COUNTERVAILING POWER OF FIRMS IN INTERNATIONAL TRADE*

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July 26, 2022

Abstract

Price variation across buyers within product categories is commonly explained by quality variation in international trade. Using uniquely detailed product descriptions, I control for quality and study market-power mechanisms of price variation across buyers. I develop a model of trade, in which buyers and sellers differ in productivity and can have market power to set prices. It predicts differential patterns of price variation with buyer productivity under oligopoly, oligopsony and bilateral bargaining in a standard international trade environment. Testing these predictions, I find that, in most markets, price variation is consistent with price discrimination by oligopolistic sellers charging lower mark-ups to more productive buyers. I identify the role of buyer's outside options in this result separately from scale economies, transfer pricing and bargaining ability. These findings imply large productive firms benefit more from trade liberalization due to their ability to further reduce input prices by threatening to use alternative suppliers.

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

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

*This paper is a revised version of Chapter 2 of my doctoral dissertation. I am very thankful to my dissertation advisors, Rob Feenstra, Andre Boik, Deborah Swenson, and Alan Taylor for their invaluable guidance and support. I would also like to thank Andrew Atkeson, Lorenzo Caliendo, Hiroyuki Kasahara, Monica Morlacco, Kadee Russ, Ina Simonovska, Sanjay Singh, the participants of RIDGE December Forum 2018, Sardinian Empirical Trade Conference, Hitotsubashi International Trade and Investment Workshop, and UC Davis International/Macro Brownbags for helpful comments and suggestions. I am especially grateful to Rob Feenstra for providing funding for data acquisition. All errors are my own.

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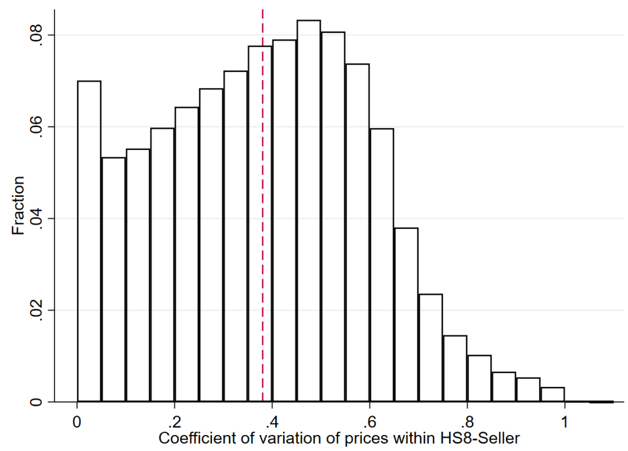
1 Introduction

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: 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. Evidence for price discrimination has been found in a large number of consumer goods' and inputs' markets such as airline tickets, coffee, retail gasoline, medical devices and wholesale pharmaceuticals (Borenstein and Rose, 1994; Shepard, 1991; McManus, 2007; Gerardi and Shapiro, 2009; Grennan, 2013; Ellison and Snyder, 2010). Labor economists, on the other hand, often explain variation in wages, or the price of labor, with differences in oligopsony/monopsony power across employers. Evidence for this mechanism has been found in markets for registered nurses, teachers, on-demand online labor platforms, etc. (Falch, 2010; Staiger et al., 2010; Ransom and Sims, 2010; Dube et al., 2020). In contrast, international trade economists, with some exceptions[1], have been mainly attributing price variation in narrow product categories to variation in product quality (Kugler and Verhoogen, 2011; Blaum et al., 2018; Bastos et al., 2018).

In this paper, I study the role of firms' market power in variation of prices across buyers, unrelated to product quality, in international trade. While market power of importers and exporters is well-documented in international trade, understanding its implications for price variation is challenging for two reasons. First, it has been difficult to exclude quality-based price variation because individual products and their qualities are "hidden" in standard product categories. Second, any price variation remaining after accounting for product quality can be driven by market power of sellers, buyers, or both because of the firm-to-firm nature of international transactions. This depends on a market structure that can vary across a wide range of markets affected by international trade. My contribution is in deriving differential implications of market power across market structures and testing them in a new customs dataset with detailed product descriptions to account for product quality.

[1] For example, Goldberg (1995), Verboven (1996), Goldberg and Verboven (2001) and Simonovska (2015) provide evidence of price discrimination in international car markets and across destination of a clothing retailer.

To study the role of market power in price variation in international trade, I use a universe of Paraguayan import transactions in the period from 2013 to 2018. This data is uniquely suited for the study as it identifies individual sellers and buyers in each transaction, as well as brands, countries of origin, per-unit weight and commercial descriptions of transacted products. Using detailed product information, I rule out "hidden" varieties and quality variation as reasons for price variation within standard product categories. Using buyer and seller identifiers, I distinguish the role of buyer's and seller's market power in observed price variation in a wide range of markets with various market structures.



Notes: Coefficients of variation are ratios of a standard deviations of unit values within an HS8-Unit-Seller-Year category over its 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 line shows the average coefficient across all categories.

Figure I

A large share of price variation across Paraguayan importers remains unexplained by differences in product characteristics and product quality in standard product categories of the same seller. To measure the extent of price variation by a seller, I compute coefficients of variation of prices across seller's transactions in each product category defined by 8-digit Harmonized systems' code (HS8). Figure I shows a density plot of these coefficients and reports the average coefficient of variation of 38%. Fontaine et al. (2020) document a similarly large extent of price variation in transactions of French exporters and attribute it entirely to price discrimination. I show that although detailed product characteristics explain a substantial portion of within-seller price variation, buyer heterogeneity independent from product characteristics is an equally important factor.

While Fontaine et al. (2020) explore the extent of within-seller price variation, I study mechanisms through which buyer heterogeneity results in price variation, conditional on product quality. I consider importer's own productivity as an underlying source of buyer heterogeneity in imports markets, unlike Alviarez et al. (2021a), who focus on importer's bargaining ability. Productivity is known to vary a lot across importers and affect their choice of quality and suppliers (Pavcnik, 2002; Amiti and Konings, 2007; Kugler and Verhoogen, 2012; Antras et al., 2017). Yet, by assuming perfect or monopolistic competition in these markets, existing models of importing assume away any effect of importer's productivity on price beyond the choice of product quality and a supplier. Hence, they cannot rationalize within-seller price variation in Figure I, unrelated to product quality.

In contrast, I show that importer productivity has an independent effect on prices of imported goods in markets featuring oligopoly, oligopsony or bilateral bargaining as their market structures. For that, I develop a model of firm-to-firm trade, in which firms on both sides differ in their productivity and interact in a market structure defined by industry-specific technological parameters. It allows me to compare how prices vary across buyers and respond to trade liberalization under different market structures in a single international trade environment.

Under (Bertrand) oligopoly, in this environment, a seller's mark-up depends on the seller's share in buyer's input expenditures. This share varies across buyers that differ in their preferences for the seller, and in their set of suppliers. I endogenize importers' set of suppliers by assuming fixed costs of adding suppliers as in Antras et al. (2017). Because only more productive importers can overcome these fixed costs, they have more suppliers and have higher elasticity of demand for each supplier's product. Price discriminating suppliers then charge lower mark-ups to more productive importers. This prediction is novel for international trade, but has been used in industrial organization since at least Katz (1987) to explain discounts large firms like Wal-mart obtain from their suppliers.[2]

This mechanism also arises in a bilateral bargaining framework of Horn and Wolinsky (1988) under the assumption that more productive buyers have better outside options. I show this by allowing for differences in buyer's own productivity in this framework, besides differences in their

[2]For anecdotal evidence of this, see, The Guardian's article *"Wal-Mart stakes its claim"* and The Wall Street Journal's article *"Court Ruling Could Cut Prices For Beer, Wine"*.

bargaining abilities studied in Alviarez et al. (2021a). If buyer's bargaining ability and productivity are not perfectly correlated,[3] then, keeping bargaining ability constant, more productive buyers can countervail seller's market power and pay lower prices if they have better outside options.

In contrast, under oligopsony with perfectly competitive sellers, prices are determined from a seller's upward-slopping average cost curve once buyers chose their optimal quantity. More productive buyers then pay higher prices, because they produce more output, get higher marginal revenue product and buy more of each input. This positive effect of buyer's productivity on price is often used to explain wage premium paid by more productive firms (Card et al., 2018; Berger et al., 2019; Manning, 2021).

To understand the extent to which price variation across importers is driven by oligopolistic price discrimination, bilateral bargaining and oligopsony, I estimate the effect of importer's productivity on prices of imported goods in a wide range of markets. Besides differential predictions across the market structures, the model yields a theoretically consistent measure of importer productivity. I show that more productive importers are those that purchase larger quantities of a given product from a given seller, conditional on the seller's share in buyer's expenditures on imported goods. Using this measure of importer productivity, I find that, in most markets, sellers charge more productive importers lower prices for the same good, in line with oligopolistic price discrimination. Exploiting richness of my data, I show that this finding is not an outcome of multinationals' transfer pricing, measurement error, and economies of scale in production and transportation.

To provide further evidence in favor of mark-up- and against cost-based mechanisms behind the negative buyer-size – price relationship, I study how seller competition affects price variation. If more productive and hence larger importers obtain discounts from their suppliers through a threat of switching to alternative suppliers, then entry of suppliers should result in larger discounts. I test this prediction using over-time variation in import tariffs as exogenous shocks to the number of foreign suppliers in a market, to address endogenous entry (Berry et al. (2019)). Using this instrument for seller's entry, I find that when faced with more competition from entrant, incumbent sellers offer larger discounts to their larger buyers. This result confirms seller competition is a prerequisite for

[3] Lewis and Pflum (2015) separately identify bargaining abilities and bargaining position in terms of outside options of hospitals negotiating prices of their services with managed care organizations. They find that hospital's size and market share are not correlated with its bargaining ability and affect prices through its bargaining position.

buyer-size discounts, in line with Snyder (1998), Gans and King (2002) and Ellison and Snyder (2010). Moreover, it rules out cost-based mechanisms of price variation, which cannot explain differential price changes across buyers in response to seller competition.

These results suggest that sellers vary mark-ups across their buyers by charging lower mark-ups to larger, more productive buyers that can have alternative suppliers. This mechanism of mark-up variation generates a new source of gains from trade. If firms import inputs to produce final goods, then trade in final goods will allow them to get lower prices from input suppliers without changes in input quality. When a firm exports more, it can overcome fixed costs of finding alternative suppliers, which makes its existing suppliers reduce their prices. I provide evidence consistent with this mechanism and show that it would not arise if bargaining abilities were the only source of firm heterogeneity (as in Alviarez et al. (2021a)).

This paper contributes to several strands of the literature across multiple fields of economics. First, it complements growing research in labor-, macro- and international economics quantifying aggregate implications of firms' market power (Berger et al., 2019; Morlacco, 2019; Kikkawa et al., 2019; De Loecker et al., 2020; Peters, 2020). While these studies assume a specific market structure as a source of firms' market power in all industries of an economy, I emphasize differential implications of firms' market power across industries with different market structures. I derive patterns of price variation in an industry that can be used to identify its market structure.

Second, this paper documents novel effects of trade liberalization studied in the international trade literature. By inducing exporting, trade liberalization has been shown to encourage firms to upgrade their technologies and input quality (Lileeva and Trefler, 2010; Bustos, 2011; Kugler and Verhoogen, 2012; Bastos et al., 2018). I show that, it additionally increases firms' countervailing power in inputs markets, which results in lower input prices, conditional on input quality. Trade liberalization in inputs markets is known to benefit firms through access to new, cheaper and better inputs (Amiti and Konings, 2007; Antras et al., 2017; Blaum et al., 2018; Halpern et al., 2015). I show that it has distributional consequences for importers of inputs: more productive importers receive larger input price reductions from the same input suppliers.

Third, this paper provides a large-scale empirical assessment of price discrimination and bargaining theories developed in the industrial organization literature (Katz, 1987; Horn and Wolinsky, 1988; Chipty and Snyder, 1999; Inderst and Valletti, 2009). They imply that pricing strategies and their welfare implications in firm-to-firm context differ from those in firm-to-consumer context because of firms' abilities to bargain and threaten each other. Customs data that predominantly consists of firm-to-firm transactions allows me to test these theories in a wide range of markets, for which domestic firm-to-firm transactions are unavailable.[4]

Finally, my results have novel implications for pass-through of global shocks studied in international macroeconomics (Berman et al., 2012; Amiti et al., 2014; Auer and Schoenle, 2016; Devereux et al., 2017; Alviarez et al., 2021a). While most of the studies focus on the role of seller's productivity and market power in pass-through of exchange rate and other global shocks, I show that buyer's productivity and ability to affect prices also matter. When more productive buyers countervail the power of sellers, they pay lower mark-ups and have higher pass-through of seller's cost shocks into their prices. These findings complement Devereux et al. (2017) and Alviarez et al. (2021a), who argue that buyer's market share and bargaining ability affect pass-through of global shocks.

2 Theoretical Framework

In this section, I develop a model of international trade in differentiated products, in which both buyers and sellers are heterogeneous in their productivity and can affect prices of transacted goods. I compare the equilibrium price dispersion that arises under various market structures such as monopolistic competition with scale economies/diseconomies, oligopoly, oligopsony and bilateral bargaining. I derive their differential testable predictions on the patterns of price dispersion and show their importance in pass-through of global shocks and effects of trade liberalization.

2.1 Environment

Consider a standard international trade environment[5], in which a country populated by homogeneous consumers that inelastically supply their labor and consume bundles of products produced in

[4] Because of difficulties in accessing data on domestic transactions between firms, in industrial organization literature, theories of price discrimination and bargaining in a firm-to-firm context have been empirically tested only in a handful of markets such as health insurance, medical devices, hospital services (Ellison and Snyder, 2010; Dafny, 2010; Grennan, 2013; Lewis and Pflum, 2015; Grennan and Swanson, 2018).

[5] In the Appendix, I show that the same results hold in a standard industrial organization environment with linear demand and cost functions, and hence are not driven by functional forms.

multiple 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 produced in several upstream sectors. A final goods' producer in a downstream sector can procure materials from either one or multiple firms in each upstream sector. Transacting with more than one supplier in each upstream industry can be costly and require a fixed payment ranging from zero to infinity. Upstream producers are heterogeneous in their productivity too, and use only labor in production, which can have scale (dis)economies or constant returns to scale.

The focus of this paper is the market structure in inputs markets upstream and its implications for the dispersion of prices within input sellers across final goods producers. For that, I assume perfect competition in labor markets and monopolistic competition in final goods' markets. I relax these assumptions in the empirical analysis.

2.2 Preferences

To focus on firms' interactions under various market structures, I model final consumers' behavior in a stylized, yet standard in international trade literature, way. I assume that all consumers in a given 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

In this economy, each final goods' variety in each sector 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 $\eta_j \geq 1$:

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

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, $f_j \geq 0$. Notice that when these fixed costs are zero or infinity, the model collapses to the standard model of trade in intermediate goods (cf. Antras et al. (2017), Blaum et al. (2019), Amiti et al. (2020), etc.)

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

To focus on the role of market structure and firms' interactions in the inputs markets upstream, I keep the market structure in final goods' markets downstream as simple as possible. As is standard in international trade literature, I assume that final goods' producers downstream are infinitesimal relative to their outputs' markets that feature monopolistic competition.[6]

In inputs markets upstream, different industry-specific parameters in this environment result in various market structures as special cases. Oligopoly in which sellers compete in prices arises when buyers differentiate between varieties of different sellers ($1 < \eta_j < +\infty$) and sellers internalize the effect of their pricing decisions on buyers' costs. Under this market structure, sellers choose prices to maximize their profits by setting their marginal revenue equal to marginal costs. In contrast, classic oligopsony arises when buyers view all sellers as perfectly substitutable ($\eta_j = +\infty$) and internalize the effect of their pricing decisions on seller's marginal costs increasing in quantity ($\gamma_j < 1$). Under this market structure, buyers choose prices of the goods they buy to maximize their profits by setting marginal product revenue equal to the seller's marginal costs.

Under basic market structures – oligopoly and oligopsony – only one side of the market, sellers or buyers have market power to affect prices. Both buyers and sellers can affect prices under two alternative market structures: bilateral bargaining and oligopoly, in which buyers affect prices by choosing the extensive margin of input sourcing. In case of bilateral bargaining, prices are used

[6] I relax this assumption and discuss its implications for the observed price dispersion in the empirical analysis.

as a (linear) instrument of sharing the total trade surplus between a buyer and a seller. In case of oligopoly in which buyers endogenously choose the number of suppliers ($0 < f < +\infty$), sellers choose prices taking buyers' strategic behavior into account.

2.5 Equilibrium input price dispersion

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 sellers can distinguish their buyers and prevent arbitrage on the market[7], this results in buyer-specific prices set as a mark-up over marginal costs:

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

where mark-up is inversely related to a buyer-specific elasticity of demand for firm k's variety of input j, $\zeta_{jk}(\varphi) \equiv \frac{\partial m_{jk}(\varphi)}{\partial p_{jk}(\varphi)}\frac{p_{jk}(\varphi)}{m_{jk}(\varphi)}$.

This pricing equation shows that product prices across buyers of the same seller can vary for two reasons: *i*) input demand elasticity varies and causes mark-ups to vary across buyers and/or *ii*) seller's production technology features non-constant returns to scale ($\gamma_j \neq 1$). If sellers are too small to set and vary mark-ups, prices can still decrease or increase with in input quantities purchased by different buyers due to scale economies ($\gamma_j > 1$) or diseconomies ($\gamma_j < 1$), respectively. After deriving mark-up variation of large sellers, I discuss how the effect of seller competition on price dispersion separates cost-based and market-power-based mechanisms of price dispersion.

To understand how large sellers' mark-ups vary across buyers, consider buyer φ's demand for firm k's variety of input j derived from final goods' production technology in (3) - (5):

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

$$\mathbb{P}_j(\varphi) \equiv \left(\sum_{n=1}^{N_m}\delta_{jk}(\varphi)^{\eta_j}p_{jk}^{1-n_j}(\varphi)\right)^{\frac{1}{1-n_j}}, \quad \mathbb{J}_s(\varphi) \equiv \left(\sum_{j\in N_s}\mathbb{P}_j(\varphi)^{1-\theta_s}\right)^{\frac{1}{1-\theta_j}} \tag{9}$$

[7] I discuss the absence of arbitrage opportunities and the existence of buyer heterogeneity as necessary conditions for oligopolistic price discrimination in Section B.2.1 and consider them in the empirical analysis in Section.

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.

Then elasticity of derived demand in (8) of a buyer of a seller, who internalizes the effect of a price increase on the buyer's costs, is

$$\zeta_{jk}(\varphi) = -\eta_j + (n_j - \theta_s)s^J_{jk}(\varphi) + (\theta_s - 1 + (1-\alpha_s)(1-\sigma_s))s^J_{jk}(\varphi)s^M_j(\varphi) \tag{10}$$

$$s^J_{jk}(\varphi) = \delta_{jk}(\varphi)^{\eta_j}\left(\frac{p_{jk}(\varphi)}{\mathbb{P}_j(\varphi)}\right)^{1-\eta_j}, \quad s^M_J(\varphi) = \left(\frac{\mathbb{P}_j(\varphi)}{\mathbb{J}_s(\varphi)}\right)^{1-\theta_s} \tag{11}$$

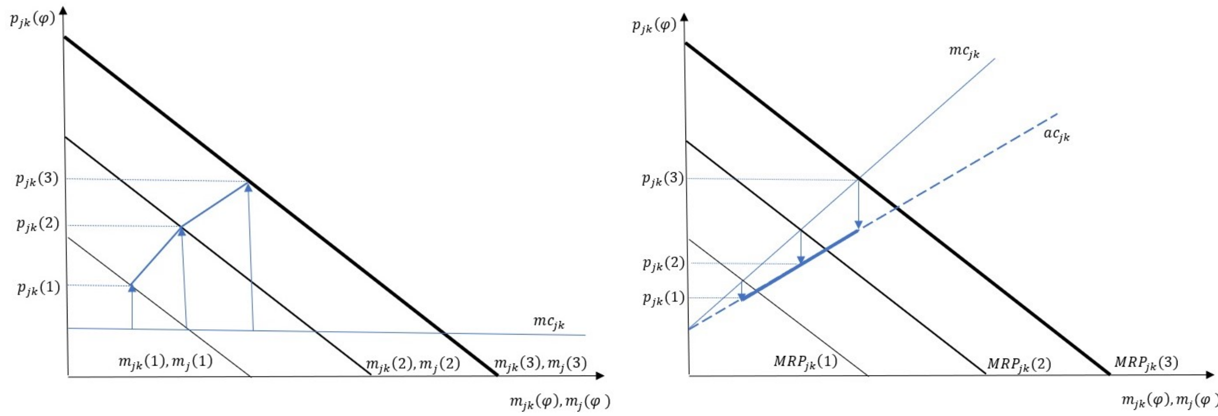
where $s^J_{jk}(\varphi)$ and $s^M_J(\varphi)$ are, respectively, the share of buyer φ's expenditures on seller k's input variety of j in total buyer's expenditures on j inputs and the share of buyer's expenditures on j's inputs in buyer's expenditures on material inputs. Under a standard assumption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

Importantly, in (8), buyer's idiosyncratic preference for the seller $\delta_{jk}(\varphi)$ and input requirements in the buyer's industry N_s act as exogenous demand shifters. This yields a standard prediction of oligopolistic price discrimination: exogenously larger buyers have lower demand elasticity and thus are charged higher prices by the same seller. Figure IIa illustrates this prediction with linear demand and cost functions, which means that it is not an outcome of CES functional form assumptions. 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 (depicted with arrows). Hence, through this mechanism a standard oligopoly predicts a positive buyer-size – price relationship.

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

Proof. *See above and Appendix A.2.1 for details.*

Oligopsony Under oligopsony with perfectly competitive sellers, buyer φ chooses input quantity



(a) An oligopolist charges larger buyers higher prices (b) More productive oligopsonists pay higher prices

Figure II.

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 IIa, prices equalize seller's marginal revenue and marginal costs for each buyer. Under oligopsony in Figure IIb, 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.

$m_{jk}(\varphi)$ to maximize profits, and input price $p_{jk}(\varphi)$ is then determined from upward sloping seller's average cost curve.[8] Having chosen labor units, buyer φ chooses input quality that equalizes buyer's marginal revenue product[9] with marginal costs:

$$(1-\alpha_s)\tilde{A}_s\tilde{\varphi}\tilde{M}_s(\tilde{\varphi})^{-\alpha_s}\left(\frac{m_j(\tilde{\varphi})}{\tilde{M}_s(\tilde{\varphi})}\right)^{-1/\theta_s} = \frac{\partial p_j(\tilde{\varphi})}{\partial m_j(\tilde{\varphi})}m_j(\tilde{\varphi}) + p_j(\tilde{\varphi}) \tag{12}$$

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.2.1.

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 (12). 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,

[8]See Bhaskar et al. (2002), Chen (2008) and Ashenfelter et al. (2010) for a discussion of the central role of diseconomies of scale in standard models of oligopsony. I show that in a bargaining framework when an oligopsonist faces an oligopolist, diseconomies of scale is not necessary for firms to affect prices.

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

input prices increase with an increase in the oligopsonist's own productivity. Figure IIb 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.

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.2.1 for details.*

Therefore, the two very different market structures, oligopoly and oligopsony generate the same pattern of within-seller price dispersion. Irrespective of whether it is sellers or buyers who have market power to set prices, under both basic market structures, exogenously larger buyers pay higher prices. I now compare this prediction to those obtained under alternative market structures, which allow for both buyers and sellers to affect prices.

Oligopoly with a replacement threat. When in oligopolistic markets, 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 if it results in higher profits under the following condition:

$$B_s \varphi^{\sigma_s - 1} \mathbb{J}'_s(\varphi)^{(1-\alpha_s)(1-\sigma_s)} \left\{ \left(\frac{\mathbb{J}''_s(\varphi)}{\mathbb{J}'_s(\varphi)} \right)^{(1-\alpha_s)(1-\sigma_s)} - 1 \right\} > f_j w, \tag{13}$$

where B_s is sector s-specific demand shifter defined in Appendix A.2.1, and $\mathbb{J}'_s(\varphi)$ and $\mathbb{J}''_s(\varphi)$ are firm-specific CES price indexes of material inputs when input j is sourced form 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. Following insights from Feenstra (1994) (see Appendix A.2.1), the reduction in this cost can be shown to come from two sources: productivity gains of 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 (13) 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 increases their demand elasticity and leads to lower prices offered by suppliers that face competition from the buyer's alternative suppliers. Since more productive buyers, all else equal, buy in larger quantities in (8), this mechanism predicts a negative buyer-size – price relationship, altering the standard prediction of oligopolistic price discrimination.

Importantly, this mechanism crucially depends on the existence of multiple sellers on the market. If there is only one supplier on market m, ($\bar{N}_m = 1$), then the seller's share in buyer's expenditure does not vary across buyers with different productivities. In this monopolistic environment, even larger buyers cannot get discounts according to the discussed mechanism. However, an exogenous increase in the number of sellers on a market is predicted to increase the discounts offered by the incumbent sellers to larger buyers.

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. All else equal, this generates a negative buyer-size – price relationship which becomes more negative with entry of new sellers.*

Proof. *See above and Appendix A.2.1 for details.*

This negative buyer-size – price relationship can be also derived in a bilateral bargaining framework in which buyer's outside options depend on the buyer's own productivity.

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

$$\max_{p_{jk}} \left[\Pi^B(N_j;\varphi) - \Pi^B(N_j \backslash k;\varphi)\right]^{\kappa_k(\varphi)} \left[\Pi^S(\Omega_k;a_k) - \Pi^S(\Omega_k \backslash \varphi;a_k)\right]^{1-\kappa_k(\varphi)} \tag{14}$$

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.

Given consumer preferences and technologies in (1) – (6), these extra profits can be written as functions of price p_{jk}:

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

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. Plugging these expressions in (14), taking first-order conditions and re-arranging the terms as in Grennan (2013) results in the following equilibrium mark-up expression:

$$\frac{p_{jk} - w/a_k}{p_{jk}} = \frac{1}{-\frac{\partial m_{jk}}{\partial p_{jk}}\frac{p_{jk}}{m_{jk}} + \kappa_k(\varphi)\frac{p_{jk}}{\Delta\Pi^B(p_{jk})/m_{jk}}}, \tag{15}$$

where marginal costs are assumed to be constant ($\gamma_j = 1$), for simplicity. As in Grennan (2013), it highlights three main sources of within-seller mark-up variation across buyers: *(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 $\Delta\Pi^B(p_{jk})/m_{jk}$). This is the case if more productive buyers have access to cheaper alternative suppliers (lower $\mathbb{J}_s(p_{jk'})$). Hence, bargaining leads to the same pattern of price dispersion as oligopoly with a replacement which additionally explains the differences in outside options across buyers with fixed costs of adding suppliers. In contrast, if buyer's ability is the only source of buyer heterogeneity as in Alviarez et al. (2021a), then buyers with higher bargaining abilities $\kappa_k(\varphi)$ are predicted to pay lower mark-ups. Therefore, heterogeneity in either bargaining abilities or productivity imply that larger buyers pay lower mark-ups. In the next subsection, I show that despite this similarity in predicted patterns of price dispersion, the two mechanisms generate different 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.2.1 for details.*

Therefore, within-seller price dispersion, conditional on product quality, can be driven by different market-power-based mechanisms depending on the market structure, as summarized in Table I. Next, I show that these mechanisms have differential implications for the effects of trade liberalization and pass-through of global shocks to domestic firms.

Table I. Market-power mechanisms and patterns of price dispersion 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	Diseconomies of scale	+
Bargaining, constant productivity	Buyer's bargaining ability	–

2.6 The effects of trade liberalization under various market structures

I study how different market structures discussed above shape the effects of two types of trade liberalization on domestic firms. I distinguish between output trade liberalization, when a foreign country lowers tariffs on final products exported by domestic producers, and input trade liberalization, when a domestic country lowers tariffs on foreign inputs imported by domestic firms.

To understand how foreign country's trade liberalization affects domestic firms, suppose that domestic firms face iceberg-type trade cost when supplying foreign consumers with preferences as in (1). Then firm's entry to foreign markets and/or a reduction of import tariffs by foreign markets acts an a positive exogenous shock to the demand on the domestic firm's output.

The effect of this demand shock on input prices faced by domestic firms crucially depends on the market structure in the input's market. In oligopolistic markets, a reduction in the foreign currency's tariffs or firm's entry into foreign markets lead to an increase in the domestic firm's derived demand for inputs in (8). If domestic buyers are price-takers in this market, seller's markups, in a CES framework, depend only on the seller's share in the buyer's expenditure and hence remain unaffected by an increase in the buyer's derived input demand.[10] In contrast, if domestic

[10] When demand and cost functions are linear, the level of input demand also affects prices: under oligopoly,

buyers can affect prices through outside options, then an increase in the derived input demand makes finding alternative suppliers more profitable which results in lower input prices. This feedback effect further encourages domestic firms to export. Importantly, foreign country's trade liberalization does not have this effect if price dispersion across domestic firm is driven by differences in bargaining abilities rather than productivity in the bargaining framework.[11]

Alternatively, in oligopsonistic markets with perfectly competitive sellers, foreign country's trade liberalization and/or firm's entry to a foreign market shift out and oligopsonist's marginal revenue product of an input on the left-hand side of (12). This encourages an oligopsonist to purchase more units of an input and increases its price following an upward sloping seller's average cost functions. This increase in input prices in oligopsonistic inputs markets as a result of (improved) access to foreign output markets can discourage some firms from exporting.

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* <u>*not affected*</u>*; under oligopsony, input prices are predicted to* <u>*increase*</u>*; under oligopoly in which buyers differ in the outside options, input prices are predicted to* <u>*increase*</u>*.*

Proof. *See above and Appendix A.2.1 for details.*

Turning to the effects of input trade liberalization, I first consider the short-term and then the long-term effects of a reduction in import tariffs by the domestic country. Import tariff $\tau_{jl} > 1$ on a product j from country l is an ad-valorem cost component of seller k from this country. In the short-term, seller's at least partially pass through changes in import tariffs into prices they charge to their buyers. In the long-term, an increase or a decrease in import tariffs result in exit or entry of foreign suppliers to domestic markets, respectively. I show that market structure in inputs markets affects how global shocks are passed-through to the economy and how input prices change in response to seller competition.

Under oligopoly, pass-through of sellers' cost shocks into prices is shaped by the seller's pricing rule in (21) extended to feature ad-valorem trade cost τ_{jl}. Assuming constant marginal costs, for

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.

[11] See Appendix A.2.1 for details.

simplicity, taking logs and then fully differentiating this rule yields:

$$\frac{d \log p_{jk}(\varphi)}{d \log \tau_{l(k)j}} = \frac{1}{1 - \Gamma_{jk}(\varphi)}, \tag{16}$$

where $\Gamma_{jk}(\varphi) \equiv \frac{d \log \mu_{kj}(\varphi)}{d \log p_{jk}(\varphi)}$ denotes mark-up elasticity with respect to price. This elasticity is negative and, in absolute value, increasing in the seller's share in buyer's expenditures on input j, $s^J_{jk}(\varphi)$. It means that sellers pass through a smaller portion of an import tariff into prices of buyers that depend more on their inputs (have higher expenditure shares).

If buyers are price-takers in oligopolistic markets, they allocate a larger share of their expenditure to and purchase in larger quantities from sellers they prefer more. As a result, larger buyers experience lower pass-through of the seller's costs into prices. In contrast, if buyers can affect prices by leveraging their outside options, then more productive buyers, all else equal, spend less on each of their suppliers but purchase in larger quantities. In this case, larger buyers experience higher pass-through of the seller's costs into prices.

Under oligopsony with perfectly competitive sellers, equilibrium input prices are determined from the upward sloping average cost curve. Re-writing it in logs and then fulling differentiating yields:[12]

$$\frac{d \log p_j(\varphi)}{d \log \tau_l} = \frac{d \log p_j(\varphi)}{d \log \epsilon_l} = \frac{1}{1 - \left(\frac{1}{\gamma_j} - 1\right) \Psi_j(\varphi)}, \tag{17}$$

where $\Psi_j(\varphi) \equiv \frac{d \log m_j(\varphi)}{d \log p_j(\varphi)}$ is the elasticity of buyer φ's input demand in (12). In a CES framework, this elasticity is negative and constant, which implies less than complete but constant pass-through of sellers' cost shocks into buyers' prices. If, instead, input supply elasticity increases with quantity, then sellers' pass-through increases with buyer size for relatively small buyers and decreases with buyer share for relatively large buyers. This pattern of pass-through of sellers' cost shocks is the opposite of that derived under oligopolistic market structure.

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*

[12] Because in this case sellers are perfectly substitutable, I omit seller subscript k.

affect prices, pass-through rates are higher for larger buyers; under oligopsony with constant input demand elasticity, pass-through rates are constant.[13]

Proof. *See above and Appendix for details.*

By affecting foreign sellers' marginal costs, domestic country's import tariffs, in the long-run, result in entry or exit of foreign sellers into the affected market. The change in the level of competition induced by tariffs on imported products can affect the dispersion of their prices across domestic buyers depending on the market structure. In oligopolistic markets, the effect of seller competition on price dispersion depends on how it affects the existing seller's market power across buyers, as discussed in Holmes (1989) and Stole (2007). If fixed costs of adding suppliers are extremely large ($f_j \to \infty$), existing suppliers keep the same level of market power with respect to all their buyers, and both prices and their dispersion are unaffected by the new sellers' entry. If fixed costs of adding suppliers f_j are zero, all buyers increase the number of their suppliers and experience a reduction in prices. However, all else equal, larger buyers of an incumbent seller with a specific preference for the seller receive a smaller price reduction because of their loyalty. Finally, if fixed costs of adding suppliers are not too big, all else equal, more productive buyers are more likely to add them and thus experience larger price reductions from their existing suppliers. All these effects of sellers' competition on the incumbent seller's price dispersion across buyers are absent under oligopsony, because it assumes perfectly competitive sellers. They are also absent under monopolistic competition with constant mark-ups because competition can only affect mark-ups which, in a CES framework, are determined solely by (constant) demand elasticity.

Proposition 7. *The effect of competition from foreign sellers (induced by domestic country's trade liberalization) on the incumbent seller's price dispersion depends on the market structure. In oligopolistic markets, within-seller price dispersion does not change, increases or decreases if fixed costs of reaching new entrants are, respectively, extremely large, zero, or finite and more likely to be overcome by more productive buyers.*

Proof. *See above and Appendix.*

Therefore, the developed theoretical framework shows that market structure determines how

[13]For the 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. (2021b).

prices vary across importers, conditional on product quality, and how they are affected by input and output trade liberalization. To understand the empirical sources and consequences of price dispersion unrelated to product quality, I take the differential predictions of different market structures to the data.

3 Data

3.1 Unique features of Paraguayan customs data

To study price variation in firm-to-firm transactions, I use a uniquely detailed customs data from Paraguay[14] 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 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 how prices of imported goods are determined.

First, the data allows me to study the sources of price dispersion *within sellers* across buyers by providing names and countries of foreign sellers in addition to importer identifiers. 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.[15] To focus on price dispersion across independent buyers of a seller, I detect affiliated firms using ownership information in Orbis data (as in Davies and Studnicka (2018), Alviarez et al. (2021a)) and similarity of names between transacting firms.[16]

Second, the unique level of detail with which products are described in these data allows me to study within-seller price dispersion across buyers unrelated to product differentiation. Each transaction is described with one of the 6 712 8-digit product codes (in an average year), which

[14] The data collected by Paraguayan customs was purchased from data provider, Datamyne. I thank my advisor, Rob Feenstra, for providing the funds for acquisition of this data.

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

[16] Details are outlined in the Appendix.

is comparable to 6 539 10-digit product codes in the US Longitudinal Firm Trade Transaction Database[17] viewed as one of the most detailed international trade data.[18] Beyond that, Paraguayan customs data reports each product's brand name, country of origin, non-generic product description (in words), units of measurement and per-unit weight (in kilograms). This additional information allows me to account for differences in (perceived) quality of product varieties "hidden" in standard product categories used in other studies of price dispersion (Kugler and Verhoogen (2011), Morlacco (2019), Kikkawa et al. (2019), Fontaine et al. (2020), Alviarez et al. (2021a)).[19]

Third, a wide range of imported products allows me to document differences in market structures across industries and study their implications for price dispersion. I exploit over-time within-sector changes in import tariffs as (plausibly) exogenous shocks to international competition to study the role of sellers market power in price dispersion. Transaction-level frequency of the data allows me to isolate mark-up variation from cost variation using fixed effects and proxies for seller's cost without model-based structural estimation of mark-ups.

3.2 Summary statistics

In 2013 - 2018, Paraguayan customs, on average, recorded around 0.8 million import transactions every year. Table II shows that the majority of these transactions, by product count, transaction count and value, are imports of differentiated products mainly used in production as materials or capital goods.

Not all of these imported intermediate and capital goods are traded between manufacturers, much like not all consumer goods are imported by final consumers directly from manufacturers. Table III reports that, based on the main economic activity provided by Paraguayan tax authorities, 34% and 11% of importers are, respectively, wholesalers and retailers. On the seller side, 4% of foreign exporters to Paraguay have word indicators that identify them as trade intermediaries or

[17] Numbers of HS10 product codes in US imports for the time period of interest (2013 - 2018) are based on the Schott (2008) data.

[18] Although product codes in the US HTS classification has 10-digits, 60% of 8-digit codes do not have any 10-digit sub-codes. Together with more detailed 8-digit product codes in Mercosur classification used in Paraguay, this makes Paraguayan data with 8-digit codes comparable to the US 10-digit codes.

[19] Goldberg (1995), Goldberg and Verboven (2005), Head and Mayer (2019), Lashkaripour (2020), Alviarez et al. (2021b) demonstrate substantial degree of product differentiation by brand, origin and per-unit weight in international trade.

Table II. 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

are reported as such in the Orbis data.[20] Although trade intermediaries, wholesalers and retailers substantially facilitate trade of landlocked Paraguay, a larger share of its imports is generated by domestic producers themselves. Annually, 10% of import transactions by count and 22% by value are generated by 14% of importers producing agricultural and manufactured goods.

Irrespective of the final use of imported products and economic activities of their buyers and sellers, most imports occur within arm's length *firm-to-firm* transactions, as shown in Table III. Intra-firm transactions between affiliates of the same multinational identified from similarity of their names, brands and information from Orbis ownership data account for about 9% of all import transactions by value. Multinational affiliates comprise around 8% and 17% of firms on buyer and seller sides, respectively, or 509 multinational buyers and 274 multinational sellers.[21]

Table III. 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

[20]See the Appendix for the list of words I use to detect intermediaries as in Ahn et al. (2011).

[21]The count of foreign affiliates on the buyer size favorably compares to the information in the WorldBase data, which records 577 foreign affiliates in Paraguay (I thank Lei Li and Harald Faldinger for sharing this information). The role of intra-firm trade in Paraguayan imports is smaller than in US imports (48%) observed in the related-parties trade data available on Pol Antras' website. The difference can be explained by Paraguay's country's size and level of development rather than measurement error. My method of detection of trade between related parties outlined in the Appendix results in twice as many intra-firm transactions in Paraguay's imports from the US as reported in the US export data.

Table IV shows that both buying and selling firms exhibit a large degree of heterogeneity along several dimensions, similarly to that documented in other customs datasets (c.f. Bernard et al. (2018), Kikkawa et al. (2019), etc.). On average, there are around 7000 importers annually transacting with around 1600 foreign sellers regularly selling goods to Paraguay (with at least 1000 import transactions in the sample).[22] An average importer annually spends $1.2 million on imported goods from 17 different 8-digit (HS8) product categories and two sellers from two different countries in two out of six sample period years. An average regular exporter to Paraguay annually earns $2.5 million from selling products in 31 different HS8 product categories to 3 firms in Paraguay. However, median importer and exporter are several times smaller in terms of the annual transactions' value, number of transacted products and trade partners.

Table IV. Joint heterogeneity of buyers and sellers in Paraguayan import transactions, 2013 - 2018

	$\bar{x}$	std	5%	10%	25%	50%	75%	90%	95%
				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.

Both buying and selling firms also differ in the number of their trading partners *within* narrow markets defined as an 8-digit HS code (HS8) product code. Although the majority of importers import products in HS8 product category from one seller and one country, about 25% of them

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

import at least one HS8 category from multiple sellers and different countries.[23] Likewise, most sellers regularly selling to Paraguay export goods in one product category to only one importer, and only a third of them have at least one product category, in which they export to multiple Paraguayan importers.[24]

Table V. Firm characteristics in 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, defined as a combination of a selling firm's name and country of purchase with more than 1000 appearances in the sample.

To test differential testable predictions on within-seller patterns of price dispersion, I use transactions of sellers with multiple buyers in the same narrow product category. These transactions account for a third of the sample and cover 20% of unique seller-HS8 product combinations, annually. Table V shows that in the subsample of interest, firms on both sides are larger and exhibit more heterogeneity compared to the full sample. In terms of the annual imported value, average seller and buyer are, respectively, 1.8 and 2.7 times larger than those in the entire sample. However, buyers of sellers with multiple buyer in a product category are a lot more heterogeneous in their sizes. This is line with the finding of Bernard et al. (2018) that larger sellers have smaller marginal buyers. The large sizes of firms and their heterogeneity on both sides of the market implies that market power on either or both sides of the market can be a source of the observed price dispersion.

[23] Expectedly, among trade intermediaries on the buyer size, the share of buyers importing at least one HS8 product category from multiple countries and sellers is higher and reaches 38%.

[24] Trade intermediaries on the seller side are more likely to sell same type of products to multiple buyers. The average number of buyers/seller-HS8 for them is 1.6; more than a half of trade intermediaries export goods from at least one product category to multiple Paraguayan buyers.

3.3 Import price dispersion

To illustrate the extent of import price dispersion in Paraguayan import transactions, I calculate unit values as a ratio of the transaction's (free-on-board, FOB) value (in $USD) and quantity (in known units) and use them as price proxies. As in Fontaine et al. (2020), I measure price dispersion with the coefficient of variation defined as a ratio of the standard deviation of prices to their mean in a given category. Figure III plots densities of coefficients of variation within HS8-Seller-Year categories for homogeneous and differentiated products as defined by Rauch (1999). Within-seller price variation is expectedly higher among differentiated products, where average coefficient of variation of 40% can be partly explained by quality/product differentiation. However, it is unexpectedly large in a subsample of homogeneous products, where, despite apriori limited scope for quality/product differentiation, the average coefficient of variation is close to 30%.

This 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 VI suggests that it explains 50% and 80% of the total price variation within HS8 product categories of differentiated and homogeneous goods, respectively. Importantly, the within-seller price variation across import transactions has a substantial between-buyers component. The last row of Table VI implies that variance of prices across buyers accounts for around 20% and 55% of within-seller price variation in HS8 categories of differentiated and homogeneous goods, respectively.

Table VI. Decomposition of price variance across Paraguayan import transactions, 2013 - 2018

	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.

Instead of studying the extent of price dispersion in narrow product categories across markets, products and sellers, as in Fontaine et al. (2020), I focus on understanding *why* prices vary across buyers of very similar products sold by the same seller. Detailed product characteristics within narrow HS8 product categories uniquely available in my data allow me to assess the role of product

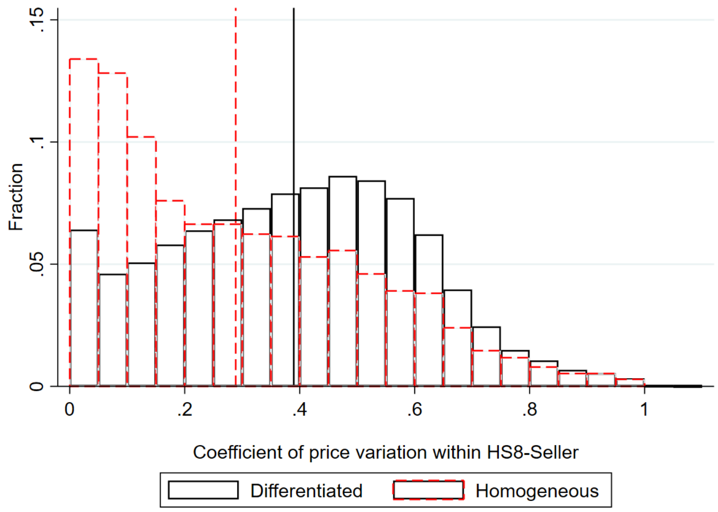


Figure III. Sellers substantially vary prices within narrow HS8 product categories

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 medianin each category were excluded, as in Fontaine et al. (2020). Vertical lines illustrate average COVs in subsamples of homogeneous and differentiated products, as classified by Rauch (1999).

differentiation and importer characteristics in within-seller price dispersion. For that, I use adjusted R^2 from regressing (log) price deviations from the annual seller-specific average in a given HS8 product category on product characteristics and importer fixed effects reported in Table VII.

In column (4), product's per-unit weight, brand and country of origin altogether, on average, explain 13% of within-seller price variation in a given product category. Adding importer fixed effects in column (6) increases the explained share of this variation to 18%. It means that, *independently* from product characteristics, importer characteristics account for 28% $(= (0.18 - 0.13)/0.18)$ of the total explained within-seller-product price variation. In contrast, in column (5), importer fixed effects alone explain, on average, 11% of within-seller product price variation, which is similar to the findings of Alviarez et al. (2021a) in the US data. Hence, product characteristics independently account for, on average, 39% $(= (0.18 - 0.11)/0.18)$ of this variation. The remaining 33% of the explained within-seller-product price variation is explained by selection of importers into importing products with certain characteristics.

The independent role of importer heterogeneity in within-seller price variation remains to be substantial even when product characteristics beyond brand and weight are accounted for. I extract these characteristics and identify individual varieties within HS8 categories from non-generic word descriptions importers are obligated to provide in a free format.[25] In case of passenger vehicles, these characteristics include the vehicle's model, brand, year of fabrication, country of assembly, engine and vehicle type, and model's trim. Controlling for these detailed characteristics, I find that importer fixed effects independently explain 20% of the total explained price variation within HS8-Seller-Year categories of passenger vehicles (see Table B5 in the Appendix).[26]

Table VII. Firm heterogeneity and product differentiation in price variation within HS8-Seller-Year

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.

In the next section, I use theoretical framework from Section 2 to study the role of firms' market power in the documented price variation across buyers of the same seller, conditional on quality.

4 Evidence of market-power mechanisms of price dispersion

4.1 Identification strategy

To distinguish between market-power mechanisms of price variation discussed in Section 2, I test their differential implications for variation of prices with buyer productivity summarized in Propositions 1 - 7. I generalize seller's pricing rules (in logs) across market structures in (7), (12) and (15) as follows:

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

[25] Appendix A describes how I cleaned and standardized product descriptions across import transactions using textual analysis techniques.

[26] Examples of vehicle models and summary statistics of their characteristics are provided in Tables B3 and B4.

Here, $s^J_{jkt}(\varphi)$ 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; and $\xi_{jkt}(\varphi)$ denotes buyer-specific error term.

Under oligopoly, a seller produces a differentiated variety and charges higher price to a buyer with a higher preference for its variety. Conditional on the purchased quantity, buyers have higher share of expenditures on products of sellers they prefer more, analogously to the quality measure in Khandelwal (2010) (see (8) and (11)). Under oligopsony with perfectly competitive sellers, sellers are identical and take up an equal share in input expenditures of all buyers. On the other hand, conditional on the buyer's preference for the seller's product, more productive buyers purchase larger quantities of this product under both oligopoly and oligopsony.

Using seller's share in buyer's expenditures, $s^J_{jkt}(\varphi)$, to measure buyer's preferences for the seller, and quantities purchased from the seller, $m_{jkt}(\varphi)$, to measure buyer's productivity, I map differential implications of market structures in Propositions 1 – 4 onto coefficients ρ_1 and ρ_2. In oligopolistic markets, $\rho_1 > 0$, while $\rho_2 = 0$ if seller's marginal costs are constant and buyers cannot countervail their market power, and $\rho_2 < 0$ if seller's marginal costs decrease in quantity and/or buyers can countervail their market power through outside options. In contrast, in oligopsonistic markets with perfectly competitive sellers, $\rho_2 > 0$, because sellers charge prices equal to their average costs that are assumed to increase in quantity. Alternatively, $\rho_1 > 0$ and $\rho_2 < 0$ can result from differences bargaining abilities rather than productivity across buyers in a bargaining framework. These results are summarized in the first two columns of Table VIII.

To identify the effect of buyer's productivity on price separately from the effect of its bargaining ability, I study how exporting by firms that import inputs impacts their imported inputs' prices. To test differential predictions across market structures summarized in Proposition 5, I estimate the following version of seller's pricing rule in (18):

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

where $\mathbb{X}_t(\varphi) = \left\{\mathbb{1}_{xt}(\varphi), \log\sum_{d_t\in N_{dt}(\varphi)} p^d_s(\varphi) q^d_s(\varphi)\right\}$ includes an exporting dummy variable equal to one if importing firm φ exports its final products and (log) sum of the firm's total sales to foreign markets at time t. Given firm's productivity φ, these variables capture over-time variation in the firm's size due to access to foreign markets.

The third column of Table VIII maps the sign of coefficient ρ_2^X onto the differential predictions of Proposition 5. If price variation across buyers of the same seller is due to differences in their bargaining abilities, then $\rho_2^X = 0$, because bargaining abilities are fixed and do not change with exporting. Alternatively, if price variation across buyers of the same seller is due to differences in outside options across buyers, then $\rho_2^X < 0$. This is because firm's scale increases with exporting and encourages them to find alternative suppliers that they use as outside options. In contrast, when an oligopsonist in inputs markets exports more of final products, the demand for inputs increases causing input prices to increase due to diseconomies of scale, $\rho_2^X > 0$.

Table VIII. Theoretical predictions under various market structures in the upstream industry

	ρ_1	ρ_2	ρ_2^X	ρ_3
Oligopoly	+	0	0	+
Oligopoly with outside options	+	−	−	−
Oligopsony	NA	+	+	0
Bargaining ability	+	−	0	−

Finally, I distinguish market-power mechanisms of price variation from variation in seller's costs by studying how competition among sellers affects the extent of price variation across their buyers. I add a interaction term between the number of sellers on a Paraguayan market, $\bar{N}_{jt}$, and buyer's quantity purchased from the seller, $m_{jkt}(\varphi)$,to seller's pricing rule in (18):

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

The sign of coefficient ρ_3 in this specification can be used to test differential predictions of the effect of competition on price variation under different market structures summarized in Proposition 7. If price variation across buyers is fully driven by seller's marginal cost variation, then entry of new sellers does not affect the extent of price variation and $\rho_3 = 0$. It is also not affected by sellers' entry under oligopsony with perfectly competitive sellers. In contrast, under oligopoly, if incumbent sellers vary prices according to the buyer's preference for the seller, then, when faced with competition, they reduce prices of their more loyal, larger buyers by less, $\rho_3 > 0$. However, if buyers can use new entering sellers as their outside options, then more productive buyers receive larger price discounts when the number of sellers on the market increases, $\rho_3 < 0$.

I estimate equations (18) - (20) using transaction-level (FOB) unit values as proxies for prices and 6-digit HS classification codes as a market j definition. As proxies for sellers' marginal costs, ν_{jkt}, I use sellers' names combined with more disaggregated 8-digit HS product codes, units of measurement, brand names, per-unit weight, commercial descriptions, and countries of origin. I rely on the importing firms' main industries reported by X, to account for differences in input requirements across final goods' industries, $\mathbb{Z}_{s(\varphi)jt}$.

I address several sources of potential endogeneity that can bias coefficient estimates in (18) - (20). First, I show that my results are not driven by a measurement error in quantities that I use to proxy for the buyer's productivity and to compute unit values as proxies for prices. Second, I address simultaneity bias which can emerge, when unobserved product quality affects prices through both seller's costs and buyer's demand.[27] Third, I consider several sources of an omitted variable bias that could hinder the interpretation of the results: non-constant marginal costs of production and transportation, firms' bargaining abilities, and ownership relationships. Finally, I address endogeneity of sellers' entry into a market using an import tariff in this market as an instrument.

4.2 Diagnosing price dispersion in firm-to-firm transactions

I now present the results of estimating seller's pricing function in (18) and (19). Table IX reports my baseline results and shows that the estimated price elasticities are not an outcome of measurement error, over-time seller productivity shocks and intra-firm transfer pricing.

The first column shows that, in line with oligopolistic price discrimination, sellers charge higher prices to buyers that allocate higher shares of their expenditures on the seller's product. However, conditional on the seller share, buyers that purchase in larger annual quantities receive a discount. Importantly, this discount remains to be significant, even after additionally controlling for the

[27] If more productive buyers purchase inputs of higher quality and product quality is not accounted for, then this will lead to an upward bias (towards zero) in ρ_2 and ρ_2^X in (18) - (20).

transaction-level quantity in column (2). It means that the negative price - buyer size relationship is not entirely driven by transaction-level quantity discounts or economies of scale. Column (4) confirms that the effect of both transaction size and annual buyer size on prices is not caused by a measurement error in quantities. It reports the same sizable discounts even after unit values with a potential measurement error – that are 5 times larger and 5 times smaller than the average in their (HS8) product category – are removed. In column (3), these discounts are estimated only slightly smaller in a subsample of transactions invoiced in US dollars, for which exchange-rate differences at the border across declaration dates are eliminated.

Table IX. Within-seller price dispersion unexplained by measurement error, exchange rate variation, outliers and intra-firm trade

Dependent Variable:	log *Transaction Price*				
	All	All	No outliers	$-invoiced	All
	(1)	(2)	(3)	(4)	(5)
log *Annual Buyer-Seller-HS6 Quantity*	-0.117***	-0.031***	-0.024***	-0.031***	-0.032***
	(0.010)	(0.006)	(0.003)	(0.005)	(0.006)
log *Transaction Quantity*		-0.231***	-0.130***	-0.232***	-0.231***
		(0.012)	(0.006)	(0.014)	(0.012)
log *Seller Share in Buyer's HS6 imports*	0.081***	0.070***	0.046***	0.072***	0.071***
	(0.009)	(0.009)	(0.004)	(0.009)	(0.009)
log *Per Unit Weight*		0.368***	0.216***	0.354***	0.368***
		(0.021)	(0.013)	(0.031)	(0.021)
Affiliated parties					-0.194**
					(0.091)
Constant	4.043***	3.892***	3.716***	3.990***	3.912***
	(0.080)	(0.077)	(0.043)	(0.085)	(0.076)
HS8-Seller-Unit-Year	✓	✓	✓	✓	✓
Industry	✓	✓	✓	✓	✓
N obs	2883734	2870148	2608192	1206606	2870148
N clusters	3351	3350	3325	2368	3350
Adj. R^2	0.940	0.954	0.980	0.957	0.954

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

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

Column (5) shows that the estimated relationship between prices and seller's share in buyer's expenditures and buyer size is independent from intra-firm (transfer) pricing. It reports that, all else equal, when selling to their affiliated buyers in Paraguay, foreign firms charge them, on average, 20% less for products in the same narrow (HS8) product category than prices charged to their arm's length buyers. However, controlling for the buyer's affiliation with the seller does not reduce eliminate price variation with transaction size, buyer size, and seller's share in buyer's expenditures. To uncover market-based mechanisms behind this variation, I focus the rest of my analysis on arms' length transactions only.

Further, I explore the role of within-seller product differentiation and quality variation in generating these patterns of within-seller price variation. They can introduce an upward bias into my estimates if complementarities between firm productivity and input quality imply a positive relationship between buyer size and imported goods' prices. However, controlling for seller's product's brand in Table X, I find an insignificant bias generated by brand differentiation within seller-HS8 product category. To limit product differentiation within Seller-HS8-Brand, in column (2) I study only pricing decisions of foreign manufacturers, who, compared to intermediaries, are less likely to sell multiple varieties of the same brand. Additionally, in column (3), I focus on prices of only homogeneous goods with apriori limited scope for product differentiation and quality variation. Finally, in column (4), I account for differences in production costs and product quality across seller's production locations and over time by including the interaction of purchase country, origin country, and month fixed effects. In all cases I find similar results as in the baseline specification, which means that the observed price variation cannot be explained by product differentiation at a more granular level.[28] In the Robustness section below, I show this directly in subsamples of passenger vehicles, for which I can identify product varieties within HS8 product categories.

Overall, estimation results in Tables IX and X are consistent with a model of oligopolistic price discrimination, where sellers charge higher prices to buyers which rely on them more and lower prices to buyers purchasing more due to their larger production scale. However, these buyer-size and transaction-size discounts, conditional on the seller's share in buyer's expenditure, can be a result of both seller's mark-up variation and economies of scale.

In Table XI, I attempt to separate these two different mechanisms and provide evidence of both. In the first column, I show how price elasticities of interest change when I control for the economies

[28]In a subsample of homogeneous goods, I find that smaller, by absolute value, price elasticities with respect to buyer size, transaction size, and seller's share in buyer's expenditures. This is in contrast to the bias implied by the productivity - quality complementary hypothesis, but in line with lower market power of firms selling homogeneous products.

Table X. Within-seller price dispersion accounting for detailed product characteristics

Dependent Variable:	log *Transaction Price*			
	(1)	(2)	(3)	(4)
	All	Producers	Homog	All
log *Annual Buyer-Seller-HS6 Quantity*	-0.039***	-0.041***	-0.021***	-0.038***
	(0.005)	(0.005)	(0.008)	(0.005)
log *Transaction Quantity*	-0.231***	-0.224***	-0.205***	-0.228***
	(0.018)	(0.019)	(0.023)	(0.019)
log *Seller Share in Buyer's HS6 imports*	0.069***	0.062***	0.035***	0.063***
	(0.008)	(0.005)	(0.009)	(0.008)
log *Per Unit Weight*	0.319***	0.322***	0.422***	0.324***
	(0.019)	(0.020)	(0.060)	(0.017)
Constant	4.413***	4.461***	2.104***	4.418***
	(0.073)	(0.080)	(0.149)	(0.073)
HS8-Seller-Unit-Year-Brand	✓	✓	✓	✓
Industry	✓	✓	✓	✓
Country-Origin-Month-Year				✓
N obs	1660435	1437537	165534	1495554
N clusters	2288	2200	943	2116
Adj. R^2	0.962	0.963	0.954	0.971

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

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

Table XI. Within-seller price dispersion accounting for economies of scale in production and transportation

Dependent Variable:	log *Transaction Price*			
	(1)	(2)	(3)	(4)
	OLS	OLS	OLS	IV
log *Annual Buyer-Seller-HS6 Quantity*	-0.020***	-0.032***		-0.030***
	(0.007)	(0.004)		(0.007)
log *Shipment HS6 Quantity*	-0.172***	-0.029***		
	(0.013)	(0.007)		
log *Transaction Quantity*		-0.214***	-0.239***	-0.238***
		(0.019)	(0.019)	(0.019)
log *Annual Buyer-Seller-HS6 Quantity, Lag*			-0.016***	
			(0.004)	
log *Seller Share in Buyer's HS6 imports*	0.074***	0.069***	0.062***	0.068***
	(0.008)	(0.008)	(0.011)	(0.011)
log *Per Unit Weight*	0.361***	0.318***	0.318***	0.317***
	(0.017)	(0.019)	(0.020)	(0.020)
Constant	4.232***	4.432***	4.305***	
	(0.075)	(0.072)	(0.077)	
HS8-Seller-Unit-Year-Brand	✓	✓	✓	✓
Industry	✓	✓	✓	✓
N obs	1660435	1660435	1183969	1183969
N clusters	2288	2288	1627	1627
Adj. R^2	0.959	0.962	0.959	0.199

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

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

of scale in transportation with transaction-level per-kilogram freight costs available in my data. It results in a reduction of transaction- and buyer- size discounts to a third and price elasticity with respect to the seller's share in buyer's expenditures to three-quarters of their values in Table X. Columns (2) - (4) provide some evidence of scale and scope economies in addition to, rather than in place of, buyer-size and transaction-size discounts. All else equal, sellers charge lower prices when selling more varieties and in larger quantities on the same (declaration) date and when delivering the same product (in HS8 category) to fulfill larger annual orders. But this does not change the extent of transaction-size and buyer-size discounts in a significant way. Therefore, the observed negative buyer size - price relationship cannot be fully explained by seller's cost savings when selling to overall larger buyers.

Results presented so far suggest that sellers vary their mark-ups by charging buyers with a specific preference for the seller a higher price and giving discounts for purchasing in larger quantities per transaction and annually. This is consistent with oligopolistic price discrimination when, all else equal, only larger buyers can get a mark-up reduction by threating to replace seller's product with their outside option. This mechanism yields patterns of price dispersion opposite to those implied by the well-studied complementarity between input quality and firm productivity (ie. Kugler and Verhoogen (2012), Blaum et al. (2019), etc.). However, Figure IV shows that the two mechanisms are not contradicting but complementing each other in explaining price dispersion in a market for passenger vehicles (HS4 code "8703").

In this market, seller names allow me to distinguish between cars of two distinct qualities: new, sold by car manufacturers, and used, sold by resellers. The dashed lines on Figure IV show that within each of these sub-markets (for used and new vehicles), there is a negative relationship between buyer size and average price. However, if the quality of cars imported by different buyers is unknown, the solid line shows no relationship between buyer size in the market for passenger vehicles and imported vehicles' prices. The scatter plot of the data suggests that this is because larger buyers tend to import new vehicles, which have higher quality and higher price than used ones. It means that unobserved differences in demand for quality of imported products across buyers introduces an upward (positive) bias to estimates of buyer-size discounts.

The novel mechanism behind buyer-size discounts proposed in this paper has several important

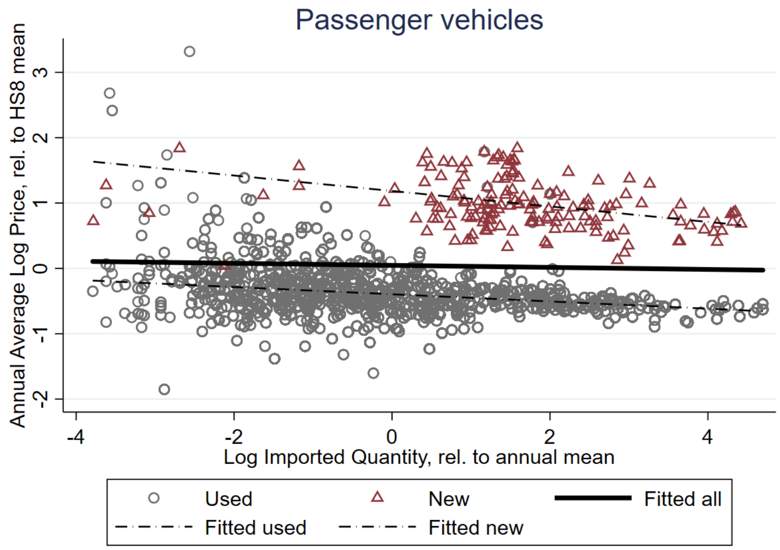


Figure IV.
The role of product quality in relationship between importer size and imported goods' prices in a market for passenger vehicles

implications. First, it increases the observed firm heterogeneity by introducing an input price bias in estimates of firm productivities. Exogenously more productive and hence larger buyers become even larger and more productive by negotiating through lower input prices. Second, this mechanism implies that large buyers downstream have power to countervail the market power of large sellers upstream. Therefore, larger downstream firms can increase the pass-through of upstream firms' cost shocks, which is found to be low due to seller market power (*ie.* Berman et al. (2012), Amiti et al. (2014)).

In Table XIII, I test an implication of countervailing buyer power for the link between exporting and prices of imported inputs across firms. It implies that a firm's expansion to (more) foreign markets generates an increase in its output scale that further allows me to extract discounts from the firm's (foreign) input suppliers. To determine how buyers' exporting revenues are related to their imported goods' prices, I estimate specification (19).

In the first column, I use variation in export revenues across buyers with most of their exports in the same HS4 industry as a source of buyer-size variation. I find a negative but statistically insignificant effect of firm's size in its output market on prices of imported goods. However, using

Table XII. The effect of exporter size on prices of imported goods

Dependent Variable:	log *Transaction Price*				
	(1)	(2)	(3)	(4)	(5)
	OLS	IV	OLS	OLS	I stage
log *Annual Export Revenue*	-0.018	-0.062***	0.064***		
	(0.015)	(0.021)	(0.023)		
log # *Destinations/Year*				-0.088***	1.407***
				(0.027)	(0.112)
log *Transaction Quantity*	-0.253***	-0.252***	-0.275***	-0.252***	-0.001
	(0.032)	(0.032)	(0.031)	(0.032)	(0.001)
log *Seller Share in Buyer's HS6 Imports*	0.087***	0.081***	0.127***	0.085***	-0.061
	(0.018)	(0.016)	(0.022)	(0.017)	(0.037)
log *Per Unit Weight*	0.396***	0.397***	0.425***	0.397***	0.002
	(0.027)	(0.027)	(0.026)	(0.027)	(0.003)
Constant	4.373***		3.460***	4.195***	11.511***
	(0.208)		(0.336)	(0.113)	(0.054)
HS8-Seller-Unit-Year	✓	✓		✓	✓
HS8-Country-Unit-Year			✓		
Year-Industry	✓	✓	✓	✓	✓
N obs	223258	223255	223255	223255	223255
N clusters	447	446	446	446	446
Adj. R^2	0.933	0.230	0.920	0.933	0.995
Kleibergen-Paap rk Wald F		157.3			

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

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

Table XIII. The effect of buyer size in exporting on prices of imported goods

Dependent Variable:	log *Transaction Price*				
	(1)	(2)	(3)	(4)	(5)
	All	All	Producers	Homogen	All
log *Annual Export Revenues*	-0.009	-0.028***	-0.027***	-0.024**	0.053**
	(0.015)	(0.006)	(0.008)	(0.011)	(0.022)
log *Transaction Quantity*	-0.164***	-0.168***	-0.166***	-0.194***	-0.194***
	(0.011)	(0.011)	(0.011)	(0.024)	(0.013)
log *Seller Share in Buyer's HS6 Imports*	0.127***	0.127***	0.133***	0.090***	0.139***
	(0.017)	(0.015)	(0.021)	(0.025)	(0.014)
log *Per Unit Weight*	0.442***	0.447***	0.442***	0.449***	0.449***
	(0.020)	(0.020)	(0.023)	(0.058)	(0.019)
Constant	3.538***	3.820***	3.670***	3.231***	2.952***
	(0.188)	(0.102)	(0.115)	(0.242)	(0.267)
HS8-Seller-Unit-Year	✓	✓	✓	✓	
HS8-Country-Unit					✓
Buyer		✓	✓	✓	
Industry-Year	✓				✓
N obs	562437	605162	456004	37102	622373
N clusters	539	536	433	282	595
Adj. R2	0.947	0.947	0.933	0.958	0.932

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

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

within-firm variation in export revenues over time in subsequent columns, I identify a statistically significant negative relationship between firm's export revenues and prices of narrowly defined (HS8) imported goods, conditional on the seller. It means that the initially insignificant result is likely caused by imprecise assignment of output markets to importers.[29] In columns (2) and (3), I focus on importing manufacturers and homogeneous goods, respectively, to show this relationship is not identified off importing intermediaries and not an outcome of product differentiation. It implies that a one percent increase in export revenue, all else equal, is associated with a 0.03% reduction of imported goods' prices, on average.

This result is in line with the model's prediction that an increase in the production scale (*e.g.* through trade liberalization) allows downstream firms to get discounts from price discriminating upstream sellers. However, it is in stark contrast with a positive correlation between imported

[29]In the Robustness section below, I show that indeed, when more general industry classification is used, buyer-size quantity discounts are estimated to be larger.

goods' prices and their buyers' total or export sales, often documented in datasets without seller information (*c.f.* Bastos et al. (2018), Blaum et al. (2019)). Interestingly, I find the same positive relationship and a comparable value of price elasticity with respect to firm's export sales in a specification *without* seller fixed effects in column (5). It means that larger exporters import their inputs from higher-priced suppliers with potentially higher quality, but receive a discount, conditional on purchasing the good from the same supplier.

An important implication of this finding is that trade liberalization in firms' output industries can improve their measured productivity even without any costly investment in products' quality. It suggests a negative buyer-size effect on input prices as a novel mechanism behind a positive link between exporting and firm productivity documented in multiple studies (*c.f.* Lileeva and Trefler (2010), Aw et al. (2008)). Moreover, it implies that larger downstream firms, which were initially close to threatening their suppliers, benefit more from trade liberalization in their output industry. These firms' profits increase not only because of an increase in sales to foreign markets but also because of a reduction in input prices implied by an increase in output scale.

4.3 Robustness checks

I further test the robustness of my findings to alternative mechanisms of price dispersion in Table XIV. The developed framework (equation (8)) suggests that within the same downstream industry, buyers that purchase more from a given seller, conditional on the seller's share in their expenditures, do so because they are more productive. To identifying buyers in the same downstream industry, I have so far used importer's main market (HS4 product code) of importing. Alternatively, in columns (1) and (2), I measure buyer size relative to the average among importers from the same industry in the Nomenclature of Economic Activities (NACE) and to the buyer's average in sample, respectively. In both cases, I find larger buyer-size discounts relative to those found in the baseline specification.

Importer fixed effects in the second column also allow me to exclude other mechanisms of price dispersion not considered in this paper. When downstream firms can charge variable markups in their output markets, then Halpern and Koren (2007) show that larger importers will be

Table XIV. Sources of within-seller price dispersion with alternative measures of buyer size and accounting for differences in production technologies across buyers

Dependent Variable:			log *Transaction Price*		
	OLS	OLS	IV	Reduced	I stage
	(1)	(2)	(3)	(4)	(5)
log *Transaction Quantity*	-0.292***	-0.230***	-0.237***	-0.238***	
	(0.017)	(0.016)	(0.018)	(0.018)	
log *Seller Share in Buyer's HS6 imports*	0.350***	0.103***	0.068***	0.062***	
	(0.080)	(0.013)	(0.012)	(0.012)	
log *Per Unit Weight*	0.299***	0.347***	0.354***	0.354***	
	(0.054)	(0.022)	(0.027)	(0.027)	
log *Annual Buyer-Seller-HS6 Quantity*	-0.199***	-0.065***	-0.031***		
	(0.056)	(0.010)	(0.008)		
log *Annual Buyer-Seller-HS6 Quantity, Lag*				-0.016***	0.551***
				(0.004)	(0.026)
Constant	5.962***	4.469***		4.157***	3.544***
	(0.444)	(0.111)		(0.087)	(0.182)
HS8-Seller-Brand-Unit-Year	✓	✓	✓	✓	✓
Industry			✓	✓	✓
NACE	✓				
Importer		✓			
N obs	245346	1940549	1314891	1314891	1314891
N clusters	32	2473	1681	1681	1681
Adj. R2	0.908	0.961	0.217	0.958	0.986
Kleibergen-Paap rk Wald F			425.3		

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

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

charged higher input prices because their price sensitivity is lower.[30] Moreover, under incomplete contracts, Grossi et al. (2019) show larger downstream firms are more likely to use relational sourcing strategies and pay higher mark-ups to incentivize suppliers to deliver on aspects not included in the contract. Finally, if firm productivity is complementary to input quality, then larger, more productive, downstream buyers, import more expensive goods whose price reflects their quality. If any of my results were driven by these mechanisms, then including importer fixed effects would have make some if not all coefficients in Table XIV insignificant. Instead, I find that accounting for these mechanisms makes buyer-size discounts larger, which is in line with an upward bias the discussed mechanisms can introduce to my baseline estimators.

[30]When larger downstream firms charge higher mark-ups, they become less sensitive to input prices, as they can pass-through more of their costs to final consumers.

Columns (3) - (5) of Table XIV address remaining after accounting for product quality time-specific sources of simulteneity bias in estimation of supply function (18). In column (4), I alternatively use its lagged by one year level, and find similar buyer-size discounts as in the baseline specification. Importantly, they are less likely driven by scale economies, because although strongly correlated as shown in column (5), lagged quantities are not directly related to current seller's costs. For this reason and to alleviate time-varying sources of endogeneity, I also instrument current quantities with their lagged levels. Column (3) shows that this instrumental variable approach yields roughly the same buyer-size discounts as the baseline specification.

The only alternative explanation for my results that remains to discuss is within-seller product differentiation in narrow HS8 product categories, unrelated to differentiation by brand. Although it seems unlikely in case of homogeneous goods, it is possible in case of highly differentiated products, which comprise a majority of Paraguayan imports. To rule out within-seller product differentiation as an explanation of my findings, I estimate seller's pricing equations in (18) and (19) in a subsample of vehicles, for which I observe the most detailed product characteristics. The estimated coefficients with their 95% confidence intervals separately for used and new vehicles are displayed in Figure V.

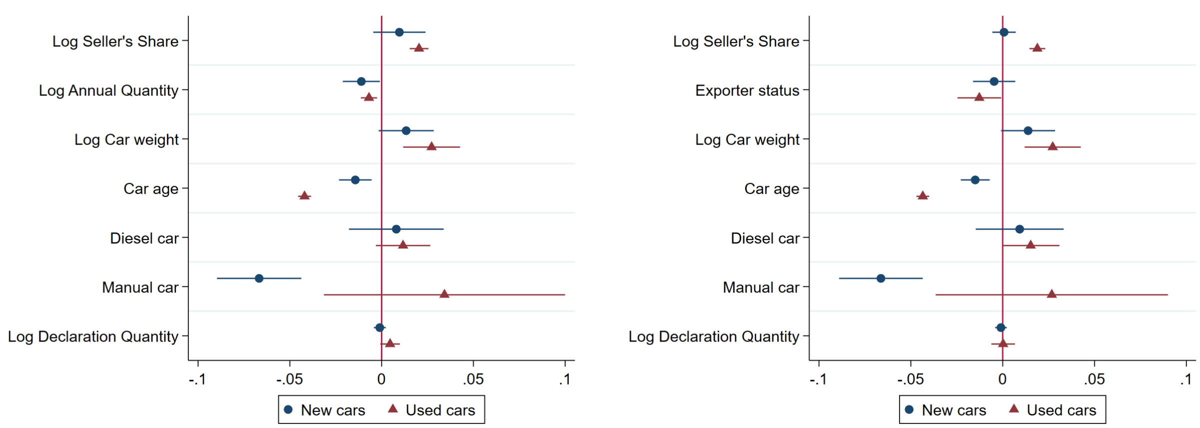


Figure V.
Variation of prices of vehicles across buyers of the same seller, conditional on vehicle's brand, model and detailed characteristics

I find that, even conditional on vehicle's model, brand, trim, engine type, size, and year of fabrication, sellers offer discounts to their larger buyers of both used and new vehicles. Exporters, which mostly import used vehicles to Paraguay, also receive a price reduction when importing the same vehicle, relative to their non-exporting rivals. This certainly cannot be explained by transaction size and measurement errors in quantities, because each vehicle is reported as a separate transaction, which makes its (FOB) value equal to its price rather than unit value.

Sellers of used vehicles tend to give out smaller discounts, which is consistent with the fact that used vehicles are less differentiated than new ones, which, in turn, gives their sellers less market power to vary prices. In Table B7 in the Appendix, I show that buyer-size discounts are larger for newer but still used vehicles. Additionally, I find that when new vehicles' sellers face competition from less old used vehicles of the same brand, they offer larger discounts to their larger buyers. This result is consistent with Ellison and Snyder (2010)'s finding that firms give larger discounts if their products have substitutable alternatives on the market. I investigate the role of competition on the observed price dispersion in more detail in the next section.

4.4 The effect of competition on price dispersion in firm-to-firm transactions

I now show that the documented patterns of price dispersion are not driven by any specific imported products but are rather a common feature of most industries. For that, I estimate seller's pricing equation (18) separately for each of 15 industries defined as chapters of HS classification. The estimated coefficients on buyer- and transaction- size with their 95-% confidence intervals in each industry are plotted in Figure VI. Transaction-level prices are strongly negatively related to transaction size in all industries and to buyer size - in 8 out of 15 industries. Industries with statistically and economically significant buyer-size discounts produce predominantly differentiated goods. This is then unsurprising that product differentiation gives sellers market power to set prices and vary them across buyers.

To explore the role of market power in buyer-size discounts more formally, I use insights from industrial organization literature (Shepard (1991), Ellison and Snyder (2010), etc.) and study how these discounts change with the change in competition among sellers. The first hypothesis is that, in absence of seller's market power, the observed price differentials across buyers reflect only differences in the seller's marginal costs. Therefore, price differentials should not be affected by competition among sellers, unless part of these differentials reflect differences in mark-ups. The second hypothesis is that competition among sellers increases buyer-size discounts if they are

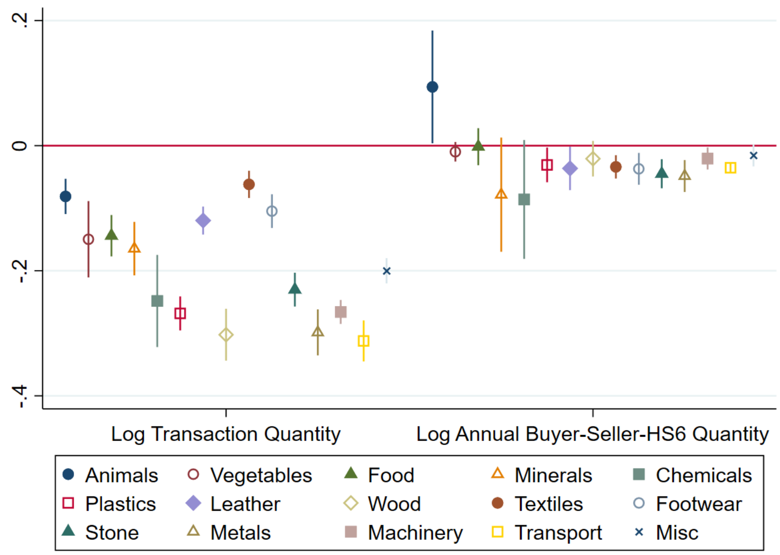


Figure VI.
The relationship between imported goods' prices and buyer- and transaction-size across industries

initially driven by larger buyers' ability to acquire a credible replacement threat. In markets with only one, monopoly, seller, the costs of finding an alternative supplier are extremely high and insurmountable even for large buyers. In contrast, in markets with a large number of potential suppliers, the costs of finding a replacement are low at least for the larger buyers. Hence, if buyer-size discounts reflect seller mark-ups' variation across buyers with different replacement threats, then these discounts are predicted to increase with seller competition.

I test both of these hypotheses in Table XV below. In the first column, I use number of sellers in HS6 product category in year 2013, to measure availability of outside options, and estimate its affect on buyer-size discounts in subsequent years. Alternatively, in the second column, I study a concurrent effect of competition on buyer-size discounts. In both cases, I find that in monopolistic markets, monopolists do not offer any discounts to their large buyers. However, in competitive environments, an increase in the number of sellers in the market results in an increase in buyer-size discounts. This is in line with the Ellison and Snyder (2010)'s hypothesis that large buyers' replacement threat is only credible in competitive markets.

In columns (3) to (5), I show that this result is not an outcome of endogenous entry of sellers. For that, in column (3), I instrument the within-HS6 over-time deviations of the number of sellers

Table XV. The effect of seller competition on buyer-size discounts

Dependent Variable:	log *Transaction Price*				
	OLS	OLS	IV	Reduced	I stage
	(1)	(2)	(3)	(4)	(5)
log *Annual Buyer-Seller-HS6 Quantity*	0.024	0.032	-0.037***	-0.037***	-0.002
	(0.018)	(0.020)	(0.006)	(0.005)	(0.005)
× log #Sellers in HS6, 2013	-0.016***				
	(0.004)				
× log #Sellers in HS6		-0.017***			
		(0.004)			
×Δ log #Sellers in HS6			-0.167*		
			(0.095)		
×Δ log Mean MFN Tariff in HS6				0.001*	-0.009***
				(0.001)	(0.000)
log *Transaction Quantity*	-0.232***	-0.231***	-0.233***	-0.233***	-0.000
	(0.018)	(0.018)	(0.016)	(0.016)	(0.000)
log *Seller Share in Buyer's HS6 imports*	0.071***	0.070***	0.069***	0.069***	0.000
	(0.009)	(0.009)	(0.008)	(0.008)	(0.001)
log *Per Unit Weight*	0.345***	0.345***	0.344***	0.344***	-0.000
	(0.024)	(0.024)	(0.022)	(0.022)	(0.000)
Constant	4.204***	4.190***		4.258***	0.010
	(0.080)	(0.080)		(0.078)	(0.036)
HS8-Seller-Brand-Unit-Year	✓	✓	✓	✓	✓
Industry	✓	✓	✓	✓	✓
N obs	1663442	1685168	1941737	1941737	1941737
N clusters	2318	2324	2477	2477	2477
Adj. R2	0.960	0.960	0.211	0.961	0.996
Kleibergen-Paap rk Wald F			312.7		

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

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

with over-time changes of mean most-favored-nations (MFN) import tariffs in HS6 category. The first-stage regression results in column (5) show that, indeed, this instrument is significantly and negatively correlated with the number of sellers in HS6 product category exporting to Paraguay. Moreover, a increase in an import tariff in a product category is associated with a reduction in buyer-size discounts, as shown in column (4). Because prices in Paraguayan customs data are reported before payment of import tariffs, their effect on price dispersion is unlikely to come through channels other than seller competition. As a result, addressing the endogeneity of sellers' entry problem using this IV yields an even larger effect of seller competition on price dispersion.

Heterogeneity analysis of price determinants across industries suggests at least two general implications. First, the sensitivity of price dispersion to seller competition confirms that buyer-size discounts themselves are a result of mark-up rather than cost variation. This is intuitive, because competitive pressure can only affect prices through seller's mark-ups rather than marginal costs. Second, it means that buyers can only countervail their large suppliers in competitive markets. This is because a replacement threat of larger buyers becomes credible only if there are alternative sources of supply in a given market.

5 Conclusions

This paper documents a surprising large variation of prices of narrowly defined products across buyers of the same seller. Using uniquely detailed product descriptions available in a new customs dataset, it shows that this variation is unrelated to differences in product quality across buyers. Instead, a large portion of this price variation is shown to be explained by a negative buyer-size – price relationship. Importantly, this relationship itself is not entirely explained by scale economies and intra-firm transfer pricing and is at least partially a result of market power. The developed theoretical framework, however, suggests that market power on only one side of the market cannot explain this pattern of price variation. It shows that standard price discrimination under oligopoly and variation in buyer power under oligopsony both imply a positive buyer-size – price relationship. However, this relationship can be reversed under oligopoly when larger buyers have outside options, which they can use as a replacement threat to get lower prices from their suppliers.

I use transactional level of disaggregation in my data, to identify the negative buyer-size effect on prices separately from quantity discounts at the transaction level. I find evidence of both mechanisms in most industries: sellers charge lower prices to larger importers and to importers shipping products in large quantities at once. By studying differences in buyer-size discounts across and within industries over time, I show that they are affected by the availability of outside options in the form of alternative suppliers. I find that in monopolistic markets larger buyers do not get buyer-size discounts, which is in line with the fact that they have no alternative suppliers to use as a threat. The documented sensitivity of buyer-size discounts to seller competition confirms mark-ups variation as their driving force and lends support to the proposed mechanism of larger buyers' outside options.

My findings suggest that when buyers are firms rather than final consumers, they can have power to countervail the market power of sellers. This countervailing power, in turn, alters standard predictions of firm-to-consumer models used to analyze firm behavior in global markets mostly consisting of firm-to-firm transactions. First, countervailing power of firms in input markets gives initially more productive firms an additional advantage over their rivals in output markets. Under free entry, in the long run, this will result in higher market concentration downstream and higher mark-ups charged to final consumers. Therefore, countervailing power benefits final consumers if the implied reduction of firms' input costs makes up for the increased mark-ups in output markets. It means that the welfare effect of recent trend towards higher mark-ups and market concentration depends on whether firms in more concentrated markets can negotiate for better input prices.

Second, when buyers are firms rather than consumers, they can be as important as sellers in determining the pass-through of global shocks throughout the economy. I show that sellers pass through more of their cost changes to their larger downstream buyers with countervailing power. Because, seller competition is necessary for countervailing buyer power, is it expected to increase the pass-through of cost shocks along the supply chain. On the other hand, higher market concentration of firms in downstream markets implies larger average buyer size in their inputs markets and hence higher pass-through of sellers' shocks.

Third, when firm size affects its input prices, conditional on quality, scale effects of trade liberalization imply a new channel of gains from trade. I find that when a firm exports more, it pays less for the same imported product from the same seller. This is explained through an increase in firm size due to exporting, which enables it to get a stronger replacement threat and a discount from the input supplier. Because initially larger firms are more likely to have this threat, they are the ones who benefit more from trade liberalization through this additional mechanism. To reconcile it with the positive link between exporting and input quality, I show that larger exporters import inputs from more expensive sellers, but pay less than smaller exporters buying the same good from the same seller. Hence, trade liberalization not only enables firms to upgrade their input quality, but also allows them to lower prices of inputs, conditional on their quality.

In addition, my results contribute to the ongoing debate on the effect of competition on price discrimination in domestic markets. I provide evidence of the third-degree price discrimination in the form of buyer-size discounts in intermediate goods' markets. I show that the extent of third-degree price discrimination across downstream firms increases with the level of international competition in upstream markets. These findings provide rationale for intermediaries, various alliances and endogenous mergers in downstream markets, but predicts them to be successful in getting lower prices only from sellers in competitive upstream markets.

A Appendix

A.1 Data

A.2 Theory

A.2.1 Proofs of Propositions in Section 2.5

Input prices under oligopoly

Proof of Proposition 1.

Under oligopoly, seller k of input j solves the following profit maximization problem:

$$\pi_{jk} = \int_{\varphi \in \Omega_{jk}} \left(p_{jk}(\varphi) - \frac{m_{jk}(\varphi)^{1/\gamma_j} w}{a_k^{1/\gamma_j}} \right) m_{jk}(\varphi) d\varphi \tag{21}$$

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:

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

where $m_s(\varphi)$ is aggregate demand for inputs in sector s. The solution to this problem is

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

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:

$$\min_{m_s(\varphi)\forall s} \quad \sum_{j\in N_s} \mathbb{P}_j(\varphi) m_s(\varphi) \quad \text{subject to} \quad \left(\sum_{j\in N_s} m_j(\varphi)^{\frac{\theta_s-1}{\theta_s}}\right)^{\frac{\theta_s}{\theta_s-1}} \geq M_s(\varphi), \tag{22}$$

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

$$m_s(\varphi) = \left(\frac{\mathbb{P}_j(\varphi)}{\mathbb{J}_s(\varphi)}\right)^{-\theta_s} M_s(\varphi), \tag{23}$$

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 (23), and then (23) into (A.2.1) 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 calculating the elasticity of their input demand in (8). Log-linearizing this derived demand and then taking the derivative with respect to log $p_{jk}(\varphi)$ then yields input demand elasticities in (10). 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:

$$\pi_s(\varphi) = p_s(\varphi)q_s(\varphi) - wL_s(\varphi) - \sum_{j \in N_s} p_j(m_j(\varphi))m_j(\varphi), \tag{24}$$

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 $p_j(m_j(\varphi)) = \frac{wm_j(\varphi)^{1/\gamma_j - 1}}{a^{1/\gamma_j}}$.

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 the oligopsonist profit function in 24), yields the profit function net of labor expenses in (12), 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 ""):

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

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

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 (13), 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 (13), I use insights from Feenstra (1994) and re-write the change in buyer's marginal costs after adding suppliers of input j as[31]

$$\frac{\mathbb{J}_s^{\prime\prime}(\varphi)}{\mathbb{J}_s^{\prime}(\varphi)} = \left(\frac{p_{jk}^{\prime\prime}(\varphi)}{p_{jk}^{\prime}(\varphi)}\right)^{\omega_j^{\prime\prime}(\varphi)} \left(s_{jk}^{J^{\prime\prime}}(\varphi)\right)^{\frac{\omega_j^{\prime\prime}(\varphi)}{\eta_j - 1}}, \tag{25}$$

$s_{jk}^{J''}(\varphi)$ is a share of seller k in buyer's expenditures on input j defined in (10); and $\omega_j^{''}(\varphi)$ is a Sato-Vartia (log-change) weight defined as:

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

The first component on the right-hand side of (25) 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

[31] 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.

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

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:

$$\max_{p_{jk}} \left[\Delta\Pi^B(N_j;\varphi)\right]^{\kappa_k(\varphi)} \left[\Delta\Pi^S(\Omega_k;a_k)\right]^{1-\kappa_k(\varphi)} \tag{26}$$

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:

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

Plugging in the expression for $\Delta\Pi^B(N_j;\varphi)$ $\Delta\Pi^S(\Omega_k;a_k)$ 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.2.2 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 (10 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 (13) 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 (12), which can be re-written as:

$$(1-\alpha_s)\tilde{A}_s^* \tilde{\varphi} \tilde{M}_s(\tilde{\varphi})^{-\alpha_s} \left(\frac{m_j(\tilde{\varphi})}{\tilde{M}_s(\tilde{\varphi})} \right)^{-1/\theta_s} = \frac{\partial p_j(\tilde{\varphi})}{\partial m_j(\tilde{\varphi})} m_j(\tilde{\varphi}) + p_j(\tilde{\varphi}) \quad (27)$$

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 (27) 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.

As shown in (16), under oligopoly and constant marginal costs ($\gamma_j = 1$), pass-through of seller's cost into buyer's prices depends on the mark-up elasticity with respect to price, $\Gamma_{jk}(\varphi)$. Using the expression for an oligopolistic mark-up in (7), it can be further re-written as:

$$\Gamma_{jk}(\varphi) \equiv \frac{d \log \mu_{jk}(\varphi)}{d \log p_{jk}(\varphi)} = \frac{1}{\zeta_{jk}(\varphi) + 1} \frac{\partial \zeta_{jk}(\varphi)}{\partial p_{jk}(\varphi)} \frac{p_{jk}(\varphi)}{\zeta_{jk}(\varphi)}$$

$$\frac{\partial \zeta_{jk}}{\partial p_{jk}} \frac{p_{jk}}{\zeta_{jk}} = \frac{p_{jk}}{\zeta_{jk}} \left\{ (\eta_j - \theta_s) \frac{\partial s_{jk}^J}{\partial p_{jk}} + (\theta_s - 1 + (1 - \alpha_s)(1 - \sigma_s)) \frac{\partial s_{jk}^J s_J^M}{\partial p_{jk}} \right\}$$

$$\frac{\partial s_{jk}^J}{\partial p_{jk}} = \frac{(1 - \eta_j) s_{jk}^J (1 - s_{jk}^J)}{p_{jk}}$$

$$\frac{\partial s_{jk}^J s_J^M}{\partial p_{jk}} = \frac{\partial s_{jk}^J}{\partial p_{jk}} s_J^M + s_{jk}^J \frac{\partial s_J^M}{\partial p_{jk}},$$

$$\frac{\partial s_J^M}{\partial p_{jk}} = (1 - \theta_s) s_J^M (1 - s_J^M s_{jk}^J) \frac{\partial \mathbb{P}_j}{\partial p_{jk}} \frac{1}{\mathbb{P}_j}$$

$$\frac{\partial \mathbb{P}_j}{\partial p_{jk}} \frac{1}{\mathbb{P}_j} = \delta_{jk}^{\eta_j} p_{jk}^{-\eta_j} \mathbb{P}_j^{\eta_j - 1}$$

where I omitted buyer index φ from buyer-specific variables, for conciseness. Sequentially plugging in these expressions one into another starting from the last one yields the following expression for the buyer's input demand elasticity with respect to price:

$$\frac{\partial \zeta_{jk}}{\partial p_{jk}} \frac{p_{jk}}{\zeta_{jk}} = \frac{(\eta_j - \theta_s)(1-\eta_j) s_{jk}^J (1 - s_{jk}^J) + (\theta_s - 1 - (\sigma_s - 1)(1-\alpha_s))\, s_{jk}^J s_J^M \left\{ (1 - s_{jk}^J)(1-\eta_j) + (1 - s_J^M s_{jk}^J) s_{jk}^J (1 - \theta_s) \right\}}{\zeta_{jk}}$$

It is positive, because $\eta_j > \theta_s > \sigma_s > 1$ imply that all components in the numerator are negative and input demand elasticity $\zeta_{jk}(\varphi)$ in denominator is negative too. It means that mark-up elasticity with respect to price, $\Gamma_{jk}(\varphi)$ is negative, because $\zeta_{jk}(\varphi) + 1$ is negative, which can be seen from:

$$\zeta_{jk}(\varphi) + 1 = (\theta_s - \eta_j)(1 - s_{jk}^J) + (\theta_s - 1)(s_{jk}^J(\varphi) s_{jk}^M(\varphi) - 1) - (1 - \alpha_s)(\sigma_s - 1) s_{jk}^J(\varphi) s_{jk}^M(\varphi) < 0$$

Therefore, because $\Gamma_{jk}(\varphi) < 0$, the pass-through of seller's cost shock $\frac{1}{1-\Gamma_{jk}(\varphi)} < 1$ is less than complete. It becomes less complete when, all else equal, seller's share in buyer's expenditures on input j, $s_{jk}^J(\varphi)$, increases. To see this, notice that $\zeta_{jk}(\varphi)(\zeta_{jk}(\varphi) + 1) >$ and decreases in seller's share in buyer's input expenditures on j, if $s_{jk}^J(\varphi) < 0.5$ At the same time, $\frac{\partial \zeta_{jk}}{\partial p_{jk}} p_{jk} < 0$ becomes more negative when $s_{jk}^J(\varphi)$ increases, all else equal. It means that, if $s_{jk}^J(\varphi) < 0.5$, all else equal, $\Gamma_{jk}(\varphi)$ becomes more negative when $s_{jk}^J(\varphi)$ increases. This, in turn, results in lower pass-through of seller's shocks to buyers with higher share of expenditures spent on the seller's product.

When buyers can choose the number of suppliers of each input, then all else equal, overall larger, more productive downstream buyers are more likely to have multiple suppliers. Larger buyers then allocate lower shares of their expenditures to each of their suppliers. Because of their lower expenditures shares with each supplier, they experience a higher pass-through of seller's cost shocks as discussed above.

In contrast, as shown in (17), under oligopsony, pass-through of seller's costs into buyer's prices are determined by the elasticity of buyer's input demand with respect to price, $\Psi_j(\varphi)$. Using the expression for the input demand in (12) in the definition of this elasticity yields:

$$\Psi_j(\varphi) \equiv \frac{d \log m_j(\varphi)}{d \log p_j(\varphi)} = \left[\frac{d \log n_j(\varphi)}{d \log m_j(\varphi)} - \frac{1}{\theta_s} \right]^{-1},$$

where $n_j(\varphi) = \frac{1}{1+(1/\gamma_j-1)\frac{m_j(\varphi)}{M_j}}$ denotes an oligopsonistic mark-down. This mark-down is constant and equal to $\gamma_j < 1$ under CES production function in the upstream sector assumed in (6). In this case, $\Psi_j(\varphi) = -\theta_s < 0$ is also constant, implying a constant incomplete pass-through of $\frac{d\log p_j(\varphi)}{d\log \tau_l} = \frac{1}{1+\theta_s(1/\gamma_j-1)} < 1$.

When input supply elasticity is not constant, then oligopolistic mark-downs are not constant across buyers, but increasing in buyer's share in the input market, $m_j(\varphi)/M_j$. It means that buyers' mark-downs adjust in response to seller's costs resulting in a non-constant pass-through. Mark-down elasticity with respect to price can be written as:

$$\frac{d\log n_j(\varphi)}{d\log m_j(\varphi)} = -\frac{\left(\frac{1}{\gamma_j}-1\right)\frac{m_j(\varphi)}{M}\left(1-\frac{m_j(\varphi))}{M_j}\right)}{1+\left(\frac{1}{\gamma_j}-1\right)\frac{m_j(\varphi)}{M}} < 0$$

Because $\gamma_j < 1$ under this market structure, this mark-up elasticity is negative and varies with $m_j(\varphi)/M_j$. Its absolute value increases in $m_j(\varphi)/M_j$ if $m_j(\varphi)/M_j < \sqrt{\gamma}_j/(\sqrt{\gamma}_j+1)$ and decreases in $m_j(\varphi)/M_j$ if $m_j(\varphi)/M_j > \sqrt{\gamma}_j/(\sqrt{\gamma}_j+1)$. Therefore, for relatively small buyers, an increase in m_j/M_j makes $\Psi_j(\varphi)$ less negative, and thus implies a higher pass-through of seller's cost shocks into prices in (17). In contrast, for relatively large buyers, an increase in m_j/M_j makes $\Psi_j(\varphi)$ more negative, and thus implies a lower pass-through of seller's cost shocks into prices in (17).

The effect of sellers' entry on prices

Proof of Proposition 7.

Under oligopoly, assuming constant marginal costs, for simplicity, the elasticity of seller k's mark-up with respect to the number of sellers on the market, $\bar{N}_m$,[32] is

$$\frac{\partial\mu_{jk}(\varphi)}{\partial\bar{N}_m}\frac{\bar{N}_m}{\mu_{jk}} = \left(\frac{\partial\mu_{jk}(\varphi)}{\partial\zeta_{jk}(\varphi)}\frac{\zeta_{jk}(\varphi)}{\mu_{jk}(\varphi)}\right)\left(\frac{\partial\zeta_{jk}(\varphi)}{\partial\mathbb{P}_j}\frac{\mathbb{P}_j}{\zeta_{jk}(\varphi)}\right)\left(\frac{\partial\mathbb{P}_j}{\partial\bar{N}_m}\frac{\bar{N}_m}{\mathbb{P}_j}\right)$$

Solving for the three elasticities in brackets using (8) (9) , yields:

$$\frac{\partial\mu_{jk}(\varphi)}{\partial\zeta_{jk}(\varphi)}\frac{\zeta_{jk}(\varphi)}{\mu_{jk}(\varphi)} = \frac{1}{1+\zeta_{jk}(\varphi)}; \qquad \frac{\partial\mathbb{P}_j}{\partial\bar{N}_m}\frac{\bar{N}_m}{\mathbb{P}_j} = \frac{1}{1-\eta_j}\bar{N}_m s_{j\bar{N}_m}$$

[32] Here, I assume a continuum rather than an integer number of sellers in each market, for a derivative to be well-defined.

$$\frac{\partial \zeta_{jk}(\varphi)}{\partial \mathbb{P}_j} \frac{\mathbb{P}_j}{\zeta_{jk}(\varphi)} = (\eta_j - 1) \left(1 + \frac{n_j}{\zeta_{jk}(\varphi)} + (\theta_s - 1 + (1-\alpha_s)(1-\sigma_s)) \frac{\theta_s - 1}{\eta_j - 1} \frac{s_{jk} s_j^M}{\zeta_{jk}(\varphi)} \left(\frac{\mathbb{P}_j}{\mathbb{J}_s} - 1 \right) \right),$$

where $s_{j\bar{N}_m} \equiv \delta_{j\bar{N}_m}^{\eta_j} \left(\frac{p_{j\bar{N}_m}}{\mathbb{P}_j} \right)^{1-\theta_j}$ is the share of expenditures spent by a buyer on a new seller.

Multiplying all the three elasticities results in a negative elasticity of the seller's mark-up with respect to the number of suppliers:

$$\frac{\partial \mu_{jk}(\varphi)}{\partial \bar{N}_m} \frac{\bar{N}_m}{\mu_{jk}} = -\frac{\bar{N}_m s_{j\bar{N}_m}}{1 - |\zeta_{jk}(\varphi)|} \left(1 - \frac{n_j}{|\zeta_{jk}(\varphi)|} - (\theta_s - 1 + (1-\alpha_s)(1-\sigma_s)) \frac{\theta_s - 1}{\eta_j - 1} \frac{s_{jk} s_j^M}{|\zeta_{jk}(\varphi)|} \left(\frac{\mathbb{P}_j}{\mathbb{J}_s} - 1 \right) \right)$$

It is negative and, all else equal, by absolute value, decreasing in incumbent seller k's share in buyer's expenditures, $s_{jk} \equiv s_{jk}(\varphi)$. This share increases in the buyer's preference for the seller, σ_{jk}, conditional on the buyer's productivity, and decreases in the buyer's productivity, conditional on the preference for the seller. Hence, if buyers are price takers and their productivity does not affect prices, buyers purchasing more from the seller because of their preferences experience smaller price reductions in response to sellers' entry. In contrast, if more productive buyers can affect prices by leveraging their outside options, sellers' entry leads to larger price reductions charged by the incumbent to their larger buyers.

B Online Appendix

B.1 Data

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 described above to the reported brand names, in order to clean and standardize them.

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 (2013 - 2018). 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,

Table B1. Product differentiation of goods imported to Paraguay, 2013 - 2018

	$\bar{x}$	std	5%	10%	25%	50%	75%	90%	95%
Product categories (HS8)									
# HS8 categories	6736	147	6630	6630	6641	6660	6826	6996	6996
# Sellers*	10	19	1	1	1	3	11	27	44
# Buyers	23	49	1	1	2	7	22	62	101
# Countries	6.3	6.6	1	1	2	4	8	15	20
# Units	2.3	1.6	1	1	1	2	3	4	5
# Brands/Seller*	3	4	1	1	1	1	3	8	11
# Origins/Seller*	1.2	0.8	1	1	1	1	1	2	2

Notes: * denotes regular (frequent) sellers or brands defined above.

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 that I cleaned from typos.

Resulting product differentiation

Table B1 provides summary statistics on product differentiation within HS8 product categories that becomes observable after the application of the textual analysis and data cleaning procedures described above.

Detection of 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 transactions in Paraguay.

Definitions of industries

In absence of information on importers' domestic activities, I classify them into industries based on their main products of importing and exporting at HS 4-digit level of disaggregation. To find an importer's main category of importing, I followed Kugler and Verhoogen (2012) and first aggregated the importer's expenditures across all years from transaction-level to the HS 5-digit level. Then I chose the HS5 category with the greatest share in total imported value and used its first 4 digits as an importer's industry code. Notice that the resulting industry categories do not change over time within an importer. This industry classification is based on the assumption that firms in the same output industry import similar goods and allocate their expenditures across imported products in a similar way.

Alternatively, for importers that also appear in Paraguayan export transactions, I determined their output industries based on the main product category in exporting. For that, I first aggregated each importer's export revenues across all years from transaction level to the HS 5-digit level. Then I chose the HS5 category with the greatest share in total export revenue for each firm and used its first 4 digits as an importer's output industry code. These industry codes also do not vary over time within an importer, and are based on the assumption that firms' mainly export their core products.

Finally, for a small subsample of Paraguayan importers that I identified in the Orbis data, I use their main NACE industry code as their output industry.

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 B2 provides examples of cleaned company names, brand names, and product descriptions.

Table B2. Examples of cleaned and standardized brands and commercial descriptions of imported products in the Paraguay's customs data (translated from Spanish)

HS code	Seller	Description	Brand
32149000	Autocolor LTDA	Mortar type ACI 20 kg bag	Votorantim
32149000	Autocolor LTDA	Mortar type ACI 20 kg bag	Quartzolit
33021000	Bebidas Refrescantes	Acid solution colorants	Coca-Cola
33021000	Bebidas Refrescantes	Aspartame	Coca-Cola
33051000	Euro 2000 SA	Shampoo Keratin Lift x 960cc	Question Professional
33051000	Euro 2000 SA	Shampoo Nutrition 960cc	Question Professional
33051000	Euro 2000 SA	Shampoo Retention 960cc	Question Professional
84833029	Data Tech Inc	Vehicle bearings	Ford
84833029	Data Tech Inc	Vehicle bearings	Toyota
87019490	Agco Maq Agricola	Tractor model A990 4x4 yellow 2017	Valtra
87019490	Agco Maq Agricola	Tractor model A750 4x4 yellow 2017	Valtra
87019490	Agco Maq Agricola	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 can extract and use as measure of car quality. These vehicle characteristics are summarized in Table B4.

Table B3. Examples of product varieties within HS8 categories of passenger vehicles (translated from Spanish)

HS8 code	HS8 description (shortened)	Variety	% of HS8 transactions
87032210	Spark-ignition, 1000-1500cc cylinder	Ist	14
87032210	Spark-ignition, 1000-1500cc cylinder	Vitz	11
87032210	Spark-ignition, 1000-1500cc cylinder	Corolla	9
87032210	Spark-ignition, 1500-3000cc cylinder	Premio	17
87032210	Spark-ignition, 1500-3000cc cylinder	Allion	14
87032210	Spark-ignition, 1500-3000cc cylinder	Sportage	4

Table B4. Vehicle characteristics extracted from product descriptions in Paraguayan customs data

	$\bar{x}$	std	med
Used	0.62	0.49	1
Car age	9.4	9.0	11
Diesel	0.29	0.45	0
Flexible fuel	0.09	0.29	0
Manual	0.29	0.46	0
Luxury trim	0.02	0.14	0
Turbo engine	0.01	0.1	0
Sedan	0.50	0.50	0
Weight	1295	20994	1133

Table B5. Firm heterogeneity and product differentiation in variation of passenger vehicles' prices 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.

Definition of a shipment

Paraguayan customs data is reported at a transaction level. I define a shipment at a more aggregated level as a unique combination of seller's name, buyer's identifier and declaration date. When doing so, I assume that all products shipped from a buyer to the seller on the same date belong to the same shipment. Table B6 reported summary statistics of thus identified shipments.

Table B6. Shipment characteristics in Paraguayan import data, 2013 - 2018

	$\bar{x}$	std	med
# Transactions/Declaration Date	7.2	17.1	3
# HS8/Declaration Date	4.9	9.6	2
Gross Weight, ton/Declaration Date	43.0	410	6.5
Freight cost, '000 $/Declaration Date	6.0	31.1	1.9
FOB Value, '000 $/Declaration Date	89.3	383	24.7
# Declaration Dates/Buyer-Year	13.8	30	3
# Transactions/Buyer-Year	98.8	532	7

B.2 Theory

B.2.1 Necessary conditions for equilibrium mark-up dispersion under oligopoly

First, the existence of price discrimination of any type requires that buyers are heterogeneous in their willingness to pay for the product. In international trade literature, there is ample evidence of importer heterogeneity along various dimension including firm productivity and number of countries of importing (Bernard et al. (2012), Antras et al. (2017) Gandhi et al. (2017), Bernard et al. (2019), etc.). It makes this condition for price discrimination likely to be satisfied.

Second, in order to price discriminate, sellers need to be able to prevent arbitrage and resell of products between buyers charged lower and higher prices. Failure to do so would reduce the extent of observable price discrimination.[33] In international trade context, price discrimination can encourage entry of trade intermediaries as arbitrageurs, which, by taking advantage of arbitrage

[33] Boik (2017) documents and studies the extent of third-degree price discrimination in the presence of arbitrage opportunities.

opportunities, will eventually reduce the extent of observed price discrimination. To account for this possibility, I allow for a separate role of trade intermediaries in the empirical analysis below.

Third, the proposed mechanism of price discrimination relies on the assumption that sellers can observe differences in buyer productivities or at least the number of suppliers each buyer has. In international trade context, this assumption on information available to the seller is more likely to hold in transactions between firms in neighboring countries. However, even when sellers cannot know their buyer's productivity, they can still engage in price discrimination by designing a price schedule that would make more productive downstream firms reveal their willingness to pay. Maskin and Riley (1984) show that such (non-linear) pricing schemes also imply that larger buyers pay lower per-unit prices. I attempt to distinguish between the two types of price discrimination in the data by using the difference between annual and transaction-level buyer size.[34]

Alternative market structures and 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

[34] Meleshchuk (2018) and Ignatenko (2020) provide evidence consistent with quantity discounts as a form of price discrimination in international trade and international transportation, respectively.

for the input, the upstream monopolists solves the following profit maximization problem, assuming her marginal costs are constant at zero (for simplicity)[35]: $\pi_M^U = w(a - z - w)/2$. 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.

Figure illustrates the mechanisms behind this comparative statics. The upstream firm chooses an input price to equalize its marginal revenue and marginal costs. When the downstream firm's own productivity or market size increase, its derived input demand increases and shifts out the seller's marginal revenue curve. This, in turn, results in a higher price charged by the upstream monopolist.

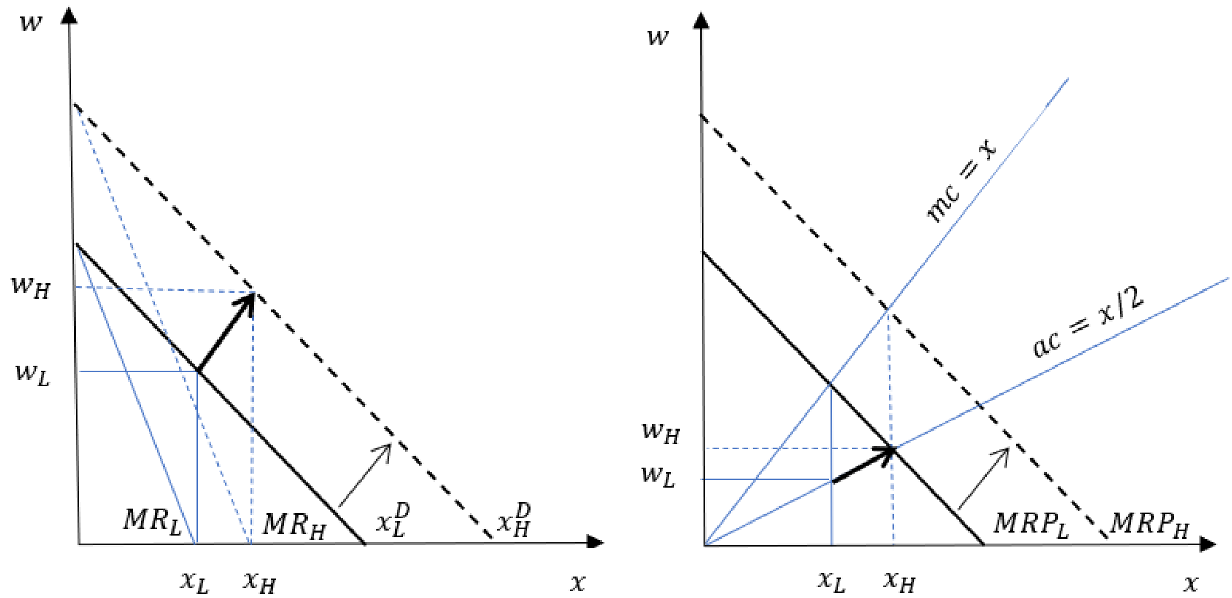
Monopsony In contrast, under monopsony, the downstream buyer sets the input price to maximize profits while taking into account the effect of this decision on the seller's marginal costs that are assumed to be increasing in quantity.[36] Assuming, for simplicity, that seller's marginal costs linearly 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.[37]

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

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

[37] 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 $(a - z)/4$.

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)).



(a) Monopolist charges more productive firm higher price (b) More productive monopsonist pays higher price

Figure VII.

Notes:

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

B.3 Additional results

Table B7. Within-seller variation of vehicle's prices, conditional on detailed product characteristics

Dependent Variable:	log *Transaction Price*			
	New	Used	New	Used
	(1)	(2)	(3)	(4)
Log Seller's Share	0.010	0.020***	0.013*	0.018***
	(0.007)	(0.003)	(0.007)	(0.003)
Log Annual Buyer-Seller Quantity	-0.011**	-0.007***	-0.049**	-0.030***
	(0.005)	(0.002)	(0.019)	(0.005)
× *Average Used Brand's Age*			0.003**	
			(0.001)	
× *Car Age*				0.002***
				(0.000)
Log Car weight	0.015	0.027***	0.015	0.027***
	(0.013)	(0.008)	(0.013)	(0.008)
Car age	-0.016***	-0.042***	-0.016***	-0.053***
	(0.005)	(0.002)	(0.005)	(0.003)
Diesel car	0.011	0.012	0.012	0.012
	(0.013)	(0.008)	(0.012)	(0.008)
Manual car	-0.082***	0.034	-0.081***	0.033
	(0.012)	(0.033)	(0.012)	(0.033)
Sedan car	0.031**	-0.168***	0.031**	-0.166***
	(0.014)	(0.058)	(0.014)	(0.058)
Log Declared Quantity	-0.002*	0.005*	-0.002*	0.005*
	(0.001)	(0.003)	(0.001)	(0.003)
Flex-fuel car	0.019**		0.019**	
	(0.008)		(0.008)	
Turbo engine	-0.008		-0.006	
	(0.047)		(0.047)	
Luxury car	0.120***		0.120***	
	(0.017)		(0.017)	
Constant	9.396***	8.088***	9.430***	8.213***
	(0.098)	(0.057)	(0.102)	(0.059)
HS8-Seller-Brand-Model-Year	✓	✓	✓	✓
Industry	✓	✓	✓	✓
N obs	71035	251042	70550	251042
N clusters	28	860	28	860
Adj. R2	0.987	0.744	0.987	0.744

* p<0.10, ** p<0.05, *** p<0.01
Robust standard errors clustered at importer level in parentheses.

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