm heterogeneity affects aggregate gains from input-trade (Antras et al., 2017; Blaum et al., 2018).

Finally, this paper documents the role of buyer's productivity and ability to affect prices in pass-through of global supply shocks into domestic prices. Sellers with market power are known to have an incomplete pass-through of their cost shocks into prices (Berman et al., 2012; Amiti et al., 2014; Auer and Schoenle, 2016; Amiti et al., 2019). However, I find that if more productive buyers can countervail the market power of sellers using their outside options, they can increase the pass-through of seller's cost shocks into their prices. Therefore, concentration of large buyers in oligopolistic markets can result in higher propagation of global supply shocks.

2 Theoretical Framework

This section develops a model of international trade, in which both buyers and sellers are heterogeneous in their productivity and can affect prices of traded goods. It flexibly embeds most standard market structures – monopolistic competition, oligopoly, oligopsony and bilateral bargaining – in a standard international trade environment.[2] I derive and compare their implications for price variation across buyers and price response to trade liberalization and sellers' cost shocks.

[1] In a quantitative model, Huang et al. (2021) find that accounting for this differential effect of trade liberalization in inputs markets substantially increases welfare gains from trade.

[2] Appendix A.1.3 shows that the same results also arise in a standard industrial organization environment with linear demand and cost functions.

2.1 Environment

Consider a country populated by homogeneous consumers who inelastically supply their labor and consume bundles of products from a number of downstream sectors. Each sector's bundle consists of a continuum of final goods' varieties, each of which is produced by one of the final goods' producers that differ in their productivity.

Production of final goods in a downstream sector requires labor as well as materials from several upstream sectors. A final goods' producer can procure an input from either one or multiple suppliers upstream. Having more than one supplier can be costly and require a fixed payment ranging from zero to infinity. Input producers are heterogeneous in their productivity too, and use only labor in production subject to scale (dis)economies or constant returns to scale.

2.2 Preferences

All consumers in a country have identical preferences represented by a Cobb-Douglas utility function over sectoral bundles, which are themselves CES aggregators:

$$U = \prod_{s=1}^{S} Q_s^{\beta_s}, \qquad \sum_{s=1}^{S} \beta_s = 1 \tag{1}$$

where $Q_s = \left(\int_{\varphi \in \Omega_s} q_s(\varphi)^{\frac{\sigma_s - 1}{\sigma_s}} d\varphi \right)^{\frac{\sigma_s}{\sigma_s - 1}}$ is a CES bundle of varieties of sector s goods, each produced by one of Ω_s firms with productivity φ, and $\sigma_s \geq 1$ is a constant elasticity of substitution of varieties in sector s. Such preferences give rise to the following demand for sector s' variety φ:

$$q_s(\varphi) = \beta_s E \mathbb{P}_s^{\sigma_s - 1} p_s(\varphi)^{-\sigma_s}, \tag{2}$$

where $\mathbb{P}_s \equiv \left(\int_{\varphi \in \Omega_s} p_s^{1-\sigma_s}(\varphi) d\varphi \right)^{1-\sigma_s}$ is a standard CES price index in final goods sector s, and $E \equiv wL$ is a consumers' income they derive from supplying labor L in exchange for wages w.

2.3 Technologies

Each final goods' variety is produced by a single firm in the downstream industry. A downstream firm with productivity φ from sector s combines labor L and a composite material input M using the following Cobb-Douglas production function:

$$q_s(\varphi) = \varphi {L_s}^{\alpha_s} M_s^{1-\alpha_s} \tag{3}$$

The composite material input in sector s, M_s, consists of N_s intermediate goods m_{js} produced in N_s upstream industries and combined in a CES bundle as:

$$M_s(\varphi) = \left(\sum_{j \in N_s} m_j(\varphi)^{\frac{\theta_s - 1}{\theta_s}} \right)^{\frac{\theta_s}{\theta_s - 1}} \tag{4}$$

where $\theta_s \geq 1$ and N_s are, respectively, the elasticity of substitution between intermediate goods, the set of intermediate goods used in production of final goods in sector s, and a buyer-specific preference for input j. Each intermediate good m_j is purchased from either one or multiple suppliers whose varieties have a constant elasticity of substitution $\eta_j \geq 1$:

$$m_j(\varphi) = \left(\sum_{k=1}^{N_m} \delta_{jk}(\varphi) m_{jk}^{\frac{\eta_j - 1}{\eta_j}} \right)^{\frac{\eta_j}{\eta_j - 1}} \tag{5}$$

where $N_m = \{1, \bar{N}_m\}$ and $\delta_{jk}(\varphi)$ is buyer φ's preference for seller k of input j.

Having several suppliers of the same intermediate good, however, can be costly due to search costs, transaction costs, or costs of backward integration into production of inputs. To allow for this possibility, I assume that in order to have multiple suppliers of the same intermediate good j a downstream firm has to incur a potentially positive and even infinitely large fixed cost, $f_j \geq 0$. When these fixed costs are zero or infinity, the model collapses to the standard model of trade in intermediate goods.

Intermediate goods' varieties m_{jsk} are produced by firms in the upstream sector that use only labor in their production, according to the following function:

$$m_{jk} = a_k \left(L_{jk} \right)^{\gamma_j} \tag{6}$$

where a_k is firm $k's$ productivity, and γ_j is a parameter governing the returns to scale in upstream production. When $\gamma_j = 1$, then firm k has constant marginal costs of production, w/a_k. In contrast, when $\gamma_j < 1$, firm k's marginal costs, $m_{jk}^{1/\gamma_j - 1} w/\gamma_j a_k^{1/\gamma_j}$, increase in output thus reflecting diseconomies of scale, while when $\gamma_j > 1$, firm k's marginal costs decrease in output thus reflecting economies of scale in production.

2.4 Market structures

I assume perfect competition in labor markets and monopolistic competition in final goods' markets[3], to focus on implications of market structures in inputs markets.

Market structures in inputs markets are determined by industry-specific technological parameters and can vary across markets. Oligopoly in which sellers compete in prices arises when products are horizontally differentiated ($1 < \eta_j < +\infty$) and sellers internalize the effect of their pricing decisions on buyers' costs. In such markets, sellers choose prices to maximize their profits by setting their marginal revenue equal to marginal costs. Classic oligopsony arises when buyers view sellers as perfectly substitutable ($\eta_j = +\infty$) and internalize the effect of their pricing decisions on seller's marginal costs increasing in quantity ($\gamma_j < 1$).[4] In this case, buyers choose prices of the goods they buy to maximize their profits by setting marginal product revenue equal to the seller's marginal costs. Finally, bilateral bargaining arises when buyers and seller negotiate price as an instrument of sharing their total trade surplus.

2.5 Equilibrium input price variation

Oligopoly Under oligopoly with price-taking buyers, seller k of product j faces derived demand from each buyer φ, $m_{jk}(\varphi)$, and chooses prices $p_{jk}(\varphi)$ to maximize profits. If a seller can distinguish between buyers and prevent arbitrage[5], the price is a buyer-specific mark-up over marginal costs:

[3] I relax these assumptions in the empirical analysis.

[4] Here, I assume that oligopsony power is driven by industry's exogenous technological parameters – diseconomies of scale, for simplicity. Upward sloping average cost curve can be endogeneized through the seller's choice of buyers (as in Berger et al. (2019)).

[5] The existence of costly arbitrage opportunities limits the extent of price variation (see Boik (2017)). Buyers of inputs competing in one market seem less likely to engage in arbitrage.

$$p_{jk}(\varphi) = \frac{\zeta_{jk}(\varphi)}{\zeta_{jk}(\varphi)+1}\frac{w m_{jk}(\varphi)^{1/\gamma_j - 1}}{\gamma_j a^{1/\gamma_j}} \tag{7}$$

where mark-up $\zeta_{jk}(\varphi) \equiv \frac{\partial m_{jk}(\varphi)}{\partial p_{jk}(\varphi)}\frac{p_{jk}(\varphi)}{m_{jk}(\varphi)}$ is inversely related to a buyer-specific input demand elasticity. The first term captures variation in seller's prices driven by mark-up variation, while the second term captures variation in seller's prices driven by marginal cost variation (when $\gamma_j \neq 1$). Here, I study mechanisms of within-seller mark-up variation and discuss how I disentangle them from marginal cost variation below and in the empirical analysis.

To understand sellers' mark-up variation across buyers, consider buyer φ's derived demand for firm k's variety of input j, given production technology in (3) - (5):

$$m_{jk}(\varphi) = \delta_{jk}(\varphi)^{\eta_j}\varphi^{\sigma_s - 1}p_{jk}(\varphi)^{-\eta_j}\mathbb{P}_j(\varphi)^{\eta_j - \theta_s}\mathbb{J}_s(\varphi)^{(1-\alpha_s)(1-\sigma_s)+\theta_s - 1}A_s, \tag{8}$$

where $\mathbb{P}_j(\varphi)$ and $\mathbb{J}_s(\varphi)$ are input sector j's and material's price indexes faced by buyer φ, and A_s is output sector s input demand shifter defined in the Appendix. The elasticity of derived input demand of a seller internalizing the effect of price increases on buyers' costs is:

$$\zeta_{jk}(\varphi) = -\eta_j + (n_j - \theta_s)s^J_{jk}(\varphi) + (\theta_s - 1 + (1-\alpha_s)(1-\sigma_s))s^J_{jk}(\varphi)s^M_j(\varphi) \tag{9}$$

$$s^J_{jk}(\varphi) = \delta_{jk}(\varphi)^{\eta_j}\left(\frac{p_{jk}(\varphi)}{\mathbb{P}_j(\varphi)}\right)^{1-\eta_j}, \quad s^M_J(\varphi) = \left(\frac{\mathbb{P}_j(\varphi)}{\mathbb{J}_s(\varphi)}\right)^{1-\theta_s} \tag{10}$$

where $s^J_{jk}(\varphi)$ and $s^M_J(\varphi)$ are, respectively, the share of buyer φ's expenditures on seller k's input variety of j in total buyer's expenditures on j inputs and the share of buyer's expenditures on j's inputs in buyer's expenditures on material inputs.

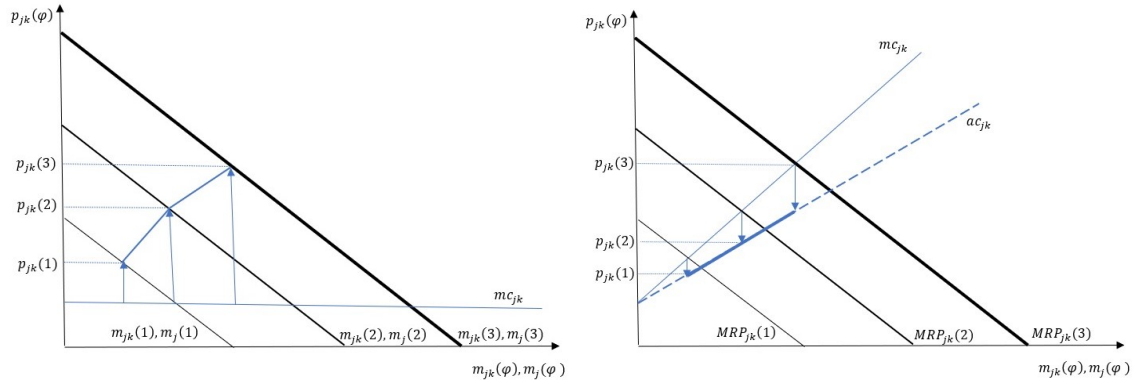
Given a standard assumption that $\eta_j \geq \theta_s \geq \sigma_s$, input demand elasticity decreases and seller's mark-up increases in both shares $s^J_{jk}(\varphi)$, $s^M_j(\varphi)$. These two shares vary thus causing mark-up variation across buyers for several reasons. First, all else equal, firms from downstream industries in which production requires more intermediate inputs (larger N_s) spend less on each input (smaller $s^M_j(\varphi)$). Second, in a given downstream industry, all else equal, firms spend more on varieties (higher $s^J_{jk}(\varphi)$) of sellers they prefer more (higher $\delta_{jk}(\varphi)$).

Besides affecting input demand elasticity, buyer's preference for the seller and number of input suppliers also affect buyer's input demand level. From its expression

in (8), buyers with higher preference for the seller, and fewer input suppliers, all else equal, demand more inputs from a given seller. This results in a standard pattern of mark-up variation under price discrimination: exogenously larger buyers have lower demand elasticity and thus are charged higher prices. This pattern is illustrated with linear demand and cost functions in Figure 2a. An exogenous increase in input demand from the level of firm 1 to that of firm 3 makes firm 3's input demand less elastic and allows a profit maximizing seller to charge firm 3 a higher mark-up.

Proposition 1. *Oligopolistic price discrimination across price-taking buyers results in a positive buyer-size – price relationship.*

Proof. *See above and Appendix A.1.1 for details.*



(a) An oligopolist charges larger buyers higher prices

(b) More productive oligopsonists pay higher prices

Figure 2. Price Variation Across Buyers under Standard Oligopoly and Oligopsony

Notes: The downward sloping lines depict total and seller-specific demand and marginal revenue product for good j of different downstream firms 1, 2, and 3. Firms are indexed in order of increasing total input demand. Equilibrium buyer-specific prices are labeled on the vertical axis. Under oligopoly in Figure 2a, prices equalize seller's marginal revenue and marginal costs for each buyer. Under oligopsony in Figure 2b, prices are equal to seller's average cost and equalize buyer's marginal revenue product and seller's marginal costs. Arrows depict absolute mark-ups and mark-downs as the difference between equilibrium prices and seller's marginal costs.

Oligopsony Under oligopsony with perfectly competitive sellers, buyer φ chooses input quantity $m_{jk}(\varphi)$ to maximize profits, and input price $p_{jk}(\varphi)$ is then determined from upward sloping seller's average cost curve.[6] Having chosen labor, buyer φ chooses

[6]See Bhaskar et al. (2002), Chen (2008) and Ashenfelter et al. (2010) for a discussion of the

input quality that equalizes buyer's marginal revenue product[7] with marginal costs:

$$(1-\alpha_s)\tilde{A}_s\tilde{\varphi}\tilde{M}_s(\tilde{\varphi})^{-\alpha_s}\left(\frac{m_j(\tilde{\varphi})}{\tilde{M}_s(\tilde{\varphi})}\right)^{-1/\theta_s} = \frac{\partial p_j(\tilde{\varphi})}{\partial m_j(\tilde{\varphi})}m_j(\tilde{\varphi}) + p_j(\tilde{\varphi}) \tag{11}$$

where $\tilde{\varphi} \equiv \varphi^{\frac{1-1/\sigma_s}{1-\alpha_s(1-1/\sigma_s)}}$, $\tilde{M}_s(\tilde{\varphi}) \equiv M_s(\varphi)^{\frac{1-1/\sigma_s}{1-\alpha_s(1-1/\sigma_s)}}$, and $\tilde{A}_s$ is downstream sector s-specific demand shifter defined in Appendix A.1.1.

Importantly, all else equal, an increase in the oligopsonist's own productivity φ leads to an increase in the marginal product revenue on the left-hand side of (11). Price-taking sellers, in equilibrium, match this increase in the oligopsonist's demand for their products by increasing their supply. Because input prices are determined from the upward sloping seller's average cost curve, input prices increase with an increase in the oligopsonist's own productivity. Figure 2b illustrates this mechanism in case of linear demand and cost functions often used in labor economics to explain firm-size wage premium (cf. Bhaskar et al. (2002), Berger et al. (2019)). It shows that an increase in the oligopsonist's own productivity from firm 1 to firm 3 allows more productive oligopsonists to get a larger mark-down relative to the perfectly competitive price (depicted with arrows). However, despite the larger mark-down, a more productive firm 3 purchases more and pays a higher price because of the diseconomies of scale in production.[8]

Proposition 2. *Under oligopsony with perfectly competitive sellers, more productive oligopsonists pay higher prices which results in a positive buyer-size – price relationship.*

Proof. *See above and Appendix A.1.1 for details.*

Therefore, when only sellers or only buyers have market power to set prices under oligopoly or oligopsony, exogenously larger buyers pay higher prices. I now consider market structures in which both buyers and sellers can affect prices, to see how it changes this pattern of price variation.

Oligopoly with endogenous outside options. When in oligopolistic markets,

central role of diseconomies of scale in standard models of oligopsony.

[7] To be precise, this is marginal revenue net of labor expenses, as in Berger et al. (2019).

[8] Berger et al. (2019) show the same patterns of price variation across buyers with varying productivities arise when upward sloping supply curve is endogenously determined by the seller's preference for the buyer (see Figure 3 on p. 12).

fixed costs of adding suppliers are positive and finite, buyers can too affect prices by altering their demand elasticity through the choice of suppliers. A buyer with productivity φ in downstream industry s pays fixed costs to purchase input j from multiple suppliers when it leads to higher profits:

$$B_s \varphi^{\sigma_s - 1} \mathbb{J}'_s(\varphi)^{(1-\alpha_s)(1-\sigma_s)} \left\{ \left(\frac{\mathbb{J}''_s(\varphi)}{\mathbb{J}'_s(\varphi)} \right)^{(1-\alpha_s)(1-\sigma_s)} - 1 \right\} > f_j w, \tag{12}$$

where B_s is sector s-specific demand shifter defined in Appendix A.1.1, and $\mathbb{J}'_s(\varphi)$ and $\mathbb{J}''_s(\varphi)$ are firm-specific CES price indexes of material inputs when input j is sourced from one and multiple suppliers, respectively. The term in brackets thus reflects the change in per-unit costs of imported material inputs associated with more input suppliers in a given input market. Using insights from Feenstra (1994), in Appendix A.1.1, I show that the reduction in these costs comes from two sources: productivity gains from input variety embedded in the CES production function and price-reducing effects of competition among input suppliers.

Because more productive buyers benefit more from the same reduction in material inputs' costs, condition (12) is more likely to be satisfied for more productive buyers, all else equal. As a result, more productive buyers self-select into having more than one supplier of each imported product and hence spend less on each variety. This mechanism makes more productive buyers more elastic to prices and thus lowers mark-ups they pay in inputs markets. Since more productive buyers, all else equal, buy in larger quantities in (8), this yields a negative buyer-size – price relationship, altering the standard pattern of price discrimination.

Importantly, for this mechanism to arise, there must be multiple suppliers on a market. If there is only one supplier, ($\bar{N}_m = 1$), then there are no alternative supplier that buyer can use as a credible replacement threat. Thus, in case of a monopoly, even the most productive buyers cannot get discounts through a replacement threat mechanism. However, discounts offered by the incumbent sellers to their larger, more productive, buyers in competitive environments are predicted to increase with the number of sellers on the market.

Proposition 3. *If, under oligopoly, buyers can choose the number of suppliers after paying a positive and finite fixed costs, then more productive buyers have more*

suppliers and are charged lower prices in each market. This yields a negative buyer-size – price relationship which becomes more negative with entry of new sellers.

Proof. *See above and Appendix A.1.1 for details.*

This negative buyer-size – price relationship can be also derived in a bilateral bargaining framework assuming that buyers' outside options vary with productivity.

Bilateral bargaining. In a bilateral bargaining framework, a buyer and a seller bargain over a price that they use as an instrument of splitting the total surplus of a transaction. Given prices of all other sellers, price is a solution to the following maximization problem:

$$\max_{p_{jk}} \left[\Pi^B(N_j;\varphi) - \Pi^B(N_j\backslash k;\varphi)\right]^{\kappa_k(\varphi)} \left[\Pi^S(\Omega_k;a_k) - \Pi^S(\Omega_k\backslash\varphi;a_k)\right]^{1-\kappa_k(\varphi)} \tag{13}$$

Here, the first term is extra profits buyer φ gets from purchasing good j from seller k; the second term is extra profits seller k gets from selling good j to buyer φ; $\kappa_k(\varphi)$ and $1-\kappa_k(\varphi)$ are buyer's and seller's bargaining abilities, respectively.

Taking the first-order conditions results in the following mark-up:

$$\frac{p_{jk} - w/a_k}{p_{jk}} = \frac{1}{-\frac{\partial m_{jk}}{\partial p_{jk}}\frac{p_{jk}}{m_{jk}} + \kappa_k(\varphi)\frac{p_{jk}}{\Delta\Pi^B(p_{jk})/m_{jk}}}, \tag{14}$$

where marginal costs are assumed to be constant ($\gamma_j = 1$), for simplicity. As in Grennan (2013), this mark-up expression highlights three sources of within-seller mark-up variation: (*i*) demand elasticity, (*ii*) bargaining ability, and (*iii*) bargaining position shaped by the buyer's outside option.

Holding buyers' bargaining ability and demand elasticity constant, more productive buyers are predicted to pay lower mark-ups if they have better outside options (lower $\Delta\Pi^B(p_{jk})/m_{jk}$). If more productive buyers have better outside options, then bargaining will lead to the same pattern of within-seller price variation as oligopoly with a replacement threat. If buyers do not vary in productivity but differ in their bargaining abilities, as in Alviarez et al. (2021a), then buyers with better bargaining abilities are charged lower mark-ups and hence purchase more from the seller. Although buyer heterogeneity in bargaining abilities and productivity both imply a negative buyer-size – price relationship, I show they have different implications for the effects of trade liberalization.

Proposition 4. *Under bilateral bargaining, given buyer's bargaining ability and demand elasticity, more productive buyers pay lower mark-ups if they have better outside options. Given buyer's productivity and demand elasticity, buyers with higher bargaining ability pay lower mark-ups.*

Proof. *See above and Appendix A.1.1 for details.*

Altogether, Propositions 1 – 4 document the differences across the market structures in patterns of within-seller price variation, conditional on product quality. I summarize these differences in Table 1 and use them to identify an industry's market structure in the next section.

Table 1. Mechanisms and Patterns of Price Variation under Various Market Structures

Market structure	Mechanism	Buyer-size – price relationship
Oligopoly	Buyer's preference for the seller Input requirements	+
Oligopoly with outside options	Buyer's productivity	–
Oligopsony	Upward-sloping supply curve	+
Bargaining, constant productivity	Buyer's bargaining ability	–

2.6 Price responses to trade liberalization and supply shocks

I derive and compare the effects of trade liberalization and global supply shocks on prices of imported goods across the market structures. I extend the developed theoretical framework and allow for trade in both inputs and final goods. I assume that firms pay additional fixed costs as well as iceberg-type trade costs such as tariffs when selling abroad. Final goods' consumers abroad have the same preferences as domestic consumers but can differ in their wages. I model trade liberalization as a reduction in either fixed costs of exporting or import tariffs on final goods abroad and consider exchange rate changes as a shock to foreign sellers' costs.

Trade liberalization in domestic firms' output markets encourages entry of domestic firms to additional markets and reduces their marginal costs of supplying foreign

consumers. In oligopolistic inputs markets, this results in an increase in a domestic firm's derived input demand in (8):

$$m_{jk}(\varphi) = \delta_{jk}(\varphi)^{\eta_j} \varphi^{\sigma_s - 1} p_{jk}(\varphi)^{-\eta_j} \mathbb{P}_j(\varphi)^{\eta_j - \theta_s} \mathbb{J}_s(\varphi)^{(1-\alpha_s)(1-\sigma_s)+\theta_s-1} A_s^*(\varphi),$$

where $A_s^*(\varphi) \equiv A_s \left(1 + \mathbb{1}_x(\varphi)\tau_s^{-\sigma_s} \left(\mathbb{P}_s^*/\mathbb{P}_s\right)^{\sigma_s - 1} E^*/E\right) > A_s$ captures input demand increase if firm decides to export ($\mathbb{1}_x(\varphi) = 1$) or a foreign country reduces tariff τ_s.

This increase in firm's demand for inputs does not affect input prices in oligopolistic markets, in which price discrimination is based on buyer's preference for the seller only.[9] However, if buyers can affect prices by choosing the number of supplier, then an increase in the derived input demand makes finding alternative suppliers more profitable and results in lower input prices. In contrast, if only buyers' exogenously fixed bargaining abilities affect input prices, then trade liberalization in buyers' output markets does not affect their input prices.[10]

Alternatively, in oligopsonistic markets with perfectly competitive sellers, trade liberalization in a foreign country increases marginal revenue product of an input on the left-hand side of (11):

$$(1 - \alpha_s)\tilde{A}_s^* \tilde{\varphi} \tilde{M}_s(\tilde{\varphi})^{-\alpha_s} \left(\frac{m_j(\tilde{\varphi})}{\tilde{M}_s(\tilde{\varphi})}\right)^{-1/\theta_s} = \frac{\partial p_j(\tilde{\varphi})}{\partial m_j(\tilde{\varphi})} m_j(\tilde{\varphi}) + p_j(\tilde{\varphi}) \tag{15}$$

where $\tilde{A}_s^* = \tilde{A}_s \left(1 + \mathbb{1}_x(\varphi)\tau_s^{-\sigma_s} \left(\mathbb{P}_s^*/\mathbb{P}_s\right)^{\sigma_s - 1} E^*/E\right)^{\frac{1}{\sigma_s(1-\alpha_s)+\alpha_s}} > \tilde{A}_s$ captures this increase. It encourages an oligopsonist to purchase larger input quantity, which increases its price following an upward sloping seller's average cost function.

Proposition 5. *The effect of improved access to foreign markets by domestic producers on input prices depends on the market structure in the input market. Under oligopoly with price-taking buyers, input prices are not affected; under oligopsony, input prices are predicted to increase; under oligopoly in which buyers differ in the outside options, input prices are predicted to decrease.*

Proof. *See above and Appendix A.1.2 for details.*

These market structures also imply differential patterns of pass-through of foreign

[9] When demand and cost functions are linear, the level of input demand also affects prices: under oligopoly, exogenously larger buyers are charged higher mark-ups. As a result, by increasing firm's demand for inputs, a reduction of foreign country's tariffs leads to higher input prices and mark-ups.

[10] See Appendix A.1.1 for details.

seller's cost shocks into prices of imported inputs. I consider volatility of exchange rate between seller's currency and currency of invoicing. In perfectly competitive markets, prices in invoices currency are a product of seller's costs and the exchange rate. Hence, when the exchange rate increases by one percent, prices in invoice currency also increase by one percent, resulting in complete pass-through. In contrast, in oligopolistic and oligopsonistic markets, firms decide how much of the shock to pass-through to buyers by adjusting their mark-ups or mark-downs.

Under oligopoly, sellers have incentives to reduce their mark-ups when their currency appreciates relative to the invoice currency. This is because when sellers increase precise in response to their currency appreciation, their share in buyer's expenditures goes down, which increases buyer's demand elasticity. For goods invoiced in US dollar (USD), seller's mark-up adjustment in response to the seller's currency appreciation relative to US dollar can be expressed as:

$$\frac{d\log p_{jk}(\varphi)}{d\log \varepsilon_k^{\$}} = -\frac{(\eta_j - 1)\Gamma(s_{jk}^J(\varphi))(1 - s_{jk}^J(\varphi))}{1 + (\eta_j - 1)\Gamma(s_{jk}^J(\varphi))(1 - s_{jk}^J(\varphi))} < 0 \tag{16}$$

where $\varepsilon_{jk}^{\$}$ is the nominal exchange rate between seller k's currency and USD (in units of producer currency per USD). $\Gamma\left(s_{jk}^J(\varphi)\right)$ is a mark-up elasticity with respect to the seller's share in buyer's expenditures; it is positive and increasing in $s_{jk}^J(\varphi)$.

This oligopolistic mark-up adjustment is negative and by absolute value increasing in the seller's share in buyer's expenditure, $s_{jk}^J(\varphi)$. Intuitively, this is because all else equal, buyers with higher expenditure shares on the seller's product are charged higher mark-ups, which leaves a larger room for mark-up adjustment. This, in turn, means that buyers with higher expenditure shares on the seller's product experience smaller changes in their prices in response to the seller's currency appreciation.

As discussed above, in oligopolistic markets, the seller's share in buyer' expenditures can vary for two reasons: exogenous differences in preferences for the seller, and endogenous number of input suppliers. These two sources of buyer heterogeneity imply different patterns of the exchange rate pass-through. If higher expenditure share on a seller's product reflect a buyer's preference for the seller, then this buyer purchases *more* from the seller and experiences a *lower* pass-through of the seller's cost increase. Alternatively, if it reflects buyer's decision to have only one supplier, then this buyer purchases *less* from the seller and experiences a *lower* pass-through

of the seller's cost increase.

In contrast, under oligopsony with perfectly competitive sellers, buyers' mark-downs decrease in response to appreciation of the seller's currency. This is because when seller's costs increase, buyer's demand decreases and reduces the mark-down. Given buyer's demand in (11) and seller's CES production function in (6), this mark-down adjustment in the seller's currency can be expressed as:

$$\frac{d\log p_{jk}(\varphi)}{d\log \epsilon_k^{\$}} = -\frac{\left(\frac{1}{\gamma_j}-1\right)\theta_s}{1+\left(\frac{1}{\gamma_j}-1\right)\theta_s} < 0, \tag{17}$$

It is negative and constant, which implies less than complete but constant pass-through of sellers' cost shocks into buyers' prices. However, if input supply elasticity is not constant, but increases with buyer's quantity share in seller's sales,[11] the pass-through rate can also vary with buyer size (see Appendix A.1.2 for details.).

Proposition 6. *Pass-through of the seller's cost shock such as import tariffs into prices across buyers depends on the market structure in the industry. Under oligopoly with price-taking buyers, pass-through rates are lower for larger buyers; under oligopoly in which buyers' outside options affect prices, pass-through rates are higher for larger buyers; under oligopsony with constant input demand elasticity, pass-through rates are constant.*[12]

Proof. *See above and Appendix A.1.2 for details.*

3 Data

I use a uniquely detailed customs data from Paraguay, to test the derived implications of various market structures for price variation. [13] for the period 2013 - 2018. Paraguay is a member of the Southern Common Market (Mercosur), together with Argentina, Brazil, and Uruguay, and actively participates in international trade

[11] This could be the case if sellers' production had diseconomies of scale at the level of total, $M_{jk} = \int_{\varphi\in\Omega_{jk}} m_{jk}(\varphi)d\varphi$, rather than buyer-specific output, $m_{jk}(\varphi)$.

[12] For analysis of pass-through of sellers' costs into prices negotiated in a bilateral bargaining framework, where buyers are heterogeneous in their bargaining abilities rather than productivity, see Alviarez et al. (2021a).

[13] The data collected by Paraguayan customs was purchased from Datamyne.

with China, the United States, and several European countries. As an agricultural economy, Paraguay specializes in exports of beef, soybeans, and other animal and vegetable products, and imports mainly manufactured goods such as machinery, electronics and transportation, for both consumption and use as inputs in production. Paraguay's customs data records the entire universe of the country's import transactions and is particularly well-suited for studying market-power mechanisms of price variation in international trade.

First, the data allows me to study within-seller variation of prices across buyers by providing names of foreign sellers and identifiers of Paraguayan buyers. Using textual analysis techniques, I standardize sellers' names by removing legal abbreviations and spelling errors, and create unique seller identifiers as a combination of a name and country. Using firms' ownership information from Orbis ownership database and similarity in their names, I identify sellers' affiliated buyers, and focus on price variation across their arm's-length buyers.[14]

Second, this data includes uniquely detailed, nearly barcode-level, product descriptions, which allow me to isolate within-seller price variation unrelated to product quality and seller's cost variation. Besides 8-digit codes in Harmonized Systems' classification[15], imported products are described with brand names, origin countries, per-unit weight (in known measurement units), and non-generic product descriptions (in words).[16] In addition, the transaction-level nature of the data allows me to account for variation in seller's costs across transactions of different sizes and over time.

Third, a wide range of imported products allows me to study heterogeneity in market structures across industries and their differential implications for price variation. I explore whether and how the number of sellers on a market affects prices a given seller charges to different buyers, to understand the role of seller's market power in the observed price variation.

[14] See Appendix for details of the textual analysis performed on the seller names.

[15] There are 6 712 8-digit codes in Paraguayan product classification.

[16] Goldberg (1995), Head and Mayer (2019), Lashkaripour (2020), Alviarez et al. (2021b) show that brands, origin countries and per-unit weight are a large source of product differentiation.

3.1 Summary statistics

In 2013 - 2018, Paraguayan customs, on average, recorded around 0.8 million import transactions every year. The majority of them, by count, weight and value, are imports of differentiated products mainly used in production as intermediate or capital goods (see Table A2). In each year, there are on average 8870 distinct importers interacting with 1550 distinct foreign sellers that regularly export their products to Paraguay (with at least 1000 import transactions in the sample). [17]

Table 2 shows that trade intermediaries, wholesalers and retailers play an expectedly important role in imports of landlocked Paraguay. Based on importers' main economic activity in NACE classification, 34% and 11% of them are wholesalers and retailers, respectively. Additionally, word indicators in foreign sellers' names and information available in Orbis data suggest that 4% of regular exporters to Paraguay are trade intermediaries. These firms coexist with a smaller number (14%) of importing manufacturers and agricultural producers accounting for a substantial share of the countries' imports (20%). I account for differences in importing behavior and price setting across trade intermediaries, wholesalers, retailers and producers from various industries using importers' NACE industry identifiers.

While most goods imported to Paraguay are transacted at arm's length between independent firms, some of them represent intra-firm trade between affiliates of the same multinational. Using similarity of buyer and seller names and information from Orbis ownership data, I identify 5% of import transactions by count as (intra-firm) trade between related parties. These intra-firm trade flows add up to 9% of annual import value in Paraguay.[18] Multinational affiliates comprise around 8% and 17% of importers and their foreign suppliers, respectively, and often transact with non-affiliated firms in Paraguayan customs data.[19] To focus on market-power rather than potential profit shifting mechanisms of price variation across importers, I use a subsample of arm's-length transactions in most of the analysis.

Paraguayan importers (buyers) and their foreign trading partners (sellers) exhibit

[17] I focus on sellers with frequently appearing names, to minimize the effect of mistakes in self-reported company names. Full sample results are similar and available upon request.

[18] The smaller share of intra-firm trade in Paraguay relative to other countries such as the US can be explained by the country's size and level of development.

[19] The identified number of foreign affiliates among Paraguayan importers (509) favorably compares to records in the WorldBase data (577). I thank Lei Li and Harald Faldinger for sharing this data.

Table 2. Firm types in Paraguayan imports, 2013 - 2018

	% firms	% transactions	% annual value	% annual weight
		A. Buyers		
Producers	14	10	22	30
Wholesalers	34	51	52	49
Retailers	11	18	13	10
MNE affiliates	8	22	31	31
		B. Sellers		
Intermediaries	4	9	4	5
MNE affiliates	17	20	21	18

Table 3. Joint heterogeneity of buyers and sellers in Paraguayan import transactions

	$\bar{x}$	std	5pct	10pct	25pct	50pct	75pct	90pct	95pct
				Panel A: Buyers					
'000 $USD	1214	8492	1.2	2.2	7.8	41.2	270.2	1524	4238
# Years	2.0	1.7	1	1	1	1	3	6	6
# HS8	17	44	1	1	1	3	14	43	81
# Countries	2.3	2.8	1	1	1	1	2	5	8
# Sellers*	2.7	4.1	1	1	1	1	3	6	9
# Countries/HS8	1.2	0.7	1	1	1	1	1	2	2
# Sellers*/HS8	1.4	1.1	1	1	1	1	1	2	3
N **Firms/Year**	8870	443	8175	8175	8767	8863	9009	9541	9541
				*Panel B: Sellers**					
'000 $USD	2574	11545	0.3	1.2	14.6	189	3605	4873	10789
# Years	3	2	1	1	1	2	5	6	6
# HS8	31	65	1	1	1	5	29	88	145
# Buyers	4.2	23.6	1	1	1	1	3	6	11
# Buyers/HS8	1.5	2.4	1	1	1	1	1	2	4
N **Firms/Year**	1546	82	1380	1380	1509	1544	1625	1630	1630

Notes: * denotes regular sellers to Paraguay, defined as a combination of a selling firm's name and country of purchase with more than 1000 appearances in the sample. Sellers and exporters, buyers and importers are used interchangeably in this paper.

a large degree of heterogeneity along several dimensions, much like in other customs datasets (c.f. Bernard et al. (2018), Kikkawa et al. (2019), etc.). Table 3 reports that an average importer annually spends $1.2 million on imported goods while the median one spends 30 times as little. Similarly, an average regular exporter to Paraguay

annually earns $2.5 million from selling products in Paraguay, while the median one earns 14 times as little. Such stark differences in import spendings and export sales across importers and their suppliers, respectively, are due to differences in the number of traded HS8 categories and number of trading partners.

Besides, buyers and sellers substantially differ in the number of trading partners they have in narrow product categories. While most the majority of smaller firms have only one partner in an HS8 category, a few large ones have multiple partners in a category. I use import transactions generated by foreign firms with multiple buyers in an HS8 product category in Paraguay to study the role of importer heterogeneity in within-seller price variation. These transactions comprise a third of the full sample and involve a quarter of Paraguayan importers and a third of their regular foreign suppliers. Buyers and sellers in these transactions are, respectively, 2.7 and 1.8 times larger than in the full sample and exhibit larger degree of heterogeneity (see Table A4).

3.2 Price variation

I use unit values calculated as a ratio of transaction's (free-on-board, FOB) value (in $USD) and quantity (in known units) as proxies for price and study their variation across buyers of the same seller. To illustrate the extent of this variation, I calculate coefficients of variation of unit values in narrow HS8 product categories. I plot the densities of these coefficients separately for homogeneous and differentiated goods as defined by Rauch (1999) in Figure 3. Within-seller price variation is expectedly higher among differentiated products, where average coefficient of variation of 40% can be partly explained by product differentiation. However, it is unexpectedly high even in a subsample of homogeneous products, where, despite apriori limited scope for product differentiation, the average coefficient of variation is close to 30%.

The within-seller price variation accounts for a large share of total price variation within narrow product categories. Variance decomposition in the first row of Table 4 suggests that it explains 50% and 80% of the total price variation within HS8 product categories of differentiated and homogeneous goods, respectively. A substantial portion of this within-seller price variation is driven by price variation across buyers of the same seller. The last row of Table 4 implies that it accounts for around 20% and 55% of within-seller price variation in HS8 categories of differentiated and

homogeneous goods, respectively.

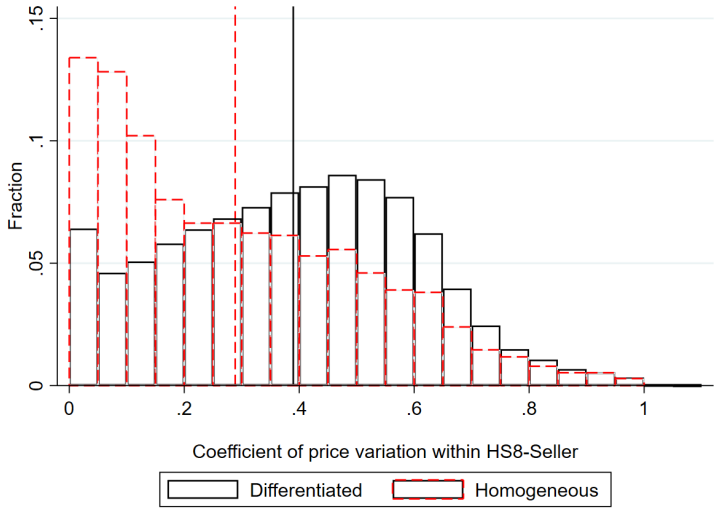


Figure 3. Sellers substantially vary prices within narrow HS8 product categories

Notes: Coefficients of variation are calculated as ratios of standard deviation of unit values over their mean within HS8-Unit-Seller categories. Unit values more than 3 times larger and less than 3 times smaller than the median in each category were excluded, as in Fontaine et al. (2020). Vertical lines show average COVs for homogeneous and differentiated products, as classified by Rauch (1999).

Table 4. Decomposition of price variance across Paraguayan import transactions

	Differentiated goods		Homogeneous goods	
Within:	HS8	HS8×Seller	HS8	HS8×Seller
Total	1.76	0.93	0.98	0.80
Within Buyer	0.85	0.77	0.39	0.38
Between Buyers	0.96	0.18	0.63	0.45

Notes: The reported numbers are variances of log price deviations from their annual averages within categories shown in the first row and the first column.

To rule out quality variation as the only source of within-seller price variation across buyers, I use detailed product characteristics as controls for quality within HS8 category. Table 5 demonstrates explanatory power of product's per-unit weight, brand, and country of origin in within-seller price variation. It reports adjusted R^2 of regressions in which (log) price deviations from the annual seller-specific average

in an HS8 category are explained by these characteristics and importer fixed effects. In column (4), product's per-unit weight, brand and country of origin together, on average, explain 13% of within-seller price variation in HS8 category. In contrast, importer fixed effects alone in column (5) explain 11% of this variation, on average. When both importer fixed effects and product characteristics are included in the regression, adjusted R^2 increases to 0.18%. This means that, independently from each other, the detailed product characteristics and importer characteristics explain 39% (= $(0.18 - 0.11)/0.18$) and 28% (= $(0.18 - 0.13)/0.18$) of the total explained within-seller price variation, respectively.[20]

Table 5. Importer and product characteristics in within-seller price variation

Dependent variable:	log Demeaned Price, HS8×Seller×Year					
	(1)	(2)	(3)	(4)	(5)	(6)
Adj. R^2	0.04	0.03	0.01	0.13	0.11	0.18
HS8, Per Unit Weight	✓			✓		✓
HS8×Brand		✓		✓		✓
HS8×Origin			✓	✓		✓
HS8×Importer					✓	✓

Notes: The reported Adj. R^2 are from regressions with log price deviations from the HS8-Seller-Year average as a dependent variable and the marked fixed effects as explanatory variables.

4 Evidence of market-power mechanisms

4.1 Identification strategy

I develop an empirical methodology that can be used to identify industry's market structure from patterns of within-seller price variation across buyers and over time.

To test Propositions 1 – 4, I estimate generalized seller's pricing rules in (7), (11) and (14) (in logs):

$$\log p_{jkt}(\varphi) = \rho_0 + \rho_1 \log s^J_{jkt}(\varphi) + \rho_2 \log m_{jkt}(\varphi) + \mathbb{Z}_{s(\varphi)} + \log \nu_{jkt} + \xi_{jkt}(\varphi), \quad (18)$$

[20] Appendix A shows that the independent role of importer heterogeneity in within-seller price variation remains to be substantial even when product characteristics beyond brand, per-unit weight and country of origin are accounted for. I extract these characteristics and identify individual varieties within HS8 categories from non-generic word descriptions provided by importers.

where $s^J_{jkt}(\varphi)$ denotes seller k's share in buyer φ's expenditures on product j at time t; $m_{jkt}(\varphi)$ is quantity of good j purchased by buyer φ from seller k at time t; $\mathbb{Z}_{s(\varphi)}$ controls for the input requirements in buyer φ's industry s; ν_{jkt} denotes seller k's marginal costs of producing good j at time t; $\xi_{jkt}(\varphi)$ denotes buyer-specific error.

Seller's share in buyer's expenditures, $s^J_{jkt}(\varphi)$, measures buyer φ's preference for seller k's variety of product j. Analogously to the quality measure in Khandelwal (2010), conditional on the purchased quantity, buyers with higher preferences for the seller, have higher expenditure shares spent on the seller's product. Conditional on the buyer's preference for the seller, more productive buyers purchase larger product quantities from the seller. This means that buyer φ's quantity of product j purchased from seller k, $m_{jkt}(\varphi)$, is a theoretically consistent measure of the buyer's productivity.

Using these measures of buyers' preferences for sellers and productivity, I test differential predictions across the market structures outlined in Propositions 1 – 4. In oligopolistic markets for differentiated products, $\rho_1 > 0$, when sellers price discriminate and charge higher mark-ups to buyers with higher preferences for their products. Moreover, in such markets, $\rho_2 < 0$, when more productive buyers can countervail the market power of sellers using their outside options. In contrast, in oligopsonistic markets with perfectly competitive sellers, $\rho_2 > 0$, because more productive buyers purchase in larger quantities and pay higher prices due to the increasing average costs. In markets with bilateral bargaining, $\rho_2 < 0$, when buyers with better bargaining abilities negotiate lower prices and then purchase more from the seller.

To distinguish the roles of buyers' productivity and bargaining abilities in within-seller price variation, I test their differential implied effects of firms' sales on their input prices in Proposition 5. I estimate a version of the seller's pricing rule:

$$\log p_{jkt}(\varphi) = \rho^X_0 + \rho^X_1 \log s^J_{jkt}(\varphi) + \rho^X_2 \log Ex_t(\varphi) + \mathbb{Z}_{s(\varphi)jt} + \log \nu_{jkt} + \xi_{jkt}(\varphi), \quad (19)$$

where $Ex_t(\varphi)$ is firm φ's total export sales at time t. The sign of estimated coefficient ρ^X_2 can be used to determine industry's market structure. Oligopoly in which sellers price discriminate based on buyers' preferences for their products, $\rho^X_2 = 0$, because only seller's share in buyer's expenditures affects prices ($\rho^X_1 > 0$). Oligopoly in which buyers can have outside options implies $\rho^X_2 < 0$, because larger sales encourage firms to add suppliers that then become their outside options. Oligopsony in which

sellers are perfectly competitive implies $\rho_2^X > 0$, because an oligopsonist's demand for inputs increases with sales causing input prices to increase due to diseconomies of scale. Bilateral bargaining with firm heterogeneity in bargaining ability rather than productivity implies $\rho_2^X = 0$, because bargaining ability is exogenously fixed.

One concern that can hinder the interpretation of estimated coefficients in (18) - (21) is non-constant seller's marginal costs. To isolate mark-up/mark-down variation from seller's marginal cost variation, I test their differential implications for price changes in response to seller competition. I augment seller's pricing rule in (18) with an interaction term of a buyer's size and number of sellers on the market, $\bar{N}_{jt}$:

$$\begin{aligned}\log p_{jkt}(\varphi) = \rho_0 + \rho_1 \log s^J_{jkt}(\varphi) + \rho_2 \log m_{jkt}(\varphi) + \rho_3 \log \bar{N}_{jt} \times \log m_{jkt}(\varphi) \\ + \rho_4 \log \bar{N}_{jt} + \mathbb{Z}_{s(\varphi)jt} + \log \nu_{jkt} + \xi_{jkt}(\varphi)\end{aligned} \tag{20}$$

If within-seller price variation is entirely driven by variation in the seller's marginal costs, then the level of competition among sellers can affect price level but not price variation across buyers and $\rho_3 = 0$. In contrast, if price variation is at least partly driven by mark-up variation, then it is affected by the level of competition among sellers. If sellers price discriminate based on buyers' preferences for the seller, then, when faced with competition, they reduce prices of their more loyal, larger buyers by less, $\rho_3 > 0$. However, if sellers price discriminate by charging lower mark-ups to buyers with outside options, then more productive, larger buyers, can use other sellers as their outside options and receive even larger discounts, $\rho_3 < 0$.

Another way of separating market-power- and cost-based price variation is by observing how sellers pass through their cost shocks into their buyers' prices. Proposition 6 shows that, in perfectly competitive markets, pass-through is complete and constant across buyers, while in imperfectly competitive markets it is incomplete and varies across buyers. I test these predictions by estimating the seller's pricing rule in first differences:

$$\begin{aligned}\Delta \log p^{\$}_{jkt}(\varphi) = \tilde{\rho}_1 \log \tilde{m}_{jkt}(\varphi) + \tilde{\rho}_2 \Delta \log \varepsilon^{\$}_{kt} + \tilde{\rho}_3 \log \tilde{m}_{jkt}(\varphi) \cdot \Delta \log \varepsilon^{\$}_{kt} \\ + \log \nu_{jk}(\varphi) + \xi_{jkt}(\varphi)\end{aligned} \tag{21}$$

where Δx and $\tilde{x}$ denote differences in values of x across time and buyers, respectively, and $\varepsilon^{\$}_{kt}$ denotes nominal exchange rate between US dollar and seller k's currency. An

increase in $\varepsilon^{\$}_{kt}$ implies appreciation of the seller's currency relative to US dollar. For transactions invoiced in US dollars, this means an increase in sellers' marginal costs that they can pass through to buyers by increasing their US dollar prices, $p^{\$}_{jkt}(\varphi)$. In oligopolistic and oligopsonistic markets, sellers and buyers absorb some increase in their marginal costs in mark-ups and mark-downs, respectively, which results in incomplete pass-through, $0 < \tilde{\rho}_2 < 1$. If sellers price discriminate based on buyers' preferences for the seller, larger buyers are charged larger mark-ups which adjust more in response to the cost shock. and implies $\tilde{\rho}_3 < 0$. If sellers price discriminate by charging lower prices to buyers with outside options, larger buyers are charged smaller mark-ups which adjust less in response to the cost shock and implies $\tilde{\rho}_3 > 0$.

Table 6. Differential implications across market structures

	ρ_1	ρ_2	ρ_2^X	ρ_3	$\tilde{\rho}_3$
Oligopoly	+	0	0	+	–
Oligopoly with differences in buyers' outside options	+	–	–	–	+
Oligopsony	NA	+	+	0	0
Bargaining with differences in buyer's bargaining abilities	+	–	0	–	NA

Table 6 shows differential implications of the market structures in Propositions 1 – 6 mapped into estimated coefficients ρ_1, ρ_2, ρ_2^X, ρ_3, and $\tilde{\rho}_3$ in equations (18) - (21). When estimating these coefficients, I address measurement error-, omitted variable-, and simultaneity biases in my estimates and their interpretation.

4.2 Diagnosing price variation in firm-to-firm transactions

To identify a market structure behind within-seller price variation across buyers, I test differential implications of market structures using equations (18) - (21). I proxy prices with transaction-level (FOB, excl. freight and insurance) unit values and define markets with 6-digit product classification codes (HS6). I use seller fixed effects interacted with fixed effects for 8-digit HS product code (HS8), unit of measurement and year to capture seller's marginal costs, ν_{jkt}. I use fixed effects for importers' 4-digit NACE industries to account for differences in input requirements between manufacturers and wholesalers/retailers, and across manufacturing sectors, $\mathbb{Z}_{s(\varphi)jt}$.

Table 7 shows patterns of price variation across buyers of the same seller predicted

by equation (18). Column (1) shows that, in a narrow HS8 product category, seller's prices increase in the seller's share in buyer's expenditures on a market, and decrease in buyer's annual purchases from the seller. All else equal, a one percent increase in the seller's share in buyer's import expenditures on a product is associated with a 0.08% price increase, while a one percent increase in the buyer's annual purchases from the sellers is associated with a 0.12% price reduction.

These effects are economically significant as they predict large price differences across importers in the data. By having, on average, 35 times larger expenditure shares on the seller's product, importers at the 75th percentile of expenditure shares are predicted to pay 33% ($= 35^{0.08}$) more for the same product than importers at the 25th percentile. By having, on average, 64 times larger annual purchases from the seller, importers at the 75th percentile of buyer sizes are predicted to pay 40% ($= 1 - 64^{-0.12}$) less for the same product than importers at the 25th percentile.

Propositions 1 – 4 suggest that these patterns of price variation across buyers of the same seller are consistent with oligopoly in markets for differentiated products. On the one hand, under this market structure, sellers charge higher mark-ups to buyers with higher preference for the seller and hence higher expenditure shares on the seller's product. On the other hand, they charge lower prices to their larger buyers because of either economies of scale or better outside options or bargaining abilities. These interpretation, yet, can be hindered by several endogeneity concerns I address.

Table 7 demonstrates that these patterns are not a result of transfer pricing between affiliated firms, measurement errors in quantities, and economies of scale in production/transportation. Column (2) adds a dummy variable for affiliated buyers of the seller, and shows that it does not change the observed patterns of price variation in any significant way. Focusing on arm's length transactions repeated through the entire sample period, columns (3) - (5) rule out economies of scale and measurement errors in quantities as a source of price variation. Column (3) shows that the results are robust to including transacted quantities to account for transaction-level economies of scale and measurement errors in quantities used to calculate unit values. Columns (4) and (5) show that the results hold when *lagged* buyer's purchases from the seller are used as a measure of and an instrument for the *current* buyer's purchases, to account for economies of scale at the annual frequency.

Table 7. Price Variation Across Buyers of the Same Seller

Dependent Variable:	log *Transaction Price*				
	(1)	(2)	(3)	(4)	(5)
	OLS	OLS	OLS	OLS	IV
$\log s^J_{jkt}(\varphi)$	0.077***	0.078***	0.069***	0.116***	0.135***
	(0.015)	(0.015)	(0.013)	(0.030)	(0.039)
$\log m_{jkt}(\varphi)$	-0.117***	-0.118***	-0.031***		-0.088**
	(0.015)	(0.015)	(0.008)		(0.045)
Affiliated Buyer		-0.243***			
		(0.080)			
log *Transaction Quantity*			-0.275***	-0.314***	-0.311***
			(0.020)	(0.022)	(0.022)
$\log m_{jkt-1}(\varphi)$				-0.043**	
				(0.021)	
Constant	4.158***	4.171***	4.450***	5.058***	
	(0.127)	(0.127)	(0.115)	(0.189)	
HS8-Unit-Seller-Year	✓	✓	✓	✓	✓
Industry	✓	✓	✓	✓	✓
Transactions	All	All	Arm's length, 6-year relationships		
N obs	981119	981119	964492	323973	323973
N clusters	728	728	726	260	260
Adj. R^2	0.937	0.937	0.946	0.901	0.192
Kleibergen-Paap rk Wald F					146.0

* p<0.10, ** p<0.05, *** p<0.01

Robust standard errors clustered at importer- and exporter- levels in parentheses.

Notes: $s^J_{jkt}(\varphi)$ denotes seller's share in buyer's expenditures and $m_{jkt}(\varphi)$ denotes buyer's annual purchases in HS6 category from the seller in year t.

Table 8 shows that price variation with seller's share in buyer's expenditures and annual quantities purchased by a buyer from the seller are not driven by product differentiation.[21] It exploits products' brand names, per-unit weight, country of origin, and commercial descriptions to control for product characteristics as precisely as it

[21]If more productive buyers import goods of higher quality from the same seller in HS8 category and product quality is not accounted for, this will lead to an upward simultaneity bias (towards zero) in ρ_2 and ρ_2^X in (18) - (20).

is possible with barcode data (cf. Broda and Weinstein (2010), Atkin and Donaldson (2015), etc.).[22] Column (1) reports similar price elasticities in these subsample of branded products as those in the full sample (column (3) of Table 7). Columns (2) and (3) show that accounting for differences in brands, per-unit weight, commercial descriptions and origin countries does not significantly alter these elasticities. Columns (4) and (5) report even larger price elasticities, by absolute value, when shipment-level economies of scale and measurement errors are accounted for with a lagged measure of buyer size.

One remaining concern that can hinder interpretation of these results is variation in seller's costs with buyer's annual rather than transactional purchased quantities. To show that it is not the only explanation for lower prices charged by sellers to their larger buyers, I estimate the effect of competition among sellers on prices of different buyers of the same seller. Table 9 presents the results of estimating specification (20). Column (1) shows that under monopoly, sellers do not vary prices across buyers, but in competitive markets, sellers charge even lower prices to their larger buyers when faced with more competition. This finding is inconsistent with economies of scale as the only source of within-seller price variation, because it should not be affected by the number of sellers on the market. However, it is consistent with competing sellers being buyers' outside options, which improve with the number of sellers on the market and result in even lower prices charged to larger buyers.

In the remaining columns of Table 9, I show that this finding is not driven by endogenous entry of sellers into markets with larger within-seller price variation.[23] I use the number of sellers on a market in year 2013 as an instrument for the number of sellers in all *subsequent* years. I interact it with *lagged* buyer's purchases from the seller to obtain an instrument for the interaction term between the number of sellers and buyer's size. Columns (2) and (4) report the reduced form and first stage results, respectively. Column (3) shows that the instrumental variable approach yields the same result: discounts to larger buyers are not offered by monopolists but increase

[22] Examples of products described with brands and commercial descriptions are presented in Table B3 in the Appendix. Among them are "Shampoo Question Professional Keratin Lift 960cc", "Shampoo Questions Professional Retention 960cc", "Tractor Valtra model A990 4x4 yellow 2017", "Tractor Valtra model BM110 4x4 yellow 2017".

[23] Although higher *price levels* are expected to encourage entry, it is not clear whether and how *price variation* affects entry.

Table 8. Price Variation Across Buyers, Unexplained by Product Characteristics

Dependent Variable:	log *Transaction Price*				
	(1)	(2)	(3)	(4)	(5)
	OLS	OLS	OLS	OLS	IV
$\log s^J_{jkt}(\varphi)$	0.058***	0.059***	0.048***	0.045**	0.061**
	(0.012)	(0.013)	(0.016)	(0.019)	(0.025)
$\log m_{jkt}(\varphi)$	-0.037***	-0.038***	-0.033***		-0.056**
	(0.009)	(0.009)	(0.011)		(0.024)
$\log m_{jkt-1}(\varphi)$				-0.022**	
				(0.009)	
log *Per-unit Weight*		0.271***	0.230***	0.233***	0.233***
		(0.036)	(0.036)	(0.039)	(0.039)
log *Transaction Quantity*	-0.266***	-0.246***	-0.247***	-0.267***	-0.264***
	(0.039)	(0.036)	(0.037)	(0.038)	(0.037)
Constant	5.096***	4.358***	4.414***	4.531***	
	(0.147)	(0.157)	(0.170)	(0.164)	
HS8×Unit×Seller×Year	✓	✓	✓	✓	✓
×Brand		✓	✓	✓	✓
×Description×Origin			✓	✓	✓
Industry	✓	✓	✓	✓	✓
N obs	226041	226041	226041	168096	168096
N clusters	372	372	372	309	309
Adj. R^2	0.972	0.974	0.979	0.975	0.179
Kleibergen-Paap rk Wald F					88.8

* p<0.10, ** p<0.05, *** p<0.01

Robust standard errors clustered at importer- and exporter- levels in parentheses.

Notes: $s^J_{jkt}(\varphi)$ denotes seller's share in buyer's expenditures and $m_{jkt}(\varphi)$ denotes buyer's annual purchases in HS6 category from the seller in year t.

with the number of sellers on the market in competitive markets.

Another explanation for lower prices charged by sellers to their larger buyers is differences in bargaining abilities across buyers under bilateral bargaining (see Alviarez et al. (2021a)).[24] I distinguish the effect of buyers' bargaining abilities and

[24]In Alviarez et al. (2021a), the only source of firm heterogeneity is differences in their exogenous bargaining ability, which can affect their outside options only through network effects.

Table 9. The Effect of Competition Among Sellers on Price Variation Across Buyers

Dependent Variable:	log *Transaction Price*			$\log m_{jkt}(\varphi) \cdot \log N_{jt}$
	OLS	OLS	IV	I stage
	(1)	(2)	(3)	(4)
$\log s^J_{jkt}(\varphi)$	0.135***	0.113***	0.139***	1.068***
	(0.039)	(0.036)	(0.047)	(0.089)
$\log m_{jkt}(\varphi)$	0.012		0.051	
	(0.047)		(0.059)	
$\log m_{jkt}(\varphi) \cdot \log N_{jt}$	-0.024**		-0.035**	
	(0.010)		(0.014)	
$\log m_{jkt-1}(\varphi)$		0.028		0.125
		(0.038)		(0.392)
$\log m_{jkt-1}(\varphi) \cdot \log N_{j2013}$		-0.018**		0.449***
		(0.008)		(0.087)
log *Transaction Quantity*	-0.265***	-0.267***	-0.265***	0.104***
	(0.020)	(0.020)	(0.019)	(0.026)
log *Per-unit Weight*	0.310***	0.311***	0.310***	-0.031***
	(0.025)	(0.025)	(0.025)	(0.010)
Constant	5.147***	4.820***		15.767***
	(0.205)	(0.175)		(1.240)
Fixed Effects:				
HS8×Unit×Seller×Brand×Year	✓	✓	✓	✓
Industry	✓	✓	✓	✓
N obs	569935	569935	569935	569935
N clusters	293	293	293	293
Adj. R^2	0.930	0.930	0.206	0.988
Kleibergen-Paap rk Wald F			64.9	

* p<0.10, ** p<0.05, *** p<0.01

Robust standard errors clustered at importer- and exporter- levels in parentheses.

Notes: $s^J_{jkt}(\varphi)$ denotes seller's share in buyer's expenditures and $m_{jkt}(\varphi)$ denotes buyer's annual purchases in HS6 category from the seller in year t, N_jt denotes the number of sellers of HS6 category to Paraguay in year t.

productivity-dependent outside options on price in Table 10. Columns (1) and (2) include importer and importer-seller fixed effects to control for buyer's overall and seller-specific bargaining abilities. They show that accounting for buyer's bargaining ability does not eliminate buyer-size discounts but makes them even bigger.[25] Columns (3) - (5) use buyers' purchases from their *previous* suppliers as an instrument for their *current* purchases uncorrelated with their ability to bargain with the *current* suppliers. They show that buyers purchasing more from their *previous* suppliers buy more from and pay less to their *current* suppliers. This cannot be explained by differences in seller-specific bargaining abilities across buyers but is consistent with a negative effect of buyer's own productivity on prices.

These results suggest that seller's price variation across buyers of narrowly defined, essentially at a bar-code level, products cannot be fully explained by cost and/or quality variation and thus provide evidence of oligopolistic mark-up variation. In line with this interpretation, Figure 4 shows that within-seller price variation across buyers, conditional on product quality, is mostly observed in markets with relatively high horizontal product differentiation that can give sellers market power to charge and vary mark-ups. It plots price elasticities with respect to seller's share in buyer's expenditures and buyer's purchases from the seller estimated conditional on detailed product characteristics across 12 markets. The largest price elasticities (by absolute value) with respect to buyer's purchases from the seller are found in markets for chemicals, plastics, textiles, stone, metals, and transport. These markets have relatively low elasticities of substitution estimated by Broda and Weinstein (2006) and high degree of horizontal product differentiation.

In Appendix A.3, I show that the findings presented here remain to hold even when *i*) instruments for buyer size based on Paraguay's consumer geography are used, *ii*) only importers that are large taxpayers in Paraguay are used in the analysis to eliminate tax evasion issues, *iii*) only products without domestic substitutes are considered (as in the model), and *iv*) more product characteristics are accounted for in markets for highly differentiated products.

[25] The upward bias in specifications without importer fixed effects can be explained with importers' market power in output markets rather than bargaining abilities. If larger importers of inputs are also larger sellers in their output markets, then they charge higher mark-ups in their output markets and thus have lower price elasticity in imported inputs markets.

Table 10. Price Variation Unexplained by Differences in Buyers' Bargaining Abilities

Dependent Variable:	log *Transaction Price*				log $m_{jkt}(\varphi)$
	(1)	(2)	(3)	(4)	(5)
	OLS	OLS	OLS	IV	I stage
log $s^J_{jkt}(\varphi)$	0.105***	0.117***	0.044***	0.059***	0.654***
	(0.021)	(0.017)	(0.008)	(0.010)	(0.059)
log $m_{jkt}(\varphi)$	-0.058***	-0.063***		-0.023*	
	(0.015)	(0.013)		(0.012)	
log $m_{jk't-1}(\varphi)$			-0.013*		0.546***
			(0.007)		(0.044)
log *Transaction Quantity*	-0.264***	-0.264***	-0.207***	-0.206***	0.050***
	(0.020)	(0.020)	(0.020)	(0.020)	(0.010)
log *Per-unit Weight*	0.328***	0.332***	0.363***	0.362***	-0.022*
	(0.020)	(0.020)	(0.050)	(0.050)	(0.012)
Constant	4.654***	4.694***	3.761***		3.465***
	(0.155)	(0.137)	(0.169)		(0.311)
HS8-Unit-Seller-Brand-Year	✓	✓	✓	✓	✓
Importer	✓				
Importer-Seller		✓			
Industry			✓	✓	✓
N obs	635497	635394	42044	42044	42044
N clusters	575	574	397	397	397
Adj. R^2	0.955	0.956	0.985	0.207	0.988
Kleibergen-Paap rk Wald F				153.7	

* p<0.10, ** p<0.05, *** p<0.01

Robust standard errors clustered at importer- and exporter- levels in parentheses.

Notes: $s^J_{jk}(\varphi)$ denotes seller's share in buyer's expenditures and $m_{jkt}(\varphi)$ denotes buyer's annual purchases in HS6 category from the seller in year t, $m_{jk't-1}(\varphi)$ denotes buyer's annual purchases from sellers other than k in year $t-1$.

4.3 Implications

Presented empirical results suggest that the observed patterns of within-seller price variation, conditional on product quality, are, at least partly, driven by differences in outside options across buyers with different productivity. Using outside options as a

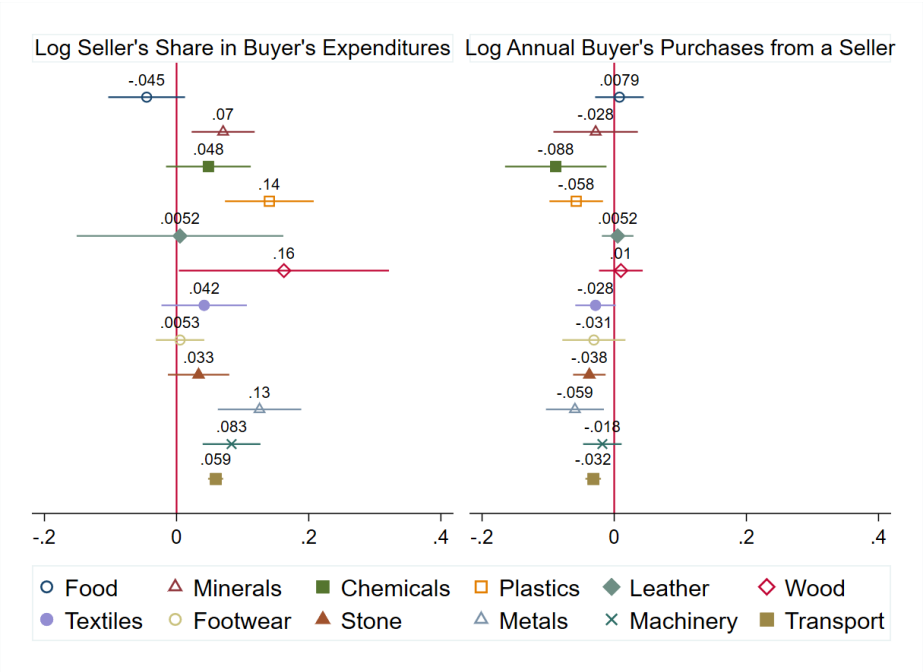


Figure 4. Patterns of Within-seller Price variation by Industry, Accounting for Detailed Product Characteristics

Notes: Coefficients ρ_1 and ρ_2 in equation (18) are estimated and plotted separately in each of the 12 broad industries accounting for variation in brand names and per-unit weight within Seller-HS8-Year.

replacement threat, more productive importers can get discounts from their suppliers and countervail their market power. To provide additional evidence of this novel mechanism of mark-up variation, I test its distinct implications.

The first implication relates to the effect of exporting on firm's imported inputs' prices. I estimate this effect using equation (19) and summarize the results in Table 11. Column (1) shows that without accounting for the seller, as is standard in the literature, importers with *higher* export sales pay *higher* prices for goods imported from the same country in the same category. This result is consistent with the productivity-quality complementary hypothesis that implies that more productive, larger, producers export more and purchase higher-quality and hence more expensive inputs (Kugler and Verhoogen, 2012; Blaum et al., 2019; Bastos et al., 2018).

However, this positive correlation between export sales and input prices becomes insignificant and even negative, once differences in suppliers across buyers are ac-

counted for. Column (2) shows that, when importing from the *same* supplier, importers that export more, all else equal, pay insignificantly less for products in the same narrow category. To alleviate reverse causality concerns in this estimate, I use the number of destinations a firm exported to in a *previous* year as an instrument for its *current* year's export sales. Columns (3) and (5) show that firms that exported to more destinations in a *previous* year pay less for goods they import in a *current* year and have higher export sales. This is expected, as more productive firms are known to export more and to more destinations at any point in time. Using this instrument, in column (4), I find that, among importers sharing a supplier, importers with higher export sales pay significantly less for goods in the same category.

This result is consistent with the implications of countervailing buyer power in oligopolistic markets. When a firm export more, its input demand increases and makes it cost efficient for the firm to invest in additional suppliers. Competition among these suppliers or threat thereof lower the mark-up charged by the firm's existing suppliers. This mechanism generates the negative effect of export sales on prices of imported inputs.

Importantly, Table 11 reconciles countervailing buyer power with the productivity-quality complementary hypothesis. The results imply that more productive firms with higher export sales choose higher-priced suppliers of higher quality goods in a given foreign country. Yet, when sharing a foreign supplier, more productive firms that export more obtain lower prices through their increased countervailing power.

The second distinct implication of countervailing buyer power in oligopolistic markets relates to pass-through of foreign sellers' cost shocks into prices of domestic buyers. To study how sellers pass-through exchange rate shocks into prices across their buyers, I estimate equation (21) and present the results in Table 12. I use US dollar-invoiced import transactions of Paraguayan importers that do not export and consider seller's currency appreciation relative to US dollar as an adverse cost shock.

Column (1) reports that a seller does not fully pass through an increase in costs due to the currency appreciation into US dollar prices faced by a buyer. A one percent appreciation of the seller's currency results in only 0.38% increase in the buyer's dollar-price of a product, on average, accounting for price levels in trading countries. Column (2) shows similar pass-through rate within a relationship, even

Table 11. The Effect of Exporting on Prices of Firm's Imported Inputs

Dependent Variable:	log *Transaction Price*				log $Ex_t(\varphi)$
	OLS	OLS	OLS	IV	I stage
	(1)	(2)	(3)	(4)	(5)
log $Ex_t(\varphi)$	0.070***	-0.009		-0.038**	
	(0.023)	(0.012)		(0.018)	
log $s^J_{jkt}(\varphi)$		0.129***	0.124***	0.122***	
		(0.017)	(0.020)	(0.020)	
log #*Destinations*$(\varphi)_{t-1}$			-0.070**		1.842***
			(0.035)		(0.162)
log *Per-unit Weight*	0.421***	0.396***	0.401***	0.401***	0.002
	(0.028)	(0.024)	(0.030)	(0.030)	(0.007)
log *Transaction Quantity*	-0.270***	-0.264***	-0.262***	-0.262***	-0.000
	(0.021)	(0.032)	(0.040)	(0.040)	(0.003)
Constant	3.076***	3.558***	3.439***		11.863***
	(0.279)	(0.225)	(0.176)		(0.132)
HS8-Country-Unit-Year	✓				
HS8-Seller-Unit-Year		✓	✓	✓	✓
Year-Industry	✓	✓	✓	✓	✓
N obs	530694	155705	124787	124787	124787
N clusters	523	322	267	267	267
Adj. R^2	0.915	0.913	0.907	0.240	0.981
Kleibergen-Paap rk Wald F				128.8	

* p<0.10, ** p<0.05, *** p<0.01

Robust standard errors clustered at importer level in parentheses.

Notes: $s^J_{jkt}(\varphi)$ denotes seller's share in buyer's expenditures and $Ex_t(\varphi)$ denotes buyer's annual export sales in year t.

after accounting for product's per-unit weight, brand, and transaction size. It means that the incomplete pass-through of exchange rate changes into prices is not driven by adjustments in product quality and logistics in response to a cost shock. In contrast, it is consistent with mark-up/mark-down adjustment, according to Proposition 6.

To identify a market power mechanism of this adjustment, I study how pass-through rates of seller's cost shocks vary across buyers. I use buyer's purchases from

Table 12. Pass-through of Exchange Rate Shocks into Prices Across Buyers

Dependent Variable:	log *Transaction Price*			
	(1)	(2)	(3)	(4)
$\Delta \log \varepsilon^{\$}_{kt}$	0.370***	0.428***	0.379**	0.393***
	(0.111)	(0.123)	(0.149)	(0.150)
$\Delta \log \varepsilon^{\$}_{kt} \times \log m(\varphi)_{jkt-1}/\bar{m}_{jkt-1}$			0.073**	0.067**
			(0.036)	(0.029)
$\log m(\varphi)_{jkt-1}/\bar{m}_{jkt-1}$			0.009	0.006
			(0.008)	(0.008)
log *Producer CPI*	0.073**	0.084***	0.062*	0.079**
	(0.031)	(0.032)	(0.036)	(0.035)
log *Paraguay's CPI*	-0.056***	-0.076***	-0.062	-0.039
	(0.019)	(0.020)	(0.050)	(0.045)
log *Per-unit Weight*		0.287***		0.286***
		(0.039)		(0.045)
log *Transaction Quantity*		-0.207***		-0.210***
		(0.023)		(0.025)
Constant	3.993***	3.965***	4.325***	4.083***
	(0.027)	(0.163)	(0.078)	(0.197)
HS8-Unit-Seller-Buyer	✓		✓	
HS8-Unit-Seller-Buyer-Brand		✓		✓
N obs	400175	354432	265496	244564
N clusters	223	220	181	180
Adj. R^2	0.976	0.983	0.975	0.981

* p<0.10, ** p<0.05, *** p<0.01

Robust standard errors clustered at importer- and exporter- levels in parentheses.

Notes: $\varepsilon^{\$}_{kt}$ denotes nominal exchange rate in units of the seller's currency per US dollar, $m_{jkt}(\varphi)$ denotes buyer's annual purchases in HS6 category from the seller in year t, $\bar{m}_{jkt-1}$ denotes average buyer's purchases from the seller in year $t-1$.

the seller in a previous year relative to the average as a measure of (relative) buyer size and productivity. I additionally interact it with the (log) change in nominal exchange rate between seller's currency and US dollar relative to the first year of the relationship. Column (3) shows that the coefficient on the interaction term is

positive, which means that sellers pass through a larger share of their cost shocks into prices of their larger buyers. Column (4) shows the same patterns of pass-through across sellers' relationships even when detailed product characteristics are taken into account. Therefore, larger pass-through rates of sellers' cost shocks into price of heir larger buyers cannot be explained by differential product quality adjustments across buyers. However, it is consistent with countervailing buyer power that implies lower mark-ups charged to larger buyers and thus higher pass-through rates of adverse seller's cost shocks.

5 Conclusions

This paper studies the sources and consequences of price variation across buyers in narrow product categories in international trade. While differences in product quality and characteristics undoubtedly contribute to this price variation, industrial organization and labor economists have long shown that it can also be an outcome of firms' market power. In international transactions that are predominantly firm-to-firm transactions between large firms, market power on both ends on a transaction can result in price variation, conditional on product quality. Therefore, patterns of price variation in international markets crucially depend on a market structure behind the market power of sellers, buyers or both.

This paper provides a framework for studying the effect of a market structure on price variation across buyers, conditional on product quality. This framework flexibly embeds oligopoly, oligopsony, and bilateral bargaining in a standard international trade environment with two-sided firm heterogeneity in productivity. It shows that mechanisms behind price variation under these market structures predict different, sometimes opposite, price responses to trade liberalization and global supply shocks. It means that quantifications of aggregate effects of trade liberalization and global shocks should take into account differences in market structures across international markets, instead of using a "one fits all" market structure.

This paper develops an empirical strategy for identifying market structures in a wide range of international markets without prior institutional knowledge. It relies on differential across market structures patterns of price variation across buyers and over

time. Applying this strategy, I document a novel mechanism through which buyers countervail the market power of sellers in international markets. More productive buyers get lower prices from the same seller, through better outside options.

This finding suggests that the growing market concentration can be an outcome of free-trade policies in intermediate goods' markets. By increasing competition among sellers, such policies are predicted to encourage larger discounts to be offered to more productive buyers of inputs. These more productive firms get a competitive advantage in their output markets, which, in the long run, increases market concentration in these markets. The welfare effect then depends on how much producers' mark-ups increase relative to a reduction in input prices when market concentration increases.

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A Online Appendix (Not for Publication)

A.1 Theory

A.1.1 Proofs of Propositions in Section 2.5

Input prices under oligopoly

Proof of Proposition 1. Under oligopoly, seller k of input j has the following profit maximization problem:

$$\pi_{jk} = \int_{\varphi \in \Omega_{jk}} \left(p_{jk}(\varphi) - \frac{m_{jk}(\varphi)^{1/\gamma_j} w}{a_k^{1/\gamma_j}} \right) m_{jk}(\varphi) d\varphi \tag{22}$$

where Ω_{jk} denotes a set of buyers purchasing product j from upstream firm k. Since in this environment buyers are price takers, they determine their demand for input j from a cost-minimization problem taking its price as given. Solving the first-order conditions separately for each buyer yields a buyer-specific price as a product of seller's costs and mark-up in (7). The mark-up, in turn, is a function of the elasticity of input demand in (8). This input demand function is derived from the buyer's cost minimization problem:

$$\min_{m_{j,k \forall j,k}} \sum_{k=1}^{N_m} p_{jk} m_{jk} \quad \text{subject to} \quad \left(\sum_{k=1} \delta_{jk}(\varphi) m_{jk}^{\frac{\eta_j - 1}{\eta_j}} \right)^{\frac{\eta_j}{\eta_j - 1}} \geq m_s(\varphi),$$

where $m_s(\varphi)$ is aggregate demand for inputs in sector s. Solving this problem yields:

$$m_{jk}(\varphi) = \delta_{jk}(\varphi)^{n_j} \left(\frac{p_{jk}(\varphi)}{\mathbb{P}_j(\varphi)} \right)^{-\eta_j} m_s(\varphi),$$

where $\mathbb{P}_j(\varphi) \equiv \left(\sum_{n=1}^{N_m} \delta_{jk}(\varphi)^{\eta_j} p_{jk}^{1-n_j}(\varphi) \right)^{\frac{1}{1-n_j}}$ is input j's price index faced by downstream buyer φ. The aggregate demand for inputs from sector s is, in turn, a solution to the following cost-minimization problem:

$$\min_{m_s(\varphi)\forall s} \sum_{j\in N_s} \mathbb{P}_j(\varphi)m_s(\varphi) \quad \text{subject to} \quad \left(\sum_{j\in N_s} m_j(\varphi)^{\frac{\theta_s-1}{\theta_s}}\right)^{\frac{\theta_s}{\theta_s-1}} \geq M_s(\varphi), \tag{23}$$

where $M_s(\varphi)$ is aggregate quantity of material inputs purchased by buyer φ. Solving this problem yields

$$m_s(\varphi) = \left(\frac{\mathbb{P}_j(\varphi)}{\mathbb{J}_s(\varphi)}\right)^{-\theta_s} M_s(\varphi), \tag{24}$$

where $\mathbb{J}_s(\varphi) \equiv \left(\sum_{j\in N_s} \mathbb{P}_j(\varphi)^{1-\theta_s}\right)^{\frac{1}{1-\theta_j}}$ is the material inputs' price index faced by buyer φ. It depends on the aggregate demand for material inputs, $M_s(\varphi)$, which is a solution to the firm's problem of choosing between material inputs and labor to minimize its costs:

$$\min_{L,M_s(\varphi)} \quad wL + \mathbb{J}_s(\varphi)M_s(\varphi) \quad \text{subject to} \quad \varphi L_s^{\alpha_s} M_s^{1-\alpha_s}(\varphi) \geq q_s(\varphi),$$

where $q_s(\varphi)$ is the demand for firm's φ product in its output industry s in (2). Plugging the solution to this problem into (24), and then (24) into (A.1.1) yields the derived demand for input j from firm φ in (8):

$$m_{jk}(\varphi) = \delta_{jk}(\varphi)^{\eta_j}\varphi^{\sigma_s-1}p_{jk}(\varphi)^{-\eta_j}\mathbb{P}_j(\varphi)^{\eta_j-\theta_s}\mathbb{J}_s(\varphi)^{(1-\alpha_s)(1-\sigma_s)+\theta_s-1}A_s,$$

$$\mathbb{P}_j(\varphi) \equiv \left(\sum_{n=1}^{N_m} \delta_{jk}(\varphi)^{\eta_j} p_{jk}^{1-n_j}(\varphi)\right)^{\frac{1}{1-n_j}}, \quad \mathbb{J}_s(\varphi) \equiv \left(\sum_{j\in N_s} \mathbb{P}_j(\varphi)^{1-\theta_s}\right)^{\frac{1}{1-\theta_j}}$$

$$A_s \equiv \beta_s E\mathbb{P}_s^{\sigma_s-1}\left(\frac{\sigma_s}{\sigma_s-1}\right)^{-\sigma_s}\left(\frac{w}{\alpha_s}\right)^{\alpha_s(1-\sigma_s)}(1-\alpha_s)^{1-(1-\alpha_s)(1-\sigma_s)}$$

As in Atkeson and Burstein (2008), oligopolists internalize the effect of their pricing decisions on their downstream buyers' costs when assessing their input demand elasticity (8). Log-linearizing this derived demand and then taking the derivative with respect to log $p_{jk}(\varphi)$ then yields input demand elasticities in (9). They are functions of seller's share in buyer's input j expenditures and in buyer's total expenditures on material inputs, $s_{jk}^J(\varphi) \equiv \frac{p_{jk}(\varphi)m_{jk}(\varphi)}{\sum_{n=1}^{N_m} p_{jk}(\varphi)m_{jk}(\varphi)}$ and $s_J^M(\varphi) \equiv \frac{\mathbb{P}_j(\varphi)m_j(\varphi)}{\sum_{j\in N_s}\mathbb{P}_j(\varphi)m_j(\varphi)}$, respectively.

Input prices under oligopsony

Proof of Proposition 2. Under oligopsony, input buyer φ chooses material inputs and labor, to solve the following profit-maximization problem:

$$\pi_s(\varphi) = p_s(\varphi)q_s(\varphi) - wL_s(\varphi) - \sum_{j \in N_s} p_j(m_j(\varphi))m_j(\varphi), \tag{25}$$

subject to the final consumers' demand in (2), downstream technology in (3) - (5), and internalizing the effect of an increase in input quantity on sellers' average costs $p_j(m_j(\varphi)) = \frac{w m_j(\varphi)^{1/\gamma_j - 1}}{a^{1/\gamma_j}}$.

Using (2), and (3) - (5), it can be re-written as a function of input quantities and their prices as:

$$\pi_s(\varphi) = \beta_s E \mathbb{P}_s{}^{\frac{1}{\sigma_s}} \varphi^{\frac{\sigma_s - 1}{\sigma_s}} L_s^{\alpha_s \frac{\sigma_s - 1}{\sigma_s}} M_s(\varphi)^{(1-\alpha_s)\frac{\sigma_s - 1}{\sigma_s}} - wL_s - \sum_{j \in N_s} p_j(m_j(\varphi))m_j(\varphi)$$

As in Berger et al. (2019), I first solve firm's problem maximization problem with respect to labor:

$$L_s(\varphi) = \Lambda_s \tilde{\varphi} \tilde{M}_s^{1-\alpha_s},$$

where $\Lambda_s \equiv \left(\frac{1}{\left(\beta_s \mathbb{E}\mathbb{P}_s{}^{\sigma_s - 1}\right)^{\frac{1}{\sigma_s}}} \frac{\sigma_s}{w \alpha_s (\sigma_s - 1)} \right)^{\frac{1}{\alpha_s(\frac{\sigma_s - 1}{\sigma_s} - 1)}}$, $\tilde{\varphi} \equiv \varphi^{\frac{1 - 1/\sigma_s}{1 - \alpha_s(1 - 1/\sigma_s)}}$, and $\tilde{M}_s(\tilde{\varphi}) \equiv M_s(\varphi)^{\frac{1 - 1/\sigma_s}{1 - \alpha_s \frac{\sigma_s - 1}{\sigma_s}}}$.

Plugging it in oligopsonist's profit function (25), yields the profit function net of labor expenses in (11), where $\tilde{A}_s \equiv (1 - \alpha_s) \left((\beta_s \mathbb{E}\mathbb{P}_s^{\sigma_s - 1})^{1/\sigma_s} \frac{\sigma_s - 1}{\sigma_s} (w/\alpha_s)^{-\alpha_s(1 - 1/\sigma_s)} \right)^{\frac{1}{1 - \alpha_s(1 - 1/\sigma_s)}}$.

Input prices under oligopoly with outside options

Proof of Proposition 3. Countervailing buyer power can arise in oligopoly when buyers are allowed to choose the number of suppliers that purchase an input from before inquiring sellers for their prices. Therefore, when making their pricing decisions, sellers internalize their effect on buyers' decision to introduce a rival. Buyers will find it profitable, when their profits from having multiple suppliers (denoted with """) exceed their profits when purchasing from only one supplier (denoted with ""):

$$\pi_s^{'}(\varphi) = \beta_s \mathbb{EP}_s^{\sigma_s - 1} \left(\frac{\sigma_s}{\sigma_s - 1}\right)^{1-\sigma_s} \varphi^{\sigma_s - 1} \left(\frac{w}{1-\alpha_s}\right)^{\alpha_s(1-\sigma_s)} \left(\frac{\mathbb{J}_s^{'}(\varphi)}{\alpha_s}\right)^{(1-\alpha_s)(1-\sigma_s)}$$

$$\pi_s^{''}(\varphi) = \beta_s \mathbb{EP}_s^{\sigma_s - 1} \left(\frac{\sigma_s}{\sigma_s - 1}\right)^{1-\sigma_s} \varphi^{\sigma_s - 1} \left(\frac{w}{1-\alpha_s}\right)^{\alpha_s(1-\sigma_s)} \left(\frac{\mathbb{J}_s^{''}(\varphi)}{\alpha_s}\right)^{(1-\alpha_s)(1-\sigma_s)} - f_j w$$

These profit functions are derived using that, as in the Melitz (2003), $\pi_s(\varphi) = \frac{p_s(\varphi)q_s(\varphi)}{\sigma_s}$, constant downstream firm's mark-up, $\frac{\sigma_s}{\sigma_s - 1}$, and its marginal costs under production function in (3) - (6) $\frac{1}{\varphi}\left(\frac{w}{1-\alpha_s}\right)^{\alpha_s} \frac{J_s(\varphi)}{\alpha_s}$.

Re-arranging the condition that $\pi_s^{''}(\varphi) > \pi_s^{'}(\varphi)$ results in condition in (12), where $B_s \equiv \frac{\beta_s}{\sigma_s} E\mathbb{P}_s^{\sigma_s - 1} \left(\frac{\sigma_s}{\sigma_s - 1}\right)^{1-\sigma_s} \left(\frac{w}{1-\alpha_s}\right)^{\alpha_s(1-\sigma_s)} \alpha_s^{(\sigma_s - 1)(1-\alpha_s)}$.

To interpret this condition (12), I use insights from Feenstra (1994) and re-write the change in buyer's marginal costs after adding suppliers of input j as[26]

$$\frac{\mathbb{J}_s^{''}(\varphi)}{\mathbb{J}_s^{'}(\varphi)} = \left(\frac{p_{jk}^{''}(\varphi)}{p_{jk}^{'}(\varphi)}\right)^{\omega_j^{''}(\varphi)} \left(s_{jk}^{J''}(\varphi)\right)^{\frac{\omega_j^{''}(\varphi)}{\eta_j - 1}}, \tag{26}$$

$s_{jk}^{J''}(\varphi)$ is a share of seller k in buyer's expenditures on input j defined in (9); and $\omega_j^{''}(\varphi)$ is a Sato-Vartia (log-change) weight defined as:

$$\omega_j^{''}(\varphi) \equiv \frac{\left(s_j^{M''}(\varphi) - s_j^{M'}(\varphi)\right) / \left(\log s_j^{M''}(\varphi) - \log s_j^{M'}(\varphi)\right)}{\sum_{i \in N_s} \left(s_i^{M''}(\varphi) - s_i^{M'}(\varphi)\right) / \left(\log s_i^{M''}(\varphi) - \log s_i^{M'}(\varphi)\right)}$$

The first component on the right-hand side of (26) reflects the reduction in seller k's price of input j after the buyer adds other suppliers of that input, while the second component takes into account a positive effect of the growth of input varieties on buyer's productivity. When a buyer starts purchasing an input from multiple suppliers, then seller k's share in buyer's expenditures on that input falls from one to $s_{jk}^{J''}(\varphi) < 1$, and the larger this reduction, the larger the variety gains of productivity for the buyer. Unsurprisingly, these variety gains disappear when seller differentiation within industry goes down or, in other words, when their products become perfectly substitutable ($\eta_j \to +\infty$).

Input prices in a bilateral bargaining framework

[26]Here I follow Amiti et al. (2020) in assuming that a buyer's taste for a given seller in an input market does not depend on the number of sellers the buyer sources this input from.

Proof of Proposition 4. When buyer φ and seller a_k bargain over price p_{jk} of input j, the price is a solution to the following maximization problem, taking other sellers' prices as given:

$$\max_{p_{jk}} \left[\Delta\Pi^B(N_j;\varphi)\right]^{\kappa_k(\varphi)} \left[\Delta\Pi^S(\Omega_k;a_k)\right]^{1-\kappa_k(\varphi)} \tag{27}$$

where firms' extra profits from successful negotiations can be written as:

$$\Delta\Pi^B(p_{jk}) = B_s\varphi^{\sigma_s-1}\left\{\mathbb{J}_s(p_{jk})^{(1-\alpha_s)(1-\sigma_s)} - \mathbb{J}_s(p_{jk'})^{(1-\alpha_s)(1-\sigma_s)}\right\}$$
$$\Delta\Pi^S(p_{jk}) = \left(p_{jk} - \frac{w m_{jk}(p_{jk})^{1/\gamma_j-1}}{\gamma_j a_k^{1/\gamma_j}}\right) m_{jk}(p_{jk}),$$

where $\mathbb{J}_s(p_{jk'})$ are unit input costs when buyer φ and seller k fail to reach agreement over input j's price. First-order conditions for this problem expressed in logs are as follows:

$$\kappa_k(\varphi)\frac{\frac{\partial\pi^B(p_{jk})}{\partial p_{jk}}}{\Delta\Pi^B(N_j;\varphi)} + (1-\kappa_k(\varphi))\frac{\frac{\partial\pi^S(p_{jk})}{\partial p_{jk}}}{\Delta\Pi^S(\Omega_k;a_k)} = 0$$

Re-arranging the terms, one can get:

$$\frac{\partial\pi^B(p_{jk})/\partial p_{jk}}{\partial\pi^S(p_{jk})/\partial p_{jk}} = \frac{1-\kappa_k(\varphi)}{\kappa_k(\varphi)}\frac{\Delta\Pi^B(N_j;\varphi)}{\Delta\Pi^S(\Omega_k;a_k)}$$

Plugging in expression for $\Delta\Pi^B(N_j;\varphi)$ and $\Delta\Pi^S(\Omega_k;a_k)$ and solving for price yields:

$$p_{jk}(\varphi) = w/a_k + \kappa_k(\varphi)\frac{\Delta\Pi^B}{m_{jk}(\varphi)}\left(1 + \frac{p_{jk}(\varphi) - w/a_k}{m_{jk}(\varphi)}\frac{\partial m_{jk}(\varphi)}{\partial p_{jk}(\varphi)}\right)$$

Here, the first term on the right-hand side represents seller's marginal costs assumed to be constant, for simplicity, while the second term is seller's absolute mark-up. Solving for the percentage mark-up, as a share of the price, results in the expression in the main text:

$$\frac{p_{jk} - w/a_k}{p_{jk}} = \frac{1}{-\frac{\partial m_{jk}}{\partial p_{jk}}\frac{p_{jk}}{m_{jk}} + \kappa_k(\varphi)\frac{p_{jk}}{\Delta\Pi^B(p_{jk})/m_{jk}}},$$

A.1.2 Proofs of Propositions in Section 2.6

The effect of foreign country's trade liberalization

Proof of Proposition 5. In oligopolistic markets, a reduction in the foreign

country's tariffs or domestic firm's entry into a foreign market lead to an increase in the domestic firm's derived demand for inputs in (8).

$$m_{jk}(\varphi) = \delta_{jk}(\varphi)^{\eta_j} \varphi^{\sigma_s - 1} p_{jk}(\varphi)^{-\eta_j} \mathbb{P}_j(\varphi)^{\eta_j - \theta_s} \mathbb{J}_s(\varphi)^{(1-\alpha_s)(1-\sigma_s)+\theta_s-1} A_s^*(\varphi)$$

Here, $A_s^*(\varphi) \equiv A_s \left(1 + \mathbb{1}_x(\varphi)\tau_s^{-\sigma_s} \left(\mathbb{P}_s^*/\mathbb{P}_s\right)^{\sigma_s - 1} E^*/E\right) > A_s$ captures an increase in firm's input demand following its decision to export ($\mathbb{1}_x(\varphi) = 1$) or a reduction of the foreign country's tariff τ_s.

If, in oligopolistic markets, buyers are price takers, their input demand elasticities for a seller's product in (9 and hence mark-ups are determined by the seller's share in the buyer's expenditures. As shown in (8), these shares do not vary with the total demand of the buyer for the seller's product. Therefore, in this case, a reduction in foreign country's tariffs or a domestic firm's entry into a foreign market does not affect its input prices.

In contrast, if, in oligopolistic markets, exogenously larger (more productive) buyers can affect prices through outside options, an input demand shifter $A^* > A$ encourages buyers to make costly investments in getting better outside options. Condition in (12) that needs to be satisfied for a buyer to get more suppliers in a market when exporting by domestic firms is possible becomes:

$$B_s^*(\varphi)\varphi^{\sigma_s - 1} \mathbb{J}_s'(\varphi)^{(1-\alpha_s)(1-\sigma_s)} \left\{ \left(\frac{\mathbb{J}_s''(\varphi)}{\mathbb{J}_s'(\varphi)} \right)^{(1-\alpha_s)(1-\sigma_s)} - 1 \right\} > f_j w,$$

where $B_s^*(\varphi) \equiv B_s \left(1 + \mathbb{1}_x(\varphi)\tau_{fs}^{-\sigma_s} \epsilon_f^{\sigma_s} \left(\mathbb{P}_{fs}/\mathbb{P}_s\right)^{\sigma_s - 1} E_f/E\right) > B_s$ if $A_s^*(\varphi) > A_s$. As a result, for initially large enough domestic firms, better exporting opportunities allows them to get lower prices from their existing suppliers. Under oligopsony, a reduction in the foreign country's tariffs or domestic firm's entry into a foreign market lead to an increase in the oligopsonist's marginal revenue product of each input. It increases the value of the expression on the right-hand side of (11), which can be re-written as:

$$(1 - \alpha_s)\tilde{A}_s^* \tilde{\varphi} \tilde{M}_s(\tilde{\varphi})^{-\alpha_s} \left(\frac{m_j(\tilde{\varphi})}{\tilde{M}_s(\tilde{\varphi})} \right)^{-1/\theta_s} = \frac{\partial p_j(\tilde{\varphi})}{\partial m_j(\tilde{\varphi})} m_j(\tilde{\varphi}) + p_j(\tilde{\varphi}) \tag{28}$$

Here, $\tilde{A}_s^* = \tilde{A}_s \left(1 + \mathbb{1}_x(\varphi)\tau_s^{-\sigma_s} \left(\mathbb{P}_s^*/\mathbb{P}_s\right)^{\sigma_s - 1} E^*/E\right)^{\frac{1}{\sigma_s(1-\alpha_s)+\alpha_s}} > \tilde{A}_s$ captures an increase in the marginal revenue product of an oligopsonist that decides to export or experiences a reduction of the foreign country's tariff.

For the oligopsonistic market to reach a new equilibrium, marginal costs on the left-hand side of (28) should increase to balance an increased marginal product revenue of an oligopsonist. Because, under oligopsony, marginal and average costs are assumed to increase in quantities, it means that in the new equilibrium, an oligopsonist purchases more units of each input. Because sellers are perfectly competitive and set prices equal to their average costs it results in higher prices charged to the oligopsonist.

Pass-through of seller cost shocks into prices

Proof of Proposition 6. Under oligopoly, mark-up adjustment to an adverse supply shock such as seller's currency appreciation is

$$\frac{d\log p_{jk}}{d\log \varepsilon_{jk}^{\$}} = \Gamma(s_{jk}^J(\varphi))\frac{d\log s_{jk}^J(\varphi)}{d\log \varepsilon_{jk}^{\$}} \tag{29}$$

The first term is mark-up elasticity with respect to the seller's share in buyer's expenditures:

$$\Gamma(s_{jk}^J(\varphi)) \equiv \frac{d\log \mu_{jk}(\varphi)}{d\log s_{jk}^J(\varphi)} = \frac{\left[\eta_j - \theta_s + (\theta_s - 1 + (1-\alpha_s)(1-\sigma_s))s_J^M(\varphi)\right] s_{jk}^J(\varphi)}{\zeta_{jk}(\varphi)(\zeta_{jk}(\varphi)+1)} =$$
$$= \frac{\zeta_{jk}(\varphi) + \eta_j}{\zeta_{jk}(\varphi)(\zeta_{jk}(\varphi)+1)} > 0$$

The second term is elasticity of the seller's share in buyer's expenditures with respect to the exchange rate:

$$\frac{d\log s_{jk}^J(\varphi)}{d\log \varepsilon_{jk}^{\$}} \equiv (1-\eta_j)\left(1 + \frac{d\log p_{jk}(\varphi)}{d\log \varepsilon_k^{\$}} - \frac{d\log \mathbb{P}_j(\varphi)}{d\log \varepsilon_k^{\$}}\right) > 0$$

Using this expression in (29) and solving for $\frac{d\log p_{jk}}{d\log \varepsilon_{jk}^{\$}}$, results in:

$$\frac{d\log p_{jk}(\varphi)}{d\log \varepsilon_k^{\$}} = -\frac{(\eta_j - 1)\Gamma(s_{jk}^J(\varphi))}{1 + (\eta_j - 1)\Gamma(s_{jk}^J(\varphi))}\left(1 - \frac{d\log \mathbb{P}_j(\varphi)}{d\log \varepsilon_k^{\$}}\right) \tag{30}$$

The second term reflects perceived effect of seller's mark-up adjustment on buyer's

costs:

$$\frac{d\log \mathbb{P}_j(\varphi)}{d\log \varepsilon_k^{\$}} = s_{jk}^J(\varphi) + s_{jk}^J(\varphi)\frac{d\log p_{jk}(\varphi)}{d\log \varepsilon_k},$$

assuming that exchange rate changes are not large enough to affect buyer's decision to add suppliers. Plugging this expression into (30) and solving for $\frac{d\log p_{jk}(\varphi)}{d\log \varepsilon_k^{\$}}$ yields the expression in the main text:

$$\frac{d\log p_{jk}(\varphi)}{d\log \varepsilon_k^{\$}} = -\frac{(\eta_j-1)\Gamma(s_{jk}^J(\varphi))(1-s_{jk}^J(\varphi))}{1+(\eta_j-1)\Gamma(s_{jk}^J(\varphi))(1-s_{jk}^J(\varphi))} \leq 0$$

It is negative as long as $s_{jk}^J(\varphi) > 0$: large sellers reduce their mark-ups in response to appreciation of their currency with respect to invoice currency (US dollar). This mark-up reduction gets larger when $\Gamma(s_{jk}^J(\varphi)) \cdot (1-s_{jk}^J(\varphi))$ increases. This term is positive and equals zero when $s_{jk}^J(\varphi) = 0$ and when $s_{jk}^J(\varphi) = 1$. It means that it increases in $s_{jk}^J(\varphi)$ up to a certain value of $s_{jk}^J(\varphi)$, and decreases afterwards. Specifically, it increases in $s_{jk}^J(\varphi)$ if $s_{jk}^J(\varphi) < 1/2$. To see this, write its derivative as:

$$\Gamma'(s_{jk}^J(\varphi))(1-s_{jk}^J(\varphi)) - \Gamma(s_{jk}^J(\varphi)) = \Gamma(s_{jk}^J(\varphi))\left[\frac{\Gamma'(s_{jk}^J(\varphi))}{\Gamma(s_{jk}^J(\varphi))}(1-s_{jk}^J(\varphi)) - 1\right],$$

$$\text{where}\quad \Gamma'(s_{jk}^J(\varphi)) \equiv \frac{\partial\Gamma(s_{jk}^J(\varphi))}{\partial s_{jk}^J(\varphi)} = -\underbrace{\frac{\zeta_{jk}^2(\varphi)+2\eta_j\zeta_{jk}(\varphi)+\eta_j}{\zeta_{jk}^2(\varphi)(\zeta_{jk}(\varphi)+1)^2}}_{<0}\cdot\underbrace{\frac{\partial\zeta_{jk}(\varphi)}{\partial s_{jk}^J(\varphi)}}_{>0} > 0$$

Because $\Gamma(s_{jk}^J(\varphi)) > 0$, the derivate in (A.1.2) is positive if and only if the second term in parenthesis is positive:

$$\begin{aligned}
\frac{\Gamma'(s_{jk}^J(\varphi))}{\Gamma(s_{jk}^J(\varphi))}(1-s_{jk}^J(\varphi)) - 1 > 0 &\Leftrightarrow \frac{\Gamma'(s_{jk}^J(\varphi))}{\Gamma(s_{jk}^J(\varphi))} > \frac{1}{1-s_{jk}^J(\varphi)} \\
&\Leftrightarrow \frac{-(\zeta_{jk}^2(\varphi)+2\eta_j\zeta_{jk}(\varphi)+\eta_j)}{\zeta_{jk}(\varphi)(\zeta_{jk}(\varphi)+1)} > \frac{s_{jk}^J(\varphi)}{1-s_{jk}^J(\varphi)} \\
&\Leftrightarrow \underbrace{\frac{\eta_j-|\zeta_{jk}(\varphi)|}{|\zeta_{jk}(\varphi)|}}_{>0} + \underbrace{\frac{\eta_j-1}{|\zeta_{jk}(\varphi)-1|}}_{>1} > \underbrace{\frac{s_{jk}^J(\varphi)}{1-s_{jk}^J(\varphi)}}_{<1 \text{ if } s_{jk}^J(\varphi)<1/2}
\end{aligned}$$

Hence, for $s_{jk}^J(\varphi) \in (0, 1/2)$, the negative mark-up adjustment increases in $s_{jk}^J(\varphi)$. In turn, this means, that buyers with larger expenditure shares spent on the seller's product, experience a smaller increase in prices in the invoice currency in responds

to the seller's currency appreciation. This is because sellers absorb more of their cost increase in initially larger mark-ups charged to buyers with higher expenditure shares on their products.

Under oligopsony with competitive sellers, prices are determined from the upward sloping supply curve, which, in the invoice currency can be expressed as:

$$p_{jk}^{\$} = \varepsilon_k^{\$} \frac{w_k m_{jk}^{1/\gamma_j - 1}}{a_k^{1/\gamma_j}}$$

Fully differentiating it with respect to the nominal exchange rate, $\varepsilon_k^{\$}$, yields:

$$\frac{d \log p_{jk}^{\$}}{d \log \varepsilon_k^{\$}} = 1 + \left(\frac{1}{\gamma_j} - 1 \right) \frac{d \log m_{jk}(\varphi)}{d \log p_{jk}^{\$}} \frac{d \log p_{jk}^{\$}}{d \log \varepsilon_k^{\$}}$$

Solving for $\frac{d \log p_{jk}^{\$}}{d \log \varepsilon_k^{\$}}$ results in the following expression for exchange rate pass-through of into buyer dollar-price:

$$\frac{d \log p_{jk}^{\$}}{d \log \varepsilon_k^{\$}} = \frac{1}{1 - \left(\frac{1}{\gamma_j} - 1 \right) \frac{d \log m_{jk}(\varphi)}{d \log p_k^{\$}}} < 1$$

It is less than complete because oligopsonist's input demand elasticity, $\frac{d \log m_{jk}(\varphi)}{d \log p_k^{\$}}$ is negative. Input demand on the left-hand side of (11) implies that $\frac{d \log m_{jk}(\varphi)}{d \log p_k^{\$}} = -\theta_s$. In this case, pass-through is incomplete and constant across buyers because of the negative adjustment of price in the seller's currency:

$$\frac{d \log p_{jk}}{d \log \varepsilon_k^{\$}} = -\frac{\theta_s}{1 + \left(\frac{1}{\gamma_j} - 1 \right) \theta_s} < 0$$

The pass-through can vary across buyers if input supply elasticity is not constant. This could be the case if sellers had diseconomies of scale at the level of their total output rather than at the level of output per buyer.[27] For example, assume that

[27] Alternatively, input supply elasticity is not constant if buyers and seller are differentiated as in Berger et al. (2019).

seller's total cost function is

$$TC(M_{jk}) = \varepsilon_k^{\$} w_k \frac{M_{jk}^{1/\gamma_j}}{a_k^{1\gamma_j}}, \qquad M_{jk} = \int_{\varphi \in \Omega_{jk}} m_{jk}(\varphi) d\varphi$$

In this case, oligopsonistic mark-downs are not constant across buyers, but increasing in buyer's share in seller's output, $m_{jk}(\varphi)/M_{jk}$. Moreover, these mark-downs adjust in response to the seller's currency appreciation resulting in a non-constant pass-through into prices in the invoice currency:

$$\frac{d \log p_{jk}^{\$}}{d \log \varepsilon_k^{\$}} = \frac{1}{1 + \left(\frac{1}{\gamma_j} - 1\right) \theta_s \frac{m_{jk}(\varphi)}{M_j}} < 1$$

Here, the pass-through is more complete for smaller buyers $m_{jk}(\varphi) \to 0$, and less complete for larger buyers of the seller.

A.1.3 Linear functional forms

Building on the simple set-up from Horn and Wolinsky (1988), I consider a market with one upstream seller and one downstream buyer. The buyer combines one unit of an in-house produced input with one unit of an input purchased from the upstream seller in production of a good, for which there is a linear consumer demand. The upstream input seller's production technology, in general, can feature increasing, decreasing or constant returns to scale.

Assume that the buyer incurs marginal cost z to produce the in-house input and faces the linear demand function $p(q) = a - q$. Because the in-house and purchased inputs are used one for one in production, by assumption, the buyer purchases $x = q$ units of the seller's input to produce q units of output. The price of the purchased input w depends on whether it is procured in a market featuring monopoly, monopsony or the combination of the two (bilateral bargaining).

Monopoly If the procured input market is a monopoly, then input and final goods' prices are determined from two consecutive monopoly problems. Solving them backwards, the downstream firm first maximizes profits keep the input price w as given: $\pi_M^D = (a - q - z - w)q$. It determines the profit maximizing output quantity, which, in turn, determines buyer's demand for the input purchased from the upstream

monopolist: $x(w) = q(w) = \frac{a-z-w}{2}$. Faced with this derived demand for the input, the upstream monopolists solves the following profit maximization problem, assuming her marginal costs are constant at zero (for simplicity)[28]: $\pi_M^U = w(a-z-w)/2$. This results in the equilibrium input price under monopoly $w^M = (a-z)/2$. Importantly, this price decreases with the downstream firm's marginal costs of production of the in-house input z and increases in consumers' maximum willingness to pay a.

Monopsony In contrast, under monopsony, the downstream buyer sets the input price to maximize profits while taking into account the effect of this decision on the seller's marginal costs that are assumed to be increasing in quantity.[29] Assuming, for simplicity, that seller's marginal costs linearly increase in quantity, the monopsonist maximizes: $\pi_m^D = (a-x-z-x)x$. This yields the following equilibrium input price: $w_m = (a-z)/4$. It is expectedly lower than the input price under monopoly, which, under the same upward sloping marginal cost assumption becomes $2(a-z)/3$. However, monopsony implies the same comparative statics with respect to the downstream firm's own productivity and market size. Input prices under monopsony, much like under monopoly, decrease in the buyer's marginal costs or increase in its own productivity and increase in the downstream market size. However, the underlying mechanism is different, as illustrated on Figure.The monopsonist sets lower input prices by restricting the quantity to avoid an increase in seller's costs. When the monopsonist becomes more productive, consumers demand more of the monopsonist's output for every price, which requires more inputs from the upstream industry. Because, under monopsony, input prices are determined from the upward sloping marginal cost function, more inputs are purchased by a more productive monopsonist at a higher price.[30] This comparative statistics has been recognized in the labor economics literature (Bhaskar et al. (2002), Berger et al. (2019)) and used to explain the wage premium paid by larger establishments (Idson and Oi (1999)).

Bilateral bargaining Finally, consider the case when input prices are determined

[28] In a fully-fledged model embedded in an international trade environment, I allow for a general cost structure of the sellers.

[29] Increasing marginal cost of production is the necessary condition for the monopsony power (see Ashenfelter et al. (2010)).

[30] Notice that more productive monopsonists and monopsonists in larger markets pay higher input prices, despite getting larger mark-downs relative to the perfectly competitive inputs market. Under perfect competition, the input price is $w_{PC} = (a-z)/2$, which implies a mark-down of $(a-z)/4$.

as a result of bilateral bargaining between the two firms. Extending the original setting in Horn and Wolinsky (1988), allow for potentially different bargaining abilities of the buyer with bargaining power ϕ and the seller with bargaining power $1-\phi$. Assuming again that seller's marginal costs are constant at zero, the input price w solves the following maximization problem: $\left(\pi_B^D\right)^{\phi}\left(\pi_B^U\right)^{\phi} = \left(\pi_B^D(w)\right)^{\phi}\left(wx(w)\right)^{1-\phi}$, where $\pi_B^D(w)$ and $x(w)$ are the downstream firm's profits and demanded input quantity, given the input price w, respectively. In the Appendix, I show that $w_B = (a-z)(1-\phi)/2$ solves this problem. Notice that if downstream production only relies on the input procured from the upstream market, as is assumed in Horn and Wolinsky (1988) and Alviarez et al. (2021b), then the downstream firm's productivity z will not affect the price. In this case, the input price varies only with the size of the downstream market a and the exogenous parameter of the buyer's bargaining ability ϕ. Naturally, when buyer's bargaining ability, ϕ, increases, input price decreases while input quantity increases. In contrast, when the size of the downstream market a increases, input price also increases. The introduction of the downstream firm's own productivity z in this basic setting shows that, conditional on the buyer's bargaining ability, an improvement in the firm's productivity (a reduction in z) results in a higher input price. Intuitively, this is because linear prices in the bilateral bargaining are used as an instrument to share the surplus, which increases with the downstream firm's own productivity. This mechanism behind the positive buyer productivity - price relationship is different from that in case of the monopsony, because, unlike monopsony, it does not require diseconomies of scale in production. Importantly, it also implies a stark differences between the effects that buyer's bargaining ability and raw productivity have on input prices. Unlike an increase in the downstream firm's productivity, an increase in its bargaining power only redistributes the unchanged total surplus towards the buyer. As a result, *higher* bargaining power implies *lower* input prices, while *higher* raw productivity implies *higher* input prices.

A.2 Data

A.2.1 Cleaning

Textual analysis of firm and brand names

Before cleaning company names reported in Paraguayan customs data, I used

them to identify trade intermediaries on both buyer and seller sides. For that, I used Stata's regular expressions (*regex*) to look for words common for trade intermediaries in their names: export, import, trading, exportadora, importadora, exp, imp, etc. To identify wholesalers and retailers among Paraguayan importers, I merged their names with names of Paraguayan companies in the Orbis data, which reports companies' main NACE industries. Wholesalers and retailers are firms operating mainly in 2-digit NACE industries "46" and "47", respectively.

To standardize foreign seller names, I first clean the reported names from commonly used legal abbreviations (Ltd., Limited, Incorportated, LLC, GMBH, Group, Company, Holding, etc), names of their countries (reported separately in the data) and names of largest world cities. I also removed word indicators of trade intermediaries (exp, imp, trading, etc.) discussed above.

Then, to correct spelling mistakes in seller names, I calculated a similarity score between every two cleaned company names, using Stata's *matchit* function. This similarity score ranges from 0 to 1, where a score of 1 implies a perfect similarity between two strings, according to the chosen string matching technique. I started with the strictest *token* technique, for which I used the threshold similarity score value of 0.9 to identify the two names as the same. This resulted in clusters of firms with very similar names, to which I assign a common name. Then to these common names I sequentially applied other techniques in the order of their strictness: *circular fourgram-*, *threegram-*, *fivegram-*, and *bigram-*. Each time I assigned a common name to firms with a similarity score above 0.75 and proceeded by matching the resulting names with another method. This procedure allowed me to substantially reduce the number of unique seller names from 255 278 to 89 365.

I apply the same procedure to clean and standardize reported brand names too.

Definitions of regular sellers and brands

I identify a foreign seller with its unique name (cleaned and standardized) and a reported country from which a good is exported to Paraguay. This way, each location of a multinational firm is treated as a separate firm. Then I define a regular (or frequent) seller to Paraguay as a foreign seller with at least 1000 recorded transactions throughout the sample period. For these regular sellers, I manually checked that the variations of each regular seller's name in the original data were indeed due to spelling

mistakes and that my textual analysis correctly identified them as the same seller.

I define a regular (or frequent) brand name as a cleaned brand name which appears in at least 300 transactions in my sample. For these regular brands, I also manually checked that a common brand name assigned to initially differently spelled brands only corrected misspelling in the original brand names.

Units of measurement

I assigned kilograms to products whose HS6 code is suggested to be reported in kilograms in the Mercosur Nomenclature. Moreover, I assign kilograms as the units of measurement to transactions, whose reported unit of measurement is not kilograms but whose commercial quantity was equal to the reported (gross or net) weight. All other products were assigned the reported unit of measurement cleaned from typos.

Intra-firm transactions and multinational affiliates

In absence of an indicator for intra-firm transactions in my data, I infer them from the available names of transacting firms and brands of transacted products. First, for each transaction, I check whether a cleaned and standardized seller name appears as a part of an importer's name. This way I detect transactions between, for example, "Unilever de Paraguay" and "Unilever de Brazil", "Unilever de Uruguay", "Unilever de Argentina; "Yazaki do Brasil" and "Yazaki de Paraguay"; "Tetra Pak" and "Tetra Pak Paraguay". Secondly, I check whether a cleaned and standardized brand name appears as a part of an importer's name. The idea behind this step is that a foreign seller will not be producing a product under its buyer's name unless they are in the long-term relationships that potentially involve common ownership. This helps me identify transactions between related parties whose names do not have anything in common. And finally, I identify as intra-firm trade transactions between firms with common ownership, according to the information available in the Orbis ownership data. As a result of this procedure, around 6% of all import transactions in Paraguayan customs data are classified as intra-firm transactions.

Furthermore, I define an importer as a multinational affiliate if it has intra-firm transactions with at least one foreign seller to Paraguay. Analogously, I define a foreign seller as a multinational affiliate if has at least one intra-firm transaction.

Definitions of industries

Importers' industries are defined as their main NACE industry classification codes.

Textual analysis of commercial descriptions

Importers are obliged to provide non-generic product descriptions in a free format. To achieve some standardization of them, I first clean them of all information that is provided separately: seller names, countries of purchase, countries of origin, brand names, quantities (in numbers and in words), units of measurement, and weight. I also removed all Spanish, Portuguese and English articles and propositions, and verbs such as "includes", "contains", etc. Table A1 provides examples of cleaned brand names, and product descriptions.

Table A1. Examples of cleaned and standardized brands and commercial descriptions of imported products in the Paraguay's customs data (translated from Spanish)

HS code	Description	Brand
32149000	Mortar type ACI 20 kg bag	Votorantim
32149000	Mortar type ACI 20 kg bag	Quartzolit
33021000	Acid solution colorants	Coca-Cola
33021000	Aspartame	Coca-Cola
33051000	Shampoo Keratin Lift x 960cc	Question Professional
33051000	Shampoo Nutrition 960cc	Question Professional
33051000	Shampoo Retention 960cc	Question Professional
84833029	Vehicle bearings	Ford
84833029	Vehicle bearings	Toyota
87019490	Tractor model A990 4x4 yellow 2017	Valtra
87019490	Tractor model A750 4x4 yellow 2017	Valtra
87019490	Tractor model BM110 4x4 yellow 2017	Valtra

This conservative cleaning procedure ensures that after its application most potentially relevant product information is not removed. However, it does not take into account the fact that different importers can use different words or use them in a different order to describe the same product characteristics. I address this problem in a subsample of passenger vehicles (HS4 code "8703"), for which relevant product characteristics are known.

For passenger vehicles, I use Stata's regular expressions to find word indicators for used cars ("used", "usado", etc.), manual and automatic cars ("mec", "mt", "mecanica", "automatica", etc.), diesel and gasoline cars ("diesel", "naftero", "gasolina", etc.), flexible fuel cars ("flex", "flex fuel", etc.), sedan and hatchback car models ("sedan", "sdn", "hatch", etc.). I extract information on vehicles' years of fabrication

and calculate car ages as a difference between transaction's year and the identified year of fabrication. Additionally, some brands have indicators for a turbo engine (TDI, TFSI, etc.) and luxury trims (GLS, GL, LTZ, etc.) that I use as another quality measure.

A.2.2 Additional summary statistics

Table A2 shows that most goods imported to Paraguay are differentiated intermediate goods.

Table A2. Types of imported goods in Paraguay, 2013 - 2018

	% transactions	% annual value	% annual weight
	A. By differentiation		
Homogeneous	12	22	48
Differentiated	88	59	22
	B. By final use		
Capital	14	22	4
Intermediate	45	34	54
Consumer	29	23	13

Table A3 shows that importer heterogeneity remains to be an important independent determinants of within-seller price variation even when detailed characteristics of passenger vehicles are taken into account. Independently from each other, these characteristics and importer fixed effects explain, on average, 20% and 65% of the total explained variation of prices within Seller-HS8-Year, respectively.

Table A4 shows summary statistics for a subsample of interest: transactions of sellers selling products from the same HS8 category to multiple buyers in Paraguay.

A.3 Robustness checks and additional results

Table A5 shows patterns of price variation across buyers of the same seller identified with buyers' output market size as an instrument for annual purchases from the seller. The identification relies on importers that never export, and hence sell their output in their local markets. I define a local market as a district (one of 249), and use its population and area as demand-side instruments for buyer's purchases. Reduced-form

Table A3. The role of product differentiation and importer heterogeneity in price variation for passenger vehicles within HS8-Seller-Year (HS4 code "8703")

Dependent variable:	log Demeaned Price, HS8-Seller-Year				
	(1)	(2)	(3)	(4)	(5)
Adj. R^2	0.09	0.28	0.36	0.15	0.42
HS8×Brand×Origin	✓				✓
HS8×Brand×Origin×Model		✓	✓		✓
Weight + Other vehicle's characteristics			✓		✓
HS8×Importer				✓	✓

Notes: The reported Adj. R^2 are from regressions with log price deviations from the HS8-Seller-Year average as a dependent variable and the marked fixed effects as explanatory variables. Other vehicle's characteristics include: car age, dummy variables for used (as opposed to new) cars, gasoline engine (as opposed to diesel), manual (as opposed to automatic) box, turbo engine, sedan (as opposed to hatchback), and luxury model's trim.

Table A4. Firm characteristics in the subsample of interest

	$\bar{x}$	std	50%
Panel A: Buyers			
'000 $USD	3256	15009	194
# HS8	38.5	71	10
# Countries	3.6	4	2
# Sellers*	3.4	5.0	2
*Panel B: Sellers**			
'000 $USD	4731	16502	1020
# HS8	46.6	80	19
# Buyers	8.3	14.6	4

Notes: * denotes regular sellers to Paraguay as defined above.

and first stage results in columns (3) and (4), respectively, show that importers in districts with higher population density, all else equal, purchase more from and pay less to a given foreign seller in a given product market. Instrumenting for buyer size, in column (2), I find larger buyers get discounts when buying from the same seller.

Table A6 shows that buyer-size discounts in Table 7 are not a result of misreporting for tax evasion reasons. It reports the results of estimating equation (18) using import

Table A5. Price variation across buyers of the same seller, non-exporting importers

Dependent Variable:	log *Transaction Price*			
	(1)	(2)	(3)	(4)
	OLS	IV	OLS	I stage
$\log s^J_{jkt}(\varphi)$	-0.004	-0.007	0.039***	-0.736***
	(0.009)	(0.026)	(0.008)	(0.070)
$\log m_{jt}(\varphi)$	-0.057***	-0.061**		
	(0.007)	(0.030)		
$\log Area(\varphi)$			0.018**	-0.285***
			(0.009)	(0.053)
$\log Population(\varphi)$			-0.058**	0.411***
			(0.024)	(0.119)
log *Per-unit Weight*	0.356***	0.356***	0.361***	-0.080***
	(0.035)	(0.035)	(0.035)	(0.020)
Constant	3.712***		3.951***	3.916**
	(0.115)		(0.335)	(1.728)
HS8×Unit×Seller×Brand×Industry×Year	✓	✓	✓	✓
N obs	281988	281988	281988	281988
N clusters	595	595	595	595
Adj. R^2	0.975	0.082	0.975	0.936
Kleibergen-Paap rk Wald F		22.8		

* p<0.10, ** p<0.05, *** p<0.01

Robust standard errors clustered at importer- and exporter- levels in parentheses.

Notes: $s^J_{jkt}(\varphi)$ denotes seller's share in buyer's expenditures and $m_{jt}(\varphi)$ denotes buyer's annual purchases in HS6 category in year t.

transactions of Paraguay's largest taxpayers.[31] In this subsample, buyer-size discounts do not disappear, but become even larger. This cannot be explained by tax evasion, as the largest tax payers are not likely to engage in misreporting. But it is consistent with them being the largest importers with much better outside options. They are 363 importers that account for 56% of Paraguay's annual import value.

Table A7 shows that the documented patterns of price variation across buyers of

[31]The lists of top 500 tax payers in Paraguay is reported here www.set.gov.py

Table A6. Price variation across buyers of the same seller, large taxpayers

Dependent Variable:	log *Transaction Price*			
	(1)	(2)	(3)	(4)
	OLS	OLS	IV	I stage
$\log s^J_{jkt}(\varphi)$	0.167***	0.152***	0.183***	0.284***
	(0.036)	(0.038)	(0.047)	(0.027)
$\log m_{jkt}(\varphi)$	-0.091***		-0.108***	
	(0.021)		(0.038)	
$\log m_{jkt-1}(\varphi)$		-0.049***		0.458***
		(0.018)		(0.037)
log *Transaction Quantity*	-0.283***	-0.294***	-0.289***	0.045***
	(0.024)	(0.027)	(0.026)	(0.014)
log *Per-unit Weight*	0.313***	0.302***	0.302***	-0.006**
	(0.031)	(0.032)	(0.032)	(0.003)
Constant	5.263***	4.952***		4.104***
	(0.186)	(0.164)		(0.238)
HS8-Unit-Seller-Year	✓	✓	✓	✓
Industry	✓	✓	✓	✓
N obs	345250	282315	282315	282315
N clusters	317	260	260	260
Adj. R^2	0.917	0.909	0.231	0.983
Kleibergen-Paap rk Wald F statistic			153.611	

* p<0.10, ** p<0.05, *** p<0.01

Robust standard errors clustered at importer- and exporter- levels in parentheses.

Notes: $s^J_{jkt}(\varphi)$ denotes seller's share in buyer's expenditures and $m_{jkt}(\varphi)$ denotes buyer's annual purchases in HS6 category from the seller in year t.

the same seller are not driven by buyer's choice between unobserved domestic and observed foreign sellers in a market. It shows the results of estimating equation (18) in a subsample of products, which are not likely to be produced domestically in Paraguay. These products account for about 22% of the country's import transactions and are from HS8 categories, in which Paraguay never exported any products during the sample period. Price variation across buyers of these products is qualitatively similar to that in the full sample, but buyer-size discounts are smaller. This is consistent with

the documented effect of competition on the extent of price discrimination: in markets without competition from domestic suppliers, buyer-size discounts are smaller.

Table A7. Price variation across buyers of the same seller, product without exported domestic substitutes

Dependent Variable:	log *Transaction Price*			
	(1)	(2)	(3)	(4)
	OLS	OLS	IV	I stage
$\log s^J_{jkt}(\varphi)$	0.062***	0.060***	0.067***	0.233***
	(0.013)	(0.013)	(0.015)	(0.032)
$\log m_{jkt}(\varphi)$	-0.025***		-0.030*	
	(0.009)		(0.016)	
$\log m_{jkt-1}(\varphi)$		-0.013*		0.429***
		(0.007)		(0.049)
log *Transaction Quantity*	-0.164***	-0.169***	-0.167***	0.079***
	(0.016)	(0.019)	(0.019)	(0.011)
log *Per-unit Weight*	0.358***	0.373***	0.372***	-0.039***
	(0.036)	(0.043)	(0.042)	(0.013)
Constant	2.851***	2.931***		4.998***
	(0.145)	(0.149)		(0.445)
HS8-Unit-Seller-Year	✓	✓	✓	✓
Industry	✓	✓	✓	✓
N obs	168419	105974	105974	105974
N clusters	444	354	354	354
Adj. R^2	0.983	0.984	0.233	0.985
Kleibergen-Paap rk Wald F statistic:			75.986	

* p<0.10, ** p<0.05, *** p<0.01

Robust standard errors clustered at importer- and exporter- levels in parentheses.

Notes: $s^J_{jkt}(\varphi)$ denotes seller's share in buyer's expenditures and $m_{jkt}(\varphi)$ denotes buyer's annual purchases in HS6 category from the seller in year t, $N_j t$ denotes the number of sellers of HS6 category to Paraguay in year t.

Figure 5 shows that product differentiation does not fully explain the observed patterns of price variation across buyers of the same sellers even in a subsample of most differentiated products. It plots coefficients and their 95% confidence intervals from estimating seller's pricing equation (18) in a subsample of passenger vehicles. In

their commercial descriptions, I observe the most detailed product characteristics such as vehicle's model, brand, trim, engine type, size, year of fabrication, and whether it is used or new. Figure shows that these characteristics have expected effects on the vehicle's price: ie. older and manual cars are sold with a discount. However, accounting for these characteristics and shipment size, I still hind that when buying from the same seller, importers that import cars in larger annual quantities are charged less for the same vehicle. This result cannot be an outcome of measurement errors in quantities, because each vehicle in Paraguayan customs data is reported as a separate transaction.

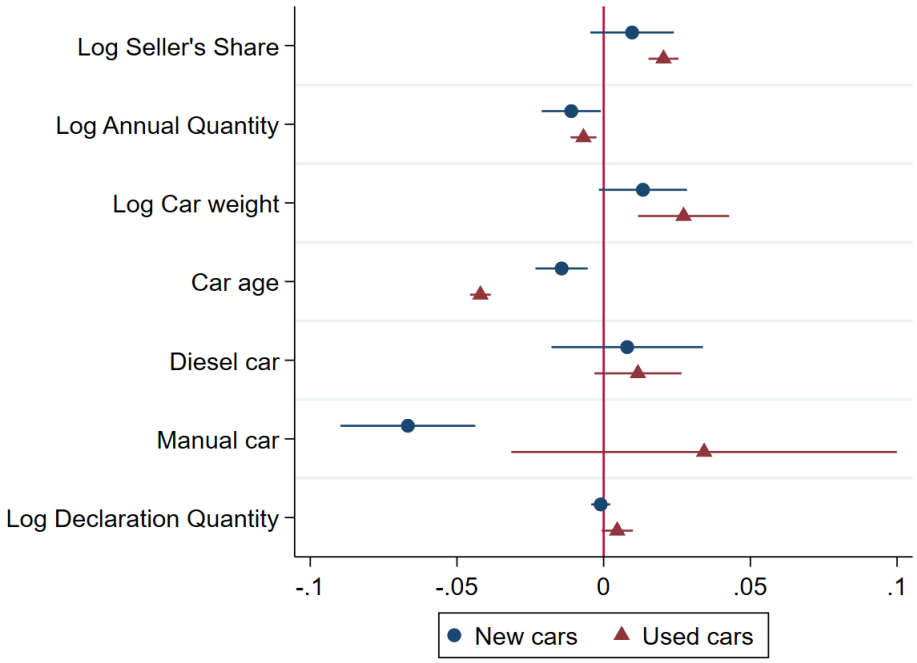

Figure 5. Variation of prices of vehicles across buyers of the same seller, conditional on vehicle's brand, model and detailed characteristics

Notes: Estimated coefficients in equation (18) and their 95%-confidence intervals are plotted for a subsample of imported passenger vehicles (HS4 code "8703"). The estimates are obtained separately for new and used vehicles using specification with Seller-HS8-Brand-Model fixed effects and accounting for detailed vehicle characteristics.