International Trade, Volatility, and Income Differences

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Abstract

This paper investigates the impact of domestic microeconomic volatility on international trade. I identify domestic microeconomic volatility as a key barrier to international trade, particularly for developing economies. Leveraging cross-country and Colombian firm-level data, I show a negative relationship between microeconomic volatility and both total exports and new exporters' growth. I propose a novel general equilibrium model incorporating variable markups and new exporters' dynamics that can replicate these empirical findings. Relaxing the CES assumption and introducing new exporters' dynamics is crucial for generating the observed negative trade-volatility relationship. I find the model's quantitative results further help to explain the lower trade engagement of developing economies: microeconomic volatility reduces both trade and GDP per capita. I show that standard models mispredict volatility's impact on trade, and hence, they overestimate export trade costs for developing economies. This explanation accounts for nearly two-thirds of the variation in estimated trade frictions across development levels. *JEL* Codes: F10, F12, F14, F23, F63, O19, O24, L11

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1 Introduction

Living standards vary significantly across the globe, and with them, so do international trade patterns. Countries with a higher level of development have more exporters per capita, which are larger and more likely to continue exporting.[1] Hence, developed countries engage in more trade than less developed ones. The existing literature attributes this gap to estimated export costs which, in turn, have been shown to impede development (de Sousa et al., 2012; Waugh, 2010). But how can we unleash the benefits of eliminating these trade costs? To answer this question, we must understand the source of these relatively high trade costs in developing economies.

This paper shows that domestic microeconomic volatility plays a critical role in shaping these endogenous non-policy trade barriers by reducing both trade and GDP per capita. Domestic economic instability discourages firms' investment in foreign markets, suppressing exporter growth, trade volumes and GDP per capita. The impact of domestic volatility on trade outweighs its effect on domestic sales due to the relatively high costs of accessing foreign markets.[2]

To show the relevance of this explanation, I develop a novel general equilibrium model that integrates variable price elasticity demand with firms' growth through customer capital accumulation consistent with the observed patterns in micro-level data. Unlike CES models, this framework accurately replicates the negative relationship between volatility and trade, offering a new solution to the long-standing puzzle of microeconomic volatility's impact on trade (e.g. Alessandria et al., 2015; Baley et al., 2020). The model also sheds light on the lower trade engagement of developing economies, previously attributed to higher trade costs to exports but lacking a clear explanation for their cause (Blum et al., 2019; de Sousa et al., 2012; Fieler, 2011; Waugh, 2010). I show that microeconomic volatility reduces both trade and GDP per capita, explaining nearly two-thirds of the variation in estimated trade

[1] See Fernandes et al. (2015) for a study of the relationship between exporter characteristics and development.

[2] See Das et al. (2007), Alessandria et al. (2021), Fitzgerald et al. (2021), Steinberg (2021)

frictions across development. This suggests standard models overestimate these trade costs by neglecting volatility's impact.

The paper proceeds by first developing a simplified model to isolate the key mechanisms. I then utilize cross-country and Colombian firm-level data to empirically test the model's aggregate predictions and the proposed mechanisms. Finally, I construct a general equilibrium model with firm heterogeneity and persistent productivity shocks to quantitatively assess the impact of volatility on trade.

I use the simplified model to highlight the core mechanisms behind the negative relationship between firm-level sales volatility and total exports. The model consists of exporters that invest in customer capital to grow into foreign markets (Fitzgerald et al., 2021; Steinberg, 2021) and face a demand structure featuring variable price elasticity. I show two theoretical results. First, the effects of micro volatility on total exports hinge on the shape of the firm's revenue function with respect to the firm's productivity. When revenue functions are concave in firms' productivity, microeconomic volatility reduces total exports. Second, if price elasticity varies with firms' productivity, revenue functions become concave in firms' productivity.

I use cross-country data to test the aggregate relationships between microeconomic volatility and trade predicted by the simplified model. Three key features emerge from this analysis: (1) developing countries exhibit higher microeconomic volatility; (2) more volatile countries tend to export less, even after accounting for standard gravity equation variables; and (3) the influence of development on trade diminishes by a third when controlling for microeconomic volatility.

Next, I employ Colombian firm-level data to empirically validate the presence of the two main mechanisms discussed earlier: variable price elasticity and new exporters' dynamics influenced by customer capital accumulation. The empirical results support these mechanisms in the data. Shifts in their demand intercept drive exporters' growth trajectories, consistent with findings from previous studies such as Fitzgerald et al. (2021) and Steinberg (2021). Using a novel identification strategy that minimizes assumptions about the production function to estimate export markup responses, I find that larger exporters adjust markups more in response to cost changes than their smaller counterparts.

The empirical findings also confirm one of the critical implications of the mechanisms for new exporters' growth: exporters exposed to higher domestic volatility experience slower growth over their life cycles. This suggests that increased domestic volatility diminishes exporters' incentives to invest in customer capital in foreign markets.

Having validated the primary micro-level assumptions, I expand the simplified model into a general equilibrium small open economy model: its aim is to quantitatively assess the impact of microeconomic volatility on trade. This extended model incorporates firm heterogeneity and persistent productivity shocks at the firm level and introduces new exporters alongside variable price elasticity. Within this framework, two parameters dictate whether new exporters' dynamics or variable price elasticity are active, yielding four possible model combinations. This versatile structure facilitates a thorough examination of the contribution of each micro-level mechanism in elucidating both aggregate and micro-level implications.

The quantitative findings show that the benchmark model, including new exporters' dynamics and variable price elasticity, adequately predicts the previously mentioned empirical patterns. On the other hand, whether the other models have one or none of the mechanisms, they can't reproduce these empirical observations. Ignoring the dynamic elements of exporters' decisions or assuming constant price elasticity of demand comes at the cost of missing out on understanding the crucial relationships between exports and volatility and, consequently, on the positive association between GDP per capita and total exports generated by differences in volatility.

The model's quantitative predictions are striking. For example, if we compare countries with the highest 10% and lowest 10% of micro-volatility, the export levels for the latter are 103% higher due solely to differences in volatility. To give another example, if Colombia experienced micro-volatility levels similar to those in Belgium or Sweden, its exports would increase by approximately 55% and 69%, respectively. Additionally, the quantitative findings show that because the CES model counterfactually predicts a positive relationship between volatility and trade, these models require approximately 67% higher iceberg costs to match the observed relationship between exports, volatility, and GDP per capita. These results show that two-thirds of the estimated differences in trade costs to export across development levels found by de Sousa et al. (2012) are picking up the effect of volatility on trade.

In essence, this paper underscores the crucial role of domestic volatility in shaping endogenous, non-policy trade barriers. This result questions the prevailing view that gains from trade solely stem from changes in trade policy-oriented measures. Its findings also highlight the challenges developing nations encounter in mitigating these barriers, given the persistent difficulty in reducing microeconomic volatility across many countries.

Literature. The paper relates to several strands of literature at the intersection of macroeconomics, international trade, firm dynamics, and development and makes at least three contributions.

To the best of my knowledge, this paper is the first to connect domestic microeconomic volatility with the lower international trade engagement of developing economies. Traditional models fail to explain this phenomenon (e.g. Alessandria et al., 2015; Baley et al., 2020). Unlike previous research (e.g. Blum et al., 2019; de Sousa et al., 2012; Fieler, 2011; Limão et al., 2001; Rodrik, 1998; Waugh, 2010), this study utilizes insights from a novel model with new exporter dynamics and variable markups, aligning with micro-level data patterns. It shows that standard frameworks overestimate trade costs to export in developing economies due to their inability to capture the negative relationship between domestic volatility and exporters' investment in foreign customer capital.

The second contribution of the paper is to the understanding of investment under uncertainty by focusing on a specific type of investment: customer capital accumulation. This investment is crucial for firm growth in domestic and international markets (as shown by Alessandria et al., 2021; Einav et al., 2021; Fitzgerald et al., 2018; Fitzgerald et al., 2021; Ruhl et al., 2017; Steinberg, 2021)

While extensive literature exists on investment under uncertainty (e.g. Abel, 1983; Bloom, 2009; Hartman, 1972; Lucas et al., 1971; Pindyck, 1982), this paper differs by examining firm-level investment decisions for customer capital in new markets. This work proposes a novel mechanism explaining how volatility discourages investment: variable price elasticity at the firm level. This complements existing literature on how economic frictions shaped the effects of uncertainty on investment (e.g. Arellano et al., 2019; Basu et al., 2017; Pindyck, 1982). Traditionally, research focused on three main frictions: (1) Investment frictions and the real option effect (e.g. Alessandria et al., 2019; Bloom, 2007; Bloom, 2009; Handley et al., 2017; Martin et al., 2020; Novy et al., 2020; Pindyck, 1982); (2) financial frictions (e.g. Arellano et al., 2019; Merga, 2020); and (3) sticky prices (e.g. Basu et al., 2017; Fernández-Villaverde et al., 2015). This paper's empirical and theoretical findings demonstrate the relevance of firm-level variable price elasticity as a novel mechanism, complementing existing frameworks. While focusing on export markets, the insights can be applied to domestic markets as well.

The third contribution of this paper is to document that domestic volatility reduces new exporters' growth. It develops a novel framework based on Fitzgerald et al. (2021) and Steinberg (2021) to explain this dynamic. By relaxing the constant price elasticity assumption, the model captures: (1) exporter life-cycle patterns in terms of prices and quantities, (2) heterogeneous markup responses to firm cost changes, and (3) the negative relationship between exporter growth and domestic volatility (absent in other new exporter models). I develop this framework within a general equilibrium small open economy, allowing me to test the aggregate relevance of the micro-level findings to explain the relationship between total exports and microeconomic volatility.

Layout. The rest of the paper is structured as follows. Section 2 presents a toy model highlighting the main mechanisms and the relevance of different assumptions to generate positive or negative effects on how volatility affects exports. Section 3 presents the data sources. Section 4 presents the estimation strategy and results for the aggregate facts. Section 5 turns to the micro-level facts using administrative firm-level data from Colombia. Section 6 presents the general equilibrium model, and section 7 deals with its estimation and quantitative results. Section 8 concludes.

2 The mechanism in a simple example

Before delving into the empirical outcomes and the general equilibrium model, I will establish a simple example to highlight the primary mechanism in its most intuitive form. The goal here is to demonstrate how the variable or constant price elasticity assumption can reshape the relationship between firms' volatility, total exports, and exporters' growth. This illustration will be conducted within the framework of exporters utilizing a linear production function that expands by augmenting their customer capital in the market they sell. This will underscore the importance of exporters' dynamic decisions in understanding how volatility impacts their choices. In this particular context, our initial focus will be on how the influence of volatility on total exports hinges on the curvature of the revenue function to firms' productivity. Subsequently, I will emphasize the impact of assumptions about price elasticity on this curvature.

Consider a model with a continuum of exporters that solves a two-period problem. These firms initiate their life with a certain amount of customer capital, which we denote as A. The decision of whether or not to engage in exporting is exogenously determined. Their production process hinges on a linear technology, $q = zl$, and they optimize their value by allocating resources, specifically labor, in production and investment in customer capital. The dynamic problem they face is determining how much to invest in their customer capital for the upcoming period, all before the idiosyncratic productivity shock z is realized and before gaining knowing the outcome of exporting ($m = 1$) or not ($m = 0$). These productivity shocks are drawn from a continuous distribution, $F(z)$, and exhibit a standard deviation denoted as σ_z. The exporting condition,m, follows a Bernoulli distribution (with probability $pr(m = 1) = \iota$). The demand for a firm's product is given by

$$q(A, p) = A^{\alpha}\hat{q}(p)Q^{f},$$

A^{α} is the intercept of demand that depends on firms' customer capital, $\hat{q}(p) := q(1, p)$ denotes the static component of demand as a function price, p. The firm's static problem is to choose p to maximize its profits, $\pi(A,z,m)$, after it observed z and m. Firms' optimal profits can be re-written as

$$\pi(A,z,m) = A^{\alpha}\hat{\pi}(z,m),$$

where $\hat{\pi}(z,m) := \pi(1,z,m)$. Because firms use labor to invest in customer capital, which fully depreciates in the next period, their dynamic problem is

$$\max_{A'} A^{\alpha}\hat{\pi}(z,m) - wA' + \beta\mathbb{E}_{F'}\{A'^{\alpha}\hat{\pi}(z',m')|_{z=z}\} \tag{1}$$

s.t.

$$A' \geq 0$$

If firms do not export, $m = 0$, then $\hat{\pi}(z,0) = 0$. The optimal condition for customer capital tomorrow is given by

$$A'(z) = \left\{\frac{\alpha\iota\beta}{w}\mathbb{E}_{F'}\{\hat{\pi}(z',1)|_{z=z}\}\right\}^{\frac{1}{1-\alpha}} \tag{2}$$

this optimal investment decision underscores how the curvature of operational profits to firms' productivity plays a pivotal role in determining the impact of higher uncertainty on investment choices. When profits are convex in firms' productivity, greater uncertainty, due to a mean-preserving spread, leads to higher investments by exporters. In contrast, a mean-preserving spread reduces investment if profits exhibit concavity. To comprehend these outcomes, consider the following intuition: heightened uncertainty increases the likelihood of better and worse productivity outcomes. When profits are convex, the expected profit gains from better outcomes outweigh the profit reductions from worse outcomes, resulting in a higher expected return for acquiring an additional customer. Conversely, the opposite holds when profits exhibit concave behavior in firms' productivity.

Differences in the profit function, arising from variations in the curvature of the revenue function, yield significant implications for how increased uncertainty affects the exporters' growth over time and, consequently, the total exports. To highlight the core mechanism, let's assume that firms' productivity follows an independently and identically distributed (iid) pattern, allowing us to express the next period's total exports as

$$Exp = A^{\alpha} \int p(z)\hat{q}(z)dF(z)$$

where $A'(z) = A \ \forall \ z$ since $z \sim iid$. To better understand how the curvature of the revenue function determines volatility effects on total exports, let $G(z)$ represent a second cumulative distribution function derived from $F(z)$ via a mean-preserving spread and denote variables x_G as variable x derived under distribution $G(z)$. We can right the export differences between a country with low and high uncertainty as,

$$\ln\left(\frac{Exp_G}{Exp}\right) = \underbrace{\ln\left(\frac{A_G^{\alpha}}{A^{\alpha}}\right)}_{\text{dynamic response}} + \underbrace{\ln\left(\frac{\int p(z)\hat{q}(z)dG(z)}{\int p(z)\hat{q}(z)dF(z)}\right)}_{\text{static response}} \tag{3}$$

The overall export response to increased volatility depends on the interaction of the dynamic and static responses, as described in the first and second terms of the equation 3. The dynamic response deals with how heightened uncertainty impacts firms' expected gains from acquiring more customers, which is closely tied to the curvature of the firm's profit function, as previously discussed. Meanwhile, the static response reflects alterations in the distribution of sales. It's worth noting that, conditionally, on the firm's productivity, the static sales component - $p\hat{q}$ - remains the same for different distributions. Thus, the static response captures shifts in total sales due to changes in the productivity distribution.

The direction of the dynamic and static responses depends on the curvature of the revenue function. When considering a linear production function, profits will exhibit concavity if a firm's revenue is concave to productivity. This aligns with our previous discussion. When revenues are concave, the expected increase in revenue from more favorable outcomes isn't sufficient to offset the expected revenue decline due to a higher likelihood of unfavorable outcomes. Consequently, total expected revenues decrease, resulting in a negative dynamic response to uncertainty. Similarly, the static response becomes negative when revenues display concavity. In this scenario, the reduction in total sales is because the reduction in total sales of the higher share of less productive firms surpasses the sales increase attributed to the larger share of more productive firms.

Lemma 1. *Under monopolistic competition and linear production function, if the curvature of the revenue function is concave on firms' productivity, then a mean preserving spread reduces total exports. The contrary is true for the convex case.*

Proof: *See appendix C.1*

These results imply that neglecting the importance of domestic volatility or inaccuracies in specifying the revenue function can significantly impact the estimation of trade determinants, particularly in estimating trade costs at the origin country. For instance, let's consider a scenario where the data-generating process results in revenue being concave in the firm's productivity. If we employ a static or dynamic model with a convex revenue function, we will estimate higher trade costs for exports to all destinations from the origin country. This is because the model will predict increased exports as firms' volatility rises, whereas, in the actual data-generating process, greater volatility reduces total exports. Similarly, suppose we accurately account for the curvature of the revenue function but use a static model when the data-generating process presents new exporters' dynamics. In that case, we will overlook the dynamic response to volatility. Consequently, models with incorrectly specified revenue functions and lacking dynamic elements will fail to capture the correct relationships between total trade and volatility, leading to inflated estimates of export costs in the origin country.

Lemma 2. *Under monopolistic competition and linear production function, if the curvature of the revenue function in the model is misspecified, assuming convexity instead of concavity, then the model will estimate higher iceberg trade costs when volatility is reduced.*

Proof: *See appendix C.1*

I now explore how the variable or constant price elasticity assumption can impact the curvature of revenue and profit functions. I formalize this outcome in lemma 3. However, to gain some insight, consider that the transformation of productivity into revenue can be dissected into two primary effects: a direct effect and an indirect effect. The direct effect relates to how changes in marginal costs affect prices, while the indirect effect pertains to how price changes impact quantities sold. In the context of constant price elasticity, if firms' productivity increases, they will fully transmit the cost reduction into lower prices, constituting the direct effect. Yet, when price elasticity surpasses two, the price decline is more than offset by the increased quantities sold - this is the indirect effect. Consequently, revenues rise in a manner that exceeds the proportionality to firms' productivity change due to the strong response of quantities to price changes.

The previous result, however, does not necessarily hold true when price elasticity varies in conjunction with quantities sold, resulting in a weakening of both the direct and indirect effects. In this case, as firms' productivity increases, they reduce prices less than the previous scenarios due to their markup increases, mitigating the movement along the demand curve. Additionally, as firms decrease their prices, quantities become less responsive to price changes, damping the indirect effect. Consequently, if price elasticity is sufficiently responsive, revenues will increase with firms' productivity, albeit with a concave shape.

Lemma 3 . *Under monopolistic competition and linear production function, if the price elasticity is sensitive enough to firms' prices, then revenues are a concave function of firms' productivity.*

Proof: *See appendix C.1*

3 Data

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

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

I merge this data with firm-level data from "Superintendencia de Sociedades," which reports the variables firms declare 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, which I deflate with the production price index. The data sets cover a sub-sample of 20,000 firms, the most prominent firms representing around 90% of total value-added in the country. The sample is skewed towards larger firms, generating a concern due to possible bias for firm-level empirical facts. However, since the paper focuses on exporters' behavior, this alleviates this concern for two reasons. First, the largest firms in the economy are the ones that are exporters, and second, exports are highly concentrated on larger firms.

4 Cross-country evidence

This section focuses on the cross-country evidence. I start by reexamining the relationship between exports and the level of development. Unconditional on the level of volatility, there exists a positive relationship between aggregate exports and level of development (Blum et al., 2019; de Sousa et al., 2012; Fernandes et al., 2015; Fieler, 2011; Waugh, 2010). Second, I show that, conditional on a country's micro volatility, the relationship between aggregate exports and GDP per capita reduces substantially. This result can be explained by the fact that, on average, higher volatility is negatively related to export performance and that developing economies tend to have more micro volatility, as I document in Figure 1 consistent with the findings of macro volatility as in Ramey et al. (1995),Aghion et al. (2010),Badinger (2010), Imbs (2007), Koren et al. (2007).

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

Microeconomic volatility measure. We would like to use pure firms' productivity shocks to pin down the microeconomic volatility. However, given the data limitations, this is not plausible, so I focus on changes in domestic sales and treat the model consistently. To rely on a measure that completely purged out the common effects on firms due to aggregate or sectoral changes, compute the firm-level shocks by incorporating country-industry-year fixed (Yeh (2021) and Di Giovanni et al. (2020)). So we can estimate,

$$\Delta\text{Domestic Sales}_{i,j(i),c,t} = \gamma_{j(i),c,t} + e_{i,j(i),c,t} \tag{4}$$

where ΔDomestic $\text{Sales}_{i,j(i),c,t}$ is the percentage change in domestic sales of firm I, belonging to main industry, j(i), in-country origin c, in year t. $\gamma_{j(i),c,t}$ denotes country-industry-year fixed effects so that $e_{i,c,t}$ can be interpreted as pure firm-level changes in domestic sales.[4] Once we have the firm-level shock estimates, we can compute the country's microeconomic volatility as the average observed standard deviation across time for each country i as

$$\sigma_c^{\omega} := \sum_{t=1}^{T} \frac{\sqrt{\sum_{i\in N_{c,t}} \frac{\left(\hat{e}_{i,c,t}\right)^2}{|N_{i,t}|-1}}}{T}$$

where $|N_{i,t}|$ represents the total number of firms in the country c, and I make use that the mean of the firm-level shocks is zero.[5]

Exports, volatility, and income differences: Estimation. To empirically understand the relevance of micro volatility on international trade, I estimate a gravity equation expanded with this measure. I decompose the logarithm of the country c's exports to destination country d (denoted by $\ln(x_{cdt})$), in an origin country fixed effect (α_c), a destination

[4] To avoid these changes being directly related to foreign demand or supply shocks, I restrict the sample to those firms that do not declare any direct or indirect export or import in the database.

[5] 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 of the economy.

time fixed effect (γ_{dt}), and a vector of bilateral variables ($\boldsymbol{y}_{cdt}$), and variables for the domestic economy that varies over time, $\boldsymbol{h}_{ct}$,

$$\ln(x_{cdt}) = \alpha_c + \gamma_{dt} + \boldsymbol{\beta} \boldsymbol{y}_{cdt} + \boldsymbol{\beta}_2 \boldsymbol{h}_{ct} + \varepsilon_{cdt} \tag{5}$$

as in Head et al. (2014) and Eaton et al. (2002) I proceed in a two-step procedure to understand the variables that relate to the origin component of a country, α_c. Once I have estimated the vector $\hat{\alpha}_c$, I project it against a set of variables to understand how they relate to different country characteristics, as follows

$$\hat{\alpha}_c = \beta_0^{\alpha} + \beta_1^{\theta} \ln \sigma_c + \beta_2^{\alpha} \ln \frac{GDP_c}{L_c} + \boldsymbol{\theta}_3 \bar{\boldsymbol{y}}_{cj} + \boldsymbol{\theta}_4 \bar{\boldsymbol{h}}_c + \boldsymbol{\theta}_5 \bar{\boldsymbol{Q}}_c + e_c \tag{6}$$

the two coefficients of interest are β_1^{α} and β_2^{α}, as the former captures the relationship between the average exports of a country and its microeconomic volatility, σ_c, and the latter captures the relationship between the average exports and the average level of GDP per capita of the country, $\frac{GDP_c}{L_c}$. I control for countries' quality institutions, their level of financial development, and direct measures of exporting costs represented by the vector $\bar{\boldsymbol{Q}}_c$, using three indexes developed by the World Bank that capture the quality of the contract enforcement, the financial development of the country, and the declared export costs that exporters face.[6]. Following Head et al. (2014), I control for the average of bilateral-time variables denoted by $\bar{y}_{cj}$, origin countries' time variables, $\bar{h}_c$, standard gravity equation, and countries' terms of trade (TOT) volatility.

Aggregate Fact 1: Positive Relationship between Exports and Income per Capita. Table 1 presents the results for several estimations: the case without controlling by countries' volatility measures and when we control by its volatility. Columns (1), (2), and (4) show the estimates (6) without controlling for the volatility measure, where in column (1), I only control for country size, column (2) includes all the gravity controls, and the declared

[6]The inclusion of these three indexes is because they are correlated with the level of development, potentially 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).

export costs as shown by last row of the table, and column (4) adds institutional for contract enforceability, and the financial development index. Both results show significant and relevant relations between the level of development and the average export to each market, even after controlling for country size, the declared cost to export, the country's institutional environment, and financial development (column 4). Consistently with the findings documented by Waugh (2010), Blum et al. (2019), Fernandes et al. (2015) and de Sousa et al. (2012).

Aggregate Fact 2: Negative relationship between microeconomic volatility and exports. Columns (3) and (5) of Table 1 are homologous to columns (2) and column (4), but adding the variable of interest, the microeconomic volatility measures. Two results emerge from its observation. First, the estimated relationship between exports and the level of GDP per capita drops between 20% to 30% after controlling for the level of micro-volatility. Second, a negative relationship exists between average exports and countries' microeconomic volatility. To put these results in context, the estimates suggest that a country with a standard deviation higher level of micro volatility relative to the mean exports, on average, is between 30% to 34% less. Moving from the first quartile to the last third quartile of the distribution is associated with an increase in total exports between 37% and 42%.

Given the novelty of the aggregate fact 2, I perform several robustness checks of this result in appendix A.2. I find that the results are robust when using different measures of microeconomic volatility.

These aggregate results provide a new potential explanation of why estimated export costs are associated with variations in the level of development even after controlling for the standard determinants of international trade. Volatility does not only predict considerable variations of average exports across countries but also captures 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 empirical findings are consistent with the previously discussed model, as discussed in lemmas 1 to 3, where if price elasticity is responsive enough, and exporters grow slowly over their life cycle, higher volatility decreases exports.

Nonetheless, these documented aggregate relationships are not necessarily causal. Because of the cross-country nature of the exercise and despite the efforts to control for the relevant variables, a potential omitted-variable bias cannot be ruled out. This is why, in the following sections, I will proceed in two ways to provide more evidence in favor of this new explanation. First, I will focus on micro-level data from Colombia. I will test the firm-level assumptions behind lemmas 1 to 3 and their firm-level predictions. Second, after showing that neither the main assumptions nor the predictions at the firm level can be rejected, I will estimate a full flesh general equilibrium small open economy, with heterogeneous firms and new exporters' dynamics to use it as a laboratory to observe what are the model's predictions regarding higher microeconomic volatility in terms of total exports and GDP per capita.

5 Firm-level facts

I will now use the micro-level data from Colombia to show three facts supporting the assumptions and predictions of the simplified mode, which are highlighted in section 2. In the first part of this section, I focus on how exporters adjust their prices to changes in their marginal cost of production; I document evidence supporting that firms' markups vary with firms' relative productivity, implying by lemma 3, the plausible existence of concave revenue functions. I relegate the most detailed analyses to the appendix because this fact has been shown in Berman et al. (2012) and discussed theoretically in Arkolakis et al. (2017).

The stylized model discussed in the second section shows that if exporters grow by expanding the intercept of their demand and if revenue is concave, in this case, microeconomic volatility should discourage new exporter expansion if price elasticity is high enough. In the second part of this section, I test the first assumptions regarding exporters' growth and its implications.

5.1 Firm-level variable markups

Estimating the markup elasticity in the data. The objective is to test whether relatively more productive firms respond more by changing markups to changes in their marginal cost. To understand how we can estimate the markup responses by observing price changes, let's start with the markup definition.

Markups, μ, are defined as the ratio between the product's price and the product's marginal cost of being sold to the market. Assuming that firms' sales are set ultimately in the currency of the market selling to, prices are given by the following equation

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

where $\frac{Mc_{i,d,l,t}}{e_{d,t}}$ denotes the marginal cost of production in foreign currency for firm i, product l, destination d, at time t. $e_{d,t}$ is the bilateral exchange rate, $p_{i,d,l,t}$ denotes prices and $\mu_{i,d,l,t}$ represents the markups at time t that firm i set sell to market (d,l). It is important to highlight two consequences that follow this definition for the case of constant markups. First, the exchange rate pass-through to prices should equal minus one. Second, exchange rate pass-through should not vary across destinations. Contrary to the coming findings and the ones in Berman et al. (2012).

Given my data constraint, to test if firms respond more by changing markups to changes in their marginal cost when they are more productive, I use firms' market share in the market they served as a proxy for the ratio of the exporters' relative productivity in the market they served, and exchange rate shocks as changes in the marginal cost in foreign currency.[7]

However, to estimate the changes in markups due to changes in the exchange rate depending on firms' relative productivity, we need to control the changes that exchange rate movements have on the cost of production. Otherwise, we would obtain biased estimates of markup responses to shocks.[8] If we assume that the firm's i marginal cost can be decom-

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

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

posed into two components: (1) the marginal cost of production, common to all destinations, denoted as $Mc^a_{i,l,t}$, and (2) the cost of selling the product to a destination d, denoted by $Mc^b_{l,d,t}$, which we generally refer as iceberg cost; then we can control for the changes in the marginal cost of production. By exploiting variation across destinations within firm-product-time and product-time-destination, we can recover the markup changes by observing the price responses to changes in cost. The following equation should clarify this result,

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

Suppose the markup responses vary across destinations within the exporter, depending on the exporter's relative productivity in that market. In that case, we can use exchange rate shocks interacting with the exporter's market share to recover the differential reaction of firms' markup to changes in their marginal cost, dependent on their relative size. To test if markup changes vary with exporters' market share, we can then estimate

$$\Delta p_{i,d,l,t} = \beta_1 \Delta e_{i,d,l,t} \times \text{exp. share}_{i,d,l,t-1} + \boldsymbol{\beta} \text{exp. share}_{i,d,l,t-1} \times \boldsymbol{X} + \gamma^1_{i,l,t} + \gamma^2_{i,l,d} + \gamma^3_{l,d,t} + e_{i,d,l,t} \tag{7}$$

where Δ denotes log differences of the variables over a year, and $\boldsymbol{X}$ represents a matrix with unit vectors, log changes in destination import prices, log changes of Colombian export prices, and log changes in destination real GDP. $\gamma^1_{i,l,t}$ denotes the firm-product-time fixed effects, $\gamma^2_{i,l,d}$ firm-product-destination fixed effects and $\gamma^3_{l,d,t}$ denotes the product-destination-time fixed effects. Under the previously mentioned assumptions, β_1 captures the differential markup responses to movements in the exchange rate due to firms' differences in their market share. Note that while this estimation procedure captures the markup responses to shocks, it cant be used to estimate the level of markups.

A concern of directly estimating equation (7) is that exchange rate variation might reflect changes in the destination country, which can bias the estimate. However, we can use an instrumental variable approach to solve this concern. In particular, I instrument the bilateral exchange rate variation intersected with the firm's sales shares with the remittances flows from third countries to Colombia interacted with firms' sales shares. I relegate the detailed presentation on the instrument variable approach and its implementation to the appendix B.1.

Firm-level fact 1: Markup changes increase with market shares. Table 2 presents the estimation results. Panel 1 shows the estimates for the first stage; the F-statistic is on the order of 80 for the case without control by destination changes in GDP (column 2) and around 101 when this control is added (column 4), alleviating the concerns of the possibility of weak instruments for all of the cases I presented. Second, as expected, when we compare the OLS results (columns 1 and 2) with the IV ones (columns 2 or 4), we find that our concern about the possible estimation bias triggered by shocks in the destination economy was valid; nonetheless, all estimates are positive. The results show that the markup response to shocks in the firms' marginal cost is increasing in the exporter's market share. Particularly, a firm with a one percentage point higher market share will optimally decide to do an exchange rate pass-through between 0.82% and 0.65% lower, as shown by columns (2) and (4) of Panel 2, respectively.

As a validation exercise, panel 3 presents a similar estimate but considers quantities as the dependent variable. The estimation results provide insights into the soundness of the instrument. While the OLS estimates -columns 1 and 2- predict a quantity change inconsistent with predicted price changes in panel 2, the IV results -columns 2 and 4- show results consistent with the predicted price changes in panel 1. After using the IV, not only do quantities respond relatively less, as firms that have higher market share reduce prices less, but the results are also consistent with price elasticity higher than 1, as we would expect.

Appendix B.1 discusses the IV strategy in more detail and presents several robustness results as shown in Table A.4. The results are robust to dropping the firm-destination-product fixed effects, conditioning only to exporters that continue exporting the following year, and repeating the analyses after 2012 instead of the one carried out from 2008 onwards.

5.2 Exporters' growth

Domestic volatility and exporters' growth. I now turn to test the models' assumption regarding new exporters' dynamics and its implication over new exporter growth under uncertainty highlighted in section 2.

Before starting the empirical analyses, it is worth mentioning why I will focus on the evolution of export intensity over exporters' life cycle. To understand this, note that according to the model presented in section 2, exporters' growth over their life cycle in a particular market can be decomposed by two components: (1) the growth driving the demand shifter - the customer capital accumulation, A, in terms of that model-, and (2) by the differential evolution of prices across markets.[9] This is because of the export intensity - exports from firm i of product l, to destination d, at time t, can be written as,

$$\exp \text{int}_{i,l,d,t} = A^{\alpha}_{i,l,d,t} \frac{\hat{q}(p_{i,l,d,t})}{\hat{q}(p_{i,l,\text{dom},t})} \quad ,$$

and consequently, the log difference over time is given by,

$$\Delta \exp \text{int}_{i,l,d,t} = \Delta A^{\alpha}_{i,l,d,t} + \Delta \frac{\hat{q}(p_{i,l,d,t})}{\hat{q}(p_{i,l,\text{dom},t})}$$

Now, suppose that price dynamics do not evolve differently over exporters' life cycles in each market, as shown in the coming results. In that case, common shocks to the firm will affect similarly the static component across markets -$\hat{q}(.)$-, and hence $\Delta \frac{\hat{q}(p_{i,l,d,t})}{\hat{q}(p_{i,l,\text{dom},t})} \approx 0$. Therefore, $\Delta \exp \text{int}_{i,l,d,t}$ will capture the evolution of the unobservable component $\Delta A^{\alpha}_{i,l,d,t}$.

Firm-level fact 2: New exporters grow by shifting their demand. Panel (a) of Figure 2 presents the estimates of the evolution of exporter intensity -conditional on prices - over the exporters' life cycle after entering a new market. Panel (b) shows the same evolution but for relative prices. The details of the estimation procedure regarding exporters' growth are presented in detail in appendix B.2, as the results and estimations procedures

[9] Note that here I am abstracting from the market aggregate variables changes, as destination time fixed effects can capture them.

are similar to the ones presented by Fitzgerald et al. (2021) and Steinberg (2021), but applied to the Colombian case. Consistent with their findings, the results show that the differential evolution of exporters' prices across markets is constant over their life cycle. Still, the export intensity grows over the exporters' life cycle, even conditional on exporters' prices. Consequently, exporters grow into markets by shifting the intercept of the demand they face conditional on prices.

Firm's exposure to volatility and exporters' growth. The previous firm-level facts show that we can't reject two key assumptions presented in the simplified model in section 2: the existence of variable markups and exporters that grow by shifting the intercept of their demand. Under these assumptions, one of the model predictions highlighted in section 2 is that if price elasticity is responsive enough, volatility will reduce exporters' growth over their life cycle. I will now proceed to test this implication.

I follow a strategy similar to the previous section to compute firms' exposure to domestic volatility. However, I can exploit a leave-one-out strategy using Colombian firm-level data. I start by taking out the common shocks for firms in the same industry by regressing the change of the log change of domestic sales against the main product of export-year fixed effects, as follows

$$\Delta\text{Domestic sales}_{i,j(i),t} = \gamma_{j(i),t} + \Delta\hat{s}^{D}_{i,j(i),t}. \tag{8}$$

where $\Delta\text{Domestic sales}_{i,t}$ denotes the log difference of domestic sales over time, $\gamma_{j(i),t}$ is the main-product time fixed effects - $j(i)$ is firm's i main product of export-, and $\Delta\hat{s}^{D}_{i,t}$ is the residual component that captures the firm-level shocks.

Then, we can use the shocks to other firms within the same main product of exports, $j(i)$, to compute firms' exposure to domestic volatility. The focus on shocks to domestic sales to third firms obeys two reasons: first, it allows me to avoid the volatility measure being related to foreign demand shocks, and second, it prevents the measure from being related to shocks to the firm itself. I compute the average cross-sectional standard deviation of firm-level shocks $\Delta\hat{s}^{D}_{i,t}$, at time t, for all the firms besides the firm i, whose main export product, at the sixth digit level is $l^{6d}(i)$ as,

$$\sigma_{i,t} = \sqrt{\frac{\sum_{j \neq i \in N_{l^{6d}(i)}} \left(\Delta \hat{s}^{D}_{j(i),t}\right)^2}{|N_{l^{6d}(i),t}| - 1}} \tag{9}$$

where $|N_{l^{6d},t}|$ denotes the number of firms whose main export product at the sixth digit product is l^{6d}. $\sigma_{i,t}$, hence measures the average volatility of the firm-level domestic shocks to the firms other than i that share its main product of export $l^{6d}(i)$, which I will use as my benchmark measure of firm's i exposure to volatility.

Firm-level fact 3: New exporters grow less when exposed more to domestic volatility. I estimate the following equation to asses how domestic volatility relates to exporters' dynamics,

$$\begin{aligned} \Delta_h \ln \left(\frac{\exp \text{int}_{i,l,d,t+h}}{\exp \text{int}_{i,l,d,1}} \right) &= \sum_{j=1}^{6} \beta_j^1 \ln \sigma_{i,t} \mathbb{I}_{\{\text{age}=j\}} + \sum_{j=1}^{6} \beta_h^2 \mathbb{I}_{\{\text{age}=j\}} \\ &\quad + \gamma^a_{i,l,t} + \gamma^b_{d,t} + \gamma^c_{cohort_i,l,d,t} + controls_{i,l,d,t} + e_{i,l,d,t} \end{aligned} \tag{10}$$

where $\exp \text{int}_{i,l,d,t}$ denotes the export intensity of product l - at the sixth digit-, that firm i, at time t, sells to destination d, defined as the exports divided by the firm's total domestic sales. $\mathbb{I}_{h=j}$ is a dummy variable equal to one if the firm's age in that particular market is h. $\gamma^a_{i,l,t}$ and $\gamma^b_{d,t}$ represent firm-product-time and destination-time fixed effects, capturing those variations in export intensity common to the destination or firm-product for each period. Additionally, results are conditional on the cohort of entry to that market γ^c_{cohort}, representing fixed effects by the year and month of entry. Among controls, I control the price firms charge when selling to that particular market, as there is evidence that when exchange time-varying uncertainty increases, firms might increase their markups as in Merga (2020).

Higher exposure to domestic volatility reduces firms' incentive to grow in their foreign markets. The estimation results are presented in Figure 3. The figure shows the estimated differences in the cumulative change of exports over the exporters' life cycle. It plots the estimated coefficients, β_j^1, and its confidence interval for all new exporters with a tenure of at least six years on each market. The estimated coefficients are presented in column (6) of Table A.3 of the appendix; several robustness checks are also presented and discussed in the appendix B.3. In particular, results are not changed if we: (1) use less strict fixed effects; (2) allow the sample to contain firms with smaller or larger tenure in the market; (3) use change in export quantities as dependent variables instead of export intensity; (4) use different measures of exposure to domestic volatility.

6 The model

We now turn to our general model, a small open general equilibrium economy model incorporating variable markups, extensive and intensive margin decisions into exporting, and persistent firm-level shocks. The economy has a continuum of firms producing intermediate goods, a representative firm producing a domestic bundle, a final good firm producing the consumption good, and a representative household. The household provides labor inelastically and uses labor and profits income to consume a final good. The final consumption goods and the domestic bundle firms are competitive and have a technology that converts domestic intermediate and imported goods into final consumption goods. The intermediate goods firms can sell to the domestic and foreign markets, both monopolistic competitive markets. There are no aggregate shocks.

6.1 Model structure

The timing in the model is as follows. At the end of any given period, firms decide how much to invest in foreign customer capital, allowing exporters to shift their demand's intercept in the foreign market - the intensive margin. At the beginning of the next period, idiosyncratic shocks are realized. Intermediate goods firms decide if they export, set their prices for each market they serve, produce, and sell their products to final goods firms or foreign markets if they face a foreign demand. The firm producing the domestic bundle buys the intermediate goods and sells them to the final good firm, which also buys the import bundle to produce the final goods. Households consume and receive payments for their work and their firms' profits. Trade is balanced, so aggregate savings are equal to zero.

Domestic consumers. The representative consumer of this economy owns the firms and holds risk-free bonds in zero net supply. Every period, she observes her bond holdings, b, and the aggregate state of the economy $\mathbb{S}$, decides how much to consume and save, and provides labor inelastically, L^s. Her problem is given by:

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

s.t.

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

In equilibrium $b = 0$, implying that total exports are equal to total imports, the net trade balance in this economy is zero, and 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 final consumption good is produced using two goods as inputs: a bundle of imported goods, M, and a bundle of domestic goods, D, which are combined in the following way to produce the final good C,

$$\left(M^{\frac{\gamma-1}{\gamma}}\upsilon + (1-\upsilon)D^{\frac{\gamma-1}{\gamma}}\right)^{\frac{\gamma}{\gamma-1}} \geq C\ , \tag{11}$$

where υ represents the home bias. The price of each of these bundles is given by P^m and P^D, respectively, and P^m is normalized equal to one. The final good firm chooses the amount of domestic and imported consumption bundles to solve

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

subject to (11). The solution to this problem yields the following demand for the domestic bundle:

$$D = M\left(\frac{\nu}{1-\nu}\right)^{-\gamma}\left(P^D\right)^{-\gamma} \tag{12}$$

Domestic bundle. The production for the domestic bundle uses intermediate differentiated goods and is given by the following conditions,

$$\int_{\omega\in\Omega^d}\Upsilon\left(\frac{q^d(\omega)}{D}\right)d\omega = 1 \tag{13}$$

where, as in Klenow et al. (2016), $\Upsilon(x)$ is given by

$$\Upsilon(x) = 1 + (\theta-1)e^{\frac{1}{\eta}}\eta^{\frac{\theta}{\eta}-1}\left(\Gamma(\frac{\theta}{\eta},\frac{1}{\eta}) - \Gamma(\frac{\theta}{\eta},\frac{x^{\frac{\eta}{\theta}}}{\eta})\right),\ \theta > 1;\ \eta > 0 \tag{14}$$

where $\Gamma(a,b)$ represents the incomplete gamma function, I call θ the price elasticity parameter, and η the super-elasticity parameter - note that both the price elasticity and super-elasticity are not constant. As it will be clear later, conditional on θ, η shapes the firm's markup responses to changes in the intermediate goods prices. The producer of the domestic bundle will observe intermediate good prices $\{p^d(\omega)\}$ and choose the intermediate quantities $q^d(\omega)$ of variety ω to solve,

$$\min_{q(\omega)}\int_{\omega\in\Omega}p^d(\omega)q^d(\omega)d\omega \tag{15}$$

subject to equations (14), and (13). The solution to this problem yields the following demand for variety ω,

$$\log q(\omega) = \frac{\theta}{\eta}\log\left(-\eta\log\left(\frac{p^d(\omega)}{p_c^d}\right)\right) + \log D \quad \text{if } p^d < p_c^d \tag{16}$$

where p_c^d is the choke price for the domestic varieties in the economy - the maximum price at which the domestic bundle producer will be willing to buy a variety - and is given by

$$p^c = e^{\frac{1}{\eta}} \frac{\theta - 1}{\theta} \frac{P}{\tilde{D}} \tag{17}$$

where P is the price index for the intermediate goods, defined as $P := \int_\Omega \frac{q(\omega)}{D} p(\omega) d\omega$, and $\tilde{D} := \int_\Omega \Upsilon'(\frac{q(\omega)}{D}) \frac{q(\omega)}{D} d\omega$.[10]

Foreign consumer's problem. Intermediate firms can sell to a foreign importer. The importer takes aggregate demand, Q^*, and foreign prices, P^*, as given.[11] The importer observes the prices of the intermediate goods and solves,

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

s.t.

$$\int_{\omega \in \Omega^*} A(\omega)^\alpha \Upsilon \left(\frac{q^*(\omega)}{A(\omega)^\alpha Q^*} \right) d\omega = 1 \tag{18}$$

where $\Upsilon(x)$ denotes the indirect utility function of the representative consumer and is given by (14); $A(\omega)$ represents the customer capital that the domestic exporter, producing variety ω, has when selling to this foreign market, and α is the elasticity of customer capital to demand; as follows from the foreign demand function given by

$$\log q^*(A, p^*) = \frac{\theta}{\eta} \log \left(-\eta \log \left(\frac{p^*(\omega)}{p^{c*}} \right) \right) + \log A^\alpha + \log Q^* \quad \text{for } p^*(\omega) < p^{c*}, \tag{19}$$

note that $A(\omega)$ ends up being a demand shifter, over which firms can invest and grow into the foreign market as in Fitzgerald et al. (2021). As before, p^{c*} denotes the choke price of the foreign economy. However, because the domestic economy is a small open economy, p^{c*} is assumed to be constant, unlike p^c, which is an equilibrium object. Also, note that the equation shows how both cross-sectional variable markups are consistent with new ex-

[10] See Arkolakis et al. (2017) for the proof on how when $\eta \to 0$ the model converges to CES, and $p^c \to \infty$.

[11] As the domestic economy is small, foreign aggregate price and foreign demand are assumed to be invariant to the condition of the domestic market.

porters that grow by shifting the intercept of their demand. While the evolution of A dictates the new exporters' dynamic, the cross-sectional markups depend on the ratio between the firm's price and the stock price of the economy. Also note that if $\alpha \to 0$, there will be no new exporters' dynamics, and the model will behave as a static model as firms will face no benefit from investing in customer capital.

Intermediate good firms. As stated before, a continuum of firms with the potential to produce intermediate goods populates the economy. Each potential producer of a variety can produce using a linear production function with time-varying labor productivity. Because the production of each variety, ω, is the same conditional on the firm's i productivity, z_i, and its customer capital, A_i, we can characterize each variety by these two characteristics. Furthermore, the joint distribution of productivity and customer capital will be enough to characterize the distribution of intermediate firms, denoted by $\Psi(z,A)$. Firms' productivity follows a Markov process governed by the transition probability $f(z',z)$.

The timing is as follows. At the beginning of time t, firm i observes its productivity z_i and the level of customer capital A_i. It decides if it wants to sell in the domestic and international markets. Contingent on selling to each market, it sets the prices for each market, hires the workers, and produces. At the end of the period, it decides how much to invest in customer capital to sell in the foreign market. When selling to the domestic market, they can reach all the customers available, so there are no gains from investing in domestic customer capital. On top of the investment cost in customer capital, reaching the international market has additional costs. To be able to sell to foreign markets, firms need to pay the fixed cost, f_e, and they also face an iceberg cost, $\tau > 1$. Furthermore, the firms' customer capital depends on firms being present in the market; when a firm stops exporting, it loses the customer capital it accumulated. The firm's problem can be decomposed into a static and a dynamic problem.

Firms' static problem. Now, I characterize the firms' static problems when selling to the international market. Nevertheless, if we set $\alpha = 0$ and $\tau = 1$, the coming equations characterize the static problem when selling to the domestic economy. The firm's static problem consists of choosing the optimal price such that it maximizes its operational profits, given its production technology, the economy choke price, p^c, wages, and the aggregate quantities, as in

$$\pi(z_i, A_i) = \max_{p_i, l_i} p_i^* q_i^*(A, p_i) - wl_i$$

subject to its production technology, $q_i^* = \frac{l_i \tau}{z_i}$, and equation (19). By choosing the price to maximize their profits, firms implicitly choose their products' price elasticity, conditional on the demand behavior. By staring at equation (19), one can realize the firms' price elasticity, ξ is given by,

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

the usual maximization argument implies that firms' markups are given by,

$$\mu(p) = \frac{\theta}{\theta + \eta \log(\frac{p}{p^{c*}})} \quad \text{for all } p \leq p^{c*} \tag{20}$$

hence, markups are decreasing with firms' prices. Put differently, it implies that more productive firms will charge higher markups while less productive firms will charge smaller markups. This result is consistent with the firm-level fact one in the previous section and the findings by De Loecker et al. (2016) and Berman et al. (2012). Additionally, the price elasticity equation and the markup equation imply boundaries for the optimal prices such that $\mu(p) \geq 1$, and $\xi(p) \geq 1$

As discussed in Section 2, the behavior of price elasticity and, consequently, the firm's markup is essential to determine the shape of the revenue function in terms of the firms' productivity. In this case, the average price elasticity will ultimately depend on two parameters, θ and η. Depending on their value, the model will generate standard "Oi-Hartman-Abel", under which higher volatility on firms will increase exports, sales, and GDP or shut it down, generating the opposite relationships.

Firm's dynamic problem. In the model, firms make two dynamic decisions directly related to the firm's extensive and intensive margin. These decisions are the exporting decision, denoted by m, and the investment decision to accumulate more customers, denoted by i_d, done using workers. As firms can't sell their customer capital, they can't make negative investments. To invest i_d in customer capital, the amount of labor required is given by

$$c(i_d, A) = i_d - \frac{\phi}{2}\left(\frac{i_d}{A_i}\right)^{\iota} \tag{21}$$

note that firms' customer capital is given by two-component

$$A_i = k_i + A^{min} \tag{22}$$

a minimum level of customer A^{min}, that is fixed and equal for all firms exporting paying the exporting fixed cost, and k_i that is where firms can invest and accumulate customer capital, according to the following law of motion,

$$k_i' = m\left(i_d + k_i(1-\delta)\right), \tag{23}$$

when $m = 0$ and firms do not export, they will lose all the accumulated customer capital and only have $A' = A^{min}$ the following period. Denoting with an apostrophe the variables next period, and by $\mathbb{S}_t$ the vector of aggregate state variables, the firm dynamic problem is to solve

$$\begin{aligned} V(z_i, A_i, \mathbb{S}) = \max_{m \in \{0;1\}; i_d \in [0;\infty)} & \pi^d(z_i, 1) + m(\pi(z_i, A_i) - w f_e) - \\ & - wc(i_d, A_i) + \mathbb{E}\left[\Lambda(S) V(z_i', A_i', \mathbb{S}')\right] \end{aligned} \tag{24}$$

subject to (22) and (23). 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_e. When 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 the domestic customer capital of the economy is normalized to one.

Firm's optimal dynamic behavior. Two main equations characterize the firms' exporter behavior. The optimal capital customer the firm decides to have in the next period is given by,

$$\frac{\partial wc(i_d,A)}{\partial A'} \geq \Lambda \overbrace{(1 - Pr(z_i'^*|z_i))}^{\text{export prob.}} \overbrace{\mathbb{E}_{z_i}\left\{\frac{\partial V(A',z')}{\partial A'}|z_i' > z_i'^*\right\}}^{\text{Expected MR conditional on exp.}} \tag{25}$$

note that this condition holds with equality when firms decide to invest in customer capital, $i_d > 0$. In this case, firms decide to equalize the marginal cost of investment, the left-hand side of equation (25), to the expected marginal return on investment, the right-hand side of the same equation. Using Leibniz's rule, we get that two components determine the expected marginal return on investment. The first is the expected probability that in the next period, where z'^* denotes 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 denotes the marginal expected return of investment conditional on exporting. Both of these terms are affected by the uncertainty that firms face concerning the realization of future shocks.

As in Melitz (2003), firms will export if productivity is higher than the productivity threshold $z^*(A,\mathbb{S})$. They will decide the contrary when their productivity is below that threshold. The firm productivity threshold is then characterized by the case when the firm is indifferent to export or not, given by

$$\hat{\pi}(z_i^*,A) + \overbrace{\mathbb{E}_F\{\Lambda[V(A',z') - V((A^{min},z')]\}}^{\text{Option value}} = w(f_e + c(i_d,A)) \tag{26}$$

the marginal firm is indifferent between staying in the export market or not if the operational profits of doing so plus the option value of not losing the customer capital it had accumulated is equal to the investment cost plus the exporting fixed cost. Firms will not face any option value in a static case or an economy where customer capital is unaffected by the exporter's decision. The existence of the option value generates the well-known effects of hysteresis on international trade, given that firms with higher customer capital, and consequently, that, on average, spend more time in the export market, will be less likely to drop their export condition. The existence of the option value and hysteresis is a vital margin to be present in the model, as its absence will upward bias the absolute values effects of uncertainty on total trade. This is because the option value tends to increase under higher uncertainty, delaying export exits as discussed in Merga (2020).

6.2 Equilibrium

Let's now specify the conditions for equilibrium in this economy. Market clearing in the labor markets implies that labor inelastically supply, L^s, equals labor demand determined by the sum of labor used for production, investment, and fixed costs,

$$\int l(z,A)d\Psi(z,A) = L^s \quad , \tag{27}$$

total output for the economy is equal to the labor income plus firm profits,

$$Y = wL^s + \int (\pi^d(z_i,1) + m(\pi(z_i,A_i) - wf_e))d\Psi(z,A) \quad , \tag{28}$$

and total exports are given by

$$Exp = \int p^*(z,A)q^*(z,A)d\Psi(z,A) \quad , \tag{29}$$

because of the zero net supply of the bond market, trade is balanced, implying that nominal exports and imports are equal to nominal exports, $Exp = Imp$. The demand for the domestic bundle used to produce the final consumption good is given by,

$$D = Imp\left(\frac{\nu}{1-\nu}\right)^{-\gamma}\left(P^d\right)^{-\gamma}$$

where I make use of the fact that nominal imports, Imp, are equal to the imported quantities, M, since $P^m = 1$. The price of the domestic bundle is given by $P^d = \int \frac{q(z,1)}{D} p(z)d\Psi(z,A)$, and the price of the consumption is given by P^C characterized by the usual price index for CES.

The supply for the domestic bundle, D, is given by the following conditions,

$$\int \Upsilon\left(\frac{q(z,1)}{D}\right) d\Psi(z,A) = 1 \tag{30}$$

characterizing the equilibrium domestic choke price, p^c defined in equation (17). The evolution of the firm productivity and customer capital joint distribution, $\Psi(z,A)$, is given by,

$$H(z_t,A_t;\mathbb{S}_t) = \int f(z_t,z_{t-1})\phi(A_t,A_{t-1},z_{t-1};\mathbb{S}_{t-1})d\Psi(z_{t-1},A_{t-1}) \tag{31}$$

where $H(.)$ is the transition function for the measure of firms, $\Psi_t = H(\mathbb{S}_{t-1})$. $f(z_t,z_{t-1})\phi(A_t,A_{t-1},z_{t-1};\mathbb{S}_{t-1})$ denotes the measure of firms that will transition from (A_{t-1},z_{t-1}) to (A_t,z_t), when $\mathbb{S}_t$, is the aggregate state of the economy.

Given the initial measure Φ_0; an equilibrium consists of policy and value functions of intermediate goods firms $\{V(z_t,A_t,\mathbb{S}_t),A'(z_t,A_t,\mathbb{S}_t),q^s(z_t,\mathbb{S}_t),q^{*s}(z_t,A_t,\mathbb{S}_t),m(z_t,A_t,\mathbb{S}_t)\}$; of consumers $\{V^C(b,\mathbb{S}_t)b'(b_t,\mathbb{S}_t),C(b_t,\mathbb{S}_t)\}$; of final good producers $\{M(,\mathbb{S}_t),D(,\mathbb{S}_t)\}$; of domestic bundle producers $\{D(\mathbb{S}_t),q^d(\mathbb{S}_t)\}$; the price of the export and domestically sold intermediate goods $\{p^s(z,\mathbb{S}_t),p^{*s}(z,\mathbb{S}_t)\}$; the domestic choke price $\{p^c(,\mathbb{S}_t)\}$; the price of labor units $\{w(,\mathbb{S}_t)\}$; the price of the bonds $\{r(,\mathbb{S}_t)\}$; the price of the consumption good and the domestic bundle, $\{P^c(,\mathbb{S}_t),P^D(,\mathbb{S}_t)\}$; and the evolution of the aggregate states Ψ_t governed by the function $H(,\mathbb{S}_t)$, such that for all time (1) the policy and value function of intermediate good firms satisfy their optimal conditions, (2) domestic consumer decisions are optimal, (3), the final consumption producer and the domestic bundle producer decisions are optimal, (4) the bond market clears and trade is balanced, (5) labor and goods markets clear, and (6) the evolution of the measure of firms is consistent with the policy functions of the firms and consumers, and with their shocks.

7 Quantitative analysis

Now, we turn to our quantitative exercise, which aims to test the model's ability to capture the firm-level facts and the observed patterns between total exports, microeconomic volatility, and GDP per capita. Because the model nests, static models, or models with constant markups, I will use these features to test the relevance of each mechanism in explaining the aggregate patterns.

I begin by discussing the model's parameterization. Since the model is highly nonlinear, I solved it using global methods. I explain the algorithm to solve for its equilibrium in Appendix D. I then explore the models' implications at the firm and aggregate levels, starting at the firm level. I begin by studying the model's prediction of exporters' dynamics under different levels of micro-volatility. Finally, I test the four models' predictions for the aggregate relationships of interest.

7.1 Model calibration

Because the model is highly nonlinear, all parameters affect all the moments, and all are set to match the moments together. Nevertheless, some parameters have a clear empirical moment counterpart based on the model's prediction. Two parameters are externally calibrated. These parameters are the consumer's discount rate, β, and the Armington elasticity, γ, set to 0.98 and 2.5, respectively. The home bias, ν, is set to match Colombia's trade openness of 0.37. The consumer's utility function is assumed to be given by

$$u(c) = ln(c),$$

the firms' productivity follows an AR(1) process,

$$\ln z_{i,t} = \mu + \rho \ln z_{i,t-1} + \varepsilon_{i,t}$$

where $\varepsilon_{i,t}$ is assumed to be normally distributed, with standard deviation σ_z. Both ρ and σ are set to match the AR(1) process estimates for domestic sales in Colombia.

The rest of the parameters governing the firms' decisions are set to match the exporter data from Colombia. The parameters τ and A^{min} are set to match the average export intensity of all exporters and of the new exporters', while f^e is set to match the share of exporters over the total active firms. The parameters $\alpha, \iota, \phi, \delta$ are set to match the exporters' export intensity evolution over their life cycle.

Finally, the parameters governing the price elasticity, θ, and η, are set to lie within the markup range estimated for Colombia, and the empirical results are presented in Table 2. To match these estimates in the model, I perform the same exercise as in the data, but with two exceptions. First, I can directly observe the markups in the model, so I run the exact estimates as in the data but use markups as dependent variables. This prevents me from using the fixed effects used to control for the marginal cost changes, as explained in the empirical section. Second, I use wage reductions as the change in the marginal cost of production following the literature. Lastly, remember that because I am assuming that the domestic economy is a small open economy, p^{c*}, the international choke price, is assumed to be a parameter consistent with the foreign demand and the estimated parameters for the price elasticity.[12] All the values of the parameters for each of the possible models are presented in Table 3, while the target moments and the model predictions are presented in Table 4.

7.2 Model implications

Now, we can test the different models' ability to generate the empirical relations documented in the data section. To achieve this, I simulate four model combinations: with or without exporter dynamics and with or without variable markups. I want to simulate different economies that vary only in their conditional domestic sales volatility for each model.

To achieve this, I adjust the microeconomic volatility parameter. σ_z. and solve for new policy functions and the general equilibrium for each change. But, to only change the conditional variance of the domestic sales changes, I need to adjust the mean, μ, and the persistence of the shocks ρ, such that the changes in the volatility parameter, σ_Z, do not affect the average productivity and the unconditional variance distribution of firms' productivity. Without these adjustments, the shocks will generate changes in the average firm produc-

[12]In this case, p^{c*} is assumed to be the choke price that solves the foreign economy given the foreign demand function. I do this by assuming that the foreign economy has the same firm distribution and price elasticity parameters, θ and η, as the domestic economy.

tivity and will increase the share of firms on the right tail of the distribution as volatility increases. This would contradict the empirical evidence regarding the "missing" middle literature.

Quantitative result 1: Higher micro-volatility reduces new exporters' growth. I now test the model's ability to replicate the firm-level fact 3, where exporters more exposed to domestic volatility grow less over the export markets. To do this, I compare the estimated differential growth due to this higher exposure in the data and the model. Figure 3 presents the results. The benchmark model can adequately predict the qualitative relation regarding the higher domestic volatility and the differential growth of the new exporter, as shown by the yellow dotted line - model prediction- against the solid black line - empirical estimates-. Quantitatively, the model predicts a slightly bigger drop in export intensity for the initial years of the exporters' lives. However, the model also seems to underpredict the drop in export intensity growth once firms reach six years of tenure. These results are successful if we compare them to models without the variable price elasticity since these other models will predict a null or contrary relationship to the one in the data, as discussed in Section 2.

Aggregate predictions: Model vs data. Now, we turn to the models' prediction regarding the aggregate variables. To understand the relevance of volatility and the proposed mechanisms, let's re-write the total exports as in section two, but now without assuming that shocks productivity are iid, in this case, we can re-total exports as

$$Exp_t = \bar{A}\int_{z^*(A)} \frac{A_i^{\alpha}}{\bar{A}} r\hat{e}v^*(z)d\Psi(z,A)$$

where $r\hat{e}v^*(z) := p^*(z)q^*(z,1)$ is the static component of exports, and $\bar{A} := \int_{z^*(A)} A_i^{\alpha} d\Psi(z,A)$ denotes the average effective demand shifter over active exporters. Using the covariance definition and the Leibniz rule, we have that the total export response to a marginal change in a generic variable x is given by,

$$
\frac{\partial \ln Exp_t}{\partial x} = \underbrace{\frac{\partial \ln \bar{A}}{\partial x}}_{\textit{dynamic margin}} + \frac{1}{\Theta} \ln \left(\partial \frac{\overbrace{\mathbb{E}(rev_i^*(z)|z \geq z^*)}^{\textit{static margin}}}{\partial x} + \partial \frac{\overbrace{\mathbb{C}\mathbf{ov}\left(\frac{A_i^\alpha}{\bar{A}}; rev_i^*(z)|z \geq z^*\right)}^{\textit{misallocation margin}}}{\partial x} \right) - \frac{1}{\Theta} \underbrace{\int_A \frac{\partial z^*(A)}{\partial x} \frac{A_i^\alpha}{\bar{A}} rev^*(z^*) \psi_z(z^*, A) d\Psi_A(A)}_{\textit{extensive margin}}
$$

where $\Theta := \mathbb{E}(rev_i^*(z)|z \geq z^*) + \mathbb{C}\mathbf{ov}\left(\frac{A_i^\alpha}{\bar{A}}; rev_i^*(z)|z \geq z^*\right)$, $\psi_z(z^*, A)$ denotes the conditional probability density function of firms productivity, given their value of customer capital, and $d\Psi_A(A)$ is the marginal density function of customer capital.

The previous result shows that in the dynamic model with customer capital, there are, as usual, two main margins of adjustment: an intensive and extensive margin. However, in this case, unlike the case for static models or new exporters' dynamics models with iid shocks, the intensive margin is determined by three sub-margins. The three sub-margins of the intensive margin are: (i) the dynamic margin, which captures the effect on the average level of customer capital; (ii) the static margin, which captures the effect of firms' changes in their export static decision-equal to the total intensive margin on static models-; and (iii) the misallocation margin - absent in models with iid shocks-, capturing the changes on the covariance between firms' revenues per customer and firm's relative level of customer capital, a higher covariance increases export as it means that firms that obtain higher revenues per customer are reaching relative more customer.

Quantitative result 2: Higher micro-volatility reduces total exports. Panel (a) of Figure 4 shows the models' quantitative prediction regarding total exports and the volatility of domestic sales changes when we change σ_z as previously described. The models' predictions are striking. Both models with variable markups are qualitatively consistent with the documented empirical relationships between microeconomic volatility and total exports, while the model without variable markups predicts the opposite relationship. Within the models with variable markups, the model with new exporters' dynamics generates a quantitative relationship similar to the empirical relationship in the data, as it predicts an elasticity between the domestic microeconomic volatility and total exports of around 1.09, which is 76% of the point estimates found in the empirical section - column (3) of Table 1, and is 60% higher than the model without the new exporter's dynamics.

To put this result in context, if we compare the top and bottom 10% countries on the microeconomic volatility distribution, the former would increase their exports by 103% if they could reduce their microeconomic volatility to the level of those countries in the bottom 10% of the distribution. Also, for example, the results imply that if Colombia faced the microeconomic volatility levels of Belgium or Sweden, their export would grow by 55% and 69% higher, respectively.

Besides these quantitative predictions, two crucial additional outcomes emerge from the exercise. First, it implies that abstracting from the existence of variable markups to simplify the analyses comes at the cost of missing the negative relationship between microeconomic volatility and total trade. Second, abstracting from the existence of new exporting dynamics comes at the cost of quantitatively biasing down the negative relationship between microeconomic volatility and international trade. Therefore, these results present a solution and explanation to the puzzle documented in Alessandria et al. (2015).

Quantitative result 3: Micro-volatility differences generate a positive relationship between exports and GDP per capita. Panel (b) of Figure 4 shows the four models predicted relationship between total trade and GDP per capita that emerges by changing the standard deviation of firms' tfp shocks as previously explained. The models with constant elasticity of substitution predict a negative relationship between total exports and GDP per capita as we vary the microeconomic volatility, consistent with the puzzling prediction by standard international trade models discussed in Waugh (2010), Fieler (2011), de Sousa et al. (2012), Alessandria et al. (2015) and Blum et al. (2019); unlike these models, the ones with variable markups predict a positive relationship quantitatively consistent with the data.

These differences in the predictions between models with constant elasticity and variable markups imply that the former models will need higher iceberg costs to export to match the empirical relationships as microeconomic volatility increases. This is because, in the data, as microeconomic volatility decreases, the GDP per capita increases, and so do total exports. However, standard models with CES cannot capture these relationships and predict that microeconomic volatility increases exports and will need higher iceberg costs to export to compensate for this result. A back-of-the-envelope calculation implies that the new exporter dynamic model with the CES, to match the export evolution in the data, the estimated iceberg export cost should decrease by 0.73% for each percentage point increase in GDP per capita - assuming a trade elasticity of 2.5.

For my country sample, the previous result implies that the estimated iceberg cost to export by the CES model will be 67% higher in developing economies than in developed ones.[13] While seemingly a considerable number, this is in line with the quantitative cost differences found in Waugh (2010), and with the estimates by de Sousa et al. (2012), who found that exports non-tariff barriers difference among development can be up to 90%.[14] Hence, according to our model prediction, cross-country microeconomic volatility differences account for around 70% of the higher estimated export iceberg costs that developing economies face.

8 Conclusion

This paper identifies domestic microeconomic volatility as a significant barrier to international trade, and development. As a result, it explains a substantial portion of the previously unexplained variation in trade costs across development levels.

[13] The result follows by assuming a trade elasticity of 2.5. If we assume a trade elasticity in the range between 2.0 and 3.5, the iceberg cost differences would be between 51% to 91%

[14] In the paper they argue that cost to export from developing economies are around 50% higher, but this is based on a trade elasticity of 8. If we adjust it to 2.5 to be consistent with our exercise, we get 90% additional iceberg costs

The negative impact of volatility arises because it discourages exporters' investments in foreign markets, ultimately reducing trade flows. This finding challenges existing trade models with constant price elasticity assumptions.

To quantify these effects, I develop a novel general equilibrium model incorporating both variable markups and new exporter dynamics. This model successfully replicates the observed micro and macro-level relationships between trade and volatility. Notably, the model highlights the importance of these firm-level features, as abstracting from them leads to an overestimation of trade frictions.

Our results suggest that policies aimed at reducing domestic volatility could have a significant positive impact on international trade, and development. Additionally, the model lays the groundwork for future research by suggesting potential avenues for exploring the link between volatility, trade, and development. These avenues include the role of foreign trade policy uncertainty, as it suggests a stronger role for trade policy uncertainty in dampening trade flows than standard frameworks, and to study how the emphasized frictions generate differences in firm distribution across the level of development.

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Figures and Tables

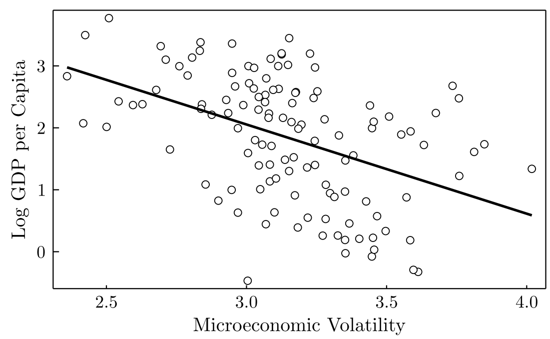
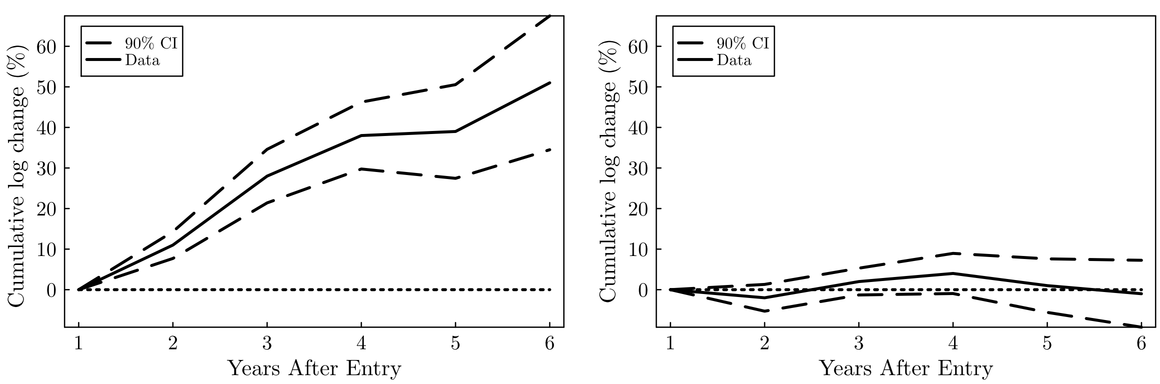


Figure 1: Volatility and GDP per Capita



(a) Export intensity dynamics

(b) Price dynamics

Figure 2: New Exporters' Dynamics

Note: Panel (a) shows the estimated log cumulative change in export intensity relative to total sales relative to firms' first year of export to the market. Panel (b) shows the same but for price changes. A market is a six-digit product-destination combination. Both estimates include firm-product-time, destination-time, and cohort fixed effects. Results in Panel (a) are presented in column 7 of Table A.2, and results from Panel (b) are from column 10 of the same table. Firms in the sample are exporters that continuously export to each market, and a new exporter is a firm that exports at a time t, after at least three years of not exporting to the market. Standard errors in brackets. Error cluster at the firm level.

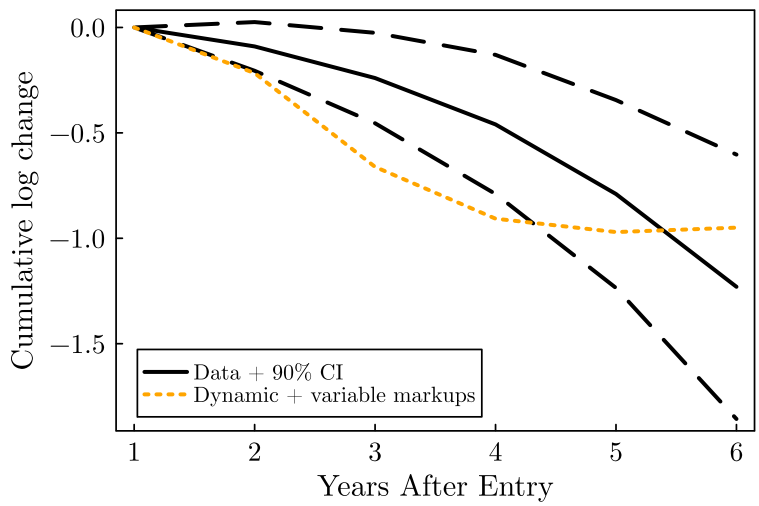
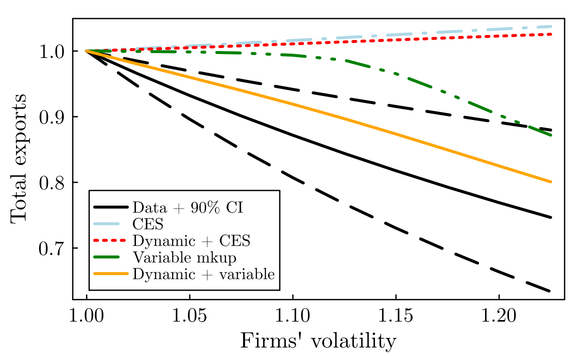
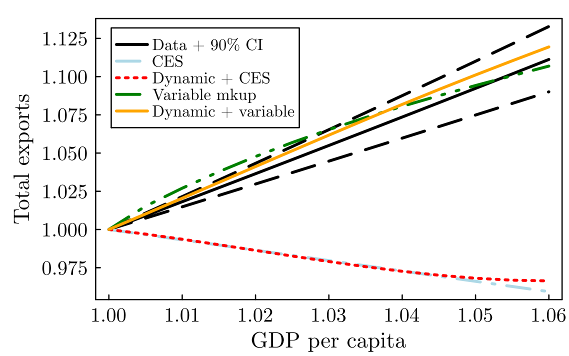


Figure 3: New Exporters Growth and Volatility: Model & Data

Note: The data results are based on the estimates for Colombian firm-level data presented in column 6 of Table A.3. The orange dotted line shows the cumulative export intensity response elasticity predicted by the model with new exporters' dynamics and variable markups when the micro volatility changes by 1%. Both estimates from the model and data are based on the export intensity cumulative change conditional on those exporters with at least six years of tenure in the market.



(a) Exports and micro volatility



(b) Exports and GDP per capita

Figure 4: Exports, volatility and GDP per capita

Note: The data results are based on Table 1. Firms' volatility refers to the standard deviation of firms' changes in domestic sales both in the model and in the data.

Table 1: Microeconomic Volatility and Average Exports

	Dependent variable: Av. Exp				
	(1)	(2)	(3)	(4)	(5)
ln(GDP per capita)	1.81***	1.27***	0.92***	1.23***	0.98***
	[0.20]	[0.15]	[0.16]	[0.16]	[0.15]
ln(Micro Volatility)			-1.44**		-1.62***
			[0.62]		[0.49]
Observations	35211	35211	35211	35211	35211
R^2	0.75	0.85	0.91	0.89	0.93
Number of countries	38	38	38	38	38
Gravity Controls	Only Size	All	All	All	All
Doing Business	-	Exp	Exp	All	All

Note: Av. Exports denote the estimated value α_i from equation (5). Trade flows are yearly at frequency. First Stage-Observation denotes the amount of observations used to estimate equation (5). The number of countries equals the observations for the second stage. Exp denotes controls for the doing business declared export cost. All add to the declared export costs, the contract enforceability index, and the financial development index. Standard errors in brackets are clustered at the origin country level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 2: Heterogeneous Markup Responses

	(OLS)	(IV)	(OLS)	(IV)
Panel 1: First Stage				
	Dependent variable: Δex. rate$_{d,t}$ $\times$ $share_{i,l,d,t-1}$			
Δremittances$_{\neq d,t}$ $\times$ $share_{i,l,d,07}$	-	0.28***	-	0.65***
	-	[0.03]	-	[0.29]
Panel 2: Second Stage (Prices)				
	Dependent variable: $\Delta \log p_{i,l,d,t}$			
Δexchange rate$_{d,t}$ $\times$ $share_{i,l,d,t-1}$	0.11	0.82***	0.09	0.65**
	[0.08]	[0.29]	[0.10]	[0.29]
Panel 3: Second Stage (Quantities)				
	Dependent variable: $\Delta \log q_{i,l,d,t}$			
Δexchange rate$_{d,t}$ $\times$ $share_{i,l,d,t-1}$	0.77***	-3.21***	0.25	-2.09***
	[0.21]	[0.70]	[0.21]	[0.62]
Observations	62,357	62,357	58,781	58,781
F-statistic		80.68		101.81
Firm-product-time FE	✓	✓	✓	✓
Destination-product-time FE	✓	✓	✓	✓
Firm-product-Destination FE			✓	✓
Controls $\times$ $share_{i,l,d,t}$	Agg. prices	Agg. prices	All	All

Note: Panel 1 shows the first stage results. Panel 2 shows the results using the log difference of unit values over a year. Panel 3 shows the estimated results for quantities exported. Exporter age denotes the minimum age of an exporter in the sample. Controls $\times$ $share_{i,l,d,t}$ denotes the addition of controls of firms' sales share among total Colombian exports and its intersection with the log change of real GDP, Colombia export price to that destination, and import price index. "Agg. prices" denote when only aggregate price changes are used, and "All" denotes the case, including GDP changes. Standard errors in brackets. Error cluster at the destination country. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 3: Calibrated Parameters

Parameters	Variable markups + Dynamics	CES + Dynamics	Variable markups + Static	CES + Static	Rationale
β	0.96	0.96	0.96	0.96	Yearly frequency discount rate
γ	2.5	2.5	2.5	2.5	Armington elasticity
Parameters estimated within model					
θ	2.90	3.80	2.90	3.80	”Average” price elasticity
η	4.20	-	5.60	-	Super elasticity
σ^{ω}	0.48	0.48	0.48	0.48	Firms’ labor productivity s.d.
ρ^{ω}	0.61	0.61	0.61	0.61	Firms’ labor productivity persistence
ν	0.71	-	0.71	-	Home bias
f_e	0.08	0.043	1.5	0.10	Exporter fixed costs
α	0.70	0.74	-	-	Customer capital: curvature
ϕ	3.72	14.30	-	-	Investment adjustment cost
δ	0.24	0.42	-	-	Customer capital: depreciation
A^{min}	0.01	0.02	1.00	1.00	Customer capital: Initial value
τ	0.44	0.2	0.38	0.61	Iceberg cost

Table 4: Target Moments

Moment	Data	Variable markups + Dynamics	CES + Dynamics	Variable markups + Static	CES + Static
Average markup	0.45	0.44	0.35	0.45	0.35
Markup sensitivity estimates	0.65	0.63	-	0.66	-
Share of exporters	0.19	0.19	0.20	0.23	0.20
Trade openness	0.37	0.37	-	0.37	-
Av export intensity new exporters	0.40	0.40	0.16	-	-
Av. export intensity	0.45	0.50	0.23	0.46	0.25
S.d. domestic sales shocks	0.36	0.30	0.58	0.30	0.58
Persistence domestic sale shocks	0.47	0.49	0.57	0.46	0.58
Cum. growth 2nd year	0.11	0.18	0.18	-	-
Cum. growth 3rd year	0.28	0.30	0.31	-	-
Cum. growth 4th year	0.38	0.39	0.40	-	-
Cum. growth 5th year	0.39	0.45	0.47	-	-
Cum. growth 6th year	0.51	0.50	0.52	-	-

Appendix

A Appendix: Cross country Data and Estimation Robustness

Here, I present more details about the data used for the cross-country analyses and the robustness of the cross-country estimates.

A.1 Cross country Data

Penn World Tables. This data covers 183 countries between 1950 and 2019. I use this data for the country's total factor productivity and other aggregate variables such as GDP, as well as export and import prices.[15]

CEPII. I use two datasets from the CEPII foundation, the "Gravity" data set and the "TradeProd" data set.[16] 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 trade margins for different exporters.

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.

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

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

A.2 Cross-Country Estimation

Measurement of microeconomic volatility. There are some potential concerns about using the cross-sectional standard deviation of the changes in firm-level domestic sales to measure volatility. To test for different measures, I use three measures and present the results in Table A.1. One measure is constructed using the firm-level labor productivity for those that do not export or import, denoted as $\textit{Micro Volatility}^{tfp}_{NonExpo}$, the other is using the labor productivity but for all firms, denoted as $\textit{Micro Volatility}^{tfp}_{All}$. The final measure, denoted by $\textit{Micro Volatility}^{Common}$, uses the common component of the three measures constructed using the principal component method.

B Appendix: Firm-level Estimation

B.1 Estimation of Markup response: Instrumental variable approach

In this appendix section, I present more details of the estimation procedure to estimate how markups respond to exchange rate changes depending on their firm's sale shares and some additional robustness checks.

As already mentioned in the main text, to test if markup changes vary with exporters' market share, we can estimate

$$\Delta p_{i,d,l,t} = \beta_1 \Delta e_{i,d,l,t} \times \text{exp. share}_{i,d,l,t-1} + \beta \text{exp. share}_{i,d,l,t-1} \times \mathbf{X} + \gamma^1_{i,l,t} + \gamma^2_{i,l,d} + \gamma^3_{l,d,t} + e_{i,d,l,t} \tag{32}$$

where the description of each variable was already detailed before in the main text.

To estimate β without bias, we need to abstract from the exchange rate variation that might reflect changes in the average productivity of the destination country, as this can bias the estimate. I use an instrumental variable approach that solves this concern. I instrument the bilateral exchange rate variation intersected with the firm's sales shares with the remittances flows from third countries to Colombia interacted with firms' sales shares to that destination. The first stage is then given by

$$\begin{aligned}\Delta e_{i,d,l,t-1} \times \text{exp. share}_{i,d,l,t-1} = \Delta \mathit{remittances}_{d,t} \times \text{exp. share}_{i,d,l,07} + \\ + \beta \text{exp. share}_{i,d,l,t-1} \times \mathbf{X} + \gamma^1_{i,l,t} + \gamma^2_{i,l,d} + \gamma^3_{l,d,t} + e_{i,d,l,t}\end{aligned}$$

Two assumptions are needed to validate this procedure. First, remittance flows to Colombia need to affect the exchange rate of Colombia with the rest of the countries; this seems natural as the average net remittances to Colombia represent, on average 10% of the total export flow. Also, it has been documented that the remittances are unlikely to vary due to exchange rate variation.[17]

The second assumption is that shocks affecting the remittances to Colombia from a third country do not generate differential price changes for a product sold in several destinations after controlling for the common shocks that may hit all the destination countries. This is conditional on global destination market shocks and the firm's common marginal cost at the product level; the changes in remittance flows from a third country cannot be generated by shocks affecting the relative differences in firms' prices to destinations.

For example, imagine Colombia and three other countries: the USA, Argentina, and Brazil. To violate this exclusion restriction, we would need the shock that changes the remittance flows from the USA to Colombia to affect the Colombian firm's relative price changes between Brazil and Argentina, conditional on the aggregate shocks affecting each country and firms' product marginal costs.

Results comparing the Iv and the OLS estimation are presented in Table A.4. Columns 1 and 3 show the OLS results, while the rest of the column presents the results using the IV strategies. As can be seen, the F-statistic range between 65.15 to 108.22 for different specifications. Relative to Table 2 presented in the main text, the current one adds four additional results in Columns 5 to 7. Column 5 presents the results of dropping the firm-destination-product fixed effects. Column 6 shows that results hold if we condition the exporter's sample to those exporters that continue exporting the following period. Column 7 presents the findings after re-estimating the IV strategy, fixing the exporter's share in 2012, and using data between 2013 and 2019 to re-do the estimates. The three columns show that results are invariant to these changes and that if something, the benchmark case (column 4) used to calibrate the model is on the conversation side of the estimates.

[17] See Mandelman (2013) and Lartey et al. (2012) for a discussion on the effect and relevance of remittances on the exchange rate, and Mandelman et al. (2020) for the small response of remittances to exchange rates

B.2 New exporters' dynamics

I revisit the facts documented in Fitzgerald et al. (2021) and Steinberg (2021) to understand how Colombian exporters grow over their life cycle after entering a new destination. Consistent with their findings, exporters increase their exports over their life cycle conditional on prices. Furthermore, I find relative prices that do not change over exporters' life cycles. Exporters grow into foreign markets by shifting their demand, conditional on prices. The evolution of quantities in a particular market, defined as a six-digit product and destination pair, by estimating:

$$\Delta_h y_{i,d,l,t} = \sum_{h=1}^{6} \beta_h \mathbb{I}^h_{\{age=h\}} + \ln p_{i,d,l,t} + \gamma^a_{i,l,t} + \gamma^b_{d,l,t} + \gamma^c_{\text{cohorts}} + \varepsilon_{i,d,l,t}$$

where $\Delta_h y$ represents the log differences between the initial value of the variable y and its value "h" years after. I estimate the above equation for two possible dependent variables: one $\text{export}^q_{i,d,l,t}$ representing the total export quantities that firm i is selling of product l to destination d in year t; the other is $\frac{\text{export}_{i,d,l,t}}{\text{Tot. sales}_{i,t}}$, representing nominal exports from firm i to each market at time t over total sales - ideally, I would want to divide by the total domestic product sales for the same product l, but that data is unavailable. I project variable y 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 $\gamma^b_{d,t}$ in my benchmark specification, $\gamma^c_{\text{cohorts}}$ represents the first month of entry I observed. Adding these fixed effects allows me to purge out the common variation in sales from firm i of product l at time t to all markets; the second set of fixed effects allows me to purge out the common variation across exporters within a destination product time. To understand the price dynamics over the exporter's life cycle, I estimate the same equation but without controlling for prices:

$$\ln p_{i,d,l,t} = \sum_{h=1}^{6} \beta^p_h \mathbb{I}^h_{\{age=h\}} + \gamma^a_{i,l,t} + \gamma^b_{d,l,t} + \gamma^c_{\text{cohorts}} + \varepsilon^p_{i,d,l,t}$$

in this case, β_h^p 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_1^p and β_1 are set to zero so that each estimate of $\{\beta_h\}_{h=1}^H$ or $\{\beta_h^p\}_{h=1}^H$ captures the cumulative change of the dependent variable to the exporter entry value. New exporters, the ones with an age equal to one, are defined as those exporters that did not export any positive amount to that product-destination market in the last three years.[18]

Results are presented in table A.2. Columns 1 to 4 show the estimation results using changes in quantities exported, columns 5 to 8 present the cumulative changes in export intensity, and columns 9 to 10 show the cumulative changes in prices over the exporters' life cycle. Results show that exporters tend to increase their exports and export intensity slowly, conditional on prices, while they do not seem to adjust relative prices across destinations. Consequently, exporters grow by shifting the intercept of their demand.

B.3 Volatility and exporter life cycle

Table A.3 presents the estimation of equation (10). Column 1 to 7 presents the results using the measure of domestic sales volatility as described by equation (9). Columns 5 to 7 estimate equation (10) conditional on those exporters with at least five and sixth years of tenure. Column 7 presents the results using the cumulative changes in total exported quantities instead of export intensity. Columns 8 and 10 use different measures of domestic volatility, as detailed below.

Robustness measure 2: A product weighted measure of firm's volatility exposure. - used in Column (8) - 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 for those firms with the same main export products at the sixth digit belonging to the product

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

category J. And take the average over time for each 6-digit product j. Denote this measure by sd_J^{hs6}

3. Compute the 6-digit product export share over the correspondingly 4-digit products for each firm i.

4. Compute the 6-digit product average share as the average share between 2006-2009 for all the firms selling that 6-product product.

5. Use the 6-digit product average computed in the previous step to weight the volatility computed in step 2 for each firm-4-digit product.

Robustness measure 3: Firm-level common shocks to construct volatility measure. The measure of volatility used in Column (9) is constructed as follows:

1. Restrict the sample to those exporters with at least two products and two countries of destination.

2. First compute the common changes in the exports of a firm i in time t, $\gamma_{i,t}$, to all its products and destination it's selling to by estimating:

$$\Delta exp_{i,l,d,t} = \gamma_{i,t} + \theta_{d,l,t} + e_{i,l,d,t} \tag{33}$$

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

Robustness measure 4: Product-specific shocks to construct volatility measure. The measure of volatility used in Column (10) is constructed as follows:

1. Restrict the sample to those exporters with at least two products and two countries of destination.

2. First compute the export firm-destination-product shocks, $\Delta e\hat{x}p_{i,l,d,t}$ by estimating:

$$\Delta exp_{i,l,d,t} = \theta_{d,l,t} + \Delta e\hat{x}p_{i,l,d,t} \tag{34}$$

3. Compute the cross-section standard deviation of $\Delta e\hat{x}p_{i,l,d,t}$ for all the firms other than i selling that 6-digit product.

4. Use the volatility in the previous step to take the firm-level average volatility.

The similar patterns documented suggest that the results are not driven by the possible selection due to firms' exit, neither by the measure of volatility used nor by the dependent variable. When I test for all these cases, the documented patterns are similar, and I can't reject the model's main predictions regarding the effects of volatility over exporters life cycle evolution.

C Model

C.1 Proofs

Lemma 1. Under monopolistic competition and linear production function, if the curvature of the revenue function is concave on firms' productivity, then a mean preserving spread reduces total exports. The contrary is valid for the convex case. Total exports can be written as:

$$Exp = A^{\alpha} \int p(z)\hat{q}(z)dF(z)$$

This is enough to prove that both $p(z)\hat{q}(z)$ and A^{α} are decreasing in volatility. So, let's start with the last term of the equation, where the argument follows Jensen's' inequality. Note that if revenues are concave on a firm's productivity, then $p(z)\hat{q}(z)$ is concave as A is given at any point in time. Define $g(z) := p(z)\hat{q}(z)$, then $\mathbb{E}_z[g(z)] = (\int p(z)\hat{q}(z)dz)$. Assume that Y is a random variable with a mean zero and independent of X. We can then define $X = Z + Y$ so that X is a mean preserving spread over Z. Now note that

$$\mathbb{E}_X[g(X)] = \mathbb{E}_Z[\mathbb{E}_Y[g(Z+Y)|_Z]] \leq \mathbb{E}_Z[g(Z+\mathbb{E}_Y[Y|_Z)]] = \mathbb{E}_Z[g(Z)]]$$

Where the inequality follows by Jensen's inequality.

I will show that A decreases volatility if revenues are concave. Note that because production is linear in labor and revenues concave, profits are concave in productivity, too. Note that by equation (2), are proportional to $\left\{\mathbb{E}_{F'}\left\{\hat{\pi}(z',1)|_{z=z}\right\}\right\}^{\frac{1}{1-\alpha}}$. By the argument above, $\mathbb{E}_{F'}\left\{\hat{\pi}(z',1)|_{z=z}\right\}$, will be decreased under a mean preserving spread.

Lemma 2. Under monopolistic competition and a linear production function with a continuous revenue function in firms' productivity, if the curvature of the revenue function in the model is miss-specified—assuming convexity instead of concavity with respect to firms' productivity—the model will estimate higher firm-level iceberg costs when volatility is reduced.

Let Exp^{e1} denote the total export from the data-generating process from Economy 1, and Exp^{e2} the data on total exports for Economy 2. For simplicity, assume the structural parameters of these economies are the same, except that for Economy 2, firms face a higher conditional volatility than Economy 1. By lemma 1, then we have that $Exp^{e1} > Exp^{e2}$.

Denote the log differences between these economies by $\Delta Exp = \ln Exp^{e1} - Exp^{e2}$. By lemma 1, this implies that in the actual data generating process $\Delta Exp > 0$.

Now, let's denote the predicted export change of the model with convex revenue function when we have a mean preserving spread over firms productivity as $\Delta Exp^{\text{convex model}}$. By lemma 1, a model with convex revenue function predicts $\Delta Exp^{\text{convex model}} < 0; as a mean, preserving spread in the$

Now, let's define $\ln \hat{\tau}$ as the difference between the prediction of the convex model and the actual data-generating process where profits are concave. Hence, we have that,

$$\ln \hat{\tau} := \Delta Exp - \Delta Exp^{\text{convex model}} > 0$$

By definition, then, we have

$$\ln \hat{\tau} = \ln(\frac{Exp^{e1}}{Exp^{e2}}) - \ln(\frac{Exp^{\text{convex model},e1}}{Exp^{\text{convex model},e2}}) > 0$$

So we get that,

$$\ln(\frac{Exp^{e1}}{Exp^{e2}}) = \ln(\frac{Exp^{convex,e1}}{Exp^{convex,e2}}) + \ln \hat{\tau}$$

Such that

$$\frac{Exp^{e1}}{Exp^{e2}} = \frac{Exp^{convex,e1}}{Exp^{convex,e2}\ \hat{\tau}^{-1}}$$

This implies that if the model revenue function is miss specified, using convex revenue functions, when the data generating process is concave, we will need the predicted exports by the convex model to be reduced by $\hat{\tau} > 1$ when we increase firms' productivity volatility to match the total export variation observed in the data. The adjustment must compensate for the predicted model increase in ΔExp^{convex} due to the revenue miss-specification.

Now, I show that conditional on all the structural parameters of the economy, except for those shaping the mean preserving spread, exists a marginal cost $\hat{mgc}$ that is higher than the actual marginal cost of production denoted by mgc for all firms, such that

$$\int rev(\hat{mgc})dF = Exp^{\text{convex model},e2}\ \hat{\tau}^{-1}$$

Hence is sufficient to show that there exists an $\hat{mgc}$, such that,

$$rev(\hat{mgc}) = \frac{rev(mgc)}{\hat{\tau}}$$

where mgc, is such that,

$$\int rev(mgc)dF = Exp^{\text{e2}}$$

It is sufficient to show that there exists an $\hat{mgc}$, such that,

$$rev(\hat{mgc}) = \frac{rev(mgc)}{\hat{\tau}}$$

To prove it, assume the contrary. We have two cases. The first case is $\hat{mgc} \leq mgc$ for some firms, and the previous equalities hold. Let's start with the case of equality for all firms since $\tau > 1$; this is a contradiction by lemma 1.

Now assume $\hat{mgc} < mgc$ for some firms, and for the rest, it holds with equality. Since $\hat{\tau} > 1$, this implies that revenues are increasing in the marginal cost- a contradiction.

The second case is that for every possible marginal cost higher than the benchmark one, we have that $\int rev(\hat{mgc})dF > Exp^{convex,e2}\ \hat{\tau}^{-1}$This implies that the revenue function is bounded below and above zero, as $\infty > \tau > 1$, and $Exp^{convex,e2} > Exp^{convex,e1} > 0$ by Lemma 1.

But by firms' problem if $\hat{mgc} \rightarrow \infty$ it implies that $p \rightarrow \infty$. Now we have two options. The first option is that as prices converge to infinity, revenues converge to infinity, but this implies revenues increase with the marginal cost of production, a contradiction. The second one is that revenues converge to zero as prices converge to infinity. This latter case implies that $Exp^{convex,e2}\ \hat{\tau}^{-1} < 0$— another contradiction by Lemma 1. Now that we know that $\hat{mgc} > mgc$, such that $\int rev(\hat{mgc})dF(z) = Exp^{convex,e2}\ \hat{\tau}^{-1}$, we can define the firm-level iceberg costs

$$\tau := \frac{\hat{mgc}}{mgc} > 1$$

which is the common firm-level iceberg cost needed by the convex revenue model to match the data after a mean preserving spread.

Lemma 3. Under monopolistic competition and linear production function, if the price elasticity is decreasing and sensitive enough to firms' prices, then revenues are a concave function of firms' productivity.

without loss of generality abstract from customer capital to facilitate the notation. Hence, revenues will be written as $rev(z) = p(z)q(p(z))$. We need to show that if price elasticity is sensitive enough, then we can have that, $\frac{\partial^2 rev(z)}{\partial^2 z} \leq 0$ Let's start by writing the revenue change relative to the firm's productivity as follows

$$\frac{drev(z)}{dz} = \frac{dp}{dz}\left[q + p\frac{\partial q}{\partial p}\right]$$

Now take the second difference,

$$\frac{d^2 rev(z)}{dz^2} = \frac{d^2 p}{dz^2}\left[q + p\frac{\partial q(p)}{\partial p}\frac{\partial p}{\partial z}\right] + \frac{dp}{dz}\left[2\frac{\partial q(p)}{\partial p}\frac{dp}{dz} + p\frac{\partial^2 q(p)}{\partial p^2}\frac{dp}{dz}\right]$$

Which we can group as

$$\frac{d^2 rev(z)}{dz^2} = \frac{d^2 p}{dz^2}\left[q + p\frac{\partial q(p)}{\partial p}\right] + \left(\frac{dp}{dz}\right)^2\left[2\frac{\partial q(p)}{\partial p} + p\frac{\partial q(p)}{\partial p} + p\frac{\partial^2 q(p)}{\partial p^2}\right]$$

Now, we know that $\frac{d^2 p}{dz^2} \geq 0$, as we assume the price elasticity decreases with firms' productivity, in constant with the; we also know that price elasticity is negative $\frac{\partial q}{\partial p} < 0$. Note that $\frac{\partial q}{\partial p} = \theta\frac{q}{p}$, where $\theta < -1$. Now let's denote the elasticity of the price elasticity to the firm's price as $\eta_{-\theta,p}$, and note that the second derivative of quantities with respect to prices is,

$$\frac{\partial^2 q}{\partial p^2} = \left[\eta_{-\theta,p} - 1 + \theta\right] \frac{\theta q}{p^2}$$

Then, we can rewrite the second derivative of the revenue function as

$$\frac{d^2 rev(z)}{dz^2} = \underbrace{\frac{d^2 p}{dz^2} \left[q(1+\theta)\right]}_{<0} + \left(\frac{dp}{dz}\right)^2 \left[2\frac{\theta q}{p} + \left[\eta_{-\theta,p} - 1 + \theta\right] p \frac{\theta q}{p^2}\right]$$

So we have that,

$$\frac{d^2 rev(z)}{dz^2} = \underbrace{\frac{d^2 p}{dz^2} \left[q(1+\theta)\right]}_{<0} + \left(\frac{dp}{dz}\right)^2 \frac{\theta q}{p} \left[1 + \eta_{-\theta,p} + \theta\right]$$

Note that in the case of constant price elasticity, we have $\eta_{-\theta,p} = 0$; hence, the second term is positive. But, when the price elasticity is not constant $\eta_{-\theta,p} > 0$. Furthermore, if $\eta_{-\theta,p} > -\theta - 1 > 0 \forall z$, then the second term is negative, and we have that $\frac{d^2 rev(z)}{dz^2} < 0$.

D Algorithm

The model only needs to solve for the economy's steady state given different parameters for σ and its counterpart adjustment in μ and ρ, such that we only do a mean preserving spread over the conditional volatility of firms' productivity.

Given the high non-linearities of the firm's problem, I solve the model using global methods. First, the firms' domestic decisions are static, and we only need to solve them for optimal prices. To solve for the export decision, firms need to know their customer capital level A, their productivity z_i, and domestic wages, w, with which they need to make a proper forecast for z_i', and w'. In principle, firms need to know the firm's distribution to solve for w and w'. But because I will solve for the steady distribution, instead of using the firms' distribution as a state variable, which is infeasible, or using the Krussel-Smith method, I will use wage prices as a state variable, which is sufficient to characterize the firm's decision, given the assumption of the small open economy.

To solve for the economy's aggregate equilibrium, I proceed as follows: When calibrating the model, I set the wage equal to one. This allows me to set wages equal to one in the baseline economy without any changes. For each change in the volatility parameters, I solve for the whole value function, policy functions, and aggregate economy again.

For each parameter value, the solution is computed as follows:

1. Fix the parameter values of the problem. and pre-set ε to small value.
2. Set a grid space of $(20X85X10)$ for firms' productivity, customer capital, and wages. Solve for the optimal value function and optimal policy function using global methods.
3. Pre-set wages to w^n
4. Use the obtained optimal policy function to expand the grid space to $(100X120)$ possible grid points for state variable. Compute a Markov transition matrix for the firms' measure for state variable, $H(.)$ conditional on wages w^n
5. Pre-set a non-degenerate aggregate distribution Ψ^j, conditional on wage w^n
6. Update Ψ using the Markov transition matrix until $|\Psi^{j+1} - \Psi^j| \leq \varepsilon$
7. Using Ψ, compute the aggregate variable and the domestic choke price p_d^c
8. Compute the excess labor demand $\Delta L = L^d - L^s$.
9. If the labor excess demand $|\Delta L| > \varepsilon$, update $w^n = w^{n+1}$ and start from 3 again.

I fix a wage level, and using the expanded space, I compute the Markov transition matrix for each firm state based on the firms' optimal decision, conditional on the pre-set wage. Using the transition matrix, I can update the aggregate distribution until it converges, given a wage. Then, after solving for all the equilibrium objects, I can construct a labor demand and supply and check if the labor market is clear. If it is not, I adjust wages and start the process again.

E Appendix Tables

Table A.1: Robustness Microeconomic Volatility and Exports

	Dependent variable: Av. Exp							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ln(GDP per capita)	1.81***	1.27***	0.92***	1.23***	0.98***	0.92***	0.94***	0.93***
	[0.20]	[0.15]	[0.16]	[0.16]	[0.15]	[0.17]	[0.16]	[0.16]
ln(Micro Volatility)			-1.44**		-1.62***			
			[0.62]		[0.49]			
ln(Micro Volatility$^{tfp}_{NonExpo}$)						-0.96**		
						[0.46]		
ln(Micro Volatility$^{\text{tfp}}_{All}$)							-0.84*	
							[0.46]	
ln(Micro Volatility$^{\text{Common}}$)								-0.14**
								[0.07]
Observations	35211	35211	35211	35211	35211	35211	35211	35211
R^2	0.75	0.85	0.91	0.89	0.93	0.93	0.92	0.93
Number of countries	38	38	38	38	38	38	38	38
Gravity Controls	Size	All	All	All	All	All	All	All
Doing Business	-	Exp	Exp	All	All	All	All	All

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

Table A.2: Exporters Life Cycle

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	$\exp^q$	$\exp^q$	$\exp^q$	$\exp^q$	$\frac{exp}{\text{Tot. sales}}$	$\frac{exp}{\text{Tot. sales}}$	$\frac{exp}{\text{Tot. sales}}$	$\frac{exp}{\text{Tot. sales}}$	$\ln(p)$	$\ln(p)$
$\mathbb{I}_{\{age_{ildt}=2\}}$	0.11***	0.13***	0.16***	0.21***	0.06***	0.08***	0.11***	0.17***	-0.02	-0.02
	[0.02]	[0.02]	[0.02]	[0.04]	[0.02]	[0.02]	[0.02]	[0.04]	[0.01]	[0.02]
$\mathbb{I}_{\{age_{ildt}=3\}}$	0.25***	0.31***	0.39***	0.59***	0.17***	0.20***	0.28***	0.42***	0.01	0.02
	[0.03]	[0.03]	[0.04]	[0.06]	[0.03]	[0.03]	[0.04]	[0.08]	[0.02]	[0.02]
$\mathbb{I}_{\{age_{ildt}=4\}}$	0.35***	0.43***	0.55***	0.68***	0.22***	0.26***	0.38***	0.48***	0.00	0.04
	[0.03]	[0.04]	[0.05]	[0.09]	[0.03]	[0.04]	[0.05]	[0.09]	[0.02]	[0.03]
$\mathbb{I}_{\{age_{ildt}=5\}}$	0.37***	0.48***	0.59***	0.60***	0.22***	0.29***	0.39***	0.34**	0.02	0.01
	[0.05]	[0.06]	[0.07]	[0.14]	[0.04]	[0.05]	[0.07]	[0.15]	[0.03]	[0.04]
$\mathbb{I}_{\{age_{ildt}=6\}}$	0.43***	0.50***	0.72***	0.65***	0.29***	0.32***	0.51***	0.46**	-0.00	-0.01
	[0.07]	[0.08]	[0.09]	[0.15]	[0.06]	[0.08]	[0.10]	[0.18]	[0.04]	[0.05]
$\mathbb{I}_{\{age_{ildt}=7\}}$	0.45***	0.49***	0.73***	0.90***	0.39***	0.43***	0.63***	1.17***	-0.01	-0.03
	[0.13]	[0.14]	[0.17]	[0.32]	[0.14]	[0.14]	[0.18]	[0.41]	[0.06]	[0.09]
Observations	55,315	51,950	37,061	17,254	52,446	49,129	34,650	51,950	17,254	15,381
R^2	0.18	0.31	0.41	0.58	0.15	0.25	0.36	0.88	0.97	0.53
Year × Dest. FE	✓	✓	✓	-	✓	✓	✓	-	✓	-
Year × Product FE	✓	✓	-	-	✓	✓	-	-	-	-
Year × Firm FE	-	✓	-	-	-	✓	-	✓	-	-
Year × Firm × Product FE	-	-	✓	✓	-	-	✓	✓	✓	✓
Year × Product × Dest. FE	-	-	-	✓	-	-	-	✓	-	✓

Note: New exporters entered the export market and have not exported that 6-digit product to that destination in at least the past three years. All exporters are continuing exporters until each year. Error cluster at the destination country. $exp.^q$ denotes the use of quantities cumulative change as dependent variable (columns 1 to 4), $\frac{exp}{\text{Tot. Sales}}$ use the ratio of nominal exports to domestic sales instead (columns 5 to 8). Columns 9 and 10 use prices as the dependent variable. Error cluster at the 6-digit product. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A.3: Volatility and Exporters Life Cycle

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	$\Delta\frac{\text{exp}}{\text{Tot. sales}}$	$\Delta\frac{\text{exp}}{\text{Tot. sales}}$	$\Delta\frac{\text{exp}}{\text{Tot. sales}}$	$\Delta\frac{\text{exp}}{\text{Tot. sales}}$	$\Delta\frac{\text{exp}}{\text{Tot. sales}}$	$\Delta\frac{\text{exp}}{\text{Tot. sales}}$	Δexp^q	$\Delta\frac{\text{exp}}{\text{Tot. sales}}$	$\Delta\frac{\text{exp}}{\text{Tot. sales}}$	$\Delta\frac{\text{exp}}{\text{Tot. sales}}$
$\mathbb{I}_{\{age_{ildt}=2\}} \times \ln\text{Vol.}$	0.01	-0.01	0.00	0.00	-0.01	-0.09	-0.05	0.01	-0.09*	0.06
	[0.03]	[0.03]	[0.04]	[0.04]	[0.06]	[0.07]	[0.06]	[0.02]	[0.05]	[0.09]
$\mathbb{I}_{\{age_{ildt}=3\}} \times \ln\text{Vol.}$	0.00	0.00	-0.00	-0.02	-0.11	-0.24*	-0.19**	-0.01	-0.07	-0.03
	[0.04]	[0.04]	[0.05]	[0.06]	[0.09]	[0.13]	[0.09]	[0.03]	[0.07]	[0.13]
$\mathbb{I}_{\{age_{ildt}=4\}} \times \ln\text{Vol.}$	-0.08	-0.08	-0.10	-0.09	-0.25*	-0.46**	-0.27**	-0.06	-0.11	-0.14
	[0.05]	[0.05]	[0.07]	[0.09]	[0.13]	[0.20]	[0.12]	[0.04]	[0.10]	[0.17]
$\mathbb{I}_{\{age_{ildt}=5\}} \times \ln\text{Vol.}$	-0.21***	-0.21***	-0.26***	-0.34***	-0.56***	-0.79***	-0.63***	-0.18***	-0.35**	-0.79***
	[0.08]	[0.08]	[0.10]	[0.12]	[0.18]	[0.27]	[0.20]	[0.06]	[0.17]	[0.26]
$\mathbb{I}_{\{age_{ildt}=6\}} \times \ln\text{Vol.}$	-0.41***	-0.46***	-0.54***	-0.66***	-0.82***	-1.23***	-0.74***	-0.21***	-0.88***	-0.88**
	[0.14]	[0.14]	[0.17]	[0.19]	[0.29]	[0.38]	[0.28]	[0.08]	[0.30]	[0.42]
$\mathbb{I}_{\{age_{ildt}=7\}} \times \ln\text{Vol.}$	-	-	-	-	-	-	-0.86**	-	-	-
	-	-	-	-	-	-	[0.35]	-	-	-
Observations	24,038	23,930	23,349	17,496	11,364	8,326	13,141	17,513	17,502	18,789
Year × Dest. FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year × Product FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year × Firm FE	-	-	Only Firm	✓	✓	✓	✓	✓	✓	✓
Year × Firm × Product FE	-	-	-	✓	✓	✓	✓	✓	✓	✓
Total tenure	≥ 3	≥ 3	≥ 3	≥ 3	≥ 5	≥ 6	≥ 5	≥ 3	≥ 3	≥ 3
Measure	Bench.	Bench.	Bench.	Bench.	Bench.	Bench.	Bench.	Measure 2	Measure 3	Measure 4

Note: The table presents the estimation of equation (10). Columns 1 to 7 use the benchmark measures of domestic exposure to volatility. Column 7 uses the change in export quantities, denoted by $\Delta exp.^q$, instead of the changes in export intensity. Columns 8 to 10 use the other measures of volatility described in B.3. Total tenure denotes the minimum years exporters continuously export to each market in the sample. Error cluster at the firm level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A.4: Robustness for Markups Estimates

	(OLS)	(IV)	(OLS)	(IV)	(IV)	(IV)	(IV)
Panel 1: First Stage							
	Dependent variable: Δex. rate$_{d,t}$ $\times$ $share_{i,l,d,t-1}$						
	-	$\Delta e \times share$	-	$\Delta e \times share$	$\Delta e \times share$	$\Delta e \times share$	$\Delta e \times share$
Δremit$._{\neq d,t}$ $\times$ $share_{.,07}$		0.28^{***}		0.28^{***}	0.29^{***}	0.28^{***}	0.36^{***}
		[0.03]		[0.03]	[0.03]	[0.03]	[0.04]
Panel 2: Second Stage (Prices)							
	Dependent variable: $\Delta \log p$						
Δexchange rate $\times$ *share*	0.11	0.82^{***}	0.09	0.65^{**}	0.59^{**}	0.69^{**}	1.15^{**}
	[0.08]	[0.29]	[0.10]	[0.29]	[0.28]	[0.30]	[0.56]
Panel 3: Second Stage (Quantities)							
	Dependent variable: $\Delta \log q$						
Δexchange rate $\times$ *share*	0.77^{***}	-3.21^{***}	0.25	-2.09^{***}	-3.21^{***}	-2.17^{***}	-3.34^{***}
	[0.21]	[0.70]	[0.21]	[0.62]	[0.70]	[0.62]	[0.80]
Observations	62,357	62,357	58,781	58,781	58,781	57,774	45,053
F-statistic	-	80.68	-	101.81	108.22	97.16	65.15
Firm-product-time FE	✓	✓	✓	✓	✓	✓	✓
Destination-product-time FE	✓	✓	✓	✓	✓	✓	✓
Firm-product-Destination FE	-	-	✓	✓	-	✓	✓
Controls $\times$ $share_{i,l,d,t}$	Agg. prices	Agg. prices	All	All	All	All	All
Continue exporting in $t+1$	-	-	-	-	-	✓	-
After year 2012	-	-	-	-	-	-	✓

Note: Columns 1 - 4 are the same as Table 2. Continue exporting denotes the case when the sample is restricted to exporters that export the following year. After the year 2012 denotes the robustness case when export shares are fixed in 2012, and the sample is taken after 2012. Standard errors are in brackets. Error cluster at the destination country. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$