International Trade, Volatility, and Income Differences

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Abstract Developing countries trade less than rich countries. I show that this lack of involvement in trade arises because high domestic volatility discourages exporters' investments in foreign market access. At the cross-country level, I find that the country's TFP volatility explains 40% of the relationship between trade and GDP per capita. Using Colombian micro-level data, I document that those exporters facing higher domestic sales volatility export less. New exporters expand relatively less over their life cycle in industries with domestic sales volatility. This dampening of the firm-level export expansion path is more severe in products with more variable markups. Motivated by these novel firm-level findings, I develop an international trade model with new exporter dynamics and non-CES demand that can account for the novel facts at the firm and the cross-country levels. These findings suggest that estimated trade frictions using static trade models reflect the consequences of domestic volatility on exporters' investment decisions to grow into foreign markets. Indeed, my quantitative findings show that the volatility differences across countries are equivalent to a 30% higher trade cost in developing economies. These volatility differences account for 40% of the differential trade cost estimated by standard models without these mechanisms.

JEL Classifications: F10, F12, F14, F23, F63, O19, O24

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1 Introduction

Living standards vary significantly across the globe, and with them, the patterns of international trade. Countries with a higher level of development have more exporters per capita that are larger and more likely to continue exporting. [1] Consequently, developed countries export more than less developed ones. These facts have been attributed to less developed countries facing relatively high export costs. Furthermore, these costs have been estimated to have large impacts on the level of development.[2] But how can we unleash the benefits of eliminating these trade costs? To answer this question, we need to understand the source of these relatively high trade costs.

This paper shows that developing countries export less mainly because they are more volatile. Firms' domestic volatility affects their incentives to invest in foreign markets, depressing exporters' growth and total trade. Domestic volatility has a relatively large effect on trade because the costs of investing in foreign market access are relatively high. [3] I show that the interaction between domestic volatility and the trade frictions that affect firm growth in foreign markets explains most of the relationship between development and international trade.

In section 3, I document new facts about domestic volatility and trade. Firstly, I present cross-country evidence on the relevance of domestic volatility to explain export differences. Three salient features stand out in the cross-country data: (1) developing countries have higher TFP volatility; (2) more volatile countries export less conditional on the level of development and standard gravity equation variables; and (3) the role of development on trade is substantially reduced after controlling for macro or microeconomic volatility. Indeed, volatility seems to have a much stronger effect on trade than the level of GDP per capita.

[1] See Fernandes et al. (2015) for a study of the relationship between exporter characteristics and development.
[2] See Waugh (2010), Blum et al. (2019), Fieler (2011) and de Sousa et al. (2012).
[3] See Das et al. (2007), Alessandria et al. (2021a).

In sections 4 and 5, I show that industry volatility shapes individual firms' expansion patterns. Specifically, I use Colombian firm-level data on domestic and international transactions to document three novel features of firm dynamics[4]. First, exporter growth is driven by increases in the relative market demand, similar to the findings of Fitzgerald et al. (2021) and Steinberg (2021). Second, exporters more exposed to domestic volatility grow slower in their export markets; higher domestic volatility reduces exporter incentive to invest in foreign markets. A fact that can't be replicated by new exporter dynamics models assuming CES demand structure. Based on this result, I propose a novel identification strategy that allows me to estimate how exporters' markup changes depending on exporters' market share with minimum assumption over the production function.

I build a dynamic model with firm heterogeneity and new exporter dynamics to quantify the role of volatility in trade. The model extends the new exporting dynamic model to allow for a variable price elasticity and, thus, variable markup. Two main reasons motivate this model: (1) the firm-level data suggest that variable markups are relevant to understand the negative relationship between volatility and exports, and (2) this allows me to test the relevance of this microeconomic mechanism. [5] I show that the standard models with CES-demand cannot match the documented micro-level facts, while allowing for variable price elasticity generates volatility to reduce firms' investment incentives. Models of international trade that assume CES demand cannot generate a negative relationship between volatility and international trade because they present the "Oi-Hartman-Abel" effect.[6] When we depart from the CES-demand framework and allow the price elasticity to vary with firms' productivity, higher uncertainty reduces the firm's expected marginal return on investment, decreasing exporters' growth and total exports. This result follows because firms' profits become concave on productivity.

[4]A key advantage of the data is that it allows me to separate domestic from international shocks

[5]I refer to standard models of new exporter dynamics as those that have: (1) monopolistic competition, (2) constant price elasticity, (3) fixed export costs, and (4) a market-specific investment decision that increases future sales conditional on firms' prices.

[6]See Bloom (2013) about the "Oi-Hartman-Abel" effect. The "Oi-Hartman-Abel" refers to the case in which higher volatility increases the firms' expected return because the expected profits in good times compensate for the profits of bad times.

Section 6 turns to the quantitative analysis. I use the model to test to what extent the micro-level mechanism can explain the novel aggregate and micro-level findings. I estimate the model's parameters to match Colombian aggregate average trade openness, the evolution of exporters over their life cycle in firm-level fact 1, and my causal estimates on heterogeneous markup response to changes in firms' marginal cost. The model can account for a firm-level fact two regarding the adverse effects of higher domestic sales volatility on exporters' growth.

Next, I test the model's ability to replicate the cross-country relation between total exports and volatility. I simulate economies with different levels of volatility on their aggregate and firm-level productivity. I compute the ergodic distribution of the model and observe how their total export responds to different levels of volatility in four different versions of the model. The four models are (1) a standard static model with firm heterogeneity, (2) a static model with variable markups, (3) a dynamic model assuming constant price elasticity, and (4) a dynamic model with variable markups. All but the fourth model predict a positive or null relationship between domestic volatility and total exports, at odds with the empirical findings. These results show the macroeconomic relevance of the micro-level findings documented in the data. Assuming that exporters make a static decision or face demand with constant price elasticity comes at the cost of missing the relationship between aggregate export and the level of volatility.

The quantitative predictions of the model are striking. Keeping macroeconomic volatility unchanged, if developing countries were to reduce their microeconomic volatility to the level of developed ones, their exports would increase on average by 97%. When I perform a similar exercise for the macroeconomic volatility, I find that exports in developing economies will grow by 26%. To put these results in context, they imply that the average volatility difference between developing and developed countries is equivalent to developing countries facing, on average, 30% higher iceberg costs. In this sense, the proposed mechanisms can account for 40% of the differential trade cost that developing countries face, as estimated by de Sousa et al. (2012). These results highlight the importance of domestic volatility as a determinant of endogenous trade barriers. The interaction between domestic volatility and firms' investment cost to grow into foreign markets significantly affects exports.

Literature. The paper relates to several strands of literature at the intersection of macroeconomics, international trade, and development.

The main contribution of this paper is to understand why developing economies engage in less international trade than developed ones. To the best of my knowledge, this is the first paper showing the relevance of domestic volatility to explain the differences in the estimated export costs in developing economies. The literature goes back to the findings of Rodrik (1998) suggesting the low export performance in Sub-Saharan countries was mainly due to trade costs, similarly Limao et al. (2001) shows the relevance of the lack of infrastructure to explain part of the relatively low levels of trade in these countries. On the other hand, Waugh (2010) shows that to match the data on trade and prices, export costs in developing economies need to be higher than in developed ones, de Sousa et al. (2012) find similar empirical results using the border effects methodology. In contrast, Fieler (2011) argues that non-homothetic preferences in demand for goods may be important to understand this relationship. These findings follow models in which firms face static decisions where volatility cannot play an important role by design. Blum et al. (2019) departs from the static frameworks with the insights of inventory models to understand this relationship. They argue that the shipment data suggest higher per-shipment costs to export in developing economies explaining part of the export cost. My approach differs from those in the literature in two ways: (1) I rely on the insights of the predictions of dynamics models, and (2) I show that the estimated trade costs are an equilibrium outcome of the interaction between domestic volatility and the dynamic nature of exporter decisions.

This paper is the first one to estimate how domestic sales volatility affects a firm market-specific growth over its life-cycle. There is extensive literature on investment under uncertainty that followed the seminal work of Lucas et al. (1971), Hartman (1972), Andrew (1983) and Pindyck (1982). I focus on a particular type of investment, the market-specific investment that firms make to grow into each market, so far ignored in this literature. [7]

More broadly, the present work proposes a new mechanism through which volatility discourages investment — the existence of variable price elasticity — contributing to the literature that studies how economic frictions interact with uncertainty affecting firm investment decisions. Until now the literature has focused on the three main frictions: (1) investments frictions that generate the real option effect (e.g. Pindyck (1982), Bloom (2007), Bloom (2009), Novy et al. (2020), Alessandria et al. (2019), Martin et al. (2020),Handley et al. (2017)); (2) financial frictions to explain why uncertainty reduces firms investment (e.g. Arellano et al. (2019) and Merga (2020)); and (3) the existence of sticky prices e.g. (Basu et al. (2017), and Fernández-Villaverde et al. (2015)). My empirical and quantitative findings show the existence and relevance of variable price elasticity as a novel mechanism complementary to the literature.

The third contribution of this paper is to develop a framework that nest the insights Fitzgerald et al. (2021) to explain how exporters grow and how their growth is affected by domestic volatility. By relaxing the assumption of constant price elasticity the extended model can account for the patterns regarding (1) exporter dynamics over their life-cycle, (2) the heterogeneous markup response to exchange rate shocks, and (3) the negative relationship between exporters growth and domestic volatility. I do this within the framework of a small open economy, allowing me to show the aggregate relevance of my micro-level findings to explain the behavior of total exports.

The fourth contribution of this paper is to the literature on the relationship between prices and exchange rates. The literature has struggled to separate the effects of exchange rates on prices as it is not clear whether the price response is driven by markup or changes in costs. I solve this problem by proposing an estimation procedure to compute the pure markup response to exchange rate shocks without having to estimate the level of markup. In this sense, my results complement Berman et al. (2012) finding that larger firms adjust

[7] Recent work has found that this investment that works as a demand shifter is essential to explain firms' growth in both their domestic and foreign markets as in Ruhl et al. (2017), Fitzgerald et al. (2021), Steinberg (2021), Alessandria et al. (2021a), Fitzgerald et al. (2018), Einav et al. (2021).

their prices less than smaller ones due to exchange rate changes, and Amiti et al. (2014) finding that larger exporters also import more, showing that exchange rate changes affect the marginal cost of production. I also propose a new instrumental variable approach to solve the endogeneity problems that may arise due to the use of exchange rate movements.

Layout. The rest of the paper is structured as follows. Section 2 presents the data sources. Section 3 presents the estimation strategy and results for the three aggregate facts. Section 4, documents the micro-level facts using firm-level administrative data from Colombia. Section 5 presents the model, and section 6 its estimation and quantitative results. Section 7 concludes.

2 Data

To document the three aggregate facts I use several data sources: Penn World table database, the Dynamic Exporter Database from World Bank, the Enterprise Survey from the World Bank, and CEPII database. In the appendix A.1 I explain the details of the cross-country data.

For the micro-level data and model estimation I use three primary data sources: (1) Administrative data from Colombian customs (2) Administrative data from "Superintendencia de Sociedades" of Colombia with the firm's balance sheet information, and (3) Colombian manufacturer survey.

2.1 Firm-level Data

I use two administrative data sets from Colombia to measure variables at the firm level. The first data set reports exports of each firm at the 8-digit product level for each destination and period. The data is monthly and provides information on the quantities shipped and the value of the shipment in Colombian pesos and U.S. dollars over the period 2006-2019. I aggregate export flows for each firm product destination yearly to avoid the usual problems with lumpiness in trade.[8]

[8]See Alessandria et al. (2019) as an example of the lumpiness in trade and its relevance for exporter behavior at high frequency.

I merge this data with firm-level data from "Superintendencia de Sociedades" which reports the variables firms declared in their balance sheet information. This dataset provides information on firms' total income, operational income, operational cost, total costs, profits, and operational profits, among other variables. These variables are in nominal Colombian Pesos, and I deflate these variables with the production price index. The data sets cover a sub-sample of 20,000, the largest firms representing around 90% of total value-added. The sample is skewed towards larger firms generating a concern due to possible bias for firm-level empirical facts. The focus on exporters alleviates this concern, generally the largest firms in the economy, and given the concentration of total exports on larger firms. Furthermore, I show that the firm-level facts are robust to include or not this data in the appendix.

3 International Trade and Volatility Around the World

This section focuses on cross-country evidence. I document two facts. First, I reexamine the relationship between exports and the level of development. I find that unconditional on the level of volatility, there exists a positive relationship between aggregate exports and level of development as in Waugh (2010), Fieler (2011), Blum et al. (2019), Fernandes et al. (2015) and de Sousa et al. (2012). Second, I show that conditional on the level of micro or macroeconomic volatility, the relationship between aggregate exports and GDP per capita reduces almost by half, becoming negligible in some cases. Aggregate fact 1 can be explained by the fact that on average developing economies tend to be more volatile[9].

Macroeconomic volatility measure. I measure the macroeconomic volatility of each country as the time-series standard deviation of the detrended estimated TFP. I proceed in several steps. First, I define $t\hat{f}p_{it}$ as the detrended value of the log of the TFP of each country i at time t.[10] The measure of TFP comes from the estimates of Penn World Tables.

[9] In appendix A.2 I document more volatile countries present lower levels of GDP per capita, consistent with the findings of Ramey et al. (1995),Aghion et al. (2010),Badinger (2010), Imbs (2007), Koren et al. (2007)

[10] I detrend the series by using an H-P filter with a smooth parameter equal to 100 since I am using annual frequency data

I then proceed to estimate the shocks to the estimated tfp assuming it follows an AR(1) process (1):

$$\ln \widehat{tfp}_{i,t} = \alpha_{0,i} + \rho_i \ln \widehat{tfp}_{t-1} + e_{i,t} \tag{1}$$

I repeat this procedure for each of the N countries, generating a vector of $\{\rho_i\}_{i\ \in N}$ and a time series of the estimated residuals for each country $\{e_{i,t}\}_{i\ \in N}$. I then compute the macroeconomic volatility as the standard deviation of $e_{i,t}$ for each country i.

Microeconomic volatility measure. To compute the firm-level shocks without the macroeconomic common component that affects firms within a country-industry-year, I follow Yeh (2021) and Di Giovanni et al. (2020). For a firm f, in country i, industry j, at time t, I first estimate:

$$\Delta \text{labor prod}_{f,i,j,t} = \gamma_{i,j,t} + e_{f,i,j,t} \tag{2}$$

Where Δlabor prod is the percentage change in labor productivity, defined as total sales over total workers, for a firm f in year t [11]. The $\gamma_{i,j,t}$ denotes country-industry-year fixed effects, so that $e_{f,i,j,t}$ can be interpreted as the pure firm-level shocks.

I compute the microeconomic volatility as the average observed standard deviation across time for each country i as follows:

$$\sigma_i^{\omega} := \sum_{t=1}^{T} \frac{\sqrt{\sum_{f \in F_{i,t}} \frac{\left(\hat{e}_{f,t} - \mu_t^{e_f}\right)^2}{|F_{i,t}|-1}}}{T}$$

where $\mu_{i,t}^{e_f}$ denotes the average of $\hat{e}_{f,i,j,t}$ across firms at year t, and $|F_{i,t}|$ is the total number of firms in country i.[12]

Exports, volatility and income differences: Estimation. To empirically understand the relevance of macro and micro volatility on international trade I estimate a gravity equa-

[11] I restrict my sample to those firms that do not declare any direct or indirect export. I do this to avoid computing the direct effects that foreign shocks may have on the volatility of firms.

[12] I follow the guideline of the World bank to weight each firm by the weights they provide so that the estimates of using the sample are representative for the economy.

tion as denoted (3). I decompose the logarithm of country i's exports to country j (denoted by$\ln(x_{ijt})$), in an origin country fixed effect (α_i), a destination time fixed effect (γ_{jt}), and a vector of bilateral variables ($\boldsymbol{y}_{ijt}$)[13],

$$\ln(x_{ijt}) = \alpha_i + \gamma_{jt} + \boldsymbol{\beta y}_{ijt} + \epsilon_{ijt} \tag{3}$$

as in Head et al. (2014) and Eaton et al. (2002) I proceed in a two-step procedure, to understand the variables that relates with the origin component of a country, α_i. Once, I have estimated equation (3) to back up the origin fixed effects, $\hat{\alpha}_i$ I estimate:

$$\hat{\alpha}_i = \beta_0^\alpha + \beta_1^\alpha \ln \sigma_i + \beta_2^\alpha \ln \frac{GDP}{L} + \boldsymbol{\alpha_3} \bar{\boldsymbol{y}}_{ij} + \boldsymbol{\alpha_4} \bar{\boldsymbol{h}}_i + \boldsymbol{\alpha_5} \bar{\boldsymbol{Q}}_i + e_i \tag{4}$$

the equation shows that countries origin fixed are related to country i level of volatility, its GDP per capita, the average of the bilateral-time variables, the average of the origin time-varying variables denoted by σ_i, $\frac{GDP}{L}$, $\bar{\boldsymbol{y}}_{ij}$, and $\bar{\boldsymbol{h}}_i$ respectively. I also control for countries' quality institution, it level of financial development, and direct measures of exporting costs denoted by the vector $\bar{\boldsymbol{Q}}_i$. In particular, I use the three indexes developed by the World Bank that captures the quality of the contract enforcement, the financial development of a country i, and the declared export costs that exporters face.[14] The two main coefficient of interest are β_1^α and β_2^α. The former captures the relationship between the average exports of a country and its volatility. The latter captures the relationship between the average exports and its level of development.

Table 1 presents the results of the estimated coefficients for β_1^α and β_2^α. In this specifications the gravity controls row denotes controls for the origin country such as, its GDP, the standard deviations of the terms of trade (TOT), the bilateral exchange rate, and countries' tot, country-pair trade agreement, a dummy for country-pair that belongs to a currency union, if country-pair currencies are peg, the average bilateral tariff, the size in sq feet for

[13]See Head et al. (2014) for a descriptions of models and the history of gravity equations in international trade.

[14]I include these three indexes obeys because they are correlated with the level of development and the volatility of a country and are also relevant for international trade Manova (2008), Manova (2013), Kohn et al. (2020), and Blum et al. (2019).

the country and its population, the distance and the level and changes of country's tfp. While in the Doing Business row, Exp denotes controls for total export declared costs, Cred denotes controls for the financial development index of the country, and Cot denotes a control for the contract enforceability of the country.

Aggregate Fact 1: Positive relationship between exports and income per capita. Table 1 presents the results for both the macro and the microeconomic volatility measures. Each of the 4 four columns presents a different specification. Columns (1) and (3) shows the estimates (4) without controlling for the volatility of a country. Both results show significant and relevant relations between the level of development and the average export to each market when we do not control for the level of volatility of a country even after controlling by country size, the declared cost to export, and the institutional environment of the country (column 3). This result is consistent with the findings on the literature.

Aggregate Fact 2: Negative relationship between volatility and exports. In Table 1, columns (2) and (4) are homologous to column (1) and column (2) but add the variable of interest, the macro or microeconomic volatility measures. The results in columns (2) and (4) of panel 1 show that the estimated relationship between exports and the level of GDP per capita drops between around 45% controlling for the level of macroeconomic volatility of each country and that it becomes non-significantly different from zero, while there exist a negative relationship between average exports and countries volatility.

Panel 2 of Table 1 shows that after controlling for microeconomic volatility the relationship between average exports and the level of GDP per capita reduces by around 35%. Furthermore, the estimates predict as before a negative relationship between volatility and average exports. There is one difference worth mentioning among these panels, as mentioned before there is only data on labor productivity changes for a subset of countries restricting the number of countries in Panel 2 of 1.

While aggregate fact 1 is well-known and documented in the literature, the second aggregate fact 2 is new to the literature. To check the robustness of this result I perform several

Table 1: Volatility and Exports Around the World

Panel 1: Macro-Economic Volatility and Average Exports

	Av. Exports	Av. Exports	Av. Exports	Av. Exports
$log(\frac{GDP}{L})$	0.50**	0.30	0.40*	0.19
	[0.19]	[0.18]	[0.20]	[0.20]
log(Macro-Volatility$_i$)		-0.64**		-0.64**
		[0.23]		[0.23]
First-stage Observations	174,025	174,025	174,025	174,025
Numb. Countries	109	109	109	109
R^2	0.55	0.59	0.56	0.60
Year × Destination × Product FE	✓	✓	✓	✓
Gravity Controls	✓	✓	✓	✓
Doing Business	Exp.	Exp.	Exp/Cred/Cont	Exp/Cred/Cont

Panel 2: Micro-Economic Volatility and Average Exports

	Av. Exports	Av. Exports	Av. Exports	Av. Exports
$log(\frac{GDP}{L})$	0.77***	0.50**	0.63***	0.43**
	[0.19]	[0.22]	[0.17]	[0.20]
log(Micro-Volatility$_i$)		-1.46**		-1.45**
		[0.68]		[0.66]
First-stage Observations	39,439	39,439	39,439	39,439
Numb. Countries	38	38	38	38
R^2	0.83	0.85	0.84	0.86
Year × Destination × Product FE	✓	✓	✓	✓
Gravity Controls	✓	✓	✓	✓
Doing Business	Exp.	Exp.	Exp/Cred/Cont	Exp/Cred/Cont

Note: Av. Exports denotes the estimated value for α_i from equation (3).Trade flows are yearly frequency. First stage-Observation correspond to the amount of observations used to estimate equation (3).Number of countries equals the observations for the second stage. Doing business denotes controls for declared export cost (Exp.), contract enforceability index, and financial development index (Cred/Cont). Standard errors in brackets. Error cluster at country level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

robustness tests in appendix A.3. I find that the results are robust to using different measures of macro or microeconomic volatility, constructing the volatility measure without global common factors, looking at trade only in manufacturing to test the relevance of trade composition, or using past volatility, and that is consistent with the firm-level responses at the intensive and the extensive margin.

The previous results show that macroeconomic and microeconomic volatility are relevant variables to predicting average exports to each market. They not only predict considerable variations of average exports across countries but also capture a significant share of the variations that had been attributed to the level of development in previous works such as in Waugh (2010), Fieler (2011), and Blum et al. (2019). These aggregate facts provide a new explanation of why export costs and export values seem to be empirically associated with variations in the level of development even after controlling for the standard determinants of international trade. As It will be clear later, standard models cannot replicate this empirical observation. The next sections document three micro-level facts that once incorporated into the model explain these relationships.

4 Volatility and Exporters' Growth

In this section, I focus on the exporter micro-level data from Colombia to show that those exporters that face higher domestic volatility grow less over their life cycle in each market they served. I document three facts: (1) exporters grow into foreign markets by expanding their demand, (2) higher exposure to domestic volatility is negatively associated with this market-specific investment exporters make to grow into foreign markets.

Firm-level fact 1: New exporters grow through increases in their demand. I revisit the facts documented in Fitzgerald et al. (2021) and Steinberg (2021) to understand how Colombian exporters grow over their life cycle. I find that while, on average, exporters increase the number of exports over their life cycle, this is not true for observed prices. This result suggests that exporters grow into foreign markets by shifting up their demand, conditional on prices.

I pin down the evolution of quantities in a particular market, which is defined as a six-digit product and destination pair. I estimate the following equation:

$$\ln \text{export}_{i,d,l,t} = \sum_{h=0}^{5} \beta_h \mathbb{I}^h_{\{age=h\}} + \ln p_{i,d,l,t} + \gamma^a_{i,l,t} + \gamma^b_{d,l,t}\gamma^c_{p\text{cohorts}} + \epsilon_{i,d,l,t}$$

where $\text{export}_{i,d,l,t}$ represents the total export value that firm i is selling of product l to destination d in year t. I project total markets against a dummy variable $\mathbb{I}^h_{\{age=h\}}$ that equals one when the exporters spent h years continuously selling product l to destination d. I control for the prices of the product, $p_{i,d,l,t}$, and I include firm-product-time fixed effects, $\gamma^a_{i,l,t}$, and product-destination-time fixed effects $\gamma^b_{d,l,t}$. The addition of these fixed effects allows me to purge out the common variation in sales for firm i of product l at time t, while the second set of fixed effects allows me to purge out the common variation across exporters within a destination product time.

I estimate the same equation to obtain price dynamics but without controlling for prices:

$$\ln p_{i,d,l,t} = \sum_{h=0}^{5} \beta^p_h \mathbb{I}^h_{\{age=h\}} + \gamma^a_{p\,i,l,t} + \gamma^b_{p\,d,l,t} + \gamma^c_{p\text{cohorts}} + \epsilon_{i,d,l,t}$$

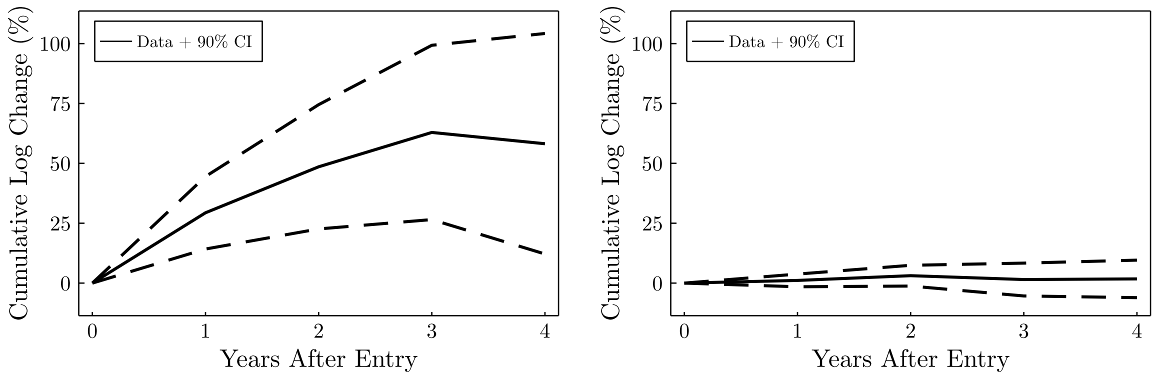
In this case, β^p_h captures the differential changes in prices over the life cycle of the exporter relative to the common variation in prices for that product l at time t.

By construction β^p_0 and β_0 are set to zero, so that each estimate of $\{\beta_h\}^H_{h=1}$ or $\{\beta^p_h\}^H_{h=1}$ captures the relative change of the dependent variable to its entry value. I define a new exporter as an exporter that did not export any positive amount to that product-destination market in the last three years[15].

Figure 1 presents the results of the estimation by plotting the estimates of β_h and β^p_h over the exporter life cycle. Consistent with Fitzgerald et al. (2021) and Steinberg (2021) I

[15] This implies that I lose the first three of my sample since I cannot observe if the exporters did any export before.

find that while exported quantities grow over exporters' life cycle, the prices are basically constant. Exporters grow into markets by facing higher demand conditional on prices.



(a) Quantity Dynamics

(b) Price Dynamics

Figure 1: New Exporter Dynamics

Note: Panel (a) shows the estimated log cumulative change in quantities relative to firms' first year of export to the market. Panel (b) shows the same but for price changes. A market is a product-destination combination. Both estimated includes firm-product-time, product-destination-time, and cohort fixed effects. Firms in the sample are exporters that continuously export to each market. A new exporter is a firm that export at time t, after three years of not exporting to the market. Standard errors in brackets. Error cluster at the firm level.

I now proceed to test how domestic volatility is related to exporters' growth. Given my data limitations, I use estimate shocks to firm-level domestic sales to estimate the volatility to which firms are exposed to.

Firm's Exposure to Volatility. I proceed in three steps to compute firms' exposure to domestic volatility, to avoid the volatility measure being directly related to firm-level shocks or foreign demand shocks I use the domestic sales of the other firms in the same industry. First, I compute the log change of domestic sales (denoted by $\Delta s^D_{f,t}$). I generate the firm-level shock to domestic sales for firm f at a time by purging out the aggregate and industry shocks that are common to the firms in the same industry at the same time t. To obtain the firm-level shocks regressing the change of the log change of domestic sales against industry-year fixed effects to compute the firm-level shocks to domestic sales [16]. I obtain the residual change in the domestic sales, which I denote it as $\Delta \hat{s}^D_{f,t}$, as shown in the following equation:

$$\Delta s^D_{f,t} = \gamma_{j,t} + \Delta \hat{s}^D_{f,t}.$$

[16]this is a similar approach to the one in Yeh (2021), and Di Giovanni et al. (2020)

Second, I define the set of those exporters whose main product at the six-digit (within the 4-digit category J) level is h_J^6 as $F_{h_J^6}$. I compute the average across all periods of the cross-sectional standard deviation of firm-level shocks $\Delta\hat{s}_{f,t}^D$ for all the firms, besides the firm f, for which whose main export product is h_J^6 as :

$$\sigma_{f,t,h_J^6} = \sqrt{\frac{1}{|F_{h_J^6}| - 1} \sum_{j \neq f \in F_{h_J^6}} (\Delta\hat{s}_{j,t}^D) - \bar{\Delta}s_{j,t}^D)^2}$$

σ_{f,h_J^6} can be interpreted as the average volatility of the firm-level domestic shocks for those firms whose main export product is within the six-digit category h_J^6, leaving out the firm f. Third, I define the set of all firms whose main exported product lies within the HS-4 digit J as F_{h^J}. I then compute the firm f exposure to volatility as follows:

$$\sigma_{f,t} = \sum_{h_J^6 \in h^J} \frac{\textit{tot. export}_{2006}^{h_J^6}}{\textit{tot. export}_{2006}^{h^4}} \sigma_{f,t,h_J^6} \tag{5}$$

Equation (5) states that firm f exposure to volatility is the weighted sum of the cross-sectional standard deviation of the other firms' shocks, σ_{f,h^6} for those products that belong to the same set F_{h^J}. I compute the weighted sum of this volatility measure by using the industry shares of how much the total exports of the products in category h_J^6 represented of the total exports J at the year 2006.

The objective of this construction as a measure of the firm's exposure to volatility is to alleviate some potential concerns. First, by using domestic sales of other firms' firm-level shocks, I alleviate the concerns that the volatility measure may be affected by the shocks affecting that particular firm. Second, by using domestic sales, I do not allow the foreign demand shocks to have a direct effect on the measure of volatility. Second, by fixing the export shares and the main products of the firm in the year 2006, I alleviate the concern that future shocks to some particular products may change total exports and through that biased the relationship between volatility and exporters' growth.

Firm-level fact 2: New exporters grow less as they are more exposed to volatility. I estimate the following equation to asses this question empirically:

$$\ln\left(\frac{\text{exp int}_{i,l,d,t+h}}{\text{Init. exp int}_{i,l,d}}\right) = \sum_{j=1}^{5}\beta_j^1 \ln\sigma_{i,t}^{\omega}\mathbb{I}_{\{\text{age}=j\}} + \sum_{j=1}^{5}\beta_h^2\mathbb{I}_{\{\text{age}=j\}} \\ + \gamma_{l,t}^a + \gamma_{d,t}^b + \gamma_{i,t} + controls_{i,m,t} + e_{i,m,t} \tag{6}$$

where exp $\text{int}_{i,l,d,t}$ denotes the export intensity of product l of firm i, at time t sells to destination d, defined as the exports divided by the firm's total sales. Init. exp $\text{int}_{i,l,d}$ is the value of exp $\text{int}_{i,l,d,t}$ over the first year of exports to that product-destination market. $\mathbb{I}_{h=j}$ is, as before, the dummy variable that is equal to one if the firm's age in that particular market is h. I add product-time and destination-time fixed effects denoted by $\gamma_{l,t}^a$ and $\gamma_{d,t}^b$, to capture those variations in the relative growth of the export share that are common to the destination or product for each period, and firm fixed effects, γ_i, is to capture the average growth of the export share that is common within the firm. The estimation of $\{\beta_\sigma^j\}_j$ comes from different sources of variations: (1) the differences in firms' exposure to domestic sales volatility across time and markets, and (2) the differential exposure to domestic volatility of those exporters that have different product mixes but that sell to the same market.

Figure 2 shows the estimated differences in the cumulative change of exports over the exporters' life cycle with a tenure of at least five years for each market. It compares the difference of the median exporter in terms of the volatility relative to one exporter facing a standard deviation smaller volatility. A firm facing one standard deviation smaller level of uncertainty is almost 80% larger after five years. The estimated coefficients are presented in column (3) of Table A.5.

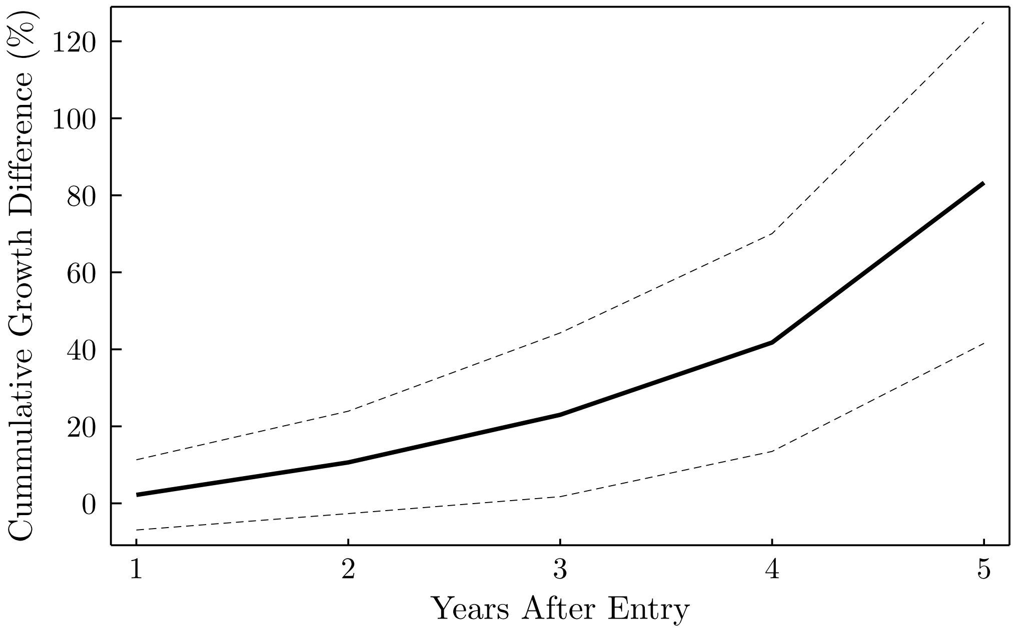


Figure 2: New Exporter Growth and Volatility

Note: Figure shows the cumulative growth difference in export intensities to each market for a firm exposed to the mean minus a standard deviation level relative to one exposed to the mean. A market is a product-destination combination. Estimates include product-time, destination-time, and firm-time fixed effects. Firms in the sample are exporters that continuously export to each market for five years or more. A new exporter is a firm that exports at a time t after three years of not exporting to the market. Dotted lines denote a 90% confidence interval. Error cluster at the firm level.

5 Markups, Volatility, and Exporters' Dynamics

In this section, I show that standard models that assume monopolistic competition, CES demand function, and linear production in labor cannot generate Firm-level fact 2 while being consistent with Firm-level fact 1. In this case, firms' profits are convex in their productivity, implying the Oi–Hartman–Abel effect is present in these types of models [17]. Higher uncertainty over firms' productivity increases the expected return on investment.

5.1 Volatility and Exporters' Dynamics in standard models.

To show that under standard assumptions, dynamics models can not reconcile firm-level facts 1 and 2, I proceed as follows. First, I define a demand shifter in which firms invest for the first firm-level facts. Then I proceed to enumerate the assumption and proposition.

[17] See Bloom (2013) for a description of the Oi–Hartman–Abel effect.

Let $z \in \mathbb{R}_+$ be the realization of a random variable Z denoting the firms' productivity and $q^d(p, A)$ denote the demand given price p, with customer capital $A \in \mathbb{R}_+$.

Definition 1: Demand Shifter. *$A \in \mathbb{R}_+$ is a demand shifter if there exists a continuous function $f : A \to \mathbb{R}_+$, such that the following four conditions hold: (1) $f' > 0$, (2) $f'' < 0$, (3) $q^d(p, A) = f(A)q^d(p, 1)$, (4) optimal prices do not depend on A, $p(z, A) = p(z, A')$ $\vee A > 0, A' > 0$, and (5) $f(1) = 1$ and $f(0) = 0$.*

Assumption 1.1: Production cost. *The firm with productivity z uses a linear technology in labor, l, to produce its output. The production q^s is given by $q^s = zl$*

Assumption 1.2: Investment cost. *$C_{i_A}(i_A)$ is a continuous differentiable function such that$C_{i_A}(.) < 0$, $C_{i_A}(.) > 0$, $C_{i_A}(.) > 0$, $C_{i_A}(.) > 0$*

Under assumption 1, we have that the operational profits functions given $\pi(z, A) = p(z, A)q(z, A) - wl$, can be written as $\pi(z, A) = f(A)\pi(z, 1)$, while total profits $\pi^T(z, A) = f(A)\pi(z, 1) - c(A', A)$.

Assumption 2: Profits function. *$\pi(z, A)$ is a continuously differentiable function in both arguments.*

Assumption 3: Convex profit function. *The profit function $\pi : (z, A) \to \mathbb{R}_+$ is convex in z.*

Proposition 1: *For all $A > 0$ and $z > 0$, under assumption, A1-A3, the firm's growth rate on its demand shifter, A' is non-decreasing with a mean preserving spread over Z.*

Proof. See appendix C.1

Proposition 1 shows that if the firm's profits are a convex function in its productivity and the investment has the usual convex adjustment costs when the firm face a mean preserving spread process (higher risk), the market-specific investment in customer capital will weakly increase conditional on a productivity level and customer level of the firm.

Assumption 4: Demand and market structure. *The market structure of the economy is given by monopolistic competition. The demand the firm, q^d is given by $q^d(p) = Dp^{-\theta}$, where $D \in \mathbb{R}_+$ and $\theta > 2$.*

Assumptions 1 to 4 describe the usual assumption that is to study the dynamic behavior of exporters as in for example Fitzgerald et al. (2021) and Steinberg (2021).

Proposition 2: *Assumption 1 and 4 implies the firm's profit functions is convex in z.*

Proof. See appendix C.1

Corollary 1: *Assumption 1,2 and 4 implies that a mean preserving spread over the firm's productivity will increase the growth rate of A in the model with CES demand, linear production function, and monopolistic competition.*

To gain intuition in proposition 1, let's assume that firms invest in the demand shifter A, but that it fully depreciates in the next period so that the investment only depends on A'. Letting firms discount future profits by β_t, the optimal investment decision, A^* is characterized by:

$$C'_{i_A}(A^*) = \beta f'(A^*)\mathbb{E}\{\pi(z,1)|z_t = z\},$$

the left term of the equation denotes the marginal cost of investment while the right one the marginal benefit of investing in customer capital. If $\pi(.,1)$ is a convex function, any mean preserving spread over firms' productivity implies an increase in the marginal expected return on investment. This leads firms to increase A^* until the expected marginal benefits equalize the marginal cost of investment. On the other hand, if $\pi(z,1)$ is a concave function on productivity, higher uncertainty will lead to a reduction in firms' investment.

The intuition for this result is as follow; higher uncertainty increases the probability of both better and worst outcome. When profits are convex, firms expect the marginal return on investment in good times to be enough to compensate for the expected drop in bad times, the standard "Hartman-Oi-Abel" effect. The opposite is true when profits are concave; in this case, in good times, the expected increase in the marginal returns is not enough to compensate for the expected reduction in the investment return during bad times.

Estimating the markup elasticity in the data. Having established proposition 1, I test the existence of variable markup in the data and find that the data rejects this assumption. Based on this empirical result, the following section develops a model of exporter dynamics and variable markups that can quantitatively match the negative relationship between trade and volatility documented in the previous sections.

I use exchange rate shocks as changes in the marginal cost in foreign currency to estimate how markups respond at the firm level. I use the export share of a firm in a particular market as a proxy for the ratio of the exporters' relative productivity in a market [18].

In appendix C.2, I show how we can identify the relative changes in markups across firms as a function of firms' characteristics by using the price responses to exchange-rate shocks. The only assumption that needs it is to assume that the marginal cost in production can be decomposed into two main components, changes driven at the firm-product-time level and changes given at the product-destination-time. A common assumption in most international trade models assuming that tariffs and iceberg costs are common across firms selling to the same market.

To estimate the exporter's markups responses using observed changes in prices, I estimate equation (40), where Δ denotes the log-time difference of the variables, $p_{i,d,l,t}$ denotes prices from exporter i, to destination d, for product l, at time t; $e_{d,t}$ denotes the exchange rate for each destination, exp. share$_{i,d,l,t-1}$ is the exporter's i market share over the total exports from Colombia to that market (given by a product-country), while $crtl_{d,t}$ denotes time-varying control for the destination country, and $\theta_{i,l,t}, \omega i, l, d, \gamma_{l,d,t}$ represents firm-product-

[18] See Arkolakis et al. (2017) for a discussion of models with variable markups and their predictions over heterogeneous exchange rate pass-through

time fixed effects, firm-product-destination fixed effects, and product-destination-time fixed effects respectively.

$$\begin{aligned} \Delta p_{i,d,l,t} =& \beta \Delta e_{d,t} \times \text{exp. share}_{i,d,l,t-1} + \beta_2 \text{exp. share}_{i,d,l,t-1} \times crtl_{d,t} \\ &+ \theta_{i,l,t} + \omega i, l, d + \gamma_{l,d,t} + e_{i,d,l,t} \end{aligned} \tag{7}$$

Given that the change in the bilateral exchange rate variation may reflect relative changes in the foreign markets, that may affect the pricing decision to those markets, I instrument the exchange rate variation with the remittances flows from third countries. In appendix C.2 I described in more detail the exclusion restriction and under what conditions it may be violated. The first stage is then given by:

$$\begin{aligned} \Delta e_{i,d,l,t-1} \times \text{exp. share}_{i,d,l,t} = & \Delta remittances_{d,t} \times \text{exp. share}_{i,d,l,2007} + \\ & + \text{exp. share}_{i,d,l,t-1} \times crtl_{d,t} + \theta_{i,l,t} + \gamma_{l,d,t} + e_{i,d,l,t} \end{aligned}$$

Firm-level fact 3: Markup changes increase with export shares. Table 2 present the results of the estimation. In Panel 1, I present the estimates for the first Stage. The first thing to note is that the F-statistic is on the order of 40 alleviating the concerns of the possibility of weak instruments for all of the cases I presented.[19] Second as expected, when we compare the OLS results (column 1), with the IV ones (column 2 or (3)) we find that our concern of the possible biased trigger by shocks in the domestic economy was valid. Nonetheless, it is worth mentioning that both estimates the instrumented one and the OLS one are positive and significant showing that exporters respond to changing markups to shocks in the marginal cost, and that the markups responses are increasing in exporter's market share. These results are sizeable. A firm with a 1% higher market share, will optimally decide to do an exchange rate pass-through that is between 0.74% and 1.10% lower, as shown by columns (2) and (3) of Panel 2 respectively, consistent with the findings of Berman et al. (2012).

[19] This is not surprising given the relevance of remittances net flows for Colombian balance of payment.

Panel 3 also presents a similar estimate but looks at quantities, which I interpret as a validity test. Two results are important, without the IV the OLS estimate predicts a change in quantities that seems unrelated to the predicted change in prices. After we do the instrument, is not only that quantities respond negatively, as expected, it is also that the magnitude of the coefficients is much larger for the quantities response than for the prices, as we should expect if it is the case that price elasticity is higher than 1.

6 The Model

Motivated by my novel empirical findings, I nest a standard Melitz type of model by adding two features. I first allow firms to build customer in the foreign market as in Fitzgerald et al. (2021), in which firms makes marketing expenditure to shift up the demand they face conditional on prices. This addition allows me to capture the firm-level fact 1 in a simple way. Second, I allow the model to present demand functions with variable prices elasticity by using Kimball (1995) preferences. I parametrize the indirect utility function following the work of Klenow et al. (2016) and Gopinath et al. (2010) such that the model is consistent with the firm-level fact 3. As will be become clear later, I show that allowing for variable price elasticity, and exporters dynamics is enough to generate the documented aggregate facts and the firm-level fact on the negative relationship between exporters growth and volatility.

The existence of variable markups shuts down the Oi–Hartman–Abel effect. This because once the model matches the estimated responses in markups, conditional on selling, firms profits become concave on firms' productivity.

Model preview In the model, a firm is a tuple of productivity (ω_i) and customer capital (A_i) that works as a demand shifter for the firm. The firm makes two static decisions, it has to decide to export or not, and the prices that will charge to each of the destinations. Firms produce output using a technology that is linear in labor, denoted by l. In case the

Table 2: Heterogeneous markup responses

Panel 1: First Stage

	(OLS)	(IV)	(IV)
	-	Δex. rate$_{d,t}$ $\times$ $share_{i,l,d,t-1}$	Δex. rate$_{d,t}$ $\times$ $share_{i,l,d,t-1}$
Δremittances$_{\neq d,t}$ $\times$ $share_{i,l,d,07}$	-	0.29***	0.41***
	-	[0.04]	[0.05]
Observations	44,369	44,369	27,257
Firm-product-time FE	✓	✓	✓
F- Statistic:	-	69.07	69.37
Destination-product-time FE	✓	✓	✓
Controls $\times$ $share_{i,l,d,07}$	GDP, TOT	GDP, TOT	GDP, TOT
Exporter Age	≥ 3	≥ 3	≥ 4

Panel 2: Second Stage (Prices)

	(OLS)	(IV)	(IV)
	$\Delta \log p_{i,l,d,t}$	$\Delta \log p_{i,l,d,t}$	$\Delta \log p_{i,l,d,t}$
Δexchange rate$_{d,t}$ $\times$ $share_{i,l,d,t-1}$	0.15***	0.71**	1.20***
	[0.05]	[0.33]	[0.36]
Observations	44,369	44,369	27,257
Firm-product-time FE	✓	✓	✓
Destination-product-time FE	✓	✓	✓
Controls $\times$ $share_{i,l,d,07}$	GDP, TOT	GDP, TOT	GDP, TOT
Exporter Age	≥ 3	≥ 3	≥ 4

Panel 3: Second Stage (Quantities)

	(OLS)	(IV)	(IV)
	$\Delta \log q_{i,l,d,t}$	$\Delta \log q_{i,l,d,t}$	$\Delta \log q_{i,l,d,t}$
Δexchange rate$_{d,t}$ $\times$ $share_{i,l,d,t-1}$	-0.04	-2.51***	-2.96***
	[0.19]	[0.72]	[0.81]
Observations	44,369	44,369	27,257
Firm-product-time FE	✓	✓	✓
Destination-product-time FE	✓	✓	✓
Controls $\times$ $share_{i,l,d,07}$	GDP, TOT	GDP, TOT	GDP, TOT
Exporter Age	≥ 3	≥ 3	≥ 4

Note: Panel (1) shows the results for the first stage results. Panel (2) shows the results using the log difference over time of unit values. Panel (3) shows the estimated results for quantities exported. Exporter age denotes the minimum age of an exporter in the sample. Controls $\times$ $share_{i,l,d,07}$ denotes the addition of controls by intersecting of firms' sales share to that market intersected with the destination market terms of trade and real GDP. Standard errors in brackets.
Error cluster at the destination country. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

firm decides to export today, it collects the profits of selling abroad and pays a fixed cost of exporting f_{exp}. The firm can invest in marketing, i_d, to increase the customer capital it has. The investment in marketing materialize in the following year as an increase in demand conditional on the price firm will charge. In case the firm decides not to export, it will not be able to initiate a marketing campaign in the foreign market, and the customer capital it has will depreciate more rapidly. I will further assume that the economy under study is an small economy that can't affect foreign prices.

6.1 Foreign Consumer's Problem

The foreign consumer takes aggregate quantities, Q^*, and prices, P^*, as given and solve the following problem:

$$\min_{q(\omega)} \int_{\omega \in \Omega} p(\omega) q(\omega) d\omega \tag{8}$$

s.t.

$$\int_{\omega \in \Omega} A(\omega)^{\alpha} \Upsilon \left(\frac{q(\omega)}{A(\omega)^{\alpha} Q} \right) d\omega = 1 \tag{9}$$

where $\Upsilon(x)$ denotes the indirect utility function of the representative consumer[20]. In (9) $A(\omega)^{\alpha}$ represents the customer capital that firm ω has when selling to this particular market.

If we defined $\psi = \Upsilon(.)^{-1}$, the demand for a variety $q(\omega)$ is given by:

$$q(p, A) = \psi(\frac{\tilde{Q} p(\omega)}{P}) A(\omega)^{\alpha} Q \tag{10}$$

where P is the price index of the market, defined as $P = \int_{\Omega} \frac{q(\omega)}{A(\omega)^{\alpha} Q} p(\omega)$, and $\tilde{Q}$ is defined by $\tilde{Q} = \int_{\Omega} \Upsilon'(\frac{q(\omega)}{A(\omega)^{\alpha} Q}) \frac{q(\omega)}{A(\omega)^{\alpha} Q}$. For what follows I follow Klenow et al. (2016) by assuming that:

$$\Upsilon(x) = 1 + (\theta - 1) e^{\frac{1}{\eta}} \eta^{\frac{\theta}{\eta} - 1} \left(\Gamma(\frac{\theta}{\eta}, \frac{1}{\eta}) - \Gamma(\frac{\theta}{\eta}, \frac{x^{\frac{\eta}{\theta}}}{\eta}) \right), \; \theta > 1; \; \eta > 0 \tag{11}$$

[20] I assume following Kimball (1995) that $\Upsilon(1) = 1, \Upsilon'(x) > 0 \Upsilon''(x) < 0$.

where I called θ as the price elasticity parameter, and I refer to η as the super-elasticity parameter. Conditional on θ, η is a key parameter that affects how a firms' markups responses to changes in their marginal cost will vary depending on their relative prices, as it will be clear in equation (13).

To further characterize exporters' demand, and the price elasticity they face, I first define the Choke price as the maximum price at which an exporter can sell a product [21]

Definition 2. Choke price: The choke price, $p^c \in \mathbb{R}_+$, is defined as the price such that for all $p \geq p^c$ and $A > 0$, $q^d(A, p) = 0$.

Under this definition, together with equation (11), the choke price but the following equation:

$$p^c = e^{\frac{1}{\eta}} \frac{\theta - 1}{\theta} \frac{P}{\tilde{Q}} \tag{12}$$

which together with equation (10) and (11) generates the following demand:

$$\log q(\omega) = \frac{\theta}{\eta} \log(\eta \log(\frac{p(\omega)}{p^c})) + \log A^\alpha + \log Q \tag{13}$$

The first thing to note is that $A(\omega)$ is a demand shifter. The second important result is that the demand elasticity to prices, defined as $\epsilon(\omega)$, can be written as a function of the choke price p^c, the price of the firm, and the parameters θ and η:

$$\xi(\omega) = -\frac{\theta}{\eta \log(\frac{p(\omega)}{p^c}))} \tag{14}$$

equation (14) implies that as $\eta \to 0$, $\xi(\omega) =\to \theta$ which is the standard CES case. Under this case the model will resemble the standard model of new exporter dynamics as in Ruhl et al. (2017), Alessandria et al. (2021b), Fitzgerald et al. (2021) and Steinberg (2021). The firm-level fact 3 shows that the CES case ($\eta \to 0$) is rejected by the data since the markups respond to changes in the firms' costs increase as firms have higher market share. Furthermore, we already saw that under the case of $\eta \to 0$, these models would generate

[21]Note that the standard CES case the Choke price converge to infinity.

counterfactual predictions in terms of the relationship between exporters' growth exports and domestic volatility.

6.2 Firm's Problem

Firms' static problem. At the beginning of time t, firm i observes its productivity $z_{i,t}$ and the level of customer capital $A_{i,t}$ it has and decides the prices to charge and the number of workers l to hire. For what follows I drop the index for variety ω, and I refer to a firm by the productivity and customer capital it has. Since customer capital here works as a demand shifter conditional on prices, I define $\tilde{q}_i^d(p_i) = q_i^d(p_i, 1)$. In this case, the firm will solve the following static problem

$$\pi(z_i, A_i) = \max_{p_i, l_i} A_i^\alpha p_i \tilde{q}_i^d(p_i) - wl_i$$

$$\text{s.t.} \quad q_i = \frac{l_i}{z_i}$$

Under standard arguments the optimal price that a firm with marginal cost of production, $\nu(\omega)$, will decide to charge will be given by:

$$\mu(\omega) = \frac{\theta}{\theta + \eta \log(\frac{p}{p^c})} \tag{15}$$

Note that equation (15) implies that the markup is decreasing in the price that firms decide to charge. Put it differently, more productive firms will charge higher markups, while less productive firms will charge smaller markups. A result consistent with the findings by De Loecker et al. (2016), Berman et al. (2012), and the firm-level fact 3 presented in the previous section.

The above result is important to understand why under variable markups, the standard "Oi-Hartman-Abel" effect shutdowns under this setup. On the one hand, when a good shock hits the firm, it will not increase production that much. This is because as the firm reduces prices, the demand becomes less responsive. On the other hand, bad shocks become more costly. This is because as firms translate their bad shock to prices, their sales will reduce more rapidly due to the relatively higher prices they face. The existence of variable markup elasticity reduces the profits increases for firms in good time and amplify the reduction in bad times. Depending on the value of η this can be big enough such that it shut-down the "Oi-Hartman-Abel".

Law of motion for customer capital. In the model, firms invest in increasing the demand they face conditional on prices. This investment translates into new customers every period after the firm loses a share δ of customers in the process. As in Fitzgerald et al. (2021) I assume that the law of motion of customer is given by equation (16).

$$A_i' = m\left(i_d + A_i(1-\delta)\right) + (1-m)A^{min}, \tag{16}$$

conditional on exporting today ($m = 1$), firms will have a customer capital level of A_i' tomorrow. If firms do not to export today, $m = 0$, they will not be able to invest in accumulating customer capital, and they will face higher lose almost all the customer they have until reaching a minimum level of customer A^{min} [22].

Firm's dynamic problem. In the model, firms take two dynamic decisions. These decisions are the exporting decision, denoted by m, and the investment to accumulate more customers denoted by i_d. The cost of investing is given by $c(i_d, A_i) = i_d - \frac{\phi}{2}\left(\frac{i_d}{A_i}\right)^2$, and $\Lambda_{t,t+1}$ denotes the stochastic discount factor. Equation (17) shows the problem of the firm conditional on the aggregate productivity $a_{i,t}$, the idiosyncratic productivity level $\omega_{i,t}$ and the customer

[22] These dynamic on the customer capital generates an option value for incumbents generates hysteresis in the exporters' behavior as having been widely documented by the literature e.g. Giovannetti et al. (1996).

base the of the firm A_i. I denote with an apostrophe the value of the state variable at t+1, and by Θ the vector of aggregate state variables that are necessary to solve the problem.

$$\begin{aligned} V(\omega_i, A_i, a, \Theta) = \max_{m\in\{0;1\}; i_d \in [0;\infty)} & \pi^d(z_i, 1) + m(\pi(z_i, A_i) - f_{exp}) - \\ & - c(i_d, A_i) + \mathbb{E}\left[\Lambda(\Theta) V(\omega_i', A_i', a', \Theta')\right] \end{aligned} \tag{17}$$

s.t.: (16)

The decision of exporting or not in this model is a discrete decision given by $m \in \{0; 1\}$. If firms decide to export $m = 1$, they will collect the total profits from exports, given by the operational profits $\pi(z_i, A_i)$ minus the fixed cost of exporting, f_{exp}. If they decide not to export ($m = 0$), firms will only collect the profits for selling to the domestic market, $\pi^d(z_i, 1)$ for which I normalize the capital customer base they have to one.

The second decision firms need to make is to decide how much they want to invest in building customer capital, denoted by i_d. Since firms only invest in growing into foreign markets, this investment captures the market-specific type of investment exporters do to grow abroad. I assume the decision of building a customer for the firm is irreversible. Firms can't make a negative investment in their customer capital. The cost of investing customer capital is given by $c(i_d, A_i) = i_d + \frac{\phi}{2}\left(\frac{i_d}{A_i}\right)^2$, where the second term denotes the convex cost of investing. I add this to capture the growth rate of firms over their life cycle.

Firm's optimal dynamic behavior. The firms' exporter behavior is characterized by two main equation. The first equation, equation (18), pins down the optimal capital customer the firm decides to have in next period. The second one, describe in equation (19), characterised the optimal decision of firms in terms of exporting, it denotes the minimum level of productivity for which the firm will be willing to export.

$$\frac{\partial i_d(A^*, A) + \frac{\phi}{2}\left(\frac{i_d(A^*,A)}{A_i}\right)^2}{\partial A^*} \geq \mathbb{E}_a \left\{ \Lambda \overbrace{(1 - Pr(\omega_i'^*))}^{\text{export prob.}} \overbrace{\mathbb{E}_{\omega_i}\left\{\frac{\partial V(A^*, z')}{\partial A^*} \,|\omega_i' > \omega_i'^*\right\}}^{\text{Expected MR conditional on exp.}} \right\} \tag{18}$$

Equation (18) holds with equality when firms decides to invest on customer capital, $i_d > 0$. In this case, firms decide to equalize the marginal cost of investment, the left-hand side of equation (18), to the expected marginal return on investment, the right-hand side of the same equation. Using the Leibniz rule, we can show that there are two components affecting the total expected marginal return on investment. One is the expected probability that in the next period, the firm will export, where I use ω'^* to define the minimum level of productivity at which the firm will decide to pay the fixed export cost to stay in the export market. The second component of the total expected return on investment is the marginal expected return of investment conditional on exporting. Both of these terms are affected by the uncertainty that firms face with respect to the realization of future shocks.

The second equation that will characterize the exporters' decision is given by equation (19), which characterizes the minimum of productivity at which firms will pay the export cost to stay in the export market, denoted by ω'^*. The marginal firm is indifferent between staying or not in the export market if the operational profits of doing so plus the optional value of not losing the customer capital she had accumulated is equal to the investment cost plus the exporting fixed cost. The equation shows how the past decisions of customer accumulation affect the extensive margin.

$$\hat{\pi}(\omega_i^*, a_t, A) + \overbrace{\mathbb{E}\{\Lambda_{t,t+1}[V(A^*, z') - V((1-\delta^{exp})A, z')]\}}^{\Delta\text{Option value}} = fe + i_d + \frac{\phi}{2}\left(\frac{i_d(A^*, A)}{A}\right) \tag{19}$$

6.3 Volatility in The Model

I assume uncertainty and volatility in the model enter through the changes in the marginal cost of production that firms face. There are two types of components that determine the productivity of the firms. The aggregate productivity, a_t, and a idiosyncratic productivity $\omega_{i,t}$. The total level of productivity that a firm has is given by $z_{i,t} = e^{\omega_{i,t}+a_t}$.

I assume that each component of the firms' productivity level follows an AR(1) process as shown by:

$$\ln \omega_{i,t} = \nu^{\omega} + \rho^{\omega} \ln \omega_{i,t-1} + \sigma^{\omega} \epsilon_{i,t}, \quad \epsilon_{i,t} \sim N(0,1) \tag{20}$$

$$\ln a_t = \nu^{a} + \rho^{a} \ln a_{t-1} + \sigma^{a} e_t, \quad e_t \sim N(0,1) \tag{21}$$

In the model, the microeconomic and macroeconomic levels of volatility are be given by σ^{ω} and σ^{a}, respectively. Each level of volatility has different implications in terms of how it directly affects the economy. The microeconomic volatility, σ^{ω}, generates higher dispersion of firms around the particular. Higher macroeconomic volatility implies that the mean level of the distribution across time becomes more volatile since. I assume that $\nu^j = -\frac{(1-\rho^j)\sigma^{j2}}{2(1-\rho^{j2})}$ for $j = \{a, \omega\}$, so that changes in σ^a do not change the mean of the productivity distribution[23].

6.4 Domestic Consumers, Final Good Production and Equilibrium

Domestic consumers. The behavior of all the consumers in this economy is captured by a representative consumer that is the owner of the firms, supply labor L, and also hold risk-free bonds. Every period she decides how much to consume, how much labor to supply and how much to save. Her problem is given by:

$$V^c(b, \Theta) = \max_{b', C} u(C, L) + \beta \mathbb{E} \left\{ V^c(b', \Theta') \right\}$$

[23]There are two moments that are affected by the changes in volatility. The second moment, and the third moment, which are given by $E(x^2) = e^{\frac{\sigma^2}{1-\rho}}$ and $E(x^3) = e^{3\frac{\sigma^2}{1-\rho}}$.

s.t.

$$P^C C + b' = wL^s + \Pi^{dom} + \Pi^{exp} + r_t b'$$

I assume that b will be provided in zero net supply at all time. This implies that the trade is balance in this economy, and that the interest rate will adjust for this to be the case. The household problem determines the stochastic discount factor for the firm given by $\Lambda = \beta \frac{u_c(C',L')}{u_c(C,L)}$.

Final good production. The good consumption bundle is produced by a representative firm that operates in a competitive market. It uses two goods as inputs, a bundle of imported goods, M, and a bundle of domestic goods, D. The price of each of these bundles is given by, P^m and and P^D, respectively. The problem of the final good producer consists in minimizing the expenditure of the inputs necessary to produce the quantity of final good C. The problem is given by:

$$\min_{M,D} P^m M + P^D D$$

s.t.

$$\left(M^{\frac{\gamma-1}{\gamma}}\upsilon + (1-\upsilon)D^{\frac{\gamma-1}{\gamma}}\right)^{\frac{\gamma}{\gamma-1}} \geq C$$

where υ represents the home bias preferences as usual. For what follows I normalize the price of the import goods to one. Under this case the demand for the domestic bundle conditional on the amount of imports is given by:

$$D = M\omega^{-\gamma}(P^d)^{-\gamma}$$

since trade is balanced all the time, this implies that given prices P^D, and exports we can solve for the demand for domestic bundle.

Domestic bundle. The domestic bundle is produced using the intermediates goods produced by the domestic firms in the economy. The production will be given a similar problem as the one of the foreign consumer. I assume firms are able to reach all the consumers in the domestic economy, so they do not need to invest in customer capital [24]. As before, the problem for the producer of the domestic bundle, in this case, will be given by:

$$\min_{q(\omega)} \int_{\omega\in\Omega} p^d(\omega)q^d(\omega)d\omega$$

s.t.

$$\int_{\omega\in\Omega^d} \Upsilon\left(\frac{q^d(\omega)}{D}\right)d\omega = 1$$

As before I assume that $\Upsilon(.)$ will be given by equation (11), and that both θ and η will be equal across markets. The price of the domestic bundle P^D is defined as $P^D = \int_\Omega \frac{q^d(\omega)}{D}p^d(\omega)$, and $\tilde{D}$ is defined by $\tilde{D} = \int_\Omega \Upsilon'(\frac{q^d(\omega)}{Q^d})\frac{q^d(\omega)}{D}$.

As before, in this case, there exists a choke price which I denote by p^c_d. The main difference between the domestic choke prices p^c_d, and the foreign choke price, p^c_f, is that while the former is an equilibrium object that depends on the state of the domestic economy, the latter I treated as a parameter in the model given my assumption of small open economy.

6.5 Equilibrium

Lets now define an equilibrium for this economy. Lets first define the tuple of aggregate state variables as $\Theta = \{a, \Omega_{\omega_i}, \Omega_A, B\}$, as a the tuple composed by the aggregate level of productivity, a, the distribution of firms productivity, Ω_{ω_i}, the distribution of customer capital Ω_A and the total bonds holding for this economy B. While individual state variables are given by the bonds holding of the consumer, b, the firm's idiosyncratic productivity, ω_i and its customer capital A.

Definition 2: *Equilibrium for the economy.* An equilibrium in this economy is composed by the consumer value function $V^c(\Theta, b)$, the bond holding decision rule $b'(\Theta, b)$ the firm's value function $V(\Theta, \omega_i, A_i)$, the customer capital decision rule $A'(\Theta, \omega_i, A_i)$, the export decision $m^{exp}(\Theta, \omega_i, A_i)$ the quantities exported $q^{exp}(\Theta, \omega_i, A_i)$, and its prices $p^{exp}(\Theta, \omega_i, A_i)$,

[24] This assumption obeys two main reasons. First is a simplifying assumption that allows me to avoid keeping track of the distribution of the domestic customer capital firms. Second, the dynamic behavior of the firms in the domestic economy and how this is related to the macro and microeconomic volatility of the country is beyond the scope of this work.

the quantities and prices for the domestic economy $q^{dom}(\Theta, \omega_i, A_i)$, $p^{dom}(\Theta, \omega_i, A_i)$ and the labor demand for firms $l^d(\Theta, \omega_i, A_i)$. Together with the aggregate prices for the final consumption good $P^c(\Theta)$, $\lambda(\Theta)$ the price of the domestic bundle $P^d(\Theta)$, the wages $w(\Theta)$, the domestic choke price $p^c_d(\Theta)$, the total labor demand $L^d(\Theta)$ the total exports $EXP(\Theta)$, imports $M(\Theta)$, the production of the domestic bundle $D(\Theta)$, the production of the consumption good $C(\Theta)$ and the total profits of firms $\Pi(\Theta)$. Such that given the parameters of the economy $\{\beta, \xi, \theta, \eta, p^c_f, \vartheta, \alpha, \phi, \delta, \gamma, \nu^\omega, \rho^\omega, \sigma^\omega, \nu^a, \rho^a, \sigma^a\}$ the following conditions holds

1. *Consumer's*: The functions solves the consumer's problem.
2. *Firm's*: The functions solves the firms' problem.
3. *Production of consumption bundle*: The functions solve the problem of representative firms producing the consumption bundle.
4. *Final good producer*: The functions solve the problem of representative firms producing the final good.
5. *Bond market*: The bond market clears and bonds holding equal to zero. Implying that total export is equal to total imports.
6. *Market clears*: The labor and the final good consumption market are clear.

6.6 Model Calibration

To test the model's ability to explain the facts documented in previous sections I calibrate the model to match some key models. I proceed by setting some parameters endogenously taken from the literature, another set of parameters I estimate directly from the data, and the third set of parameters that are set within the model to match some empirical moments.

Productivity parameters. I estimate the parameters that determine the aggregate and firm productivity shocks directly from the data. For the idiosyncratic productivity, I use the data from the labor productivity in the Colombian survey of the manufacturer, and I estimate an AR(1), for which I obtained the parameters governing the persistence, ρ^ω and the standard deviation of the shocks σ^ω. I proceed in a similar way to estimate the parameters that pin-down the aggregate productivity using the H-P filtered aggregate TFP reported by the Penn World Tables for Colombia at the annual frequency.

Investment parameters. I use the estimate of the firm-level fact one to estimate the parameters that govern the growth rate of the exporter due to the customer capital accumulation $A_{i,l,d,t}$, δ and ϕ.

Price elasticity parameters There are three parameters governing firms' optimal pricing strategies. The parameters are, θ, the price elasticity parameter, η, the super-elasticity parameter, and p^c_f the foreign market choke price. I set θ to 5, following the work of Klenow et al. (2016), and Gopinath et al. (2010). The other two parameters, η and p^c_f are set to match the data. According to the model the pass-through to prices of a change in the marginal cost for firm i selling to the market f is given by:

$$\Phi_{i,f} = \frac{\theta + \eta \log(\frac{p_i}{p^f_c})}{\theta + \eta \log(\frac{p_i}{p^f_c}) + \eta} \tag{22}$$

Equation (22) shows that the pass-through of a shock depends on the price the firm charge to that market relative to the choke price in that market. If $\eta \rightarrow 0$ markups are constant, and the price pass-through due to changes in marginal costs equals to one. In case $\eta > 0$, price changes differ across markets because of the difference in the relative prices of the firm, even after controlling for changes in the firms' marginal costs.

In appendix D I describe in detail how I target this parameter to match the empirical moment documented in the firm-level fact 3. Briefly, what I do is the following: First, I compute the firm's percentile in terms of its sales distribution. I then target the estimated markup change depending on exporters' position in their distribution. I first target the markup change of the 25th percentile exporter relative to those at the median, and the markup change of the median firm relative to the markup change of exporters on the 75th percentile of the distribution.

Table 3: Calibrated Parameters

Parameters	Value	Rationale
θ	5.0	Standard in the literature
β	0.96	Yearly frequency
σ^{ω}	0.42	Firms' labor productivity s.d.
ρ^{ω}	0.80	Firms' labor productivity Persistence
σ^{a}	0.02	Aggregate TFP s.d.
ρ^{a}	0.62	Aggregate TFP Persistence
	Parameters to estimate within model	
ν	0.33	Home bias
p_f^c	1.15	Foreign choke price
η	3.70	Super elasticity
f_e	2.95	Exporter fixed costs
α	0.95	Endogenous Demand (curvature)
ϕ	5.10	Investment Adjustment Cost
δ	0.08	Depreciation of A_i

Rest of parameters. The parameters governing the consumer decision, such as the discount factor, β, the home bias parameters, υ, are set to match an average interest rate of 2%, and the average trade openness of Colombia in the last ten years. The utility is assumed to be linear in consumption, and labor is supply is assumed to be supply inelastically at wages equal to one. The Armington elasticity is set to 1.5. I use data from the Colombian Manufacturer Survey to set the exporting fixed cost such that it matches the average share of exporting firms in Colombia of 19.5%, the parameter governing the curvature of customer capital to firms' demand, α, is set to match the exports concentration of the 5% bigger exporters.

Parameters value. Table 3 shows the parameters of the model. As I have shown before each parameter has its clear empirical moment counterpart, but all of them are set to match the moments together. Table 4 presents the target moments, besides those related to the new exporters' behavior.

Table 4: Target Moments

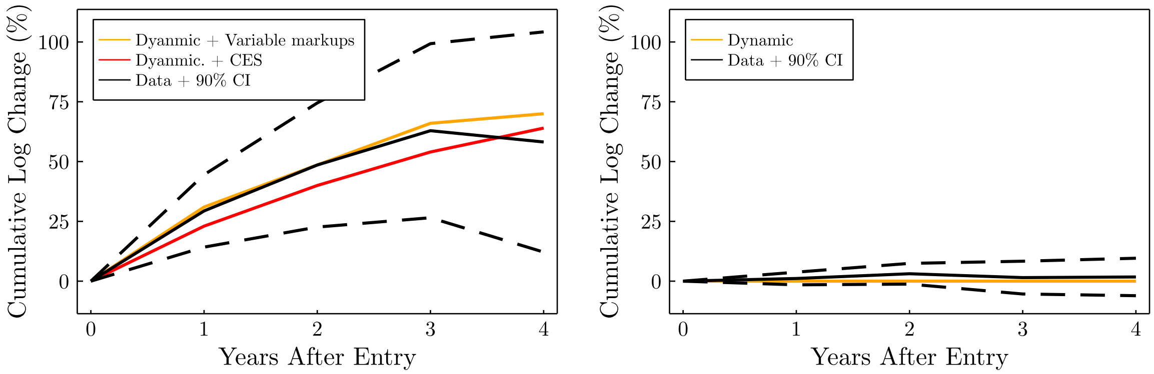
Moment	Data	Model
Relative markup changes ($\frac{50^{th}}{75^{th}}$)	0.87	0.86
Relative markup changes ($\frac{25^{th}}{50^{th}}$)	0.95	0.94
Share of exporters	0.20	0.21
Trade openness	0.32	0.32
Export concentration (top 5%)	0.33	0.30

Model fit. Panel (a) of Figure 3, presents the estimates of the data of the firm-level fact 1 and the model predictions in terms of the exporter growth for two different versions. The dynamic model with variable markups and the one with constant variable price elasticity. Panel (b) of the Figure 3 shows the same estimate for the relative prices, as expected, both model predict basically non differential changes on prices over the exporters life cycle. Table 4 presents the other target moments to set the parameters.

6.7 Model Implications

Once the model is calibrated I proceed to test the models ability to generate the empirical relations that I observe in the data. To achieve this, I simulate four different models with or without exporter dynamics and with or without variable markups. For each model I simulate different economies that vary only in their macro or micro volatility.

New exporter growth: Model vs data. I now proceed to test the model's ability to replicate the firm-level fact 2, in which those exporters more to domestic volatility grow less. To do this, I compare the log differences of the growth rate in the export intensity against



(a) Quantity dynamics

(b) Price Dynamics

Figure 3: New Exporter Dynamics: Model

Note: The data results are the ones presented in figure 1. In panel (a) the yellow line shows the dynamic model with variable markups and the red line shows the model with constant markups. Panel (b) the yellow lines show the price evolution over exporters' life cycle for both models with and without variable markups.
Error cluster at firm level.

the model predictions. To follow the model experiment as close as possible to the one in the data, I proceed as follow. I compare the prediction of the benchmark model to a case in which the domestic volatility decreases a 10%. To do this I adjust the idiosyncratic volatility that firms face to match a 10% reduction in the domestic volatility, measured as the average cross-section standard deviation in the log change in the sales of domestic volatility. Then I compute the changes in the export intensity for those exporters that in the model export continuously over 5 years, as I did in the data.

Figure 4 presents the results.The model can properly predict the qualitative relation regarding the higher domestic volatility and the differential growth of the new exporter. Quantitatively the model predicts a higher difference relative to the data during the first years of the life of the exporters. These results are successful if we compare them to models without the variable price elasticity since, as explained before proposition 1, these other models will predict null or contrary relationship to the one in the data as shown in previous sections.

Cross-country predictions: Model vs data. Now I proceed to analyse the models' prediction regarding total exports. To do this, I fixed all the parameters and the series of shocks, $e_{i,t}$ and ϵ_t, and I only change, σ^ω and σ^a. I solve the firm's and consumer decisions every

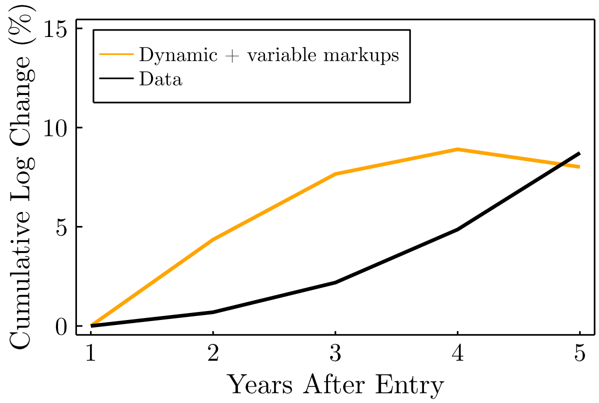


Figure 4: New Exporter Growth and Volatility: Model vs Data

Note: The data results replicates the one figure 2, but comparing a firm with a 10% smaller domestic volatility relative to the mean level. The yellow line shows the cumulative difference on export intensity predicted by the model when the volatility changes generates a 10% smaller domestic volatility relative to the benchmark case.

time for each change in σ^a and σ^ω. By doing this, I allow both changes in the uncertainty firms face and changes in the actual distribution of shocks.

To understand the relevance of volatility and of the proposed mechanism I simulate four different models. Two static models and two dynamics models. For each pair, I compute one with variable markup and another without the variable markups.[25]

The consequences of macroeconomic volatility. Figure 5 presents the models predictions on the effect of macroeconomic volatility over total exports.

The results of Figure 5 show the relevance of the exporters' dynamics and variable price elasticity to explain why volatility is negatively associated with a country's trade levels. The static models predict a positive relationship between exports and aggregate fluctuations, and a similar prediction follows from the dynamic model without variable markups. The results are not counterfactual when we allow for variable markups and exporters dynamics to coexist in the model.

Furthermore, the predictions of the model are quantitatively important. The model predicts an average elasticity between total exports and macroeconomic volatility of -0.25. Since

[25]Each model is re-calibrated to match the same moments when corresponding. Those model with variable markups are estimated to match the markup responses. The model with constant markup elasticity, is set to match the exporters growth, and I allow an small $\eta > 0$ but such that the changes in prices across distribution of exporters are close to one. The static models are generated by setting $\alpha = 0$.

developing economies are almost two times more volatile than developed ones, this implies that the macroeconomic volatility, keeping constant the micro-level volatility, depresses exports by 25% in developing economies.

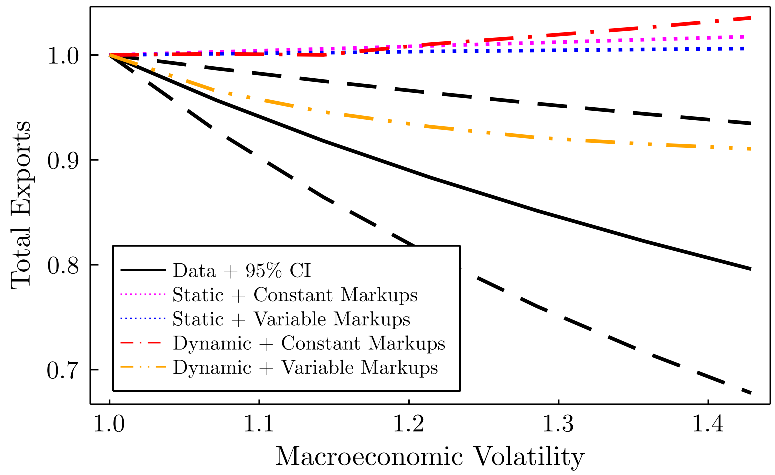


Figure 5: Total Exports and macroeconomic Volatility

The consequences of microeconomic volatility. I now proceed to do a similar experiment to understand the effects of microeconomic volatility predicted by the model, keeping the aggregate volatility constant. In this exercise, I only vary σ^{ω}. Figure 6 shows the results for this quantitative exercises for four different type of models.

In this case, model predictions are more striking. As in the previous case, all the models, except the one that allows variable markups and firms dynamic to coexist, predict a positive relationship between exports and volatility. The proposed model predicts an average elasticity between microeconomic volatility and total exports of -1.63. In terms of export differences, this implies that the differences on microeconomic volatility translate into developed economies exporting almost double the amount of developing economies.

Analyzing the different predictions of each model is insightful in understanding the role of each mechanism. When we compare the two static models, we can observe the relevance of variable markup. When firms face variable price elasticity, the reallocation of resources to the more productive firms is smaller. This result is because, relative to the CES case, more productive find it harder to expand through price reductions due to the lack of demand

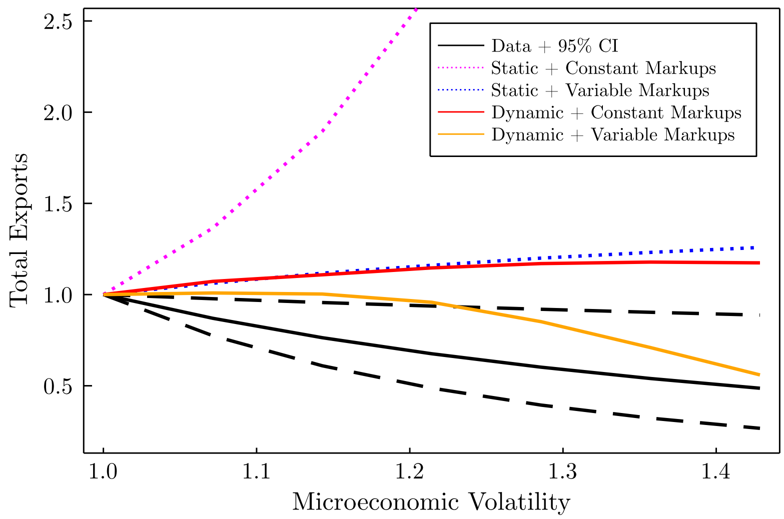


Figure 6: Total Exports and microeconomic Volatility

sensitivity to prices they face. Under variable price elasticity type of demand, firms find it harder to take advantage of good times as with constant price elasticity.

This cross-sectional intuition is similar to explaining the within-firm responses when exporters invest in growing their demand. As firms face more uncertainty and variable price elasticity, the profits of good times do not compensate for the bad moments, reducing the average expected return on investment. Consequently, higher uncertainty reduces firms' investment, depressing total exports. The effect of uncertainty on firms' investment in customer capital is enough to compensate for uncertainty's positive effect on export due to the distributional.

7 Conclusion

Developing countries trade less than rich countries. This lack of trade integration has often been attributed to relatively high non-policy trade costs. I show these non-policy trade costs reflect the highly volatile environment at home at both the macro and microeconomic levels. Domestic volatility interacts with the relatively high costs of investments that exporters make to grow in foreign markets depressing these investments and lowering trade. Domestic frictions get magnified by the dynamic nature of exporter decisions. This explanation is quantitatively consistent with cross-country and firm-level evidence relating to export behavior and volatility. I develop a novel model of new exporter dynamics with variable markup that successfully accounts for the relationship in the data. Abstracting from the proposed firm-level features would lead one to infer much larger trade friction to match the data on aggregate trade flows and development.

The mechanism and findings of this paper may contribute to different issues that have captivated recent attention, such as the effects of trade policy uncertainty or the differences in firm distribution between developing and developed economies. My findings can be generalized to describe how firms respond to all the risks arising from domestic and foreign sources. On the domestic side, domestic investment is likely distorted by the emphasized frictions generating differences in firm distribution across the level of development. On the international front, the model suggests a stronger role for trade policy uncertainty in dampening trade flows.

Furthermore, the relevance of volatility for trade suggests we should re-think the role of macroeconomic stabilization, which includes fiscal, monetary, or commercial policy in developing countries. For example, the extent to which different exchange rate regimes may mitigate or amplify the negative impact of macroeconomic volatility on international trade may provide new insight into the design of optimal exchange rate regimes. These findings also point toward the need to rethink the sources of gains from trade.

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A Appendix: Cross country Data and Estimation Robustness

A.1 Cross country Data

Penn World Tables. This data cover 183 countries between 1950 and 2019. I use this data for the country's total factor productivity and other aggregate variables such as GDP, and export and import prices. [26]

Dynamic Exporter Database. This data source provides data on the number of exporters, average exports per exporter, entry and exit rates, and new exporter growth. The data is at the origin-destination-year level. This new data has been used by Fernandes et al. (2019) and Fernandes et al. (2015). It provides data to compute the relevance of the intensive and extensive margin of trade to account for the relationship between total exports and volatility. Its disadvantage is the limited coverage of countries. It covers 70 countries from 1990 to 2012, but for most countries only covers from 2005 to 2012.

CEPII. I use two datasets from the CEPII foundation, the "Gravity" data set and the "TradeProd" data set. [27] The first data provides information on variables relevant to explain bilateral trade across countries, such as the existence of trade agreements, geographical characteristics, variables measuring cultural proximity, and the existence of a common currency. The data set covers the years 1948 to 2019.

The "TradeProd" data set provides information on bilateral trade, production, and protection in compatible industry classifications for developed and developing countries. This data runs from 1980 to 2006 for 26 industrial sectors within manufacturing—this data set yields bilateral product level exports across countries. The advantage of this data source over the Dynamic exporter database is the extended period and the number of countries. The disadvantage is the lack of data on the margins of trade for different exporters. The data

[26] See Feenstra et al. (2015) for more details.

[27] See Head et al. (2010) and De Sousa et al. (2012) at CEPII foundation webpage for more detailed about these data sets

on manufacturers serves as a robustness check to show that the results are not driven by differences in sectoral composition across development levels.

Enterprise Survey from the World Bank. This data set provides comparable data across countries on sales, labor, and capital for firms in each country. I use labor and labor productivity changes to construct comparable measures of the microeconomic volatility in each country.

A.2 Relationship Between GDP per Capita and Volatility.

Figure A.1 shows a negative relationship between the average level of GDP per Capita (Y-axis) and each measure of volatility (X-axis). Each variable is presented in logs, and the standard deviations for each measure are in percentage points. When I compare the average level of microeconomic volatility, I find that developing countries are 59% more volatile than developed countries for the sub-sample of countries I have data. When I focus on the macroeconomic volatility, developing countries are on average 74% more volatile than developed ones. [28]

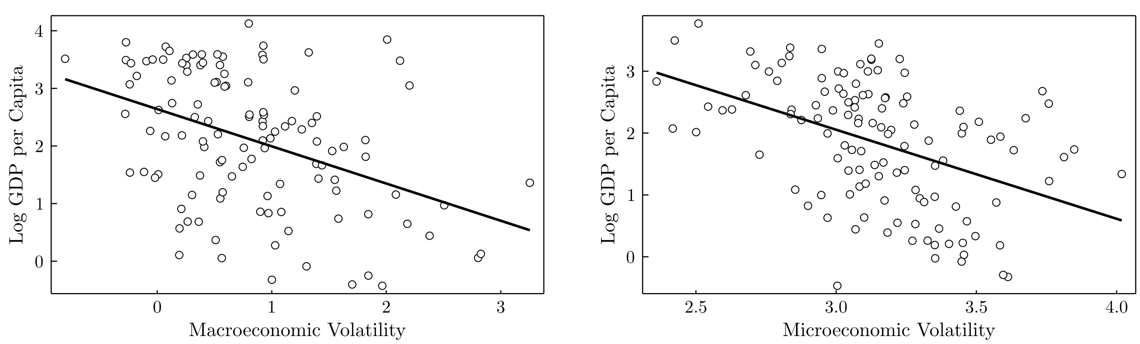

Figure A.1: Volatility and GDP per Capita

A.3 Cross-Country Estimation

Measurement of macroeconomic volatility. One concern following this estimation strategy is to what extent the results are robust to other measures of the origin country volatil-

[28] I define developed economies as those with a GDP per capita (PPP at 2011 us dollar) above 30,000.

ity. To check if results holds to different measures of volatility, I also compute the aggregate volatility using the standard deviation of log changes of the estimated TFP (denoted byMacro-Vol.$_i^{\text{Ch}}$), and using the cyclical component of the real GDP (denoted by Macro-Vol.$_i^{\text{GDP}}$). Row 2 and 5 of Table A.1 presents the results of using each measure respectively. I find that results are invariant to using different filter methods to de-trend the TFP series. I also use variations in the real GDP to construct the standard deviation of the country level of volatility and I find similar results.

Global factors in the measurement of macroeconomic volatility. Another concern, is that the volatility measures that I am using may reflect both global and domestic components, to the extent the foreign demand volatility may discourage exports and that is also making some countries more volatile domestically, this may generate similar predictions as the one observed but due to some big foreign partner being more volatile. To deal with this concern I regress the cyclical component of the TFP for all the countries against a year fixed effect using the residuals of this estimation to construct the volatility of each country. I find that results hold regardless of any of these approaches. The results using this measure of volatility that I denote as Macro-Vol.$_i^{\text{No-global}}$ are presented in the third row of Table A.1.

Reverse causality problem. One of the main concerns of the relationship that I document is the fact that actually is low trade that generates countries to be more volatile. Particularly, as countries face higher trade costs, they could be less able to smooth the domestic shocks through international borrowing and lending. This lack of ability to smooth the shocks may increase the level of estimated volatility of a country. Razin et al. (1992) did not document this to be the case after observing the volatility of countries after they went from trade or capital account liberalizations. nonetheless, To test if this may be a big concern I use the variation of the pre-sample period in the TFP, from 1950 to 1975 to construct the measure of volatility, a period in which trade was low for most countries relative to the observed levels of trade openness observed after 1980. Proceeding this way allows me to use a volatility measure that is potentially unrelated to the shocks happening to the country that may have affected its level of volatility due to its inability to smooth the domestic shocks. Results are actually stronger when using this out-of-sample measure of volatility. The results using this variable are presented on the fourth row Table A.1, for the variable Macro-Vol.$_i^{\text{pre-sample}}$. The last row of the table presents a similar measure but using the cyclical component of the real GDP Macro-Vol.$_i^{\text{GDP, pre-sample}}$

Trade composition and volatility. It may be that for some reason a particular country's structure of production affects both its volatility and its total exports. For example, a country may specialize in the production of an industry for whose products are particularly difficult to export, but that also its production is more volatile. To test for this possibility I focus only on the manufacturer sector, and I proceed in the same way as described before. Results hold when doing these exercises. I also run the benchmark estimates but now controlled by the share over total exports of the manufacturer, the agricultural, and the mining sector, I find results to be robust to this addition too.

Measurement of microeconomic volatility. There are some potential concerns about using the cross-sectional standard deviation of the changes in the firm-level labor productivity as the volatility measure in the way I described before. The main concern is that in some models, labor productivity may be just a reflection of the average markups of the firm. To solve this problem, I also firm labor changes to compute the domestic volatility. The results are presented in Table A.5.

A.4 Volatility and The Margins of Export

To understand how differences in volatility translate to smaller total exports I examine how the different margins od trade reacts to these differences in levels of volatility. This allows us to obtain the observed relevance of each margin.

The three margins of exports: Conceptual framework. Let N_{ijt}^{exp} be the number of exporters, z_{ijt}^{*} be the productivity threshold at which exports decide to exit exporting, and

Table A.1: Robustness Measures Macroeconomic Volatility and Trade

	Av. exp.	Av. exp.	Av. exp.	Av. exp.	Av. exp.	Av. exp.	Av. exp.
$\frac{\text{GDP}}{\text{L}}$	0.35**	0.18	0.16	0.15	0.27	0.17	0.20
	[0.16]	[0.18]	[0.18]	[0.18]	[0.17]	[0.17]	[0.16]
$\log(\text{Macro-Volatility}_i)$		-0.54**					
		[0.22]					
$\ln \text{Macro-Vol.}_i^{\text{Ch}}$			-0.56**				
			[0.25]				
$\ln \text{Macro-Vol.}_i^{\text{No-global}}$				-0.60***			
				[0.22]			
$\ln \text{Macro-Vol.}_i^{\text{GDP}}$					-0.53*		
					[0.27]		
$\ln \text{Macro-Vol.}_i^{\text{pre-sample}}$						-0.63***	
						[0.21]	
$\ln \text{Macro-Vol.}_i^{\text{GDP,pre-sample}}$							-0.64***
							[0.20]
Observations	254126	254126	254126	254126	254126	254126	254126
R^2	0.65	0.68	0.67	0.68	0.67	0.69	0.69
Year $\times$ Destination $\times$ Product FE	✓	✓	✓	✓	✓	✓	✓
Gravity Controls + TOT vol	✓	✓	✓	✓	✓	✓	✓
Doing Business	All	All	All	All	All	All	All

Standard errors in brackets. Error cluster at country level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Note: The table replicates the results of table 1 using different way of computing aggregate volatility. Standard errors in brackets. Error cluster at origin country. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

$x(z_{f,t})_{ij}$ be the exports of a firm with productivity $z_{f,t}$. The total exports from country i to j, ,$X_{ij,t}$, can be expressed as the number of exporters available in the economy multiplied by the average export per active exporter from i to j, denoted by $\bar{x}_{ij,t}$. Assuming these variables are a function of the micro or macro volatility of country i, we can decompose the relevance

Table A.2: Robustness Measures Macroeconomic Volatility and Trade (Manufactures only)

	Av. exp.	Av. exp.	Av. exp.	Av. exp.	Av. exp.	Av. exp.
$\frac{\text{GDP}}{\text{L}}$	0.53**	-0.01	0.09	0.32	0.09	0.11
	[0.21]	[0.27]	[0.27]	[0.20]	[0.23]	[0.21]
ln Macro-Vol.$_i^{\text{Ch}}$		-1.12***				
		[0.36]				
ln Macro-Vol.$_i^{\text{No-global}}$			-1.15**			
			[0.51]			
ln Macro-Vol.$_i^{\text{pre-sample}}$				-1.11**		
				[0.45]		
ln Macro-Vol.$_i^{\text{GDP}}$					-1.05*	
					[0.55]	
ln Macro-Vol.$_i^{\text{GDP,pre-sample}}$						-1.34***
						[0.44]
Observations	138,865	138,865	138,865	138,865	138,865	138,865
R^2	0.62	0.67	0.66	0.65	0.66	0.68
Year $\times$ Destination $\times$ Product FE	✓	✓	✓	✓	✓	✓
Gravity Controls	✓	✓	✓	✓	✓	✓
Term of Trade Volatility	✓	✓	✓	✓	✓	✓
Doing Business	All	All	All	All	All	All

Standard errors in brackets. Error cluster at country level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Note: The table replicates the results of table 1 and table A.1, conditioning the sample to exports in the manufacturing sector. Standard errors in brackets. Error cluster at origin country. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

of each margin. . Equation (23) shows that the response of total exports to changes in volatility can be decomposed into three margins: (1) the extensive margin, (2) the intensive margin,

Table A.3: Margins of Trade and the Micro-Economic Volatility

Panel 1: Micro-Economic Volatility (employment growth) and Average Exports

	Total exports	Total exports	Exporters	$\text{Exports}_{\text{Inc. firm}}$
$\frac{\text{GDP}}{\text{L}}$	0.73***	0.57**	0.92***	-0.31
	[0.22]	[0.22]	[0.14]	[0.20]
ln Micro-Volatility$_i^{\text{empl}}$		-2.58***	-1.65***	-1.82***
		[0.55]	[0.36]	[0.53]
Observations	39439	39439	39439	36339
R^2	0.85	0.89	0.94	0.88
Numb. Countries	38	38	38	38
Year × Destination × Product FE	✓	✓	✓	✓
Gravity Controls	✓	✓	✓	✓
Doing Business	Exp/Cred/Cont	Exp/Cred/Cont	Exp/Cred/Cont	Exp/Cred/Cont

Note: The table replicates the results of Panel (b) in table 1 using labor change to measure the macro-economic volatility. Standard errors in brackets. Error cluster at origin country. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

and (3) the compositional margin (I dropped the sub-index denoting the pair of countries (ij) and time (t) to simplify notation).

$$\begin{aligned}
\frac{\ln X}{\ln \sigma^x} = & \underbrace{\frac{\ln N^{exp}}{\ln \sigma^x}}_{\textit{Ext. margin}} \\
& + \underbrace{\frac{1}{\bar{x}} \left(\int_{z_t^*}^{\infty} \overbrace{\frac{\partial \ln x(z_f)}{\partial \ln \sigma^x}}^{\textit{Unc. adjustment}} x(z_f) dG(z_f) + \int_{z_t^*}^{\infty} \overbrace{\frac{\partial \ln g(z)}{\partial \ln \sigma^x}}^{\textit{Distr. adjustment}} x(z_f) dG(z_f) \right)}_{\textit{Int. Margin}} \qquad (23) \\
& + \underbrace{\frac{1}{\bar{x}} \frac{\partial z^*}{\partial \ln \sigma^x} \frac{g(z^*)}{1 - G(z^*)} x(z^*)}_{\textit{Comp. margin}}
\end{aligned}$$

Empirical relevance of the margins of exports. Given the data availability, I can only compute two components, the extensive margin and the intensive. Following Head et al. (2014) I treat the compositional effect as the unexplained component once we account for the intensive and extensive margin in the total relationship between total exports and volatility:

$$\textit{Comp. margin} = \textit{Total elasticity} - \textit{Int. Margin elasticity} - \textit{Ext. Margin elasticity}$$

To measure the relative importance of each margin, I follow the two-step strategy described before. I change the dependent variable to be the log number of the exporter and the average exports per incumbent exporter. Panel 1 of Table A.4 shows the result with macroeconomic volatility measure as the independent variable. Column 1 shows the relationship between total exports without controlling for volatility. In column 2, I control for the macroeconomic volatility. Columns 3 and 4 show the relationship between the number of the exporter, the extensive margin, and the average exports per incumbent, the intensive margin. I find that controlling for the macroeconomic volatility captures around 35% of the relationship between GDP per capita and average exports per destination. Columns 3 and 4 proceed to decompose the margins of trade. The results show that 85% of the relationship between exports and aggregate volatility is due to the extensive margin, 30% to the intensive margin, and -15% to the compositional margin.

Panel 2 of Table A.4 shows the result when I use the microeconomic volatility measure, with 68% of the reduction in exports due to the intensive margin, 55% is because of the extensive margin, and -23% is associated with the compositional margin. This finding suggests that volatility generates higher sorting into the export market and that the uncertainty channel is big enough to counteract the possible positive effect that higher volatility has through the distributional margin.

Table A.4: Margins of Trade and the macroeconomic Volatility

Panel 1: Macro-Economic Volatility and Average Exports

	Total exports	Total exports	Exporters	$\text{Exports}_{\text{Inc. firm}}$
$\frac{\text{GDP}}{\text{L}}$	0.78***	0.45**	0.81**	-0.36
	[0.21]	[0.17]	[0.09]	[0.21]
ln Macro-Volatility$_i$		-0.88***	-0.76**	-0.24
		[0.30]	[0.12]	[0.30]
First-stage Observations	36229	36229	36229	36229
R^2	0.89	0.92	0.94	0.86
Numb. Countries	29	29	29	29
Year × Destination × Product FE	✓	✓	✓	✓
Gravity Controls	✓	✓	✓	✓
Doing Business	Exp/Cred/Cont	Exp/Cred/Cont	Exp/Cred/Cont	Exp/Cred/Cont

Panel 2: Micro-Economic Volatility and Average Exports

	Total exports	Total exports	Exporters	$\text{Exports}_{\text{Inc. firm}}$
$\frac{\text{GDP}}{\text{L}}$	0.74***	0.53**	0.96***	-0.39*
	[0.20]	[0.24]	[0.14]	[0.20]
ln Micro-Volatility$_i$		-1.42**	-0.78**	-0.97**
		[0.61]	[0.38]	[0.43]
First-stage Observations	36229	36229	36229	36229
R^2	0.85	0.87	0.94	0.86
Numb. Countries	38	38	38	38
Year × Destination × Product FE	✓	✓	✓	✓
Gravity Controls	✓	✓	✓	✓
Doing Business	Exp/Cred/Cont	Exp/Cred/Cont	Exp/Cred/Cont	Exp/Cred/Cont

Standard errors in brackets. Error cluster at country level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

B Appendix: Firm-level Estimation

B.1 Volatility and Sales Dynamics Over Exporter Life Cycle

Table A.5 presents the estimation of equation (6). Column 1 to column 3 presents the results using the measure of domestic sales volatility as described in (5). Column (1) includes firm fixed effects for those exporters with 2 years or more continuously exporting to the market (product-destination), column (2) includes firm-year fixed effects, and column (3) presents the same estimation of column (2) for those exporters that exported 5 years to each market. Column (4) and (5) presents the estimation results of running the same estimation as in column (2) but using two different measures as described below.

The measure of volatility use in Column (4) is constructed as follows:

1. Compute the log difference on one year of the real domestic sales of each firm i, defined as Δdom. sales
2. Compute the cross-section standard deviation of Δdom. sales, for each year t of those firms with main products of export in the sixth digit belong to the product category J. And take the average over time, for each 6 digit product j. Denote this measure by sd_J^{hs6}
3. Compute the weighted mean by the total of exports of each 6-digit product J on the 4 digit product category K of sd_J^{hs6}. Denoted as sd^{hs4}, which contains a vector for each of 4 digit products of exports.
4. Take the lof of sd^{hs4}

The measure of volatility use in Column (5) is constructed as follows:

1. Restrict the sample to those exporters with at least 2 products and two countries of destination.
2. First compute the common changes in the exports of a firm to all of the products $\gamma_{i,t}$, by estimating:

$$\Delta exp_{i,l,d,t} = \gamma_{i,t} + \theta_{d,l,t} \tag{24}$$

3. Compute the cross-section standard deviation of $\gamma_{i,t}$, for each year t, of those firms other than i with main products of export in the sixth digit belong to the product category J. And take the average over time, for each 6 digit product j. Denote this measure by $sd_J^{hs6,Cexp}$

The similar patterns documenting in column (1) and (3), and in column (4) and (5), suggest that the possible selection because of entry and exit, while may biased the result is not enough to change the patterns. Column (4) show that if we also use the domestic changes in sales for firm i to compute the volatility measures, the patterns observed between the exposure to domestic volatility and their relative growth still hold. Lastly, column (6) use a measure of the variations in sales that are common across the markets exporters served to construct the volatility measure. This measure captures shocks that are common to the firm across the markets it served, alleviating the concerns that demand shocks may be driven these results. The similarity on the estimates and patterns suggest that the changes in demand shocks in the domestic market, or the foreign market, or the entry or exit of exporters, are not important to biased the patterns observed in the data.

B.2 Volatility and Incumbent exporters.

Given the measure of volatility, I estimate the following equation:

$$\ln \mathbf{exp}_{i,m,t} = \beta^0 + \beta^1 \ln \sigma_i^z + \beta^0 \ln \sigma_i^z + \gamma_{m,t}^1 + \gamma_{mth,y_1}^2 + \gamma_{age}^3 + controls_{i,m,t} + e_{i,m,t} \quad (25)$$

Where $\gamma_{m,t}^1$ denotes fixed effects at 2-digit product-destination-year and are fixed effects for cohort γ_{mth,y_1}^2, γ_{age}^3 denotes the age of the firm, finally $controls_{i,m,t}$ denotes controls from the firm level, as the total number of products that firm export, and the total number of products that the firms export to destination d at time t, and total number of destination, and the total number of destination at time t for product l. I also add profits and total fixed assets reported by the sub-set of firms for which I have balance sheet data, which I report separately in column (3) of Table A.6.

Table A.5: Volatility and sales dynamics over exporter life cycle.

	(1)	(2)	(3)	(4)	(5)
	$\Delta \frac{\text{exp}_{ildt}}{\text{tot. sales}}$	$\Delta \frac{\text{exp}_{ildt}}{\text{tot. sales}}$	$\Delta \frac{\text{exp}_{ildt}}{\text{tot. sales}}$	$\Delta \frac{\text{exp}_{ildt}}{\text{tot. sales}}$	$\Delta \frac{\text{exp}_{ildt}}{\text{tot. sales}}$
$\ln \text{Volatility}_{it}$	0.00	-	-	0.01	-
	[0.02]	-	-	[0.03]	-
$\mathbb{I}_{\{age_{ildt}=1\}} \times \ln \text{Volatility}_{it}$	-0.01	0.00	0.01	-0.01	0.04
	[0.03]	[0.04]	[0.05]	[0.02]	[0.08]
$\mathbb{I}_{\{age_{ildt}=2\}} \times \ln \text{Volatility}_{it}$	-0.00	-0.01	-0.04	-0.00	0.02
	[0.04]	[0.05]	[0.07]	[0.02]	[0.12]
$\mathbb{I}_{\{age_{ildt}=3\}} \times \ln \text{Volatility}_{it}$	-0.08	-0.10	-0.17	-0.06*	-0.15
	[0.05]	[0.07]	[0.10]	[0.03]	[0.16]
$\mathbb{I}_{\{age_{ildt}=4\}} \times \ln \text{Volatility}_{it}$	-0.22***	-0.26***	-0.41***	-0.13***	-0.62***
	[0.08]	[0.10]	[0.15]	[0.04]	[0.23]
$\mathbb{I}_{\{age_{ildt}=5\}} \times \ln \text{Volatility}_{it}$	-0.48***	-0.57***	-0.71***	-0.17**	-0.78**
	[0.14]	[0.17]	[0.24]	[0.07]	[0.39]
Observations	23,710	23,121	14,956	23,197	21,174
R-squared	0.26	0.30	0.36	0.29	0.23
Firm FE	✓	-	-	-	-
Firm-year FE	-	✓	✓	✓	✓
Product-year FE	✓	✓	✓	✓	✓
Destination-year FE	✓	✓	✓	✓	✓
First month-year	✓	✓	✓	✓	✓
Age exporting	≥ 2	≥ 2	$= 5$	≥ 2	≥ 2
Volatility measure	Benchmark	Benchmark	Benchmark	No leave out	Common effect

Note: The table presents the estimation of equation (6). Column (1) use the benchmark measures of domestic exposure to volatility. Column (4) and Column (5) use other two measures of volatility described in B.1. Age exporting denotes the minimum years that exporters continuously export to each market in the sample. Error cluster at firm level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Results in Table A.6 show that a one percent increase in a firm's exposure to domestic volatility is associated with a 0.60% decrease in average exports.

Table A.6: Exports and Volatility for Continuing Exporters

	(1)	(2)	(3)
	Exp$_{i,l,d,t}$	Exp$_{l,d,t}$	Exp$_{i,l,d,t}$
$\sigma_{i,t}^{sales}$	-0.60***	-0.65***	-0.75***
	[0.04]	[0.04]	[0.04]
Observations	288,389	81,916	55,426
R^2	0.45	0.49	0.55
Product X Destination X year	✓	✓	✓
Cohorts and total Age FE	-	✓	✓
Controls: Assets and profits	-	-	✓

Note: The table presents the estimation of β^1 equation (25). $Exp_{i,l,d,t}$ denotes yearly exports of each firm i to each market. Error cluster at firm level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

C Model

C.1 Proofs

To probe proposition 1 and 2 I prove a set of lemmas that allows me to characterize the firm's value function and its decisions. I then split the proof in two different type of models. The ones assuming an exporting decision after the realization of firms' productivity z_i, and for the case in which the exporting decision is taking after the firm the realization. But before I add two additional assumptions that characteristic the stochastic shocks.

Assumption A4. *Firms' productivity is distributed log normal with parameters μ and σ. Furthermore, I assume that $\mu = -\frac{\sigma^2}{2}$, such that $\mathbb{E}(z) = 1$ regardless of the level σ.*

Assumption A4 implies that changes in σ are a mean preserving spread over the distribution of shocks. I firms' productivity to be log-normal given the extensive use of this distribution on the quantitative works.

Assumption A5. *The exporter threshold, defined as z^*, is such that $z^* \geq e^{\mu + \frac{\sigma^2}{2}}$ for all firms.*

This is a technical assumption that implies that firms' exporter threshold is above the mean value of productivity. In economic terms, assumption A5 implies that no firm's whose productivity is below the average level will export. Theoretically this assumption together with A1-A5 is a sufficient condition to prove propostion 1. In the quantitative framework I do not impose this condition and I find that the standard models predicts this positive relationship.

Lemma 1. *Given Assumptions A1-A5 $V(A_i, z_i, \Omega)$ is continuous and differentiable on A_i.*

See Theorem 9.10 in Stokey et al. (1989). □

Lemma 2. *Let $V(A_i, z_i, \Omega)$ be the value of a firm with customer capital A_i, total productivity z_i, and let Ω be the state of the economy. Under assumptions A1-A5, the optimal investment decision for the firm is given by 26:*

$$\frac{\partial c(A_i', A_i)}{\partial A_i'} \geq \frac{\partial \mathbb{E}\{V(A_i', z_i, \Omega)\}}{\partial A_i'} \tag{26}$$

This follows directly from the firm's dynamic problem that is given by following:

Similar results holds if the firm at time t decides m' instead of m. □

Now I split the problem in two cases to show that proposition 1 holds regardless of the assumption of the timing about the exporting decision.

Case 1: Firms decide to export before the realization of the shock. Lemma 3. *Under assumptions A1-A5, the firm's expected marginal benefits of investing in its demand shifter, conditional on exporting (m=1) in the following period is given by:*

$$\frac{\partial \mathbb{E}\{V(A_i', z_i, \Omega)\}}{\partial A_i'} = \frac{\partial f(A_i')}{\partial A_i'} \mathbb{E}\{\pi(1, z_i, \Omega)\} - \mathbb{E}\left\{\frac{\partial c(A_i'', A_i')}{\partial A_i'}\right\} \tag{27}$$

By Lemma 1, we can use the Benveniste and Scheinkman condition to obtain that:

$$\frac{\partial \mathbb{E}\{V(A_i', z_i, \Omega)\}}{\partial A_i'} = \frac{\partial \mathbb{E}\left\{\pi(A_i', z_i, \Omega) - c(A_i'', A_i')\right\}}{\partial A_i'} \tag{28}$$

Then equation (27), follows directly from the definition of the demand shifter, and because firms made their exporting decision at t-1. □

Lemma 4. *Under assumptions A1-A5, and assuming firms decides to export a period in advanced, A'_i is weakly increasing for a mean preserving distribution of z*

By Lemma 3 we have that the optimal condition for firms' investment is given by:

$$\frac{\partial c(A'_i, A_i)}{\partial A'_i} \geq \frac{\partial f(A'_i)}{\partial A'_i} \mathbb{E}\{\pi(1, z_i, \Omega)\} - \mathbb{E}\left\{\frac{\partial c(A''_i, A'_i)}{\partial A'_i}\right\} \tag{29}$$

If equation (29) does not hold with equality then $A_i = 0$. In this case there is no firm growth.

If the firm's profits is a convex function in its productivity, then the first term on the right hand of equation (29) increases as we perform a mean preserving spread. If equation (29) holds with equality, higher uncertainty leads to higher expected profits increasing A'. If equation (29) holds with inequality, the higher uncertainty may lead firms to perform the investment or to decide to not invest. The results follows from the implicit function theorem □

Lemma 4 proves that in those models in firm's profits is a convex function in its productivity, and where firms' make the exporter decision a period in advance, there is no negative relationship between exporters growth and the uncertainty they face.

Case 2: Firms decide to export after the realization of the shock. I turn to analyse the case under which firms' take the exporting decision after they know their productivity level z_i. For this case I need the assumption A5 to hold.

Lemma 5. *Under assumptions A1-A5, the firm's expected marginal benefits of investing in its demand shifter, conditional on being in case 2 is given by:*

$$\frac{\partial \mathbb{E}\{V(A'_i, z_i, \Omega)\}}{\partial A'_i} = (1 - F_z(z'^*)) \left[\frac{\partial f(A'_i)}{\partial A'_i} \mathbb{E}\{\pi(1, z_i, \Omega) | z \geq z'^*\} - \mathbb{E}\left\{\frac{\partial c(A''_i, A'_i)}{\partial A'_i} | z \geq z'^*\right\}\right] \tag{30}$$

By Lemma 1, we can use the Benveniste and Scheinkman condition to obtain that:

$$\frac{\partial \mathbb{E}\{V(A'_i, z_i, \Omega)\}}{\partial A'_i} = (1 - F_z(z'^*)) \left[\frac{\partial \mathbb{E}\left\{\pi(A'_i, z_i, \Omega) - c(A''_i, A'_i) | z \geq z'^*\right\}}{\partial A'_i}\right] \tag{31}$$

Equation (31) follows from applying the Leibniz integral rule under the case that $z'^*(A'_i)$. From equation (31), equation (30) follows from the definition of demand shifter. $\square$

Lemma 6. *Under assumption A4 and A5, the exporter probability* $(1 - F_z(z'^*)$ *is increasing in* σ.

Since z is distributed log normal we have that:

$$F_z(z^*) = \Phi(\frac{\ln z^* - \mu}{\sigma}) \tag{32}$$

Under assumption A5, if we take the derivative with respect to σ, we have that $\frac{\partial F_z(z^*)}{\partial \sigma} < 0$ $\square$

Lemma 7. *Under assumption A1-A5* z^* *is weakly decreasing in* σ.

For a firm i, with capital customer A_i, the productivity threshold z^*, is given by:

$$\pi(z_i^*, a_t, A) = fe + c(A'_i, A_i) - \beta \mathbb{E}\{V(A'_i, z', \Omega') - V((1 - \delta^{exp})A_i, z', \Omega')\} \tag{33}$$

Under assumptions A1-A5, if firm's profits is a convex function in its productivity, by definition of the demand shifter we have that $\frac{\partial^2 \mathbb{E}\{V(A'_i, z', \Omega')}{\partial \sigma \partial A} \geq 0$. Since $\pi(.)$ is increasing in firms' productivity, z, by the implicit function theorem it follows the result of the Lemma 7. $\square$

Lemma 8. *Under assumptions A1-A5 if firms decide to export after they observed their productivity level. If the firms' profits are of the risk loving type, then for case 2,* A_i *is weakly increasing in* σ

By Lemma 5 together with Lemma 2, we have that the following condition holds:

$$\frac{\partial c(A_i', A_i)}{\partial A_i'} \geq (1 - F_z(z'^*)) \left[\frac{\partial f(A_i')}{\partial A_i'} \mathbb{E}\{\pi(1, z_i, \Omega) | z \geq z'^*\} - \mathbb{E}\left\{ \frac{\partial c(A_i'', A_i')}{\partial A_i'} | z \geq z'^* \right\} \right] \tag{34}$$

By the implicit function theorem and making use of Lemma 4, Lemma 6 and Lemma 7 the result follows. □

Proposition 1. *Given a level of A_i and z_i Under assumptions A1-A5 if the firms' profits are convex on firms' productivity, then a mean preserving spread over the firms productivity will weakly increase firms' investment on future customer capital.*

The result follows from Lemma 4 and Lemma 8 □

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Proposition 2. *In a model with linear production function, CES demand and monopolistic competition, firm's profits are convex in firm's productivity*

Under this assumptions conditional on firm customer base A_i, productivity (z_i), in an economy with wages w, and assuming without loss of generality that the aggregate sales and aggregate prices are equal to one, the firms' i profits are given by:

$$\pi(z_i, A_i) = A_i B w^{1-\theta} z_i^{\theta-1} \;\; ; \;\; B = \left(\frac{\theta - 1}{\theta}\right)^{\theta-1} \frac{1}{\theta} \tag{35}$$

This follows from the static problem of the firm. Assuming that $\theta > 2$ the profits function becomes convex on z_i. □

C.2 Estimation of markups responses

I define markups as the ratio between the price and the marginal cost of production of a particular product for each market that the firm served. By this definition, prices are given by equation (36) where i, l, d, t represent the firm, product, destination, and time respectively. $Mc^f_{i,d,l,t}$ denotes the marginal cost of production in foreign currency, $p_{i,d,l,t}$ denotes prices and $\mu_{i,d,l,t}$ represents the markups at time t that firm i set sell to market (d, l). All are denoted in the currency of the country that the firm is selling to:

$$p_{i,d,l,t} = \mu_{i,d,l,t}\, Mc^f_{i,d,l,t} \tag{36}$$

We can assume that firms' sales are set ultimately in the currency of the market selling to. [29] Assuming without loss of generality that the marginal cost of production is set in the domestic currency then we can re-write equation (36) as in (37), where $Mc_{i,d,l,t}$ is the marginal cost of selling to the market in domestic currency and $e_{d,t}$ denotes the nominal bilateral exchange rate:

$$p_{i,d,l,t} = \mu_{i,d,l,t}\, \frac{Mc_{i,d,l,t}}{e_{d,t}} \tag{37}$$

After taking logs to equation (37), there are two results that hold by definition. First, conditional in the marginal cost of production $Mc_{i,d,l,t}$, the exchange rate pass-through should be equal to minus one if markups are constant. Second, if all firms face the same markup-elasticity to prices, then exchange rate pass-through should not vary across firms. The literature has extensively documented that exchange rate pass-through to prices is incomplete and more recently it has been shown that these changes are related to exporters' market share as shown by Berman et al. (2012).

To estimate the changes in markups due to changes in the exchange rate we need to control for the changes that exchange rate movements have on the cost of production for each product-destination pair, otherwise, we should obtain biased estimates of markups responses to shocks. [30]

[29] Even though the transaction can occur in a common currency, for example us dollars, the demand for the product in destination d depends on the relative price of the good to other domestic goods which are generally posted in the domestic currency. This implies that the assumption of the currency in which firms posted their prices is irrelevant for relatively long horizon where the potential stickiness of prices becomes irrelevant.

[30] This biased is particularly likely to exist since it has been documented in Amiti et al. (2014) that larger exporters also tend to import more.

To address this concern I follow a different empirical strategy than the one in Berman et al. (2012) by exploiting variation across destinations within firm-product-time. The purpose of this estimation is not to estimate or provide a mechanism to explain the incomplete pass-through, but to obtain estimates that capture the markup changes to changes in the cost of serving each market.[31]

I assume that the marginal cost that a firm i face to sell to market (d, l) at time t, can be expressed as the product of two component: (1) the marginal cost of selling product l at t, denoted by $Mc^a_{i,l,t}$, and (2) the cost (that is common across firms) of selling the product to a destination d, which I denote by denote $Mc^b_{l,d,t}$. A common assumption in most models of international trade. This allows me to control for changes in costs and is also where iceberg cost and tariff are common within product-destination-year. Under these assumptions, we have that:

$$\ln p_{i,d,l,t} = \ln \mu_{i,d,l,t} + \ln Mc^a_{i,l,t} - \ln(e_{d,t}) + \ln Mc^b_{l,d,t} \tag{38}$$

By differentiating (38) with respect to the relative exchange rate we have (40). If markups are constant, controlling for firms' marginal cost should predict a full exchange-rate pass-trough to prices independent of firms' condition on that market.

$$\frac{\partial \ln p_{i,d,l,t}}{\partial e_{d,t}} = \frac{\partial \ln \mu_{i,d,l,t}}{\partial e_{d,t}} + \underbrace{\frac{\partial \ln Mc^1_{i,l,t}}{\partial e_{d,t}}}_{\theta_{i,l,t}} \underbrace{-1 + \frac{\partial \ln Mc^2_{l,d,t}}{\partial e_{d,t}}}_{\gamma_{l,d,t}} \tag{39}$$

If the markup elasticity varies across destinations within the exporter we can use exchange rate shocks to recover the differential reaction of firms due to markup changes in their marginal cost.[32] Using equation (40), we can test if markup changes are related to exporters' market share by observing the changes in prices.

$$\Delta p_{i,d,l,t} = \beta \Delta e_{i,d,l,t} \times \text{exp. share}_{i,d,l,t-1} + \beta_2 \text{exp. share}_{i,d,l,t-1} + \theta_{i,l,t} + \theta_{i,l,d} + \gamma_{l,d,t} + e_{i,d,l,t} \tag{40}$$

[31] The relevance of variable price elasticity to explain incomplete and heterogeneous exchange rate pass-through is discussed in Alessandria et al. (2021b) and Gopinath et al. (2010). While this is beyond the objective of this paper, the estimation procedure proposed in this section may help to discipline the changes in prices that are due to changes in markups or changes in the cost of production.

[32] See Arkolakis et al. (2017) for a generalization of how different theories and preferences can generate exchange rate pass-through to differ across firms.

I estimate equation (40) where Δ denotes log differences of the variables over a year. I add firm-product-time fixed effects and product-destination-fixed effects. These fixed effects together with my assumption on the marginal cost of production, allow me to fully control the changes in marginal cost of production due to changes in exchange rates.[33]. Given the assumption before beta captures the markup elasticity to changes in the exchange as the function of the exporters' share over total sales on that market.

As exchange rate shocks might be reflecting may reflect changes in the destination country, this can bias the estimate. I address these concerns by instrumenting the exchange rate variation intersected with the firm's sales shares of sales with the remittances flows to Colombia interacted with sales shares to the destination in the year 2007. This implies that we need to assume that remittances flow to Colombia affects the exchange rate. In this regard is worth noting that on average net remittances to Colombia represent on average 10% of the total export flow to Colombia, also the effect and relevance and remittances on exchange rate has been discussed and shown to be important in Mandelman (2013) and Lartey et al. (2012) among others. I use total remittances from third countries to alleviate the first concern expressed above by cleaning the variation in the bilateral exchange due to changes in the destination country and not in the origin country. Also, it has been documented that the remittances are unlikely to vary due to exchange rate variation as in Mandelman et al. (2020).

Note that the exclusion restriction for this estimation states the conditional on $\theta_{i,l,t}$, $\gamma_{l,d,t}$, $\theta_{i,l,d}$ the covariance between $\epsilon_{i,d,l,t}$ and $\Delta remittances_{d,t} \times$ exp. $\text{share}_{i,d,l,2007}$ is equal to zero. This condition will be violated if shocks to the remittances to Colombia from a third country generate differential price changes for a product sold in several destinations. For example, imagine we have Colombia and three other countries, the USA, Argentina, and Brazil. To violate the exclusion restriction we need that the change in the remittances flows from the USA to Colombia to affect the firm's relative prices between Brazil and Argentina, even after controlling for the common shocks that may hit all the destination countries.

[33]We can also add fixed effects at the firm-product-destination to capture the case that firms may have a particular trend in price changes related to their export share to that market. The addition or not of these fixed effects or not does not change the empirical results.

D Mapping empirical estimates to the model.

To compute the price changes to a cost shock in the model, I proceed as follows. I compute the log price difference for each firm and each period between two economies, 1 and 2, which I denoted by $\Delta p_{i,t}^{e1,e2}$. I capture the exchange rate shock by increasing the aggregate wages. Since the empirical facts capture the partial equilibrium, I keep aggregate prices constant along these two economies when I perform this exercise. For each period in time, I compare the price change for those exporters in the 25^{th}, 50^{th}, and 75^{th} of the sales distribution in the economy without the change in wages. I divide the price change of group firms in the 25^{th} by the ones in the 50^{th} (denoted as $\frac{\Delta p_{50^{th},t}}{\Delta p_{25^{th},t}}$), and the ones in the 50^{th} relative to the ones in the 75^{th} (denoted as $\frac{\Delta p_{75^{th},t}}{\Delta p_{50^{th},t}}$). Then I take the average of these two ratios over all the time I have simulated in my model. After this, I obtain two ratios of average price change between those exporters at the 25^{th} and 50^{th} percentile and between those at the 50^{th} and the 75^{th} percentile of the distribution. I make these two moments in the model to match its empirical analogous.