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Keywords: importer heterogeneity, exchange rate pass-through

JEL Classification: F1

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Importer Dispersion and Exchange Rate Pass-Through

Qingyuan Du* Yalin Liu† Jianwei Xu‡

December 5, 2022

Abstract

This paper investigates the effect of importer dispersion on exchange rate pass-through. We show theoretically that greater importer dispersion leads to lower exporter markup, thereby causing a higher exchange rate pass-through. Empirically, we use Colombia's transaction-level customs data to provide strong evidence supporting the theoretical prediction.The quantitative effect of importer dispersion on exchange rate pass-through is significant: the importer dispersion channel is at least as important as the traditional exporter heterogeneity channel. Our results are robust to various empirical specifications and become even stronger in the context of the dominant currency paradigm.

JEL Classification Numbers: *F1; F3; F4*.

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1 Introduction

Incomplete exchange rate pass-through is at the core of international macroeconomic shock transmission. To enhance understanding of the micro-mechanism of the incomplete exchange rate pass-through, a number of recent studies have explained the phenomenon from exporters' perspectives and have associated price adjustments with producers' ability to change markups (Atkenson and Burstein, 2008; Berman et al., 2012; Burstein and Gopinath, 2014).

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Exporters, however, are not the only participants in the international pricing process. Most exporters enter the local market through collaboration with local importing firms. The latter either resell goods to local consumers or use them as intermediates for next-stage production. Hence, international trade prices can also be influenced by the characteristics of importers, which affect their collaborations with exporters. In a recent study, Bernard et al. (2018) showed that buyer productivity dispersion and importer–exporter connections play an important role in determining firms' adjustments to trade shocks. In this paper, we focus on the effect of buyer side characteristics on exchange rate pass-through. Specifically, we examine how buyer dispersion will affect the way that international prices respond to exchange rate shocks.

To characterize the theoretical mechanisms, we build a simple model that incorporates importer characteristics into the exchange rate pass-through process. The key mechanism is as follows. If larger importers (importers with higher trade values of imports) are associated with higher shares of the direct expenditure on imported goods in their total costs, they will be more sensitive to trade price adjustments. As a result, an exporter is more likely to face higher demand elasticity when trading with larger importers, and vice versa (that exporters face lower demand elasticity when trading with smaller importers). In a highly dispersed import market with both large and small importers, exporters determine prices by heavily weighting the demands of large importers, as their expenditure on the exported goods is a primary contributor to exporters' profits. This implies that, on average, exporters face relatively high demand elasticity in a very dispersed import market. As importer dispersion falls, the import market is characterized by more similarly sized importers, and the average demand elasticity facing exporters is lower. As in the existing literature, the degree of exchange rate pass-through, namely the elasticity of demand elasticity (also called "super-elasticity") is positively associated with the demand elasticity of tradable goods. Hence, we can show that exchange rate pass-through rate is positively associated with importer dispersion.

Theoretically, the positive relationship between total import values and the shares of import expenditure in importers' total costs can be caused by the heterogeneity in the search or the distribution cost incurred by an importer to purchase a unit of tradable goods. The search or the distribution cost assumed in our model is consistent with the findings in Burstein et al. (2003). Specifically, when all else remains the same, a lower search or distribution cost is negatively associated with both the importer's import value and the share of the direct import expenditure in its total cost. Then exchange rate pass through is positively affected by importer dispersion based on the previous analysis.

Though the distribution cost exists in all countries in the world, it can be very important for firms in developing countries. Rodrigue (2020) showed that logistics costs can amount to 25% of delivered costs in some developing economies, while they only go as low as 8% in advanced economies. Hence, we in the empirical analysis examine how import market's characteristics influence the responses of trade prices to exchange rate movements in a typical developing country, Colombia. Specifically, we use the transaction-level trade information during the period 2005-2014 between Colombia's importers and their trading partners to investigate the explanatory power of importer dispersion for exchange rate pass-through. Using the standard deviation of importing firms' (log) imports as the measure of importer dispersion, our main result strongly supports the theoretical prediction that higher importer dispersion is associated with higher exchange rate pass-through. The estimation results show that even after we control for the effect of exporter heterogeneity (which is widely studied in the recent literature), the contribution of import market structure to explaining incomplete exchange rate pass-through is still significant. Quantitatively, our baseline result suggests that a change of one standard deviation to importer dispersion can generate roughly the same effect as a change of one standard deviation to exporter heterogeneity. Moreover, we investigate the validity of the importer dispersion channel in the context of the dominant currency paradigm and find that the predicted effect of importer dispersion on exchange rate pass-through holds more strongly for the dollar exchange rate than that for the bilateral exchange rate.

Our study contributes to the exchange rate pass-through literature with a particular focus on the import market's characteristics. A number of earlier studies have explained the role of local market factors in exchange rate pass-through. In a seminal study, Dornbusch (1989, p.405) investigated the role of the local distribution sector as "the service content of the consumer prices for goods," which influences exchange rate pass-through. Burstein et al. (2003) used data from the US and Argentina to quantitatively examine the importance of distribution margins in retail prices and exchange rate pass-through. Recently, some studies have focused on how the characteristics of importing firms affect exchange rate pass-through. For instance, Amiti et al. (2014) and Bernini and Tomasi (2015) highlighted the offsetting effect of exporting and importing activities in price-setting. Devereux et al. (2017) and Xu et al. (2019) are most related to our work by analyzing the effect of individual importer characteristics on import prices. Our study is aligned with this stream of literature but moves beyond previous studies by investigating how the aggregate market structure of importation (rather than the characteristics of individual importing firms) plays a role in determining exchange rate pass-through.

This paper also enhances our understanding of the micro-mechanisms through which exporting and importing activities interact to affect exchange rate pass-through. Prior studies provide evidence supporting exporter heterogeneity as a key factor in exchange rate pass-through (Berman et al., 2012; Chatterjee et al., 2013; Burstein and Gopinath, 2014). Amiti et al. (2014) and Devereux et al. (2017) proposed mechanisms through which the interaction between individual exporting and importing activities influences exchange rate pass-through. Our study adds to this literature by emphasizing the role of importer distributions in determining the aggregate demand for exported goods, which in turn affects exporters' pricing behaviors.

The rest of the paper is organized as follows. Section 2 presents a simple model to highlight the role of importer dispersion in determining exchange rate pass-through. Section 3 introduces the data and econometric specifications for our empirical analysis. Section 4 reports the empirical results and offers a further discussion of the validity of our key channel in the dominant currency paradigm framework. Section 5 provides concluding remarks.

2 Model

To guide our empirical analysis, we introduce a simple model to formalize the connection between the dispersion of importers and exchange rate pass-through. We denote the importing and exporting countries as Home and Foreign, respectively. We include two types of firms in our model: Home buyers and sellers. One may consider Home buyers as intermediate goods purchasers and Home retailers or sellers as domestic producers or Foreign exporters. After purchasing goods from sellers, Home buyers will transform the goods into differentiated products and sell them to Home consumers. Let q denote the final consumption by Home consumers which is aggregated over output from a continuum of Home buyers

$$q = \left(\int_0^1 q_i^{\frac{\theta-1}{\theta}} di \right)^{\frac{\theta}{\theta-1}}, \theta > 1$$

where q_i is the output by buyer i, and θ is the elasticity of substitution between different products. As in the standard literature, the aggregate price index $\tilde{p}$ is

$$\tilde{p} = \left(\int_0^1 \tilde{p}_i^{1-\theta} di \right)^{\frac{1}{1-\theta}}$$

where $\tilde{p}_i$ is the price of buyer i's aggregate output. The individual demand for buyer i's output is

$$q_i = \left(\frac{\tilde{p}_i}{\tilde{p}}\right)^{-\theta} q \tag{2.1}$$

Home buyer i can purchase goods from both domestic and foreign sellers. For simplicity, we assume that all Home buyers will import some goods from Foreign sellers. Hence, we simply adopt the term importer i to replace buyer i in the rest of the paper to emphasize the role of international relationship between Home buyers and Foreign sellers. For importer i, the output q_i consists of a continuum of differentiated goods

$$q_i = \left(\int_0^1 q_{ij}^{\frac{\eta-1}{\eta}} dj\right)^{\frac{\eta}{\eta-1}}, \ > 1$$

where q_{ij} is the quantity of goods purchased by importer i from seller j, and η is the elasticity of substitution between intermediate goods from different sellers. For simplicity, we let $[0, X)$ and $[X, 1]$ denote the sets of domestic and foreign sellers, respectively.

Similar to Burstein et al. (2003), we assume that importer i needs to pay κ_i^d and κ_i^x (in terms of Home currency) in order to purchase one unit of product from a domestic seller and a foreign seller, respectively. The κ cost can be understood as the cost spent on searching for exporters, distributing the imported goods to local consumers, and etc. Our assumption on the cost κ is in line with Burstein et al. (2003) that the distribution cost is spent mostly on domestic non-tradable services and hence, it is denominated in Home currency. In fact, even if we relax the assumption by letting the search or distribution cost κ^x partially denominated in Foreign currency, our qualitative results still hold. In the rest of our paper, we simply call the κ cost as the search cost for convenience (though it could be much broader and contains costs other than the one spent on searching trading partners in the real world). Then the total cost for importer i is

$$TC_i = \int_0^1 p_j q_{ij} dj + \int_0^X \kappa_i^d q_{ij'} dj' + \int_X^1 \kappa_i^x q_{ij} dj$$

where p_j is the price of seller j's product in terms of Home currency.

For simplicity but without changing any of our theoretical results, we let $\kappa_i^d = \kappa_i^x = \kappa_i$. Given the production function by importers, we can show that the marginal cost of importer i is

$$mc_i = \left(\int_0^1 (p_j + \kappa_i)^{1-\eta} dj\right)^{\frac{1}{1-\eta}} \tag{2.2}$$

and the demand for seller j's product by importer i is

$$q_{ij} = \left(\frac{p_j + \kappa_i}{mc_i}\right)^{-\eta} q_i \tag{2.3}$$

We can write down the optimization problem for importer i as

$$\max_{\{\tilde{p}_i\}} (\tilde{p}_i - mc_i)\,\tilde{p}_i^{-\theta}\tilde{p}^{\theta} q$$

which implies the optimal price $\tilde{p}_i$ and quantity q_i

$$\tilde{p}_i = \frac{\theta}{\theta - 1} mc_i \tag{2.4}$$

Plugging (2.4) into (2.3) and using (2.1), we obtain the demand for exporter j's product by importer i as

$$q_{ij} = \left(\frac{\theta}{\theta - 1}\right)^{-\theta} (p_j + \kappa_i)^{-\eta} mc_i^{\eta-\theta} \tilde{p}^{\theta} q \tag{2.5}$$

The aggregate demand for exporter j's product is

$$q_j = \int_0^1 q_{ij} di = \left(\frac{\theta}{\theta - 1}\right)^{-\theta} \tilde{p}^{\theta} q \left(\int_0^1 (p_j + \kappa_i)^{-\eta} mc_i^{\eta-\theta} di\right) \tag{2.6}$$

We now consider the optimization problem for exporters. Let ε denote the exchange rate which is defined as the price of Foreign currency in terms of Home currency. In this way, a rise in ε is associated with a depreciation in Home currency. Assume that the marginal costs facing exporters (c_j) are denominated in Foreign currency. Hence, the profit maximization problem for exporter j is

$$\max_{\{p_j\}} (p_j - \varepsilon c_j)\, q_j$$

Solving the profit-maximization problem by exporter j, we obtain the optimal export price condition as

$$0 = \int_0^1 (p_j + \kappa_i)^{-\eta-1} \left(p_j - \frac{\eta}{\eta - 1}\left(\varepsilon c_j + \frac{\kappa_i}{\eta}\right)\right) mc_i^{\eta-\theta} di \tag{2.7}$$

Let $G(\cdot)$ denote the distribution function of κ_i. Note that importers only differ in their search costs in our model and hence their marginal costs are functions of κ. Let $mc(\kappa)$ denote the marginal cost of a κ-type importer. (2.7) can be re-written as

$$p_j = \frac{\eta}{\eta-1}\varepsilon c_j + \frac{1}{\eta-1}\frac{\int_0^\infty (p_j+\kappa)^{-\eta-1}\kappa mc(\kappa)^{\eta-\theta}dG(\kappa)}{\int_0^\infty (p_j+\kappa)^{-\eta-1}mc(\kappa)^{\eta-\theta}dG(\kappa)} \tag{2.8}$$

Using the terms of expectation and covariance, we re-write (2.8) as

$$p_j = \frac{\eta}{\eta-1}\left(\varepsilon c_j + \frac{1}{\eta}\bar{\kappa}\right) + \frac{1}{\eta-1}Cov\left(\frac{(p_j+\kappa)^{-\eta-1}mc(\kappa)^{\eta-\theta}}{E\left[(p_j+\kappa)^{-\eta-1}mc(\kappa)^{\eta-\theta}\right]},\kappa\right) \tag{2.9}$$

where $\bar{\kappa}$ represents the mean of κ.

There are two terms on the right-hand side of (2.9). The first term is related to the marginal cost of exporter j. When there is no search cost κ, the optimal exporting price equals $\frac{\eta}{\eta-1}\varepsilon c_j$, which is the standard result in the literature under the Dixit-Stiglitz demand structure. $\eta/(\eta-1)$ in this case is the markup optimally chosen by exporters. Regarding search cost, the second term captures how the distribution of search costs across importers affects the export price p_j. If $\theta > \eta$ or θ is sufficiently close to η, the covariance term takes a negative value (as $(p_j+\kappa)^{-\eta-1}mc(\kappa)^{\eta-\theta}$ is decreasing in κ).[1] Mathematically, a greater dispersion of search cost κ may yield a more negative covariance between $(p_j+\kappa)^{-\eta-1}mc(\kappa)^{\eta-\theta}$ and κ so that exporter j reduces the markup and sets a lower trade price p_j.

As in the standard literature, it is important to understand how importer dispersion affects the markups in trade prices to analyze the role of importer distribution in determining the exchange rate pass-through. Two questions related to (2.9) may arise here: i) why does the distribution of importers (the dispersion of κ) matter for exporters' price-setting, and ii) why might exporters charge lower prices if the dispersion of κ increases? To answer the first question, it is important to note that there are two types of costs in our model: the standard direct cost associated with the expenditure on intermediate goods and the search cost incurred by importers. Everything else being equal, our model implies a negative relationship between search cost and importer size. With lower (higher) average search cost, larger (smaller) importers usually have higher (lower) shares of the direct expenditure cost of imported goods in their aggregate marginal costs. Hence, larger (smaller) importers are more (less) sensitive to adjustments in trade prices. As a result, the presence of various large and small importers in a market will matter for exporters' price-setting. Given the above, the second question can

[1]The marginal cost $mc(\kappa)$ increases with the search cost κ.

be answered. In a more dispersed import market, exporters make price decisions by weighting more heavily large importers' demands for their products. The overall market demand elasticity in this case is higher, leading to lower markups in exporters' prices.

The exchange rate pass-through in exporter j's price in our model is

$$\Lambda_j \equiv \frac{\partial \log\left(p_j\right)}{\partial \log\left(\varepsilon\right)}$$

Let σ_κ^2 denote the variance of search cost κ and define Ξ as

$$\Xi \equiv \frac{3^{\frac{1}{2}}\left(\eta+1\right)\left(2\eta+3\right)^{\frac{1}{2}}}{\eta^{\frac{1}{2}}\left(\eta+2\right)^{\frac{1}{2}}\left(\eta\left(\eta+2\right)\left(\eta^2+\eta-\frac{3}{2}\right)+4\left(\eta+\frac{3}{2}\right)\right)^{\frac{1}{2}}}$$

For technical convenience, we assume $\eta=\theta$ as in Bernard et al. (2018). We now show the following proposition.

Proposition 1. *Under the assumptions*

$$\left(\eta-1\right)\left(\eta+2\right) \geq \frac{7}{2}$$

and

$$\frac{\bar{\kappa}}{\sigma_\kappa} > \Xi$$

we can show that up to second order approximation to (2.9), the exchange rate pass-through Λ_j is increasing in the importer dispersion σ_κ^2, that is

$$\frac{\partial \Lambda_j}{\partial \sigma_\kappa^2} > 0$$

Proof. (See Appendix A). □

A few remarks about Proposition 1 are in order. First, based on previous analysis, greater dispersion of importers leads to lower exporters' markups (price over marginal cost). The standard exchange rate pass-through literature has shown that an exporter's markup is positively associated with the ability to stabilize prices in response to exchange rate shocks. As a result, a more dispersed importer market, which triggers lower exporter markups, can yield higher exchange rate pass-through, and vice versa.

Second, the key factor determines the effect of importer dispersion on exchange rate pass-through is the share of importers' direct expenditure cost of imported goods in total marginal costs. As showed in previous analysis, different shares of the direct expenditure cost yield different sensitivities in firms' responses to import price changes. The importer dispersion then affects exporters' markups and exchange rate pass-through by influencing the aggregate demand elasticity facing exporters. We in this paper consider the role of heterogeneous search cost (or distribution cost) in generating the various shares of direct expenditure cost of imported goods. But we do not exclude the possibility that other factors may also contributing to such variation in importers. In fact, as long as importers differ in their import intensities, the main theoretical prediction on the relationship between importer dispersion and exchange rate pass-through still holds.

Third, the two assumptions

$$(\eta-1)(\eta+2) \geq \frac{7}{2}$$

and

$$\frac{\bar{\kappa}}{\sigma_\kappa} > \Xi$$

are adopted only for technical convenience and help us derive the analytical results. In other words, they are sufficient but not necessary conditions. In the numerical examples provided in the Appendix B, we show that exchange rate pass-through is positively correlated with importer distribution under different assumptions on the distribution of search cost. Hence, the two conditions do not seem crucial in determining the main theoretical prediction. Even for the purpose of deriving the theoretical results, we can see that as the elasticity of substitution between imported goods η becomes reasonably high, the two conditions can easily hold. For instance, the standard literature suggests that η can take value 6. Then, the first condition $(\eta-1)(\eta+2) \geq \frac{7}{2}$ is satisfied. For the second condition, Ξ takes a value around 0.15 when $\eta = 6$, which implies that we need only the mean of the search cost to be above 15 percent of the standard deviation for the condition to hold.

Fourth, the proposition is based on the assumption, as in Bernard et al.(2018), that $\eta = \theta$, which is not a necessary condition but can greatly simplify the proof. Due to the nature of continuity, when η does not differ greatly from θ, our theoretical prediction still holds. In Appendix B, we relax this assumption in numerical examples and show that the main theoretical prediction holds robustly.

Lastly, the result of Proposition 1 does not connect the exporters' (and importers') characteristics (such as their market shares) to exchange rate pass-through although we allow for heterogeneous exporters in the model. The main reason is that we have assumed a continuum of exporters (and importers) in the model and hence, exporters' market shares do not affect their markups and then play no role in determining exchange rate pass-through. In Appendix B, we extend the baseline model by assuming finite numbers of exporters and importers. In this case, our main theoretical prediction holds, and we also show that exporters' characteristics affect exchange rate pass-through similarly as in the standard literature. Specifically, larger exporters are associated with lower exchange rate pass-through, which is consistent with Berman et al. (2012) and Amiti et al. (2014).

3 Data and Empirical Specification

3.1 Data

We use Colombia's transaction-level customs data in the empirical analysis. The data cover trade information at the 10-digit HS (HS10) product level (according to the Nandina classification system) for Colombian exporters and importers.[2] Specifically, the data include information such as Free on Board (FOB) value, volume (defined as net kilograms), and names of importers and providers and their country codes. As a proxy for prices to analyze exchange rate pass-through, we follow the literature to use unit values defined as the FOB value divided by the volume. Specifically, to create a trade price at the exporter j-product k-country of origin c level in period t used in our regressions, we aggregate the total value and volume in the raw data over that category ($jkct$) and then obtain the average price (p_{jkct}). The duration of our analysis is from 2005 to 2014. In addition, we focus on manufacturing goods but exclude the petrochemical and basic metal industries (ISIC 23 and ISIC 27) because Colombian currency (peso) is commodity-exposed and its fluctuations are strongly correlated with commodity prices.[3] Moreover, we include all importers (including intermediaries) in the baseline regression but conduct empirical tests only for local distributors in one robustness check.

We report the descriptive statistics of Colombian imports in Table 1. We find that the market is characterized by multiple matches between exporters and importers in Colombia's international trade market. On average, there are 1.780 Colombian importers per exporter

[2] In this paper, we use only information about Colombia's importers and their trading partners around the world, and we remove all of the imports from Colombia.

[3] We define manufacturing industries (from ISIC 15 to ISIC 36) by converting the HS code to ISIC Rev. 3 code.

from other countries, whereas every Colombian importer trades with 2.546 exporters all over the world. Moreover, exporters and imports from the US play an important role in Colombia's international trade.

The exchange rate data are obtained from the International Financial Statistics (IFS) database. We calculate the bilateral nominal exchange rate for the Colombian peso against their partner currencies; this exchange rate is defined as the unit of peso per another nation's currency, meaning that a rise in the index of exchange rate indicates a depreciation of the peso against the other currencies. In addition, we use the producer price index (PPI), taken from the World Development Indicators (WDI) database from the World Bank, as our country-level control variable.

3.2 Construction of Dispersion Measures

In the baseline estimation, we construct the standard deviation (SD) of the (log) imports by importers within the 6-digit HS (HS6) level to measure importer dispersion (Γ_s^{imp}(SD)).[4] The larger the Γ_s^{imp}(SD), the more dispersed is the product category that faces importing firms. Table 2 reports the top and bottom five product categories sorted by the SD of imports. The most dispersed product is *machines for making optical fibres and preforms thereof*, with an Γ_s^{imp}(SD) of 8.753, while the manufacturers of *textile materials unbleached* is among the least dispersed, with an Γ_s^{imp}(SD) of 0.029. Figure 1 depicts the trend and distribution of the dispersion measure for each HS6 product category across years, which shows that importer dispersion is relatively stable over time. To avoid endogeneity, we use the average value over the sample period for dispersion measures in our estimation.

As robustness checks, we adopt alternative measures for importer dispersion. One is the Pareto coefficient of importer's log imports (Γ_s^{imp}(Pareto)). Figure 2 shows that our distribution of the number of buyers per exporter appears to be largely consistent with a Pareto distribution. To construct the Pareto coefficient measure, we follow Bernard et al. (2018), regressing the log of the empirical 1-CDF (the importing firm's rank within the distribution) on the importer's log imports for each HS6 product. Note that the slope coefficient we estimate and use is the negative of the Pareto coefficient and is thus positively related to importer dispersion.

In addition, we use the importer's total sales to alternatively define the importer dispersion (Γ_s^{sales}(SD)). The advantage of sales over imports is that they cover dimensions of a firm's size in

[4] We also consider the dispersion measure at the HS10 and HS4 level in robustness checks, our main theoretical predictions hold.

addition to the trade channel to characterize an importer's ability to search in the international trade market. To do this, however, we need to merge the Colombian customs data with the Orbis database (which is only a sub-sample of the universal customs data) to obtain the sales information of importers.[5]

To ensure our results are not sensitive to other product definitions, we also apply dispersion measures constructed at the HS10 product level (Γ^{imp}_{HS10}(SD)) in a robustness check. The summary statistics of the main variables used in our study are reported in Table 3, and they show that the variation of importer heterogeneity is relatively large in the data. Table 4 reports the correlation matrix of dispersion measures, which shows that the alternative measures of importer dispersion are highly correlated with each other, especially those between Γ^{imp}_{s}(SD), Γ^{imp}_{s}(Pareto), and Γ^{imp}_{HS10}(SD).

3.3 Preliminary Check with Two Special Episodes

Before the formal econometric test, we show a simple correlation between importer dispersion and exchange rate pass-through. We take two episodes (2006-2008 and 2012-2014) of sharp peso movements in the sample as examples (Figure 3). In both periods, we find that the import price variation is larger for sectors with a higher degree of importer dispersion.

In the first period, the Colombian peso appreciated by 16.67% (against the US dollar) from 2006-2008, and this was accompanied by an average import price reduction by 4.10%. We limit the imported goods only from US-dollarized economies to ensure that the Colombian peso definitely appreciates with a large magnitude in the selected sample. Due to the large number of observations, we show the binned scatter plots in Figure 4. Specifically, we divide the importer dispersion into 100 equal bins and compute the mean of the log import price within each bin. Then we plot the mean of the log import price and the mean of the importer dispersion in all bins to obtain Figure 4. We show that the price reduction is more significant for product categories with higher importer dispersion than those with lower importer dispersion, as shown in the left panel of Figure 4. For example, the average price change in the top three bins (with the highest importer dispersion) is -5.548%, whereas the average price change in the bottom three bins (with the lowest importer dispersion) is -1.571%. A more general negative relationship is

[5]The Orbis database covers only a fraction of companies in Colombia, and we eventually obtain 1,505,947 observations, approximately 34% of the cleaned full sample, in the merged sample to estimate product-level dispersion. However, we lose only 151 types of products out of the original 4,209 types at the HS6 product level for the importer dispersion index.

reflected between the sector's importer dispersion and price changes, the estimated coefficient (roughly measuring the average exchange rate change) of which is -0.018 (s.e. 0.010).

In the second period, the Colombian peso depreciated by 11.40% (against the US dollar) from 2012 to 2014, and the corresponding import price change ranges from -21.99% to 30.50%. Again, our sample here contains only US-dollarized economies as the trading partners to Colombia. The right panel of Figure 4 shows a significantly positive correlation of importer dispersion and price changes across products during the second period, with the estimated coefficient (representing the average exchange rate change) being 0.017 (s.e. 0.010). The average import price increase in the top three bins (with the highest importer dispersion) is 4.080%, while the average import price increase is 1.932% in the bottom three bins (with the lowest import dispersion). These preliminary results are consistent with our theoretical prediction that a more dispersed import market should be associated with a greater import price change and a higher exchange rate pass-through.

3.4 Import-to-sales Ratio vs. Import

Our theory implies that the share of imported goods expenditure in the total cost of an importer has a crucial effect on the demand elasticity of the importer, which then builds up the relationship between importer dispersion and exchange rate pass-through. In this section, we aim to present some basic empirical facts about the share of imported goods expenditure in importers' production.

One difficulty in such analysis is that we do not directly observe the information of importers' total cost. We adopt a proxy for the share of imported goods expenditure in total cost by using the import-to-sales ratio. Note that the gap between sales and total cost is mainly profit obtained by importers. Hence the proxy is valid as long as the profit is less sensitive than total cost in response to search cost changes. Table 5 reports the regression results, which test the simple correlation between log imports and the import-to-sales ratio. Again, we show that import-to-sales ratio and log import are positively correlated and that the relationship is statistically significant.

One should note that we do not directly aim to test the relationship between search cost and the share of direct expenditure on imported goods in total cost in this section. The reasons are as follows. First, it is difficult to identify a direct measure of search ability in the data. Second, although the model assumes the heterogeneity in search cost which then yields our main theoretical prediction, the key factor that determines the role of importer dispersion in affecting exchange rate pass through is the relationship between importer size (based on import values) and the share of import expenditure in an importer's total cost. Hence, we directly test the relationship between import values and the import-to-cost ratio in this section.

Figure 5 reports the variation of the import-to-sales ratio at the HS6 level. We can see that there exist large variations in the import-to-sales ratio across industries. For example, the import-to-sales ratio ranges from 0 to 0.18 in 2010 with a median of around 0.05. The coefficient of variation (CV; the ratio of the standard deviation relative to the mean) of the import-to-sales ratio is 9.08 in the same year. As the proposed theory emphasizes the role of import intensity in determining the demand elasticity of exported goods, the large variations of the import-to-sales ratio may potentially lead to differences in price-setting by exporters across industries.

3.5 Formal Empirical Specification

In the baseline specification, we define the price changes at the exporter-HS10 product-country (of origin)-year level and estimate the following empirical equation:

$$\Delta \log \left(p_{jkct}\right) = \alpha + \beta_1 \Delta \log e_{ct} + \beta_2 \left(\Delta \log \left(e_{ct}\right) \cdot \Gamma_s\right) + \theta' Z_{ct} + \lambda_{jkc} + \varepsilon_{jkct} \tag{3.1}$$

where subscripts j, k, s, c and t refer to exporter, product, industry, country of origin, and year, respectively. Specifically, we classify the HS10 product category as the goods (k) in our theoretical analysis and the HS6 product category as the industry (s).[6] The regression equation (3.1) relates the log change in Colombia's import price ($\Delta \log \left(p_{jkct}\right)$) to the log change in the nominal exchange rate of the peso relative to the currency of the partner country c in year t ($\Delta \log \left(e_{ct}\right)$), where p_{jkct} is the price expressed in peso that an exporter charged for a specific good. To test the role of importer dispersion, we modify the standard exchange rate pass-through regression by including an interaction term of the log change in the exchange rate change ($\Delta \log \left(e_{ct}\right)$) and importer dispersion within industry s (Γ_s).[7]

Furthermore, Z_{ct} represents country-year-level control variables, e.g., log changes in the PPIs of exporting countries are used to capture the cost's influence on the producer's price.

[6] In the robustness checks, we vary the industry level, and our main result still holds.

[7] The average search cost $\bar{\kappa}$ may also affect the exporter's price setting behaviors. Such effect is controlled in the robustness check (Column (4) of Table 7).

λ_{jkc} is the exporter-product-country (of origin) fixed effect, which can capture the product-level (and industry-level) factors that affect exporter's price setting, such as the demand condition facing exporters[8] ε_{ijkct} is the error term. The exchange rate pass-through implied by such a specification of equation (3.1) is $\beta_1 + \beta_2 \Gamma_s$. As predicted by our theory, the exchange rate pass-through is higher in markets with greater importer dispersion, which implies the prediction of a positive β_2.

4 Empirical Evidence

4.1 Baseline Results

The Impact of Importer Dispersion

The baseline regression results of equation (3.1) are shown in Table 6. In the first column, we report that the average exchange rate pass-through rate for Colombia's importers is 71.1 percentage points after controlling for the exporter-product-country (of origin) fixed effect with the regression clustered at the country-year level. In other words, for an importing product, a one percent exchange rate movement induces a 0.711 percent change in the trade price (denominated in the importer's currency). The result is of the same quantitative magnitude as that discussed in Gopinath et al. (2020).

We then add our key interested variable, the interaction term of importer dispersion and exchange rate changes, into the regression. We can show that the coefficient of the interaction term in Column (2) is positive and statistically significant, implying that an increase in importer dispersion (measured by the standard deviation of the importer's log imports, Γ_s^{imp}(SD)) leads to a higher exchange rate pass-through. Particularly, for a product category with zero degrees of importer dispersion (which means that firms are of equal size or there is only one firm for the product), the average exchange rate pass-through is only 5.7 percentage points. Moreover, for a product category with an importer dispersion equaling 2.545 (the sample average), the average exchange rate pass-through rate will increase to 71.1 percentage points ($= 0.257 \times 2.545 + 0.057$), which is around the same magnitude as showed in Column (1).

[8]Following Burstein and Gopinath (2014), year fixed effect is not controlled to allow for time specific shocks in baseline regressions. However, we control product-year fixed effect in our robustness checks (Table 7c) and show that the main theoretical prediction still holds.

Considering the Exporter Heterogeneity Effect

We now incorporate the effect of the effect of exporter heterogeneity in determining exchange rate pass-through. More specifically, we quantify the effect of importer dispersion and exporter heterogeneity on exchange rate pass-through. We first follow Feenstra et al.(1996) and Auer and Schoenle (2016) to include interaction terms between exchange rate changes and exporters' market share (S_{js}), as well as the square of S_{js} (S_{js}^2), in our regression. The regression result reported in Column (3) of Table 6 confirms Auer and Schoenle's (2016) finding that the response of import prices to exchange rate changes according to the exporter's market share is U-shaped.

Further, we show that the inclusion of the exporter heterogeneity channel does not change the statistical validity of the key importer dispersion channel in Columns (4) and (5). Note that after controlling for the exporter's market power (measuring in exporter's market share), the magnitude and significance of the importer dispersion channel decreases only slightly. Column (4) also shows that when considering importer dispersion, the coefficient of the quadratic term of the exporter's market share becomes insignificant. The estimation outcome in Column (5) shows the effect of our importer dispersion channel with that of the exporter heterogeneity channel (but excluding the quadratic term of the exporter's market share). We find that an increase of one standard deviation in an exporter's market share yields a decline of 6.2 percentage points ($= -1.076 \times 5.764\%$) in exchange rate pass-through, which is slightly larger than the effect of an increase of one standard deviation in importer dispersion ($5.7\% = 0.209 \times 0.271$). In a different experiment, if we move the exporter's market share from the 5th percentile to the 95th percentile (which equals approximately 1.445 standard deviations) in its distribution over the sample, the exchange rate pass-through will fall by no more than 9 percentage points. In contrast, the corresponding effect, which stems from the importer dispersion channel and follows the same adjustment over the distribution (which equals approximately 3.354 standard deviations), is about 19 percentage points. As such, the importer dispersion generates a larger quantitative effect on the cross-sectional differences in exchange rate pass-through.

4.2 Robustness Checks

To ensure the robustness of our analysis, we implement the following robustness checks.

Alternative Dispersion Measures

We adopt alternative measures for importer dispersion in this robustness check. First, we follow Bernard et al. (2018) and consider an alternative indicator: the negative coefficient of the Pareto distribution of importing firms' imports (Γ_s^{imp}(Pareto)). Note that a larger Pareto distribution shape parameter is associated with a less dispersed importer market. We take the negative value of the Pareto coefficient such that an increase in the Pareto coefficient in our analysis implies a more dispersed importer market. The result, shown in Column (1) of Table 7a, still points to the predicted (positive) relationship between importer dispersion and exchange rate pass-through, with an increase of one standard deviation in the Pareto coefficient, causing an increase of 6.8 percentage points ($= 1.702 \times 0.040$) in the exchange rate pass-through.

Second, we use (log) sales of importers to compute the standard deviation measure (Γ_s^{sales}(SD)). The estimated result using this measure is reported in Column (2) of Table 7a, and it shows a positive but statistically insignificant effect of the SD of an importer's sales on the exchange rate pass through. One potential reason for this result is that some large firms (in terms of sales) may disproportionately search for intermediate good input from domestic markets; hence, the mechanism shown in our theory does not hold for these importers. In fact, though the correlation between the standard deviation of a firm's imports and the standard deviation of a firm's sales, shown in Table 4, is positive and statistically significant, the value is not high. This implies that a firm's sales can be largely determined by other factors instead of a firm's imports.

Lastly, we re-compute the importer dispersion measure at the HS10 level (Γ_{HS10}^{imp}(SD)) and re-estimate the impact on exchange rate pass-through. The additional result, reported in Column (3) of Table 7a, confirms that importer dispersion defined at the product level is still positively linked to exchange rate pass-through.

Zooming into Local Distributors

A key assumption in our model is that importers enter the market to directly face final consumers. This assumption may be sensitive to the potential effect arising from the global supply chain across countries, i.e., the importers may use intermediate goods for production and then re-export them to a third country. For example, Amiti et al. (2014) consider that a larger exporter is also likely a larger importer and demonstrate the offsetting effect stemming from opposite exchange rate exposures of the export and import.

To guarantee that our results are not sensitive to the global supply chain effect, we analyze a specific type of importer, namely, local distributors less likely to engage in further rounds of production in the supply chain. Specifically, we combine Colombia's customs data with its firm-level information from the Bureau van Dijk's Orbis database, and we restrict the sample to the local distributors (G45-G47) based on the NACE Rev.2 classification. The results from this sub-sample confirm a significantly positive effect of importer dispersion in determining exchange rate pass-through, with a fairly similar magnitude: a change of one standard deviation to importer dispersion generates an increase of 6.2 percentage points ($= 0.182 \times 0.341$) in the exchange rate pass-through rate (Column (4) of Table 7a).

Alternative Regression Settings

First, we add to the regression the interaction term between the average imports by all importers within an HS6 product category over the sample period and the exchange rate, thus controlling the effect of average searching ability ($\bar{\kappa}$) on exchange rate pass-through. The result in Column (1) of Table 7b shows a positive and significant coefficient on the interaction term of importer dispersion and exchange rate. Interestingly, the coefficient on the interaction term between the average imports and exchange rate is insignificant, which suggests that the second-order characteristics of the importer market (the standard deviation of imports) may be even more important than the first-order factor (the average imports) in determining exporters' pricing behaviors.

Next, as the baseline regressions are unweighted, the estimates we obtained may not fully reflect the response of import price to exchange rate changes when firms are associated with higher import-intensities. Hence, we consider the import-weighted regression. Specifically, we use the average import value of product k produced by exporter j by domestic importers as the weight, and Column (2) of Table 7b shows that our main result still holds.

Due to the generally stable environment of importers' market structure in most product categories, the effect of importer dispersion is more likely to affect the pass-through effect in a longer horizon. To check this, we further employ a three-year difference setting to measure the exchange rate pass-through with a longer duration. Column (3) of Table 7b shows that the effect of importer dispersion still holds qualitatively and quantitatively at this medium-term frequency, confirming our main result at both short and medium horizons.

Lastly, to exclude the effect of financial crises, we re-run the estimation using a sub-sample from 2005 to 2007. From the result in Column (4) of Table 7b, we conclude that our key result is not driven or greatly affected by the global financial crisis.

Alternative Fixed Effects

In the last robustness check, we consider an alternative set of fixed effects. Specifically, we adopt the exporter, country (of origin) and the product-year fixed effects. We wish to use the product-year fixed effect to capture the time-varying effect of aggregate demand characteristics that might affect exporters' pricing strategies for a certain good. Adopting the previous four importer dispersion measures, Table 7c shows that we again obtain positive and significant coefficients on the interaction terms between importer dispersion and exchange rate, which confirms that our theoretical prediction still holds. Interestingly, in such regressions, all coefficients on the interaction terms between exporter heterogeneity and exchange rate become insignificant.

4.3 The Role of the Dominant Currency Paradigm

In a seminal study, Gopinath et al. (2020) concluded that the exchange rate pass-through effect is associated with the invoicing currency, namely US dollars in the case of Colombia. The exchange rate pass-through effect is shown to be higher for dollarized economies and when using the dollar exchange rate for non-dollarized economies.

Consistent with the dominant currency paradigm, our proposed mechanism is also found to work better along the US dollar exchange rate channel. In Table 8, we follow Gopinath et al. (2020), dividing the sample into those importing from dollarized economies and those importing from non-dollarized economies.[9] In Columns (1) and (2), we examine the sub-sample of the dollarized economies as Colombia's trading partners. The importer dispersion mechanism is shown to be statistically significant in determining exchange rate pass-through with an even larger quantitative effect – a one standard deviation change to importer dispersion will cause an increase of nearly 8 percentage points ($= 0.310 \times 0.256$) in exchange rate pass-through. A similar result holds for the non-dollarized economy sample reported in the last two columns. Moreover, the effect of importer dispersion through the US dollar exchange rate channel is highly significant and generates a much larger impact than the baseline regression results. The effect, however, becomes statistically insignificant at a very small magnitude when the bilateral exchange rate measure is used.

In sum, our examination suggests that the effect of the importer dispersion channel is more likely to hold under the dominant currency paradigm for Colombia, where trade is widely

[9] As we do not have detailed information of invoicing currency for Colombia's trade flows, the currency pricing choice cannot be directly controlled for in our analysis.

invoiced in US dollars.

5 Conclusion

An importer's market dispersion plays a key role in exchange rate pass-through. We theoretically show in this paper that a higher degree of importer dispersion is associated with lower exporter markups, which restricts adjustments of import prices to respond to exchange rate shocks. Hence, greater importer dispersion implies a higher exchange rate pass-through.

Using Colombian customs data, we empirically examine the theoretical prediction and show that a higher importer dispersion leads to a larger exchange rate pass-through. Quantitatively, a change of one standard deviation to importer dispersion increases the exchange rate passthrough rate by around 5.61 percentage points, which is only slightly lower than the effect stemming from the exporter's market share change (slightly larger than 6 percentage points). Moreover, the overall effect was shown to be larger for importer dispersion than for exporter's market share ranging from the 5th to the 95th percentile of the sample (19% and 9%, respectively). In conclusion, the importer dispersion channel is at least as important as the traditional exporter heterogeneity channel in determining the exporter price. The empirical results are robust to various empirical specifications and become even stronger in the context of the dominant currency paradigm.

References

Amiti, M., Itskhoki, O., Konings, J. 2014. Importers, exporters, and exchange rate disconnect. *American Economic Review* 104(7), 1942-1978.

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

Auer, R. A., Schoenle, R. S. 2016. Market structure and exchange rate pass-through. *Journal of International Economics* 98, 60-77.

Berman, N. , Martin, P. , Mayer, T. 2012. How do different exporters react to exchange rate changes? *The Quarterly Journal of Economics* 127.

Bernard, A.B., Moxnes, A., Ulltveit-Moe, K.H. 2018. Two-sided heterogeneity and trade. *Review of Economics and Statistics* 100(3), 424-439.

Bernini, M., Tomasi, C. 2015. Exchange rate pass-through and product heterogeneity: Does quality matter on the import side?. *European Economic Review*, 77, 117-138.

Burstein, A., Gopinath, G. 2014. International prices and exchange rates, In: Gopinath, G., Helpman, E., Rogoff, K. (Eds.). *Handbook of International Economics*, Vol. 4. Elsevier, 391-451.

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

Chatterjee, A., Dix-Carneiro, R., Vichyanond, J. 2013. Multi-product firms and exchange rate fluctuations. *American Economic Journal: Economic Policy* 5(2), 77-110.

Devereux, M. B., Dong, W., Tomlin, B. 2017. Importers and exporters in exchange rate pass-through and currency invoicing. *Journal of International Economics* 105, 187-204.

Dornbusch, R. 1989. Real exchange rates and macroeconomics: a selective survey. *The Scandinavian Journal of Economics*, 401-432.

Feenstra, R., Gagnon, J., Knetter, M., 1996. Market share and exchange rate pass-through in world automobile trade.*Journal of International Economics* 40 (1-2), 187–207.

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

Huang, H., Manova, K., Pisch, F. 2021. Firm heterogeneity and imperfect competition in global production networks. In *Allied Social Science Associations 2021 Annual Meeting (ASSA 2021).*

Rodrigue, J, 2020. The Geography of Transport Systems. New York: Routledge, 456 pages. ISBN 978-0-367-36463-2.

Xu, J., Du, Q., Wang, Y. 2019. Two-sided heterogeneity and exchange rate pass-through. *Economics Letters* 183, 108534.

Figures and Tables

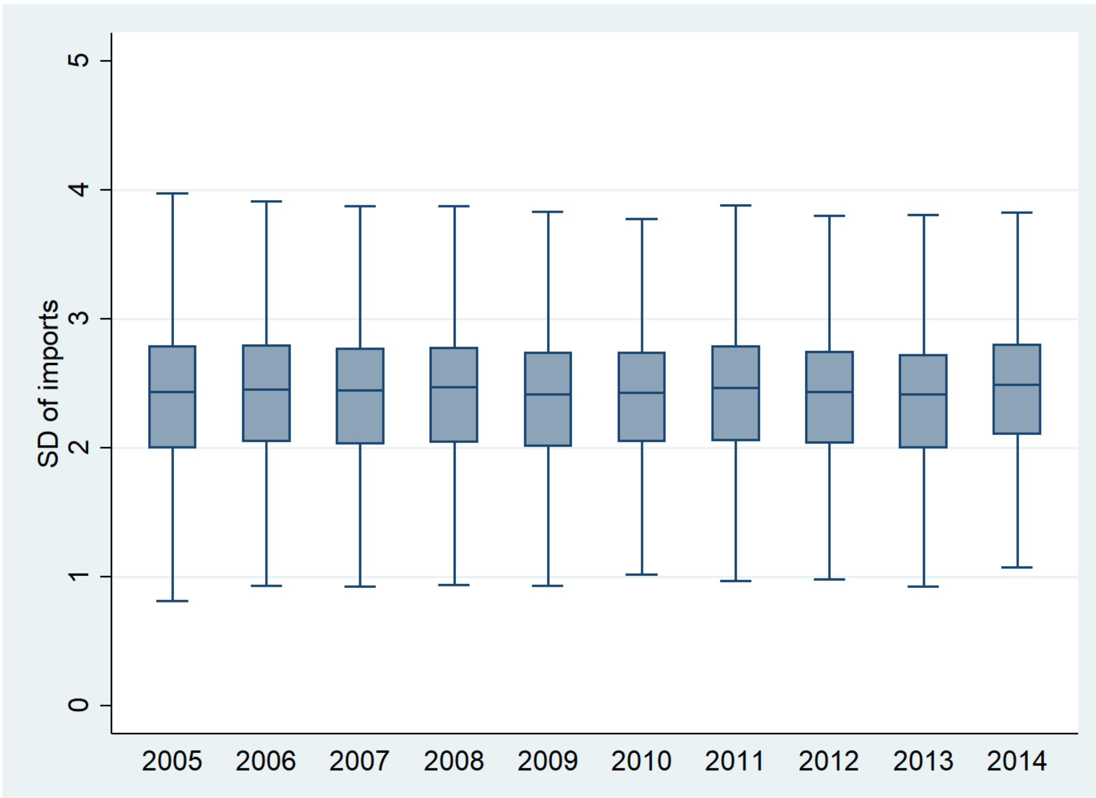

Figure 1: Standard Deviation of Firms' Log Imports for Different Goods across Years

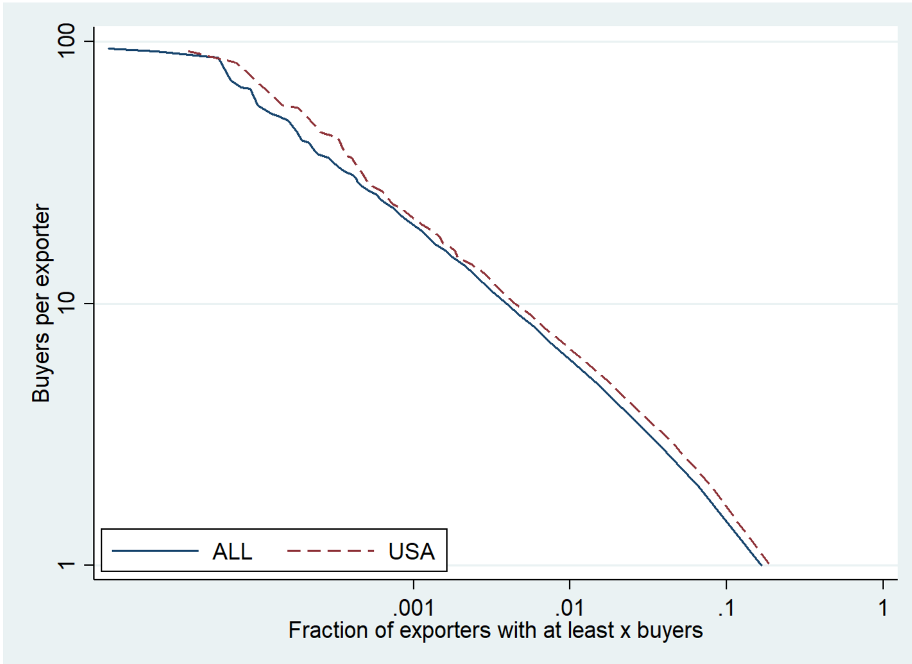

Figure 2: Distribution of the Number of Buyers per Exporter (2010)

Notes: 2010 data. The estimated slope coefficients are -0.66 (s.e., 0.0002) for all exporting countries, -0.68 (s.e., 0.0005) for U.S..

Figure 3: Colombian Peso against the US Dollar (2004=100)

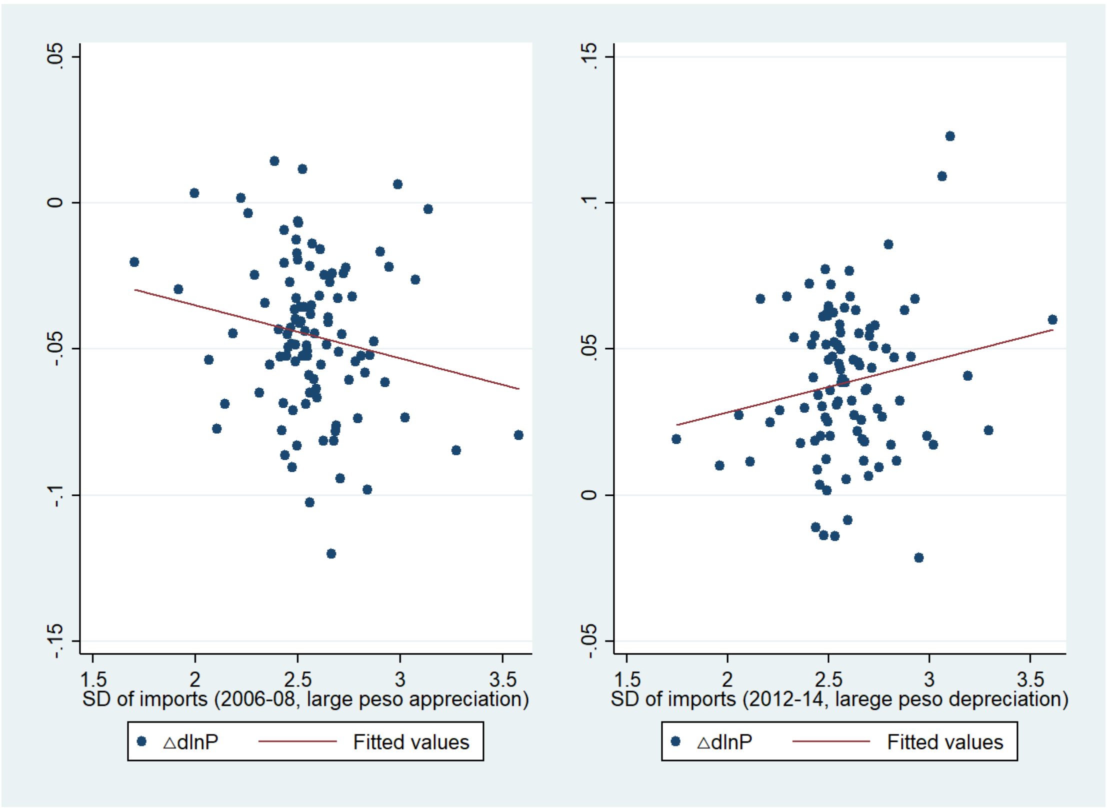

Figure 4: Two Special Episodes of Large Exchange Rate Fluctuation: Importer Dispersion vs Import Price Changes

Note: The two figures show the relationship between the average annual change of import price (y-axis) and the average SD of importers' log imports at the HS6 level (x-axis) during 2006-2008, when the Colombian peso against the US dollar is rising (left-hand side) and 2012-2014 when the Colombian peso depreciates (right-hand side), respectively. We limit the trading partners to dollarized economies: USA, Puerto Rico, Panama, Ecuador and El Salvador, and the top and bottom 1% of the price changes are winsorized in the sample. The estimated coefficients are -0.018 (s.e. 0.010) and 0.017 (s.e. 0.010) for the left-hand and right-hand side, respectively.

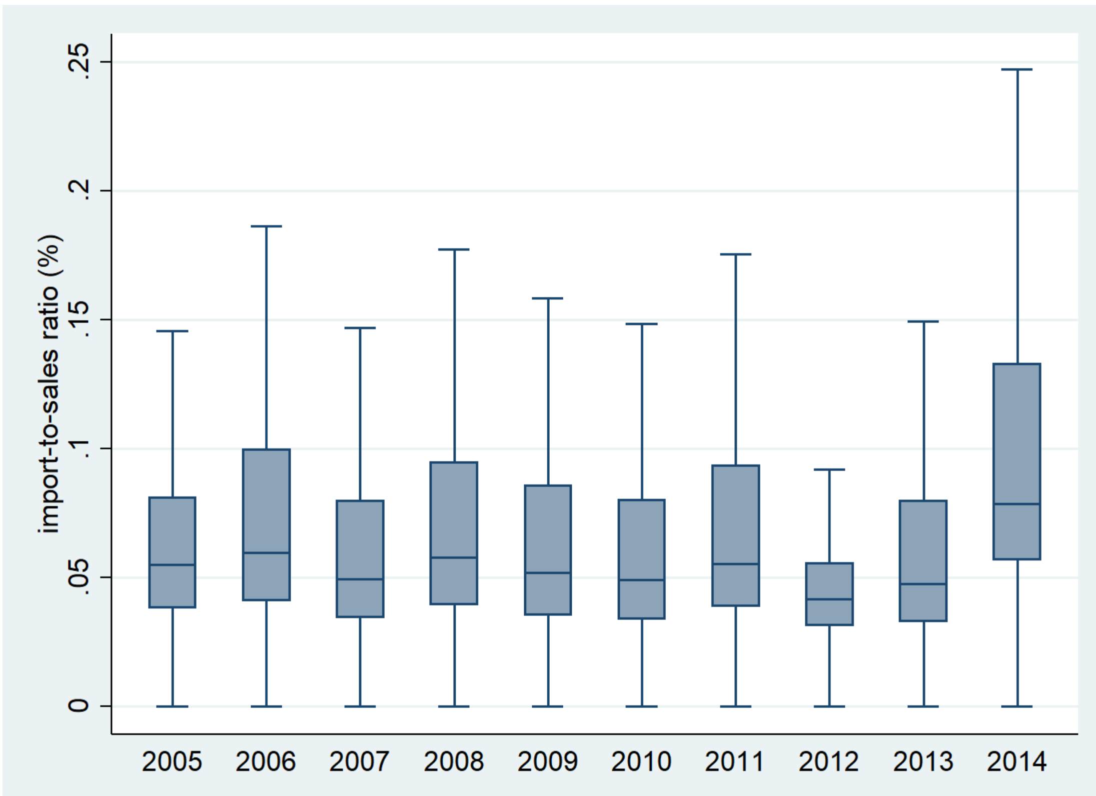

Figure 5: The variation of import-to-sales ratio at the HS6 level

Table 1: Descriptive Statistics (2010)

	Overall	OECD	Non-OECD	US
Importers/exporter, mean	1.780	2.139	1.668	3.898
Importers/exporter, median	1.158	1.037	1.195	1.000
Exporters/importer, mean	2.546	3.931	2.116	21.083
Exporters/importer, median	1.618	2.037	1.489	8.000
Share in total Colombia imports,%	100.000	63.444	36.556	30.674

Note: 2010 data. The sample includes all manufacturing products excluding exports of coke, refined petroleum products, and nuclear fuel, and basic metals. Columns of Overall, OECD and non-OECD report the un-weighted means of outcomes for all, OECD, non-OECD countries and the US.

Table 2: Top and Bottom Product categories by Importer Dispersion

Top 5		
HS6	Product description	SD
847521	Machines for making optical fibres and preforms thereof	8.753
360100	Propellent powders	5.446
880521	Air combat simulators and parts thereof	5.300
290345	Other derivatives perhalogenated only with fluorine and chlorine	5.193
530820	True hemp yarn	5.128
Bottom 5		
HS6	Product description	SD
580211	Textile materials unbleached	0.029
640191	Footwear covering the knee	0.045
551342	3 thread or 4 thread twill, including cross twill, of polyester staple fibres	0.081
847040	Accounting machines	0.110
292243	Anthranilic acid and its salts	0.111

Note: SD is the standard deviation of importing firms' log imports at the HS6 level.

Table 3: Summary Statistics

	(1) Mean	(2) SD	(3) p5	(4) p25	(5) p50	(6) p75	(7) p95
$\Delta\ln(P_{jkct})$	0.023	0.770	-1.089	-0.213	0.021	0.256	1.139
$\Delta\ln(e_{ct})$	-0.014	0.083	-0.144	-0.055	-0.005	0.039	0.092
Γ_s^{imp}(SD)	2.545	0.271	2.070	2.446	2.535	2.667	2.979
Γ_s^{imp}(Pareto)	-0.349	0.040	-0.412	-0.365	-0.351	-0.330	-0.286
Γ_s^{sales}(SD)	2.374	0.305	1.760	2.310	2.403	2.515	2.763
Γ_{HS10}^{imp}(SD)	2.546	0.291	2.031	2.437	2.542	2.677	3.006
S_{js}(%)	1.722	5.764	0.002	0.026	0.144	0.820	8.333
$\Delta\ln(\text{PPI})_{ct}$	0.028	0.049	-0.092	0.005	0.031	0.058	0.094

Note: The sample covers manufacturing goods excluding exports of coke, refined petroleum products. $\Delta\ln(P_{jkct})$ is the log change in import price expressed in peso at the exporter-country (origin)-product level across years during 2005 to 2014. $\Delta\ln(e_{ct})$ is the log change of the nominal exchange rate of peso relative to the partner country. Γ_s^{imp}(SD) and Γ_{HS10}^{imp}(SD) are the standard deviations of firms' log imports at the HS6 and HS10 level, respectively, while Γ_s^{sales}(SD) is the standard deviations of firms' log sales and Γ_s^{imp}(Pareto) is the negative of the Pareto coefficient across firms' log imports. S_{js} is the exporter's market share within HS6 level. $\Delta\ln(\text{PPI})_{ct}$ is the change in the (log) producer price indices in exporting countries.

Table 4: Pairwise Correlations

	Γ_s^{imp}(SD)	Γ_s^{imp}(Pareto)	Γ_s^{sales}(SD)	Γ_{HS10}^{imp}(SD)
Γ_s^{imp}(SD)	1.000			
Γ_s^{imp}(Pareto)	0.879*	1.00		
	(0.000)			
Γ_s^{sales}(SD)	0.498*	0.377*	1.000	
	(0.000)	(0.000)		
Γ_{HS10}^{imp}(SD)	0.932*	0.805*	0.475*	1.000
	(0.000)	(0.000)	(0.000)	

Note: * p<0.01. All measures are averaged across years.

Table 5: Import vs Import-to-sales Ratio

	Import-to-sales ratio	Import-to-sales ratio	Import-to-sales ratio
	(1)	(2)	(3)
Log(import)	0.695***	0.708**	0.788**
	(0.185)	(0.361)	(0.376)
Importer FE	NO	YES	YES
Year FE	NO	NO	YES
R^2	0.001	0.348	0.348
Observations	73,252	61,643	61,643

Note: The importer-level import-to-sales ratio is standardized between 0 and 10000. Robust standard errors are in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Table 6: Exchange Rate Pass-through, Importer Dispersion and Exporter Heterogeneity

	$\Delta\ln(P_{jkct})$	$\Delta\ln(P_{jkct})$	$\Delta\ln(P_{jkct})$	$\Delta\ln(P_{jkct})$	$\Delta\ln(P_{jkct})$
	(1)	(2)	(3)	(4)	(5)
$\Delta\ln(e_{ct})$	0.711***	0.057	0.749***	0.226	0.204
	(0.094)	(0.236)	(0.086)	(0.244)	(0.239)
$\Delta\ln(e_{ct})\times\ \Gamma_s^{imp}$(SD)		0.257***		0.204**	0.209**
		(0.095)		(0.103)	(0.102)
$\Delta\ln(e_{ct})\times\ S_{js}$			-2.208***	-2.023**	-1.076***
			(0.766)	(0.824)	(0.315)
$\Delta\ln(e_{ct})\times\ S_{js}^2$			2.230*	2.102	
			(1.215)	(1.293)	
Exp-Prod-Cty FE	YES	YES	YES	YES	YES
R^2	0.176	0.176	0.176	0.176	0.176
Observations	714,627	714,627	714,627	714,627	714,627

Note: All regressions control the changes in log PPI in exporting countries and exporter-product-country (origin) fixed effects (Exp-Prod-Cty FE). Standard errors (in parentheses) are clustered at country (origin)-year level, *** p<0.01, ** p<0.05, * p<0.1.

Table 7a: Robustness Checks: Alternative Measures and Local Distributors

	$\Delta\ln(P_{jkct})$	$\Delta\ln(P_{jkct})$	$\Delta\ln(P_{jkct})$	$\Delta\ln(P_{jkct})$
	(1)	(2)	(3)	(4)
$\Delta\ln(e_{ct})$	1.332***	0.488**	0.114	0.308
	(0.224)	(0.224)	(0.227)	(0.291)
$\Delta\ln(e_{ct})\times$ Γ_s^{imp}(Pareto)	1.702***			
	(0.511)			
$\Delta\ln(e_{ct})\times$ Γ_s^{sales}(SD)		0.104		
		(0.111)		
$\Delta\ln(e_{ct})\times$ Γ_{HS10}^{imp}(SD)			0.244***	
			(0.093)	
$\Delta\ln(e_{ct})\times\Gamma_s^{imp}$(SD)				0.182*
				(0.096)
$\Delta\ln(e_{ct})\times S_{js}$	-1.163***	-1.112***	-1.055***	0.333
	(0.306)	(0.345)	(0.303)	(0.366)
Exp-Prod-Cty FE	YES	YES	YES	YES
R^2	0.176	0.176	0.176	0.192
Observations	714,649	714,078	714,590	85,669

Note: Changes in log PPI in exporting countries are controlled in all regressions. Columns (1)-(3) alter the importer dispersion with Pareto coefficient of imports and SD of sales at the HS6 level, and SD of imports at the HS10 level, respectively. Columns (4) restricts sample with only local distributors. Standard errors (in parentheses) are clustered at country (origin)-year level, *** p<0.01, ** p<0.05, * p<0.1.

Table 7b: Robustness Checks: Alternative Settings

	$\Delta\ln(P_{jkct})$	$\Delta\ln(P_{jkct})$	$\Delta\ln(P_{jkct})$	$\Delta\ln(P_{jkct})$
	(1)	(2)	(3)	(4)
$\Delta\ln(e_{ct})$	0.223	0.211		0.062
	(0.621)	(0.244)		(0.394)
$\Delta\ln(e_{ct})\times\Gamma_s^{imp}$(SD)	0.208**	0.206**		0.262**
	(0.099)	(0.104)		(0.120)
$\Delta\ln(e_{ct})\times S_{js}$	-1.076***	-1.070***		-0.893***
	(0.315)	(0.322)		(0.187)
$\Delta\ln(e_{ct})\times Mean_s^{imp}$	-0.001			
	(0.031)			
$\Delta_3\ln(e_{ct})$			-0.405	
			(0.372)	
$\Delta_3\ln(e_{ct})\times\Gamma_s^{imp}$(SD)			0.381**	
			(0.151)	
$\Delta_3\ln(e_{ct})\times S_{js}$			-1.321***	
			(0.297)	
Exp-Prod-Cty FE	YES	YES	YES	YES
R^2	0.176	0.176	0.310	0.307
Observations	714,627	714,627	305,072	96,240

Note: Changes in log PPI in exporting countries are controlled in all regressions. Column (1) includes the average import within the HS6 level ($Mean_s^{imp}$). Column (2) is the import-weighted regression. Column (3) is at the longer horizon, and Column (4) restricts sample before year 2008. Standard errors (in parentheses) are clustered at country (origin)-year level, *** p<0.01, ** p<0.05, * p<0.1.

Table 7c: Robustness Checks: Alternative Fixed Effects

	Γ_s^{imp}(SD)	Γ_s^{imp}(Pareto)	Γ_s^{sales}(SD)	Γ_{HS10}^{imp}(SD)
	(1)	(2)	(3)	(4)
$\Delta\ln(e_{ct})$	-0.144	0.591***	-0.019	-0.153
	(0.185)	(0.169)	(0.141)	(0.163)
$\Delta\ln(e_{ct})\times$ importer_dispersion	0.158**	0.939**	0.117**	0.162**
	(0.073)	(0.466)	(0.059)	(0.065)
$\Delta\ln(e_{ct})\times S_{js}$	-0.008	-0.036	-0.026	-0.007
	(0.225)	(0.225)	(0.216)	(0.229)
Exporter FE	YES	YES	YES	YES
Country FE	YES	YES	YES	YES
Product-Year FE	YES	YES	YES	YES
R^2	0.117	0.117	0.116	0.117
Observations	929,751	929,753	929,304	929,745

Note: The dependent variables are the same as in the baseline regression, $\Delta\ln(P_{jkct})$. Changes in log PPI in exporting countries are controlled in all regressions. Columns (1) to (4) adopt different importer dispersion measures. Standard errors (in parentheses) are clustered at country (origin)-product-year level, *** p<0.01, ** p<0.05, * p<0.1.

Table 8: Dollarized and Non-dollarized Countries

	Dollarized		Non-dollarized	
	$\Delta\ln(P_{jkct})$	$\Delta\ln(P_{jkct})$	$\Delta\ln(P_{jkct})$	$\Delta\ln(P_{jkct})$
	(1)	(2)	(3)	(4)
$\Delta\ln(e_{US,ct})$	0.993***	0.212	0.739***	-0.138
	(0.075)	(0.439)	(0.076)	(0.265)
$\Delta\ln(e_{US,ct})\times\Gamma_s^{imp}$(SD)		0.310*		0.345***
		(0.181)		(0.107)
$\Delta\ln(e_{US,ct})\times S_{js}$		-0.976		0.047
		(0.785)		(0.364)
$\Delta\ln(e_{ct})$			0.340***	0.443
			(0.090)	(0.312)
$\Delta\ln(e_{ct})\times\Gamma_s^{imp}$(SD)				-0.033
				(0.121)
$\Delta\ln(e_{ct})\times S_{js}$				-0.734***
				(0.260)
Exp-Prod-Cty FE	YES	YES	YES	YES
R^2	0.448	0.448	0.181	0.181
Observations	433,133	433,133	389,240	389,240

Note: Dollarized economies are USA, Puerto Rico, Panama, Ecuador and El Salvador, while the rest partners are non-dollarized economies. All regressions control the changes in log PPI in exporting countries and exporter-product-country (origin) fixed effects (Exp-Prod-Cty FE). Standard errors (in parentheses) are clustered at country (origin)-year level, *** p<0.01, ** p<0.05, * p<0.1.

A Proof of Proposition 1

Proof. We define

$$\mu^{m}\left(p_{j}\right) \equiv E\left[\left(p_{j}+\kappa\right)^{m}\right]$$

Then

$$\begin{aligned}
Cov\left(\left(p_{j}+\kappa\right)^{-\eta-1},\kappa\right) &= \int_{0}^{\infty}\left(\left(p_{j}+\kappa\right)^{-\eta-1}-\mu^{-\eta-1}\left(p_{j}\right)\right)\left(p_{j}+\kappa-\mu^{1}\left(p_{j}\right)\right)dG\left(\kappa\right) \\
&= \mu^{-\eta}\left(p_{j}\right)-\mu^{-\eta-1}\left(p_{j}\right)\mu^{1}\left(p_{j}\right)
\end{aligned}$$

Re-writing (2.9) (under the assumption $\eta=\theta$), we obtain

$$p_{j}=\frac{\eta}{\eta-1}\varepsilon c_{j}+\frac{1}{\eta-1}\left(\frac{\mu^{-\eta}\left(p_{j}\right)}{\mu^{-\eta-1}\left(p_{j}\right)}-\mu^{1}\left(p_{j}\right)\right)$$

Doing the algebra, we have

$$p_{j}=\varepsilon c_{j}+\frac{1}{\eta}\frac{\mu^{-\eta}\left(p_{j}\right)}{\mu^{-\eta-1}\left(p_{j}\right)} \tag{A.1}$$

We expand $\mu^{m}\left(p_{j}\right)$ around $\kappa=\bar{\kappa}$ up to second order and obtain

$$\begin{aligned}
\mu^{m}\left(p_{j}\right) &= E\left[\left(p_{j}+\bar{\kappa}\right)^{m}+m\left(p_{j}+\bar{\kappa}\right)^{m-1}\left(\kappa-\bar{\kappa}\right)+\frac{1}{2}m\left(m-1\right)\left(p_{j}+\bar{\kappa}\right)^{m-2}\left(\kappa-\bar{\kappa}\right)^{2}\right] \\
&= \left(p_{j}+\bar{\kappa}\right)^{m}+\frac{1}{2}m\left(m-1\right)\left(p_{j}+\bar{\kappa}\right)^{m-2}\sigma_{\kappa}^{2}
\end{aligned}$$

Then

$$\frac{\mu^{-\eta}\left(p_{j}\right)}{\mu^{-\eta-1}\left(p_{j}\right)}=\left(p_{j}+\bar{\kappa}\right)\left(\frac{\left(p_{j}+\bar{\kappa}\right)^{2}+\frac{1}{2}\eta\left(\eta+1\right)\sigma_{\kappa}^{2}}{\left(p_{j}+\bar{\kappa}\right)^{2}+\frac{1}{2}\left(\eta+1\right)\left(\eta+2\right)\sigma_{\kappa}^{2}}\right) \tag{A.2}$$

Re-writing (A.1) by using (A.2), we can obtain

$$\Gamma_{j}=\varepsilon c_{j}+\bar{\kappa} \tag{A.3}$$

where

$$\Gamma_{j}\equiv\frac{1}{\eta}\left(\eta-1+\frac{\left(\eta+1\right)\sigma_{\kappa}^{2}}{\left(p_{j}+\bar{\kappa}\right)^{2}+\frac{1}{2}\left(\eta+1\right)\left(\eta+2\right)\sigma_{\kappa}^{2}}\right)\left(p_{j}+\bar{\kappa}\right)$$

Then

$$\frac{\partial\Gamma_j}{\partial p_{jk}} = \frac{1}{\eta}\left(\eta-1+\frac{(\eta+1)\,\sigma_\kappa^2\left(\frac{1}{2}(\eta+1)(\eta+2)\,\sigma_\kappa^2-\left(p_j+\bar{\kappa}\right)^2\right)}{\left(\left(p_j+\bar{\kappa}\right)^2+\frac{1}{2}(\eta+1)(\eta+2)\,\sigma_\kappa^2\right)^2}\right) \tag{A.4}$$

Under the assumption $(\eta-1)(\eta+2)>\frac{7}{2}$, we can show that

$$\begin{aligned}\frac{\partial\Gamma_j}{\partial p_j} &= \frac{(\eta-1)\left(\left(p_j+\bar{\kappa}\right)^2+\frac{1}{2}(\eta+1)(\eta+2)\,\sigma_\kappa^2\right)^2+(\eta+1)\,\sigma_\kappa^2\left(\frac{1}{2}(\eta+1)(\eta+2)\,\sigma_\kappa^2-\left(p_j+\bar{\kappa}\right)^2\right)}{\eta\left(\left(p_j+\bar{\kappa}\right)^2+\frac{1}{2}(\eta+1)(\eta+2)\,\sigma_\kappa^2\right)^2}\\ &> \frac{((\eta-1)(\eta+2)-1)(\eta+1)\,\sigma_\kappa^2\left(p_j+\bar{\kappa}\right)^2}{\eta\left(\left(p_j+\bar{\kappa}\right)^2+\frac{1}{2}(\eta+1)(\eta+2)\,\sigma_\kappa^2\right)^2}>0\end{aligned}$$

Taking the derivative of Γ_j with respect to σ_κ^2, we also can show that

$$\frac{\partial\Gamma_j}{\partial\sigma_\kappa^2} = \frac{\eta+1}{\eta}\frac{\left(p_j+\bar{\kappa}\right)^3}{\left(\left(p_j+\bar{\kappa}\right)^2+\frac{1}{2}(\eta+1)(\eta+2)\,\sigma_\kappa^2\right)^2}>0 \tag{A.5}$$

We now show how importer dispersion affect the exchange rate pass-through. Note that $\Lambda_j=\frac{\partial p_j}{\partial\varepsilon}\frac{\varepsilon}{p_j}$. By (A.3), we can obtain

$$\frac{\partial p_j}{\partial\varepsilon}=\frac{c_j}{\frac{\partial\Gamma_j}{\partial p_j}}>0$$

Then

$$\frac{\partial\Lambda_j}{\partial\sigma_\kappa^2}=-\frac{\varepsilon c_j}{\frac{\partial\Gamma_j}{\partial p_j}}p_j^{-1}\left[p_j^{-1}\frac{\partial p_j}{\partial\sigma_\kappa^2}+\left(\frac{\partial\Gamma_j}{\partial p_j}\right)^{-1}\left(\frac{\partial\left(\frac{\partial\Gamma_j}{\partial p_j}\right)}{\partial\sigma_\kappa^2}+\frac{\partial\left(\frac{\partial\Gamma_j}{\partial p_j}\right)}{\partial p_j}\frac{\partial p_j}{\partial\sigma_\kappa^2}\right)\right] \tag{A.6}$$

Note that the total differentiation of equation (A.3) gives

$$\frac{\partial p_j}{\partial\sigma_\kappa^2}=-\frac{\frac{\partial\Gamma_j}{\partial\sigma_\kappa^2}}{\frac{\partial\Gamma_j}{\partial p_j}} \tag{A.7}$$

Substituting (A.7) into (A.6), we obtain

$$\frac{\partial\Lambda_j}{\partial\sigma_\kappa^2}=\frac{\varepsilon c_j p_j^{-1}}{\left(\frac{\partial\Gamma_j}{\partial p_j}\right)^2}\left(p_j^{-1}\frac{\partial\Gamma_j}{\partial\sigma_\kappa^2}+\frac{\partial\left(\frac{\partial\Gamma_j}{\partial p_j}\right)}{\partial p_j}\frac{\frac{\partial\Gamma_j}{\partial\sigma_\kappa^2}}{\frac{\partial\Gamma_j}{\partial p_j}}-\frac{\partial\left(\frac{\partial\Gamma_j}{\partial p_j}\right)}{\partial\sigma_\kappa^2}\right)$$

Define Ω_j as

$$\Omega_j \equiv \frac{\frac{3}{2}(\eta+1)(\eta+2)\sigma_\kappa^2 - \left(p_j+\bar{\kappa}\right)^2}{\left(p_j+\bar{\kappa}\right)^2 + \frac{1}{2}(\eta+1)(\eta+2)\sigma_\kappa^2}$$

We can show that

$$\frac{\partial\left(\frac{\partial\Gamma_j}{\partial p_j}\right)}{\partial p_j} = -\frac{2(\eta+1)}{\eta}\frac{\sigma_\kappa^2\left(p_j+\bar{\kappa}\right)}{\left(\left(p_j+\bar{\kappa}\right)^2+\frac{1}{2}(\eta+1)(\eta+2)\sigma_\kappa^2\right)^2}\Omega_j$$

and

$$\begin{aligned}
\frac{\frac{\partial\Gamma_j}{\partial\sigma_\kappa^2}}{\frac{\partial\Gamma_j}{\partial p_j}} &= \frac{1}{p_j+\bar{\kappa}}\frac{\frac{(\eta+1)\left(p_j+\bar{\kappa}\right)^4}{\left(\left(p_j+\bar{\kappa}\right)^2+\frac{1}{2}(\eta+1)(\eta+2)\sigma_\kappa^2\right)^2}}{\eta-1+\frac{(\eta+1)\sigma_\kappa^2\left(\frac{1}{2}(\eta+1)(\eta+2)\sigma_\kappa^2-\left(p_j+\bar{\kappa}\right)^2\right)}{\left(\left(p_j+\bar{\kappa}\right)^2+\frac{1}{2}(\eta+1)(\eta+2)\sigma_\kappa^2\right)^2}} \\
&< \frac{1}{p_j+\bar{\kappa}}\frac{\eta+1}{\eta-1+\frac{(\eta+1)\sigma_\kappa^2\left(\frac{1}{2}(\eta+1)(\eta+2)\sigma_\kappa^2-\left(p_j+\bar{\kappa}\right)^2\right)}{\left(\left(p_j+\bar{\kappa}\right)^2+\frac{1}{2}(\eta+1)(\eta+2)\sigma_\kappa^2\right)^2}} \\
&= \frac{1}{p_j+\bar{\kappa}}\frac{\eta+1}{\eta-1+\frac{1}{2(\eta+2)}\frac{(\eta+1)(\eta+2)\sigma_\kappa^2\left((\eta+1)(\eta+2)\sigma_\kappa^2-2\left(p_j+\bar{\kappa}\right)^2\right)}{\left(\left(p_j+\bar{\kappa}\right)^2+\frac{1}{2}(\eta+1)(\eta+2)\sigma_\kappa^2\right)^2}} \\
&= \frac{1}{p_j+\bar{\kappa}}\frac{\eta+1}{\eta-1+\frac{1}{2(\eta+2)}\frac{\left((\eta+1)(\eta+2)\sigma_\kappa^2-\left(p_j+\bar{\kappa}\right)^2\right)^2-\left(p_j+\bar{\kappa}\right)^4}{\left(\left(p_j+\bar{\kappa}\right)^2+\frac{1}{2}(\eta+1)(\eta+2)\sigma_\kappa^2\right)^2-}} \\
&< \frac{1}{p_j+\bar{\kappa}}\frac{\eta+1}{\eta-1+\frac{1}{2(\eta+2)}} = \frac{(\eta+1)(\eta+2)}{(\eta-1)(\eta+2)+\frac{1}{2}}\left(p_j+\bar{\kappa}\right)^{-1}
\end{aligned}$$

Then

$$\frac{\partial\left(\frac{\partial\Gamma_j}{\partial p_j}\right)}{\partial p_j}\frac{\frac{\partial\Gamma_j}{\partial\sigma_\kappa^2}}{\frac{\partial\Gamma_j}{\partial p_j}} > -\frac{2(\eta+1)^2(\eta+2)}{\eta\left((\eta-1)(\eta+2)+\frac{1}{2}\right)}\frac{\sigma_\kappa^2}{\left(\left(p_j+\bar{\kappa}\right)^2+\frac{1}{2}(\eta+1)(\eta+2)\sigma_\kappa^2\right)^2}\Omega_j \qquad \text{(A.8)}$$

We now compute the derivative $\frac{\partial \Lambda_j}{\partial \sigma_\kappa^2}$. By (A.5), (A.8) and ,

$$\frac{\partial \Lambda_j}{\partial \sigma_\kappa^2} > \frac{\frac{\eta+1}{\eta}\left(p_j+\bar{\kappa}\right)^2}{\left(\left(p_j+\bar{\kappa}\right)^2+\frac{1}{2}(\eta+1)(\eta+2)\sigma_\kappa^2\right)^2}\frac{\varepsilon c_j p_j^{-1}}{\left(\frac{\partial \Gamma_j}{\partial p_j}\right)^2}\left(\frac{p_j+\bar{\kappa}}{p_j}-\left(\frac{2(\eta+1)(\eta+2)\sigma_\kappa^2}{\left((\eta-1)(\eta+2)+\frac{1}{2}\right)\left(p_j+\bar{\kappa}\right)^2}+1\right)\Omega_j\right) \tag{A.9}$$

Doing the algebra by substituting the expression of Ω_j into (A.9), we can show that

$$\begin{aligned} \frac{\partial \Lambda_j}{\partial \sigma_\kappa^2} &= \frac{\frac{\eta+1}{\eta}\left(p_j+\bar{\kappa}\right)^2}{\left(\left(p_j+\bar{\kappa}\right)^2+\frac{1}{2}(\eta+1)(\eta+2)\sigma_\kappa^2\right)^2}\frac{\varepsilon c_j p_j^{-1}}{\left(\frac{\partial \Gamma_j}{\partial p_j}\right)^2} \\ &\quad \cdot\left(\frac{p_j+\bar{\kappa}}{p_j}-\frac{2(\eta+1)(\eta+2)\sigma_\kappa^2+\left((\eta-1)(\eta+2)+\frac{1}{2}\right)\left(p_j+\bar{\kappa}\right)^2}{\left((\eta-1)(\eta+2)+\frac{1}{2}\right)\left(p_j+\bar{\kappa}\right)^2}\Omega_j\right) && \text{(A.10)} \\ &> \frac{\frac{\eta+1}{\eta}\left(p_j+\bar{\kappa}\right)^2}{\left(\left(p_j+\bar{\kappa}\right)^2+\frac{1}{2}(\eta+1)(\eta+2)\sigma_\kappa^2\right)^2}\frac{\varepsilon c_j p_j^{-1}}{\left(\frac{\partial \Gamma_j}{\partial p_j}\right)^2}\left(\frac{p_j+\bar{\kappa}}{p_j}-\frac{4\left(\frac{3}{2}(\eta+1)(\eta+2)\sigma_\kappa^2-\left(p_j+\bar{\kappa}\right)^2\right)}{\left((\eta-1)(\eta+2)+\frac{1}{2}\right)\left(p_j+\bar{\kappa}\right)^2}\right) && \text{(A.11)} \end{aligned}$$

where the first inequality holds due to the fact

$$\frac{2(\eta+1)(\eta+2)\sigma_\kappa^2+\left((\eta-1)(\eta+2)+\frac{1}{2}\right)\left(p_j+\bar{\kappa}\right)^2}{\left(p_j+\bar{\kappa}\right)^2+\frac{1}{2}(\eta+1)(\eta+2)\sigma_\kappa^2} = 4+\frac{\left((\eta-1)(\eta+2)-\frac{7}{2}\right)\left(p_j+\bar{\kappa}\right)^2}{\left(p_j+\bar{\kappa}\right)^2+\frac{1}{2}(\eta+1)(\eta+2)\sigma_\kappa^2} \geq 4$$

If p_j is sufficiently high such that

$$\frac{3}{2}(\eta+1)(\eta+2)\sigma_\kappa^2-\left(p_j+\bar{\kappa}\right)^2 < 0 \tag{A.12}$$

we immediately can obtain

$$\frac{\partial \Lambda_{jk}}{\partial \sigma_\kappa^2} > 0$$

If (A.12) does not hold, by (A.3), we can show that

$$\begin{aligned} \eta\left(\varepsilon c_j+\bar{\kappa}\right) &= \left(\eta-1+\frac{(\eta+1)\sigma_\kappa^2}{\left(p_j+\bar{\kappa}\right)^2+\frac{1}{2}(\eta+1)(\eta+2)\sigma_\kappa^2}\right)\left(p_j+\bar{\kappa}\right) \\ &\geq \left(\eta-1+\frac{(\eta+1)\sigma_\kappa^2}{\frac{3}{2}(\eta+1)(\eta+2)\sigma_\kappa^2+\frac{1}{2}(\eta+1)(\eta+2)\sigma_\kappa^2}\right)\left(p_j+\bar{\kappa}\right) \\ &= \left(\eta-1+\frac{1}{2(\eta+2)}\right)\left(p_j+\bar{\kappa}\right) \end{aligned}$$

That is

$$p_j < \frac{\eta(\eta+2)}{(\eta-1)(\eta+2)+\frac{1}{2}}(\varepsilon c_j+\bar{\kappa})-\bar{\kappa} = \left(\frac{\eta(\eta+2)(1+a_j)}{(\eta-1)(\eta+2)+\frac{1}{2}}-1\right)\bar{\kappa}$$

where we define

$$a_j \equiv \frac{\varepsilon c_j}{\bar{\kappa}}$$

In this case,

$$\frac{p_j+\bar{\kappa}}{p_j} > 1+\frac{\bar{\kappa}}{p_j} > 1+\frac{1}{\frac{\eta(\eta+2)(1+a_j)}{(\eta-1)(\eta+2)+\frac{1}{2}}-1} = A_j$$

where

$$A_j \equiv \frac{\eta(\eta+2)(1+a_j)}{\eta(\eta+2)(1+a_j)-(\eta-1)(\eta+2)-\frac{1}{2}}$$

We now show that (A.9) can be re-written as

$$\begin{aligned}
\frac{\partial\Lambda_j}{\partial\sigma_\kappa^2} &> \frac{\frac{\eta+1}{\eta}(p_j+\bar{\kappa})^2}{\left((p_j+\bar{\kappa})^2+\frac{1}{2}(\eta+1)(\eta+2)\sigma_\kappa^2\right)^2}\frac{\varepsilon c_j p_j^{-1}}{\left(\frac{\partial\Gamma_j}{\partial p_j}\right)^2}\left(A_j-\frac{4\left(\frac{3}{2}(\eta+1)(\eta+2)\sigma_\kappa^2-(p_j+\bar{\kappa})^2\right)}{\left((\eta-1)(\eta+2)+\frac{1}{2}\right)(p_j+\bar{\kappa})^2}\right) \\
&= \frac{\frac{\eta+1}{\eta\left((\eta-1)(\eta+2)+\frac{1}{2}\right)}}{\left((p_j+\bar{\kappa})^2+\frac{1}{2}(\eta+1)(\eta+2)\sigma_\kappa^2\right)^2}\frac{\varepsilon c_j p_j^{-1}}{\left(\frac{\partial\Gamma_j}{\partial p_j}\right)^2}\left(\begin{array}{c}\left(A_j\left((\eta-1)(\eta+2)+\frac{1}{2}\right)+4\right)(p_j+\bar{\kappa})^2 \\ -6(\eta+1)(\eta+2)\sigma_\kappa^2\end{array}\right)
\end{aligned} \quad (A.13)$$

By (A.3), we have

$$\eta(\varepsilon c_j+\bar{\kappa}) = \left(\eta-1+\frac{(\eta+1)\sigma_\kappa^2}{(p_j+\bar{\kappa})^2+\frac{1}{2}(\eta+1)(\eta+2)\sigma_\kappa^2}\right)(p_j+\bar{\kappa}) < \left(\eta-1+\frac{2}{\eta+2}\right)(p_j+\bar{\kappa})$$

Hence

$$p_j+\bar{\kappa} > \frac{\eta}{\eta-1+\frac{2}{\eta+2}}(\varepsilon c_j+\bar{\kappa}) = \frac{\eta(\eta+2)(1+a_j)}{(\eta-1)(\eta+2)+2}\bar{\kappa} \quad (A.14)$$

Plugging (A.14) into (A.13), we obtain

$$\frac{\partial\Lambda_j}{\partial\sigma_\kappa^2} > \frac{\frac{(\eta+1)^2(\eta+2)}{\eta\left((\eta-1)(\eta+2)+\frac{1}{2}\right)}\frac{\varepsilon c_j p_j^{-1}}{\left(\frac{\partial\Gamma_j}{\partial p_j}\right)^2}}{\left((p_j+\bar{\kappa})^2+\frac{1}{2}(\eta+1)(\eta+2)\sigma_\kappa^2\right)^2}\left(\frac{B(a_j)\left(\frac{\eta(\eta+2)}{(\eta-1)(\eta+2)+2}\right)^2}{6(\eta+1)(\eta+2)}\left(\frac{\bar{\kappa}}{\sigma_\kappa}\right)^2-1\right) \quad (A.15)$$

where we define $B(a_j)$ as

$$B(a_j) \equiv \left(A_j\left((\eta-1)(\eta+2)+\frac{1}{2}\right)+4\right)(1+a_j)^2$$

we can show that

$$\begin{aligned}\frac{\partial B(a_j)}{\partial a_j} &= (1+a_j)\left(2A_j\left((\eta-1)(\eta+2)+\frac{1}{2}\right)+8-\left(\frac{(\eta-1)(\eta+2)+\frac{1}{2}}{\eta(\eta+2)(1+a_j)-(\eta-1)(\eta+2)-\frac{1}{2}}\right)A_{jk}\right)\\ &= (1+a_j)\left(\left(2-\frac{1}{a_j\eta^2+(2a_j+1)\eta+\frac{3}{2}}\right)A_j\left((\eta-1)(\eta+2)+\frac{1}{2}\right)+8\right)\\ &= (1+a_j)\left(\frac{2a_j\eta^2+4a_j\eta+2}{a_j\eta^2+2a_j\eta+\frac{3}{2}}A_j\left((\eta-1)(\eta+2)+\frac{1}{2}\right)+8\right)>0\end{aligned}$$

Due to the fact $B(a_j)$ is strictly increasing in a_j, we further show that $\frac{\partial \Lambda_j}{\partial \sigma_\kappa^2}$ in (A.15) reaches the lower bound when $a_j=0$, that is

$$\frac{\partial \Lambda_j}{\partial \sigma_\kappa^2} > \frac{\frac{(\eta+1)^2(\eta+2)}{\eta((\eta-1)(\eta+2)+\frac{1}{2})}}{\left((p_j+\bar{\kappa})^2+\frac{1}{2}(\eta+1)(\eta+2)\sigma_\kappa^2\right)^2}\frac{\varepsilon c_j p_j^{-1}}{\left(\frac{\partial \Gamma_j}{\partial p_j}\right)^2}\left(\Xi^{-2}\left(\frac{\bar{\kappa}}{\sigma_\kappa}\right)^2-1\right)$$

where as defined in Proposition 1,

$$\Xi=\frac{3^{\frac{1}{2}}(\eta+1)(2\eta+3)^{\frac{1}{2}}}{\eta^{\frac{1}{2}}(\eta+2)^{\frac{1}{2}}\left(\eta(\eta+2)\left(\eta^2+\eta-\frac{3}{2}\right)+4\left(\eta+\frac{3}{2}\right)\right)^{\frac{1}{2}}}$$

Under the assumption

$$\frac{\bar{\kappa}}{\sigma_\kappa}\geq \Xi$$

we have

$$\frac{B(a_j)\left(\frac{\eta(\eta+2)}{(\eta-1)(\eta+2)+2}\right)^2}{6(\eta+1)(\eta+2)}\left(\frac{\bar{\kappa}}{\sigma_\kappa}\right)^2-1$$

and then,

$$\frac{\partial \Lambda_j}{\partial \sigma_\kappa^2}>0$$

□

B Adding the Effect of Exporters' Heterogeneity on Exchange Rate Pass-Through

B.1 Model

We in this appendix consider a model with finite importers and exporters. We let N^m, N^d and N^x denote the number of importers, domestic sellers and foreign exporters, respectively. The aggregate output q in this case becomes

$$q = \left(\sum_{i=1}^{N^m} q_i^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}}$$

The aggregate price index $\tilde{p}$ in this case is

$$\tilde{p} = \left(\sum_{i=1}^{N^m} \tilde{p}_i^{1-\theta} \right)^{\frac{1}{1-\theta}} \tag{B.1}$$

Importer i purchases products from both domestic sellers and Foreign exporters,

$$q_i = \left(\sum_{j'=1}^{N^d} q_{ij'}^{\frac{\eta-1}{\eta}} + \sum_{j=1}^{N^x} q_{ij}^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}}$$

with marginal cost mc_i

$$mc_i = \left(\sum_{j'=1}^{N^d} \left(p_{j'} + \kappa_i^d\right)^{1-\eta} + \sum_{j=1}^{N^x} \left(p_j + \kappa_i^x\right)^{1-\eta} \right)^{\frac{1}{1-\eta}}$$

Given the marginal cost mc_i, the profit maximization problem for importer i is

$$\max_{\{\tilde{p}_i\}} (\tilde{p}_i - mc_i) \left(\frac{\tilde{p}_i}{\tilde{p}} \right)^{-\theta} q$$

The aggregate output q contains the information from the demand side. For simplicity, we do not write down the full demand side problem but assume that the aggregate demand is independent of individual firms' price decisions.[10] Empirically, we control for various fixed

[10] In a full general equilibrium model, the optimal condition derived from households' optimization problem implies that the aggregate demand depends on the economy-wide wage rate and aggregate labor supply, which firms usually take as exogenous when optimally setting their prices in the standard macro models.

effects (including the industry-year fixed effect) to capture the demand side information in regressions. Under such simplifying assumption, the first order condition with respect to $\tilde{p}_i$ is

$$\tilde{p}_i = \frac{\epsilon^m(s_i^m)}{\epsilon^m(s_i^m)-1} mc_i \tag{B.2}$$

where

$$\epsilon^m(s_i^m) \equiv \theta(1-s_i^m) \text{ and } s_i^m \equiv \frac{\tilde{p}_i^{1-\theta}}{\tilde{p}^{1-\theta}}$$

As in Atkeson and Burstein (2008), s_i^m captures the market share of importer i. Given $\tilde{p}_i$, we have

$$q_i = \left(\frac{\tilde{p}_i}{\tilde{p}}\right)^{-\theta} y = \tilde{p}_i^{-\theta}\tilde{p}^{\theta} y \tag{B.3}$$

For exporters, the individual demand for exporter j's product from importer i is

$$q_{ij} = \left(\frac{p_j+\kappa_i^x}{mc_i}\right)^{-\eta} q_i = \left(\frac{p_j+\kappa_i^x}{mc_i}\right)^{-\eta} \tilde{p}_i^{-\theta}\tilde{p}^{\theta} y$$

Then the aggregate demand q_j is

$$q_j = \sum_{i=1}^{N^x} q_{ij}$$

For exporter j, the export price p_j is chosen by maximizing the profit $(p_j - \varepsilon c_j) q_j$. The first order condition implies

$$0 = \sum_{i=1}^{N^x} \left(\frac{p_j+\kappa_i^x}{mc_i}\right)^{-\eta} \tilde{p}_i^{-\theta} \left[\begin{array}{c} 1-\eta\left(1-\frac{(p_j+\kappa_i^x)^{1-\eta}}{mc_i^{1-\eta}}\right)\frac{p_j-\varepsilon c_j}{p_j+\kappa_i^x} \\ -\theta\frac{p_j-\varepsilon c_j}{\tilde{p}_i}\frac{\partial \tilde{p}_i}{\partial p_j} + \theta\frac{p_j-\varepsilon c_j}{\tilde{p}}\left(\sum_{i'=1}^{N^m}\left(\frac{\tilde{p}_{i'}}{\tilde{p}}\right)^{-\theta}\frac{\partial \tilde{p}_{i'}}{\partial p_j}\right) \end{array}\right] \tag{B.4}$$

By (B.2),

$$\frac{\partial \tilde{p}_i}{\partial p_j} = \frac{\epsilon^m(s_i^m)}{\epsilon^m(s_i^m)-1}\left(\frac{p_j+\kappa_i^x}{mc_i}\right)^{-\eta} + \frac{mc_i}{(\epsilon^m(s_i^m)-1)^2}\frac{\partial s_i^m}{\partial p_j} \tag{B.5}$$

$$\frac{\partial s_i^m}{\partial p_j} = (\theta-1)\left(\frac{s_i^m}{\tilde{p}}\left(\sum_{i=1}^{N^m}\left(\frac{\tilde{p}_{i'}}{\tilde{p}}\right)^{-\theta}\frac{\partial \tilde{p}_{i'}}{\partial p_j}\right) - \frac{s_i^m}{\tilde{p}_i}\frac{\partial \tilde{p}_i}{\partial p_j}\right) \tag{B.6}$$

Substituting (B.6) into (B.4), we can re-write the first order condition as

$$0 = \sum_{i=1}^{N^x}\left(\frac{p_j+\kappa_i^x}{mc_i}\right)^{-\eta}\tilde{p}_i^{-\theta}\left[1-\eta(1-s_j^x)\frac{p_j-\varepsilon c_j}{p_j+\kappa_i^x} + \frac{\theta}{\theta-1}\frac{\partial s_i^m}{\partial p_j}\frac{\tilde{p}_i}{s_i^m}\frac{p_j-\varepsilon c_j}{\tilde{p}_i}\right] \tag{B.7}$$

where

$$s_j^x \equiv \frac{\left(p_j + \kappa_i^x\right)^{1-\eta}}{mc_i^{1-\eta}}$$

We now can see that the size of exporter j (s_j^x) will also affect the optimal choice of p_j.

B.2 Numerical Examples

In general it is hard to obtain the analytical solution of $\{p_j\}$ to (B.7), hence we conduct numerial analysis in this section.

B.2.1 Solving the Model

To solve (B.7), we need to calculate the derivatives $\left\{\frac{\partial \tilde{p}_i}{\partial p_j}\right\}$ and $\left\{\frac{\partial s_i^m}{\partial p_j}\right\}$. We can re-write (B.5) and (B.6) as

$$a_i \frac{\partial \tilde{p}_i}{\partial p_j} - \sum_{i=1}^{N^m} b_{i'} \frac{\partial \tilde{p}_{i'}}{\partial p_j} = d_{ij}$$

where

$$\begin{aligned}
a_i &\equiv \left(1 + \frac{\theta(\theta-1)\, mc_i}{\left(\epsilon^m\left(s_i^m\right)-1\right)^2} \frac{s_i^m}{\tilde{p}_i}\right)\left(\frac{\theta(\theta-1)\, mc_i}{\left(\epsilon^m\left(s_i^m\right)-1\right)^2} \frac{s_i^m}{\tilde{p}}\right)^{-1} \\
b_i &\equiv \left(\frac{\tilde{p}_i}{\tilde{p}}\right)^{-\theta} \\
d_{ij} &\equiv \frac{\epsilon^m\left(s_i^m\right)}{\epsilon^m\left(s_i^m\right)-1}\left(\frac{p_j+\kappa_i}{mc_i}\right)^{-\eta}\left(\frac{\theta(\theta-1)\, mc_i}{\left(\epsilon^m\left(s_i^m\right)-1\right)^2} \frac{s_i^m}{\tilde{p}}\right)^{-1}
\end{aligned}$$

Define Δp and z as

$$\Delta p = \begin{pmatrix} \frac{\partial \tilde{p}_1}{\partial p_1} \\ \frac{\partial \tilde{p}_2}{\partial p_1} \\ \vdots \\ \frac{\partial \tilde{p}_{N_k^m}}{\partial p_1} \\ \vdots \\ \frac{\partial \tilde{p}_1}{\partial p_{N_k^x}} \\ \frac{\partial \tilde{p}_2}{\partial p_{N_k^x}} \\ \vdots \\ \frac{\partial \tilde{p}_{N_k^m}}{\partial p_{N_k^x}} \end{pmatrix}, \; z = \begin{pmatrix} d_{11} \\ d_{21} \\ \vdots \\ d_{N_k^m,1} \\ \vdots \\ d_{1,N_k^x} \\ d_{2,N_k^x} \\ \vdots \\ d_{N_k^m,N_k^x} \end{pmatrix}$$

and a $(N_k^m N_k^x) \times (N_k^m N_k^x)$ matrix A as

$$A = \begin{pmatrix} a_1 - b_1 & -b_2 & \cdots & -b_{N_k^m} & & & & & \\ -b_1 & a_2 - b_2 & \cdots & -b_{N_k^m} & & & & & \\ \vdots & & \ddots & \vdots & & & & & \\ -b_1 & -b_2 & \cdots & a_{N_k^m} - b_{N_k^m} & & & & & \\ & & & & \ddots & & & & \\ & & & & & a_1 - b_1 & -b_2 & \cdots & -b_{N_k^m} \\ & & & & & -b_1 & a_2 - b_2 & \cdots & -b_{N_k^m} \\ & & & & & \vdots & & \ddots & \vdots \\ & & & & & -b_1 & -b_2 & \cdots & a_{N_k^m} - b_{N_k^m} \end{pmatrix}$$

We can show that

$$\Delta p = A^{-1} z$$

which solves the derivatives $\left\{ \frac{\partial \tilde{p}_i}{\partial p_j} \right\}$. Substituting the values of $\left\{ \frac{\partial \tilde{p}_i}{\partial p_j} \right\}$ into (B.6), we can solve $\left\{ \frac{\partial s_i^m}{\partial p_j} \right\}$.

B.2.2 Parameters

We first set values to model parameters. As in Huang et al. (2021), we assume that the products of Home retailers (importers in our model) are more substitutable than the products of exporters (and Home sellers), that is, $\theta > \eta$. We select reasonable values of θ and η in the literature by setting $\eta = 4$ and $\theta = 6$, but we also run experiments under a different parameter setting ($\eta = 6$, $\theta = 4$) as robustness checks. For simplicity, we let $N^m = N^d = N^x = 50$. For exporters' productivities ($1/c_j$ in our model), we assume that they are drawn from a Pareto distribution with shape parameter $\gamma_c (> 1)$. As in Melitz and Ottaviano (2008), this implies that exporters' marginal costs are drawn from a random distribution with distribution function

$$F(c) = \left(\frac{c}{c_{\max}} \right)^{\gamma_c}$$

where $c_{\max}$ is the maximum value of the marginal cost. We set γ_c to 2.5 and $c_{\max}$ is chosen such that the mean of marginal cost c is one. Specifically, $c_{\max} = \frac{\gamma_c + 1}{\gamma_c}$.

We assume that it is less costly to search products from domestic sellers, $\kappa_i^d < \kappa_i^x$. For simplicity, we arbitrarily let $\kappa_i^d = 0.8\kappa_i^x$ for importer i.[11] We now consider two types of distribution of κ_i^x in our numerical examples. First, we consider a simple case that κ_i^x is drawn from a uniform distribution $[\bar{\kappa}-\Delta, \bar{\kappa}+\Delta]$, where $\bar{\kappa}$ is the mean of κ_i^x and $\Delta(>0)$ captures the dispersion of κ_i^x. In the numerical solutions, we fix the mean $\bar{\kappa}$ to one and vary the dispersion parameter Δ to see how exchange rate pass-through responds to the changes in Δ. The main advantage of conducting such analysis is that we can exclude the effect of changing mean $\bar{\kappa}$ on exchange rate pass-through when we consider various dispersions of κ_i^x. In other words, the effect on exchange rate pass-through due to changes in Δ is purely driven by the dispersion channel. In the second experiment, we assume that the efficiency of obtaining one unit of products from a seller by importer i $(1/\kappa_i^x)$ is drawn from a Pareto distribution with shape parameter $\gamma_\kappa(>1)$. Similarly, this implies that the distribution function of κ_i^x is

$$G(\kappa) = \left(\frac{\kappa}{\kappa_{\max}}\right)^{\gamma_\kappa}$$

One potential issue with the Pareto distribution is that when we vary γ_κ, the mean $\bar{\kappa}$ changes as well as the dispersion of κ given a common upper bound of κ. To minimize the effect of changes in $\bar{\kappa}$ on exchange rate pass-through, we adjust $\kappa_{\max}$ accordingly when varying γ_κ. Specifically, we set $\kappa_{\max} = \frac{\gamma_\kappa+1}{\gamma_\kappa}$ such that the mean $\bar{\kappa}$ takes value one in all experiments. In Appendix B.2.3, we provide details on how we obtain discrete draws of κ_i^x from the two assumed distributions.

For exchange rate, we assume that the long run exchange rate takes value $\bar{\varepsilon}=1$. To compute the exchange rate pass-through, we let ε increase and decrease by 1% and denote the equilibrium trade prices when the exchange rate rises and falls by p_j^- and p_j^+, respectively. The average exchange rate pass-through around the equilibrium exchange rate level is computed by

$$\Lambda_j = \frac{1}{2}\left[\frac{\log\left(p_j\big|_{\varepsilon=1}\right)-\log\left(p_j^-\right)}{0.01}+\frac{\log\left(p_j^+\right)-\log\left(p_j\big|_{\varepsilon=1}\right)}{0.01}\right]$$

B.2.3 Discrete Draws of κ^x from Two Continuous Distributions

Uniform Distribution

Given $\bar{\kappa}$ and Δ, we equally divide the interval $[\bar{\kappa}-\Delta, \bar{\kappa}+\Delta]$ into N^m-1 sub-intervals. In

[11] In unreported robustness checks, we vary the ratio of κ_i^d/κ_i^x and can show that our main theoretical prediction holds robustly.

this case, the length of each interval is

$$l = \frac{2\Delta}{N^m - 1}$$

Let $\kappa_1^x = \bar{\kappa} - \Delta$ and $\kappa_n^x = \bar{\kappa}_1 + (n-1)\,l$, we can obtain a vector $\kappa^x = \{\kappa_n^x\}_{n=1}^{N^m}$. We use the vector κ^x as the search costs of all importers spent on products from foreign exporters in our model.

Pareto Distribution

We fix the mean at $\bar{\kappa}$. Note that the distribution function of κ implies

$$\bar{\kappa} = \frac{\gamma_\kappa}{\gamma_\kappa + 1}\kappa_{\max}$$

Hence, we set the upper bound of κ as a function of the shape parameter

$$\kappa_{\max}(\gamma_\kappa) = \frac{\gamma_\kappa + 1}{\gamma_\kappa}\bar{\kappa}$$

when adjusting the values of γ_κ.

To draw a finite number of κ_i^x from the range $(0, \kappa_{\max})$, we divide the whole range into $\tilde{N}$ intervals. In our numerical examples, we set $\tilde{N} = 5$. To obtain those intervals, we proceed by the following steps:

1. We pick a value $\kappa_{\min}$ such that

   $$G(\kappa_{\min}) = 0.02$$

   That is, if we draw a κ from the interval $(0, \kappa_{\max})$, with two percent chance, κ falls into the range $(0, \kappa_{\min})$. The cutoff value 0.02 is arbitrarily choosen in our experiment but we can show that when varying such threshold, we obtain similar numerical results.

2. We equally divide $(\kappa_{\min}, \kappa_{\max})$ into $\tilde{N} - 1$ intervals. The length of each interval l is

   $$l = \frac{\kappa_{\max} - \kappa_{\min}}{\tilde{N} - 1}$$

   Let $\kappa_1 = \kappa_{\min}$, and $\kappa_n = \kappa_{\min} + (n-1)\,l$, we can write the intervals as $\left\{(\kappa_n, \kappa_{n+1})\right\}_{n=1}^{\tilde{N}}$.

3. We now draw κ_i^x from interval (κ_n, κ_{n+1}). If we randomly draw κ from $(0, \kappa_{\max})$, the

distribution of κ_i^x implies that the chance of falling into interval (κ_n, κ_{n+1}) is

$$prob_n = \left(\frac{\kappa_{n+1}}{\kappa_{\max}}\right)^{\gamma_\kappa} - \left(\frac{\kappa_n}{\kappa_{\max}}\right)^{\gamma_\kappa}$$

Then the number of draws from interval (κ_n, κ_{n+1}) is

$$k_n = prob_n \cdot N^m$$

where we take values of the nearest integer of $prob_n \cdot N^m$ for k_n.

Given k_n, we define $\Delta_n \equiv \frac{\kappa_{n+1} - \kappa_n}{k_n}$ and let

$$\kappa_n(\tau) = \kappa_{n+1} - (\tau - 1)\Delta_n,\ \tau \le k_n$$

Then we obtain the draws κ_n^x as

$$\kappa_n^x = \{\kappa_n(\tau)\}_{\tau=1}^{k_n}$$

4. In interval $(0, \kappa_1)$, the number of draws is determined by

$$k_0 = N^m - \sum_{n=1}^{\tilde{N}-1} k_n$$

Given k_0, we let

$$\Delta_0 = \frac{\kappa_1}{k_0} \text{ and } \kappa_0(\tau) = \kappa_1 - (\tau - 1)\Delta_0,\ \tau \le k_0$$

We then obtain the draws in interval $(0, \kappa_1)$ as

$$\kappa_0^x = \{\kappa_0(\tau)\}_{\tau=1}^{k_0}$$

5. Combining all κ_n^x, we obtain the draws of κ_i^x from the entire range $(0, \kappa_{\max})$ as

$$\kappa^x = \{\kappa_n^x\}_{n=0}^{\tilde{N}-1}$$

B.2.4 Results

We present the numerical results under the two different assumptions on the distribution of κ^x.[12] In the first type of experiments when we assume the uniform distribution of κ_i^x, results are showed in Figure B1. Though we only plot the exchange rate pass-though and markup for several types of exporters (exporters with marginal costs at 10th percentile, 50th percentile and 90th percentile in the sample), the numerical results show that for all exporters, as importer dispersion Δ goes up, exchange rate pass-through will rise which confirms the theoretical prediction in the benchmark model with infinite importers and exporters. The effect of importer dispersion on exchange rate pass-through can be mainly explained by the changes in exporters' markups. As in our previous analysis, an increase in importer dispersion yields a relatively higher demand elasticity for products of an exporter. In this case, exporters are more likely to set lower prices to importers to avoid significant declines in demands for their products. That is, exporters are associated with lower markups when importer dispersion rises. This in turn leads to higher exchange rate pass-through.

In the second type of experiments when we assume Pareto distribution of $1/\kappa_i^x$, results are showed in Figure B2. In all experiments, we can see a negative relationship between exchange rate pass-through and the shape parameter γ_κ. Note that an increase in γ_κ is associated with lower importer dispersion (as showed in Figure B3), we again confirm the theoretical prediction that an increase in importer dispersion yields higher exchange rate pass-through. Similarly, we can see that in most cases exporters' markups decrease when importer dispersion goes up (though the trend is not as obvious as in the uniform distribution experiment) which helps explaining the effect of importer dispersion in determining the exchange rate pass-through. Note that even though we adjust the value of $\kappa_{\max}$ to prevent sizable changes in the mean of κ_i^x, the finite number of draws still cannot ensure the same mean for all γ_κs (as showed in Figure B3). But since the changes in the mean of κ_i^x are relatively small, the importer dispersion channel in determining the exchange rate pass-through will not be overruled.

Our numerical examples are also consistent with the standard literature that the market share of an exporter plays important role in determining exchange rate pass-through. In Figures B1 and B2, we can show that for larger exporters with lower marginal costs (for instance, exporters with marginal costs at the 10th percentile), they are associated with higher markups

[12] We do not present the robustness check results when varying different sets of parameters in this paper since the numerical examples are adopted mainly to explain the theoretical mechanism. The results are available upon request.

and then lower exchange rate pass-through.

One caveat applies here. The numerical results only show the mechanism how importer dispersion affects exchange rate pass-through. We do not aim at quantitatively matching the empirical facts closely in our numerical examples as our model does not take important factors such as the endogenous matching between importers and exporters into account. Hence the exchange rate pass-through in the numerical results may differ from what data implies.

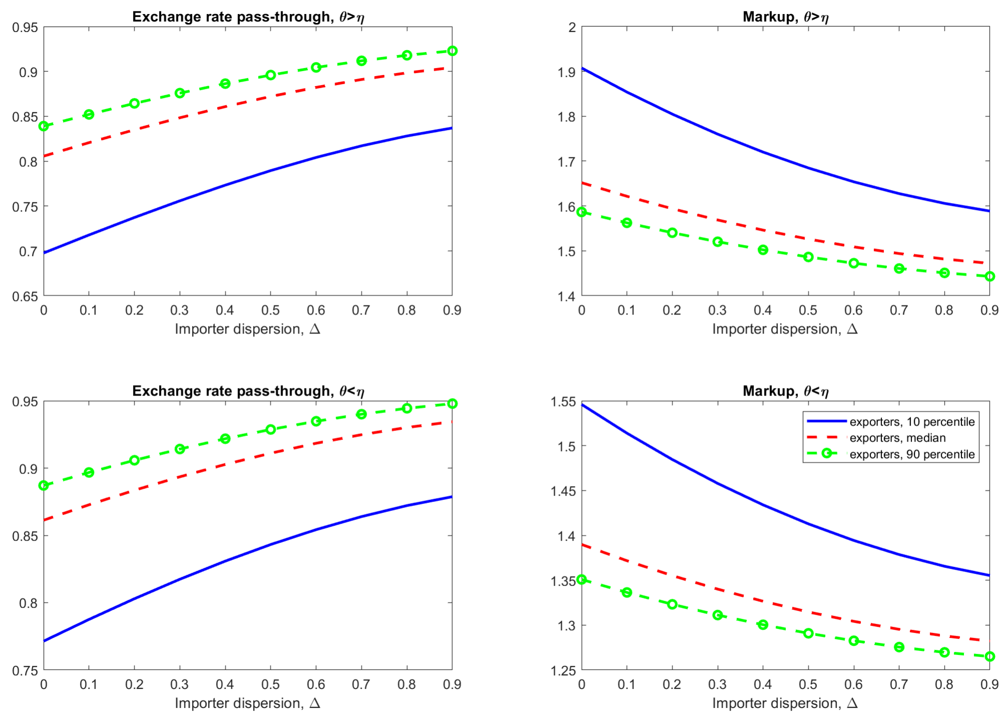

Figure B1: Exchange rate pass-through and markup vs importer dispersion, uniform distribution

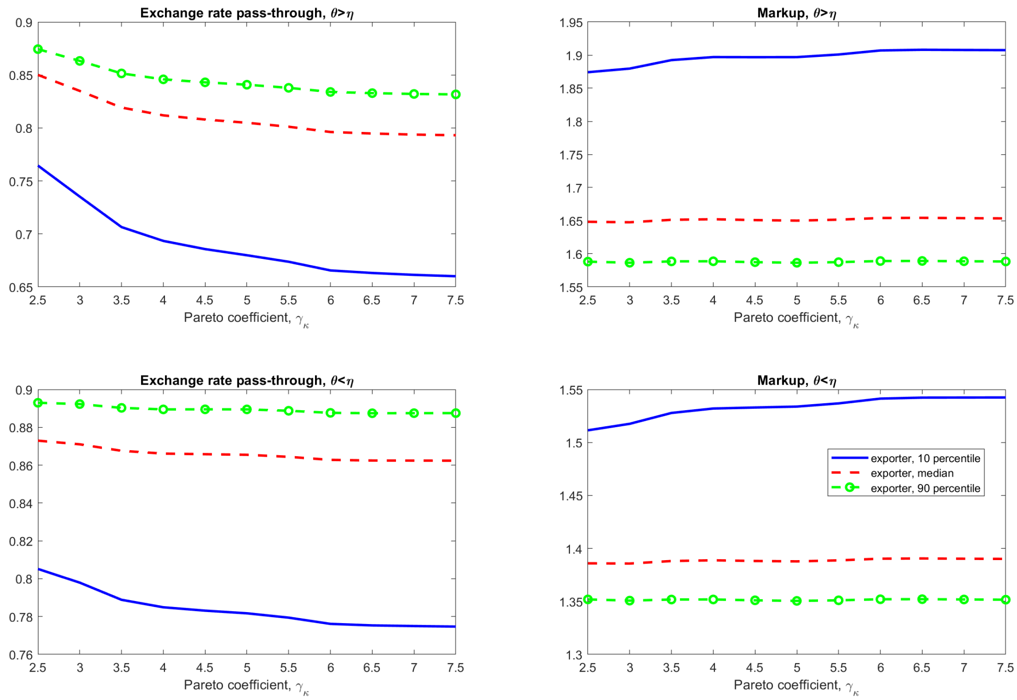

Figure B2: Exchange rate pass-through and markup vs importer dispersion, Pareto distribution

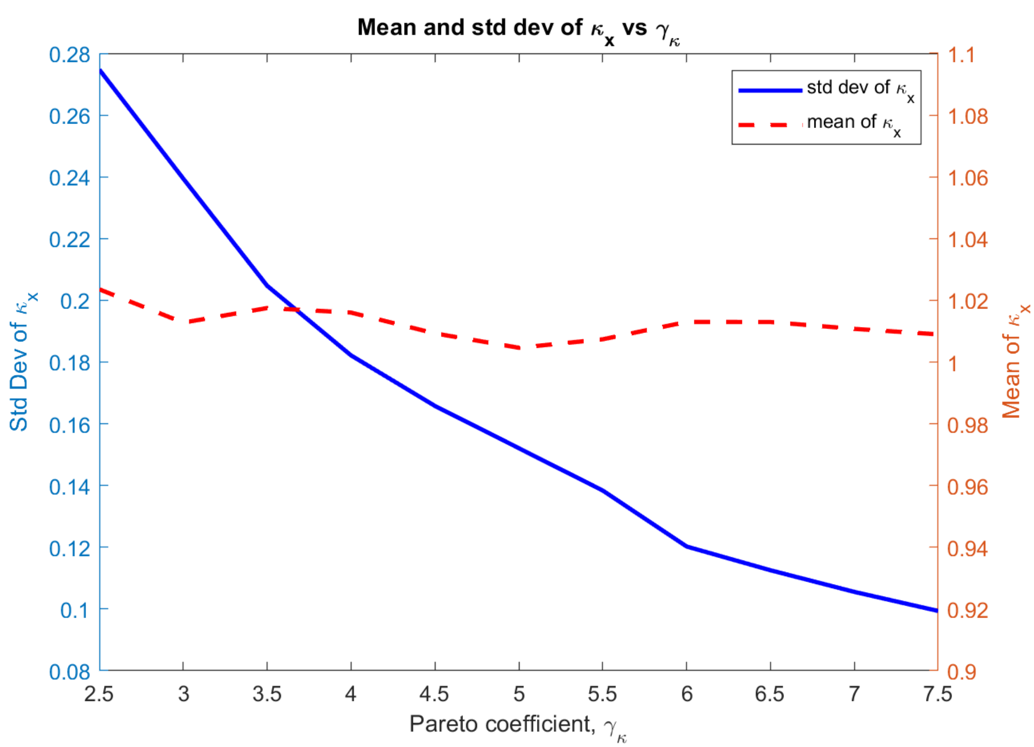

Figure B3: Std Dev and mean vs Pareto coefficient