International Trade, Volatility, and Income Differences

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Abstract

This paper presents a unified explanation for two puzzles in trade and development: developing countries' unexplained high export costs and the negative correlation between firm-level volatility and exports. I propose a novel general equilibrium model featuring heterogeneous firms, variable demand elasticity, and exporter dynamics. Under this framework, downturn profit losses outweigh boom gains, reversing the "Oi-Hartman-Abel" effect typically found in heterogeneous firm models. Consequently, firm-level volatility discourages exporting and investment, significantly reducing income and aggregate exports. Quantitatively, the model explains a substantial share of the puzzling cross-country export cost differences and the observed negative relationship between firm-level sales volatility and both income and exports. *JEL* Codes: F10,F12, F14, L11, O11, D81

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1 Introduction

The stark disparity in living standards across the globe is mirrored in international trade patterns. Developed nations engage in more trade, with a greater number of larger and more persistent exporters (Besedeš, 2011; Fernandes et al., 2015; Hummels and Klenow, 2005). Existing research explains these patterns by estimating higher common costs of exporting in developing economies (Blum et al., 2019; de Sousa et al., 2012; Waugh, 2010). However, the underlying causes of these higher common costs remain unclear. This paper provides an answer: firm-level productivity volatility acts as an unmeasured trade barrier, explaining why developing countries appear to face higher export costs. Standard models miss this channel because they predict volatility increases exports—the opposite of what the data show.

My theory resolves two puzzles: the negative correlation between firm-level volatility and trade (Alessandria et al., 2015; Baley et al., 2020), and the high export costs of developing economies (Blum et al., 2019; de Sousa et al., 2012; Waugh, 2010). The key insight is that variable price elasticity makes profits concave in productivity. When combined with dynamic export investment, higher volatility discourages firms from expanding abroad, reducing exports and income. Quantitatively, reducing volatility from the median to the first quartile increases exports by around 84%.

The dampening effect of volatility on exports and overall income is rooted in two crucial factors, typically absent in standard models with firm heterogeneity but present in the micro-level data: variable price elasticity of demand (henceforth, price elasticity) and dynamic export decisions. When price elasticity increases sufficiently with respect to firm prices, reductions in profits during downturns outweigh potential gains in upswings. This has a negative effect on expected profits and total sales, thereby reversing the standard "Oi-Hartman-Abel" effect, in which higher volatility typically increases expected returns and production.[1] This static channel operates through markup adjustments. Dynamic export decisions further amplify the negative relationship: domestic firm-level volatility discourages firms from investing in expanding foreign sales, hindering their growth and resilience, ultimately resulting in significantly lower exports and income.

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

I begin with a simplified model to build intuition and derive four key results that guide the empirical and quantitative analysis. First, I demonstrate that a mean-preserving spread in firms' productivity reduces total trade if firms' revenue functions are concave in productivity. Second, I show that this concavity critically depends on how price elasticity varies with firm prices: sufficiently variable price elasticity can generate concave revenue functions. Third, when exporters invest in customer capital to increase foreign sales, the negative impact of firm-level volatility on total trade is intensified due to reduced exporter growth. Fourth, a misspecified revenue function leads the model to estimate that increases in export costs accompany rising firm productivity volatility, thereby matching the observed data. These last two results provide clear testable implications that I confront with data before performing quantitative analyses.

I test the model's assumptions and predictions using both micro-level and cross-country data. Using Colombian firm-level data, I find evidence consistent with variable price elasticity and exporter dynamics driven by shifts in foreign demand, as in Fitzgerald. et al. (2024) and Steinberg (2023). I also document that exporters facing higher firm-level volatility experience slower growth, as predicted by the model. I complement this micro evidence with cross-country data. Across countries, firm-level sales volatility is negatively correlated with GDP per capita and positively correlated with common export costs—the origin-specific component of trade frictions affecting all destinations, identified via standard gravity techniques (Fally, 2015; Waugh, 2010). Indeed, conditioning on volatility reduces the estimated development-common export cost relationship by approximately 30%. While these cross-country correlations do not imply causality, they provide key moments to test the model's quantitative evaluation.

To assess the full aggregate consequences of the proposed mechanism, I develop a general equilibrium model that quantifies the proposed mechanism. In the full quantitative model, firms face productivity shocks, self-select into exporting (as in Melitz, 2003), and incur sunk investments to build customer capital abroad, as in Fitzgerald. et al. (2024) and Steinberg (2023). However, unlike these previous works, I introduce variable price elasticity, akin to Klenow and Willis (2016) and Edmond et al. (2023). The quantitative model nests four different models, whose combinations are defined by: (1) the existence or absence of exporter dynamics and (2) the existence or absence of variable price elasticities. To discipline the parameters underlying these microeconomic behaviors, I match the micro-level estimates in the model through indirect inference.

The quantitative results provide strong support for the proposed mechanism. Specifically, my proposed model predicts negative correlations between firm-level domestic sales volatility, GDP per capita, and total trade, as well as an income-exports relationship consistent with the data. Notably, a reduction in firms' productivity volatility that moves a country from the median to the first quartile of firm-level sales volatility increases exports by 84%. However, when variable markups are shut down, the model predicts a positive correlation among firm-level sales volatility, total trade, and income, which is inconsistent with empirical evidence. This demonstrates that sunk cost investment in customer capital alone is insufficient to explain the observed negative volatility-export relationship (Alessandria et al., 2015). Nevertheless, when variable markups are included, sunk investment in customer capital becomes important. The investment decision amplifies the negative effects of changes in firms' productivity volatility on total trade by nearly 60%, underscoring the importance of dynamic intensive margins.

The proposed mechanism also has significant implications for the effect of firm productivity volatility on income. Consider, for example, an increase in firm-level productivity volatility that moves a country from the first or second quartile to the third quartile of firm-level sales volatility; this would reduce GDP per capita by about 35% and 25%, respectively. This highlights the mechanism's substantial role in explaining how firm-level productivity volatility differences affect development.

In essence, this paper identifies a novel mechanism through which volatility and uncertainty in firms' productivity discourage firms from investing in expansion over their life cycle, reducing both income and total trade. Firm-productivity volatility creates significant trade barriers that are negatively correlated with income and distinct from traditional trade policy-driven barriers. These findings have two policy implications. First, non-trade policies that reduce firm-level volatility can significantly foster trade and development, challenging the view that trade gains depend solely on trade policy. Second, reducing volatility-driven barriers may be particularly difficult for developing economies, as history suggests.

Literature. This paper contributes to several literatures at the intersection of international trade, firm dynamics, and development.

First, I provide a novel explanation for why developing economies face higher export costs, offering a micro-founded resolution to the puzzling negative correlation between firm-level volatility and trade (e.g. Alessandria et al., 2015; Baley et al., 2020; Handley and Limão, 2022). While this pattern is well documented (e.g. Blum et al., 2019; de Sousa et al., 2012; Waugh, 2010), its causes remain unclear. I show that cross-country differences in firm-level productivity volatility generate an export cost-income relationship consistent with the data, without relying on exogenous cost differences, consistent with my novel empirical evidence.

Second, I propose a novel mechanism through which firm-level volatility reduces trade and income. Standard models with firm heterogeneity, even with sunk-cost investment, predict that volatility in firms' productivity increases exports, inconsistent with the data (e.g. Alessandria et al., 2015; Baley et al., 2020). Existing explanations rely on risk aversion (e.g. Esposito, 2022; Handley and Limão, 2022; Limão and Maggi, 2015). I show that variable price elasticity generates concave profit functions, reversing the standard prediction without assuming risk aversion. This mechanism also contributes to understanding how idiosyncratic volatility affects development. Unlike existing work focusing on macro and financial frictions(e.g. Aghion et al., 2010; Koren and Tenreyro, 2007; Ramey and Ramey, 1995), I show that firm-level volatility also affects income through a distinct channel: markup adjustments and export investment.

Third, I contribute to the literature on exporter dynamics (Eaton et al., 2007; Fitzgerald. et al., 2024; Ruhl and Willis, 2017; Steinberg, 2023). I document that domestic firm-level volatility slows the growth of new exporters, and I develop a framework that combines customer capital investment (as in Fitzgerald. et al., 2024; Steinberg, 2023) with variable price elasticity (as in Arkolakis and Morlacco, 2017; Edmond et al., 2023) that explains this fact. My empirical strategy for identifying variable markups builds on Amiti et al. (2014), extending their approach by fully controlling for changes in marginal cost to isolate markup adjustments.

Lastly, my model reconciles two seemingly contradictory findings: variable markups across the cross-section that correlate with exporters' shares, and stable prices over exporters' life cycles as they increase their market share in the destination market. I solve this by showing that markups vary across firms due to differences in relative prices, which indirectly relates to firms' market share, but individual exporters grow through demand shifts in the intercept of the demand rather than price adjustments.

Layout. In Section 2, I start with a simplified model to highlight the mechanism's intuition. Section 3 presents the data. Section 4 uses micro-level data to test the model's main assumptions.

Section 5 presents the cross-country conditional correlations. Section 6 introduces the general equilibrium model, and Section 7 introduces the quantitative predictions of the baseline model and its version without the proposed mechanism. Section 8 concludes.

2 The mechanism in a simple example

This section highlights the mechanism's intuition in a simple example model. It begins by showing how the curvature of firms' revenue functions determines the effect of firm-level volatility on exports. Then, it illustrates how the curvature of the revenue function is affected by assumptions about the price elasticity of demand. The basic result is that when price elasticity varies sufficiently with prices, the profit function becomes concave. The concavity of profit and revenue functions implies that mean-preserving spread over firms' productivity tends to reduce firms' exports through both static sales and investment decisions.

A continuum of firms solves a two-period problem. Each firm has customer capital A, draws export status $m \sim Bernoulli(\iota)$, and produces using linear technology with productivity $z \sim F(z)$, having standard deviation σ_z. Firms' investment to expand their customer capital is sunk and occurs before the productivity shock z_i and the realization of the export status. The firm's demand is given by:

$$q(A, p, Q^f) = A^\alpha \hat{q}(p) Q^f, \tag{1}$$

A^α is the demand shifter that depends on firms' customer capital, $\hat{q}(p) := q(1, p)$ is the static component of demand depending on price, p, and Q^f is the foreign economy's total expenditure - which is constant for now. The firm's static problem is to choose a price to maximize its profit function, $\pi(A, z, m)$, given z and m. Firms' optimal profits can be rewritten as

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

where $\hat{\pi}(z, m) := \pi(1, z, m)$. When $m = 0$, then $\hat{\pi}(z, 0) = 0$. The firms' dynamic problem is:[2]

$$\max_{A' \in [0;\infty)} A^\alpha \hat{\pi}(z, m) - wA' + \beta \mathbb{E}_{z'} \{ A'^\alpha \hat{\pi}(z', m') \,|\, z \} \tag{2}$$

[2] Firms use labor to invest in customer capital, which fully depreciates in the last period.

If firms decide to invest, tomorrow's customer capital is given by

$$A'(z) = \left\{ \frac{\alpha \iota \beta}{w} \mathbb{E}_{z'} \left\{ \hat{\pi}(z', 1)|_{z=z} \right\} \right\}^{\frac{1}{1-\alpha}} \tag{3}$$

Equation (3) shows that the curvature of profits with respect to productivity determines how firm-level volatility affects investment. A mean-preserving spread in $F(z)$ increases the likelihood of both better and worse productivity outcomes. When profits are concave, the expected reduction in profits from worse outcomes outweighs the gains from better outcomes, lowering the expected return on the investment. The opposite holds when profits are convex. The opposite holds when profits are convex. This leads to the first key result:

Proposition 1. *Under monopolistic competition and linear production function, if the revenue function is continuous and concave (convex) on firms' productivity, then a mean-preserving spread over the firms' idiosyncratic productivity shocks reduces (increases) exporters' growth.*

Proof: *See appendix A*

Proposition 1 shows that exporters' growth is differentially affected by idiosyncratic productivity volatility, depending on the shape of their revenue function. I will revisit this implication and test it in the empirical section.

These results have direct implications for aggregate exports. To show this, I simplify the analysis by assuming that firms' productivity follows an independent and identically distributed (iid) process. Next period's total exports are given by:

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

where $A'(z) = A \ \forall \ z$ since $z \sim iid$. Define $G(z)$ as a mean-preserving spread of $F(z)$, and denote variables x_G as any variable x derived under distribution $G(z)$. We can write the log export ratio between a country with low and high firm-level volatility as,

$$\ln\left(\frac{Exp_G}{Exp}\right) = \underbrace{\ln\left(\frac{A_G^{\alpha}}{A^{\alpha}}\right)}_{\text{dynamic response}} + \underbrace{\ln\left(\frac{\int p(z)\hat{q}(z)dG(z)}{\int p(z)\hat{q}(z)dF(z)}\right)}_{\text{static response}} \tag{4}$$

Equation (4) decomposes the total export response into two components: (1) a dynamic response through customer capital investment, and (2) a static response through the productivity distribution. We saw that if profits are concave, a mean-preserving increase decreases the dynamic response. Lemma 1 expands the result to total exports.

Lemma 1. *If the production function is linear in inputs and the curvature of the revenue function is concave (convex) regarding firms' productivity, then a mean-preserving spread over firms' productivity reduces (increases) total exports.*

Proof: *See appendix A*

Lemma 1 follows from two effects: the dynamic effect of higher volatility on customer capital investment (Proposition 1), and the static effect on total sales through changes in the productivity distribution. The latter implies that, under a mean-preserving spread, if revenues are concave, gains from positively affected firms are offset by losses from negatively affected firms; the converse holds for the convex case. Before analyzing how demand assumptions affect revenue curvature, I examine their implications for trade cost estimation.

The result in Lemma 1 has implications for empirical work: assuming convex revenues when they are concave biases export cost estimates. This is formally proved in Proposition 2. For example, assuming convexity when revenue is concave spuriously predicts a positive volatility-export relationship. To match the data, the misspecified model requires overestimating the export costs as volatility increases. Ignoring dynamic export decisions similarly biases results as shown in equation (4).

Proposition 2. *Under monopolistic competition and linear production function, if the revenue function is continuous and misspecified, assuming convexity instead of concavity, the convex model will over-estimate the export costs for an economy with a mean-preserving spread on firms' productivity.*

Proof: *See appendix A*

The previous results showed the importance of the shape of the profit function in understanding how a mean-preserving spread affects total exports. We can now turn to examine how assumptions about demand price elasticity affect the curvature of the revenue function.

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

Proof: *See appendix A*

The intuition of Proposition 3 is as follows. Productivity increases revenue via lower prices and higher quantities. Under constant elasticity, the entire productivity gain passes through to lower prices, generating a more-than-proportional increase in quantity and revenue. However, when price elasticity falls with prices, firms moderate price cuts, raising markups and weakening the direct price effect. Simultaneously, demand becomes less price-sensitive, dampening the quantity response. This can lead to a concave revenue-productivity relationship depending on the elasticity's responsiveness to prices. This result is similar to the specific case shown in Klenow and Willis (2016).

Proposition 3 explains why the models with constant elasticity fail to generate a negative relationship between firm-level volatility and total exports. They generate a convex revenue function in firms' productivity. Crucially, the proposition also implies that the presence of variable price elasticity is insufficient to guarantee a concave revenue function. The model's capacity to generate concave revenue depends on the degree of variability in price elasticity. Therefore, in the quantitative section, I estimate the key parameters governing this variability using indirect inference.

The key insight is that variable price elasticity can reverse the standard volatility-exports relationship. The following sections test the model's main assumptions—variable markups and exporter dynamics—using micro-level data, then examine cross-country predictions. I subsequently extend the model to a general equilibrium to quantify the mechanism's aggregate relevance.

3 Data

Testing the mechanism requires both cross-country data on trade and volatility, and firm-level data to identify markup behavior and exporter dynamics. I use four main sources. To document the aggregate facts, I use two main data sources: the Enterprise Survey from the World Bank and the Trade and Production Database (TradeProd) from CEPII. [3]

Cross-country data. The TradeProd database offers several advantages. It covers 162 countries and nine industrial sectors over the period 1966-2018. Importantly, it reports both domestic and foreign sales, which facilitates the estimation of common export costs. It also allows me to exploit a border dummy to quantify the differential impact of firm-level volatility on export relative to domestic sales, which I do in the appendix. The database includes additional control variables, which I supplement by merging with the CEPII Gravity database (Conte et al., 2022). This allows

[3] For details regarding the (TradeProd) database see (de Sousa et al., 2012; Mayer et al., 2023).

me to estimate bilateral and aggregate common export costs, conditional on important country characteristics.

A limitation is the database's sectoral scope: it includes only nine aggregated industrial sectors. This is not a primary concern, however, since the main mechanism operates through firm-level markup adjustments and customer capital investment—features most relevant for differentiated industrial sectors rather than homogeneous commodities.[4]

For cross-country firm-level statistics, I use the World Bank Enterprise Surveys (WBES, 2006–2024), which covers 160+ economies with nationally representative samples designed for cross-country comparability. I use the provided weights throughout.[5] Two limitations of the WBES are uneven data availability across countries and potential bias toward the formal sector. Neither is likely to affect results: the missing data is unrelated to the paper's question, and exporters predominantly operate in the formal sector.

Firm-level data. For the micro-level analysis and model estimation, I turn to Colombian administrative data from two 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 customs data reports firm-level exports at the 8-digit product level by destination and month, including quantities and values in both Colombian pesos and U.S. dollars, over the period 2006–2019. I aggregate annual firm-product-destination flows to address the usual lumpiness in trade data.

I merge the custom data with firm-level data from "Superintendencia de Sociedades", which reports the variables from firms' balance sheet information. This dataset provides information on firms' total income, operational income, operational cost, total costs, profits, and operational profits. These variables are in nominal Colombian Pesos, which I deflate with the production price index when needed. The data sets cover a sub-sample of 20,000 firms a year between 2006 and 2015. These firms are the largest in the economy, representing around 90% of total value-added.[6]

[4]For more details, see Mayer et al. (2023)

[5]Details regarding the sample methodology can be found in the WBES sampling note available here.

[6]The sample is skewed toward larger firms, but this is less concerning given that exporters are predominantly large firms.

4 Firm-level facts.

This section tests the model's key assumptions using the Colombian firm-level data described in Section 3. The objectives are twofold: to provide evidence for the mechanism's existence, and to obtain moments and parameters for model calibration.

4.1 Markups and firm size

Motivation. As will be clear in the model section, markup responses depend on the exporter's price relative to the choke price. This relative price can be proxied by market share (Amiti et al., 2014; Arkolakis and Morlacco, 2017).

Testing whether markup responses vary with market share requires isolating markup variation from price data. This is challenging because observed export prices reflect both markups and marginal costs, the latter comprising production and distribution costs. I address this with an estimation procedure that uses high-dimensional fixed effects to absorb both cost components, leaving residual price variation that identifies markup changes.

To see the identification strategy, assume firm i's price for product l sold to destination d is set in foreign currency:

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

where $e_{d,t}$ is the bilateral exchange rate, $\mu_{i,l,d,t}$ is the markup, and $Mc_{i,l,d,t}$ denotes marginal cost in domestic currency. Further assume, as is standard, that marginal cost has two components: production costs common to all destinations ($Mc_{i,l,t}$), and destination-specific selling costs ($\tau_{l,d,t}$):

$$\ln Mc_{i,l,d,t} = \ln Mc_{i,l,t} + \ln \tau_{l,d,t}$$

Log-differencing prices and taking derivatives with respect to a generic variable $x_{i,l,d,t}$ yields:

$$\frac{\partial \Delta \ln p_{i,l,d,t}}{\partial x_{i,l,d,t}} = \frac{\partial \Delta \ln \mu_{i,l,d,t}}{\partial x_{i,l,d,t}} + \underbrace{\frac{\partial \Delta \ln Mc_{i,l,t}}{\partial x_{i,l,d,t}}}_{\text{absorbed by } \theta_{i,l,t}} + \underbrace{\frac{\partial \Delta \ln \tau_{l,d,t}}{\partial x_{i,l,d,t}} - \frac{\partial \Delta \ln e_{d,t}}{\partial x_{i,l,d,t}}}_{\text{absorbed by } \gamma_{l,d,t}} \tag{5}$$

The key insight from equation (5) is that two sets of fixed effects isolate markup responses: firm-product-time effects ($\theta_{i,l,t}$) absorb production costs common across destinations, while product-destination-time effects ($\gamma_{l,d,t}$) absorb selling costs and exchange rates. The residual variation identifies markups.

Empirical specification. Given the previous identification strategy, I estimate the heterogeneous markup responses by interacting exchange rate changes with export share in the destination market. Firm's export share is given by:

$$\text{exp. share}_{i,l,d,t} = \frac{\text{exports}_{i,l,d,t}}{\sum_{j\in\mathscr{J}_{d,l,t}} \text{exports}_{j,d,l,t}}$$

where $\mathscr{J}_{d,l,t}$ denotes the set of Colombian firms exporting product l to destination d in year t. I then estimate:

$$\Delta p_{i,l,d,t} = \beta_1 \Delta e_{d,t} \times \text{exp. share}_{i,l,d,t-1} + \boldsymbol{\beta}\text{exp. share}_{i,l,d,t-1} \times \boldsymbol{X} + \theta_{i,l,t} + \gamma_{i,l,d} + \gamma_{l,d,t} + e_{i,l,d,t} \quad (6)$$

where Δ denotes log differences over a year, and $\boldsymbol{X}$ includes a constant, log changes in destination import prices, Colombian aggregate export prices, and destination real GDP. The fixed effects $\gamma_{i,l,t}$, $\gamma_{i,l,d}$, and $\gamma_{l,d,t}$ denote firm-product-time, firm-product-destination, and product-destination-time effects, respectively.

The coefficient β_1 captures how markup responses to exchange rate movements vary across firms with different market shares. This is because, as discussed above, the firm-product-time fixed effects absorb all marginal cost changes. This is especially important because, as Amiti et al. (2014) discuss, larger exporters tend to be more import-intensive, creating a correlation between market share and marginal cost changes that my specification absorbs.

One concern remains: if exchange rate movements reflect destination-market conditions, they may directly affect exporters' market shares, thereby biasing β_1. To address this endogeneity, I instrument the bilateral exchange rate variation (interacted with firms' 2007 market shares) using remittance flows from third countries to Colombia ($remittances_{d,t}$) defined as follows:[7]

$$\text{remittances}_{d,t} = \sum_{k\in\mathscr{D}_{d,t}} \text{remittances}_{k,t}$$

where $\mathscr{D}_{d,t}$ denotes all remittance-origin countries other than destination dd d in year t.

The exclusion restriction requires that remittance inflows affect exporters' prices only through bilateral exchange rates. This is plausible: remittance flows are driven by migrants' income abroad, and family needs in Colombia (Mandelman, 2013), not by product-specific export con-

[7] Remittances to Colombia averaged 10% of total exports during this period, generating substantial exchange-rate variation that is plausibly orthogonal to destination-specific demand shocks.

ditions. The fixed effects absorb any direct impact on Colombian production costs, aggregate demand, or destination-specific conditions. The first-stage specification is:

$$\begin{aligned}\Delta e_{i,l,d,t} \times \text{exp. share}_{i,l,d,t-1} = \Delta remittances_{d,t} \times \text{exp. share}_{i,l,d,07} + \\ + \beta \text{exp. share}_{i,l,d,t-1} \times \mathbf{X} + \theta_{i,l,t} + \gamma_{i,l,d} + \gamma_{l,d,t} + \varepsilon_{i,l,d,t}\end{aligned} \tag{7}$$

Firm-level fact 1: Markup response increases with the firm's market share. Table 1 presents the estimation results. Panel 2 presents the main result: markup adjustments to cost shocks are increasing in exporter market share. A positive β_1 indicates that while an exchange rate depreciation allows exporters to lower prices, firms with larger market shares reduce prices less, choosing instead to raise markups. Specifically, a one percentage point higher market share is associated with a 0.65% to 0.82% higher markup response to a 1% depreciation. This pattern is consistent with the incomplete pass-through documented by Amiti et al. (2014) and the variable demand elasticity frameworks of Arkolakis and Morlacco (2017) and Edmond et al. (2023). This is the key to the mechanism: smaller firms cannot adjust markups, so negative shocks hit their profits harder. This asymmetry generates the concave profit function that reverses the standard volatility-investment relationship.

Panel 1 shows the first-stage estimates, confirming instrument strength with F-statistics ranging from 80 (column 2) to 101 (column 4), while Panel 3 provides a consistency check using quantities as the dependent variable. The OLS estimates indicate positive quantity responses, which are inconsistent with Panel 2 and suggest endogeneity bias. The IV estimates indicate negative quantity responses, implying demand elasticities between 2 and 5, consistent with the literature (Boehm et al., 2023; Simonovska and Waugh, 2014).

Appendix B.2 presents robustness checks in Table A.7. The results are robust to dropping firm-destination-product fixed effects, restricting the sample to continuing exporters, and using post-2012 data with market shares fixed in 2012.

4.2 Exporters' growth and firm-level volatility

I now turn to testing the model's assumption regarding new exporters' dynamics and its implications for exporters' growth under uncertainty highlighted in Section 2.

Table 1: Heterogeneous Markup Responses

	(OLS)	(IV)	(OLS)	(IV)
Panel 1: First Stage				
	Dependent variable: Δex. rate$_{d,t}$ $\times$ $exp.share_{i,l,d,t-1}$			
Δremittances$_{\neq d,t}$ $\times$ $exp.share_{i,l,d,07}$	-	0.28***	-	0.29***
	-	[0.03]	-	[0.03]
Panel 2: Second Stage (Prices)				
	Dependent variable: $\Delta \log p_{i,l,d,t}$			
Δexchange rate$_{d,t}$ $\times$ $exp.share_{i,l,d,t-1}$	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$_{d,t}$ $\times$ $exp.share_{i,l,d,t-1}$	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-Destination FE			✓	✓
Controls $\times$ $exp.share_{i,l,d,t}$	Agg. prices	Agg. prices	All	All

Note: All cases include Destination-product-time and Firm-product-time fixed effects. 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 $\times$ $expshare_{i,l,d,t}$ 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" denotes when only aggregate price changes are used, and "All" denotes the case, including GDP changes. Standard errors in brackets. Standard errors cluster at the destination country. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

Estimation. The evolution of customer capital is unobservable. However, equation (1) implies that customer capital can be identified from export intensity after controlling for relative price changes:[8]

$$\Delta \text{exp int}_{i,l,d,t} = \alpha \overbrace{\Delta A_{i,l,d,t}}^{\Delta \text{customer capital}} + \Delta \overbrace{\frac{\hat{q}(p_{i,l,d,t})}{\hat{q}(p_{i,l,\text{dom},t})}}^{\Delta \text{relative price}}$$

Hence, the drivers of exporters' growth relative to domestic growth can be assessed by estimat-

[8] Note that here I am abstracting from the market aggregate variables changes, since the destination time fixed effects take care of them.

ing:

$$\Delta_h y_{i,l,d,t} = \sum_{h=0} \beta_h \mathbb{I}^h_{\{\text{age}_{(i,l,d)}=h\}} + \beta_2 \ln p_{i,l,d,t} + \gamma_{i,l,t} + \gamma_{d,l,t} + \gamma_{\text{cohorts}} + \varepsilon_{i,l,d,t} \ ; \tag{8}$$

where $\Delta_h y$ is the log difference of the dependent variable between year t and the entry year, with h denoting years since entry.[9] The dependent variable is firms' i export intensity, defined as product l sales to destination d over total domestic sales. The key regressor is an age dummy, $\mathbb{I}^h_{\{\text{age}=h\}}$, indicating h years of continuous export of product l to destination d. The specification controls for product prices ($\ln p_{i,l,d,t}$), firm-product-year fixed effects ($\gamma_{i,l,t}$), product-destination-year fixed effects ($\gamma_{d,l,t}$), and entry cohort fixed effects (γ_{cohorts}).[10] These fixed effects absorb common sales variation across markets for a given firm-product-year and common variation across exporters within a destination-product-year. Hence, the vector $\{\beta_h\}_{h=1}^{6}$ estimates the average cumulative change in export intensity relative to each firm's entry value, conditional on firm-level prices and controlling for any product-destination variation. Price dynamics are then estimated using the same specification but omitting the price control.

Firm-level fact 2: New exporters grow by shifting their demand curve. Panel (a) of Figure 1 presents the estimates of the evolution of exporters' export intensity, conditional on prices, over their life cycle after entering a new market. Five years after entry, conditional on survival, export intensity grows by around 40%. Panel (b) shows the relative price evolution over exporters' life cycle. On average, prices remain flat over the exporter's life cycle in a given market. These two results imply that export intensity expansion into foreign markets is driven by shifts in the exporters' demand intercept as in Fitzgerald. et al. (2024) and Steinberg (2023). The model captures these dynamics through customer capital accumulation.[11]

Firm's exposure to volatility and exporters' growth. I now explore how firm-level volatility relates to exporters' growth over their life cycle. To construct the firm-level volatility measures, I use within-firm annual changes in domestic sales.

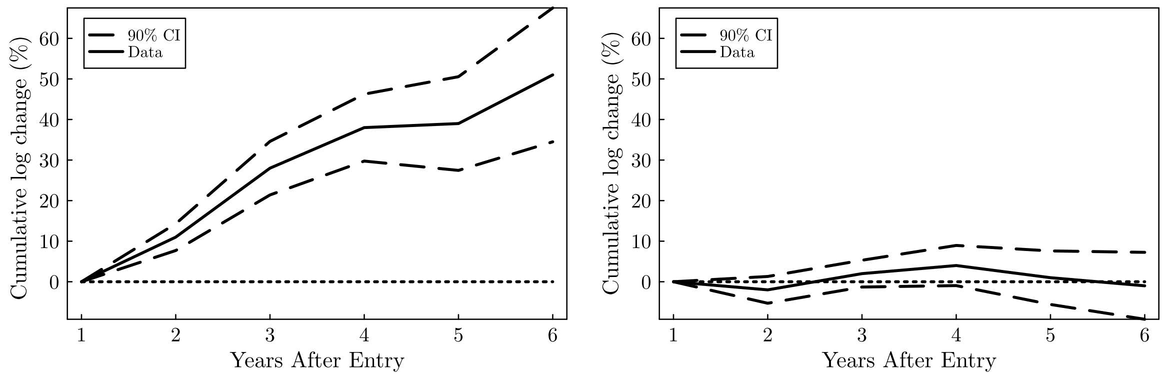
$$\Delta\text{dom. sales}_{i,j(i),t} = \gamma_{j(i),t} + e_{i,j(i),t}$$

[9] A new exporter is one that did not export product l to destination d in the previous two years.

[10] Prices are proxied by unit values.

[11] The estimated coefficients used in Figure 1 are presented in column 10 of Table A.5 in the appendix, together with other robustness tests.

Figure 1: New Exporters' Dynamics



(a) Export intensity dynamics

(b) Price 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.5, 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 time t after at least three years of not exporting to the market. Standard errors in brackets. Standard errors cluster at the firm level.

where Δdom. $\text{sales}_{i,j(i),t}$ is the log change in domestic sales of firm i, whose industry is $j(i)$ during year t. $\gamma_{j(i),t}$ denotes industry-year fixed effects, so that $e_{i,j(i),t}$ can be interpreted as pure idiosyncratic firm-level changes in domestic sales (Di Giovanni et al., 2024).

I then compute firm i's exposure to domestic volatility using a leave-one-out strategy:

$$\sigma_{i,t} = \text{sd}_{j \neq i, j \in \mathscr{J}_{i,t}} \left(e_{i,j(i),t} \right)$$

where $\mathscr{J}_{i,t}$ denotes the set of firms in the same industry as firm i at time t, excluding firm i itself.

Three features of this measure are central. First, the leave-one-out construction ensures $\sigma_{i,t}$ reflects the local volatility environment, not firm $i's$ own performance. Second, focusing on domestic sales maintains consistency with the cross-country WBES measures. Third, while idiosyncratic domestic sales shocks reflect both productivity and demand shocks, any demand component acts as measurement error, biasing estimates toward zero. My results should therefore be interpreted as conservative lower bounds on the true structural relationships.

Appendix B.2 provides further details and robustness checks using alternative volatility specifications and measures for exporters' growth.

Estimation. To assess how domestic firm-level volatility relates to exporters' life-cycle, I estimate the same equation as in (8), expanded with firms' volatility measure as follows:

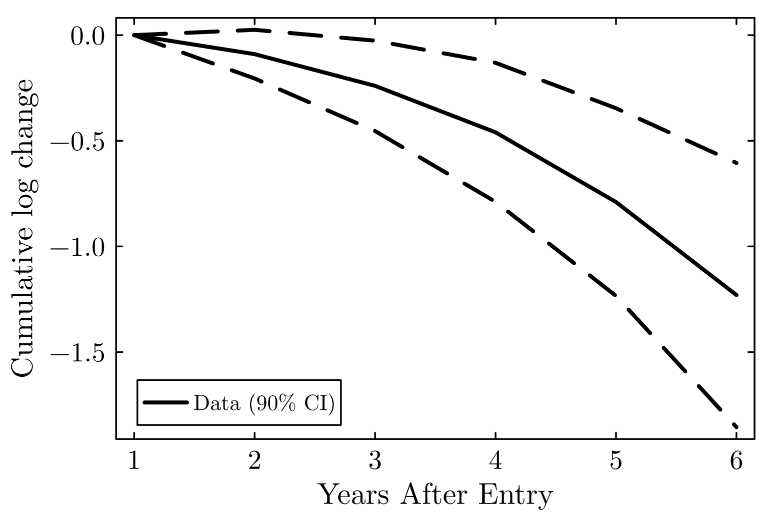
$$\begin{aligned}\Delta_h y_{i,l,d,t} = &\sum_{h=0} \beta_1^h \mathbb{I}_{\{\text{age}_{i,l,d}=h\}} \ln \sigma_{i,t} + \sum_{h=0} \beta_2^h \mathbb{I}_{\{\text{age}=h\}} + \beta_3 \ln \sigma_{i,t} \\ &+ \gamma_{i,l,t} + \gamma_{d,t} + \gamma_{cohort_i,l,d,t} + \beta_4 \ln p_{i,l,d,t} + e_{i,l,d,t}\end{aligned} \tag{9}$$

All variables and fixed effects are the same as before. But now, the coefficients of interest is the vector $\{\beta_1^h\}_{h=1}^6$ which shows the differential cumulative export performance of firms over their life cycles following a 1% increase in domestic firm-level sales volatility measures.

Firm-level fact 3: Domestic firm volatility slows new exporter growth. Figure 2 presents the estimates for $\{\beta_1^h\}_{h=1}^6$. This is direct evidence for the model's core prediction: higher volatility slows exporter growth, consistent with Proposition 1. Specifically, a 1% increase in volatility reduces new exporters' cumulative growth in export intensity by more than 1 log percentage point six years after entry.

The estimated coefficients used in Figure 2 are presented in column (6) of Table A.6 in the appendix, together with other robustness tests. The appendix B.2, presents several robustness checks for both firm-level facts. For example, using less strict fixed effects, changing exporters' minimum tenure in the export market, changing the dependent variable to total sales, and using different measures of exposure to domestic firm-level volatility. All results remain unchanged.

Figure 2: New Exporters Growth and Firm-level Volatility.



Note: The data results show the estimated coefficient for $\{\beta_1^h\}_{h=0}^6$, which captures how a firm's export intensity changes after a 1% increase in its exposure to volatility. The estimated coefficients together with additional robustness are presented in column 6 of Appendix Table A.6.

I now turn to cross-country data with two objectives: to document aggregate patterns consistent with the model, and to provide moments for evaluating the quantitative predictions.

5 Aggregate Facts

This section documents three stylized facts regarding the relationship between firm-level volatility, export costs, and economic development. While these variables are jointly determined in equilibrium, they provide empirical regularities against which the model's quantitative predictions will be evaluated. I first detail the estimation of origin-specific common export costs and idiosyncratic firm-level volatility. I then revisit an established fact from the literature before presenting two new empirical findings.

Export costs measurement. To estimate countries' common export costs I follow Waugh (2010). First, assume that total trade costs from i to j at time t, $d_{ij,t}$, are given by:

$$\ln d_{ij,t} = \ln \exp\ \text{cost}_{i,t} + \ln \widehat{d}_{ij,t} \ ;$$

$\widehat{d}_{ij,t}$ denotes bilateral trade costs (distance, tariffs, etc.); and $\exp\ \text{cost}_{i,t}$ represents the common export cost that country i faces when selling to any destination. This origin-specific component is the primary object of interest: it captures trade barriers affecting a country's aggregate export capacity rather than destination-specific market access. I identify this term by exploiting asymmetries in the estimated multilateral resistance terms, as derived below.

Define $X_{i,j,t}$ as country j's expenditure share on goods from country i, and let $\lambda_{i,j,t} \equiv X_{i,j,t}/X_{j,j,t}$ denote the trade share normalized by the destination's home share. Following the standard gravity framework (Eaton and Kortum, 2002; Waugh, 2010), the trade share is given by:

$$\ln \lambda_{i,j,t} = S_{i,t} - S_{j,t} - \theta(\exp\ \text{cost}_{i,t} + d_{ij,t})$$

where $S_{i,t}$ captures the multilateral resistance term of country i. I estimate the following gravity equation via Poisson Pseudo-Maximum Likelihood (PPML), which ensures consistent estimation in the presence of zeros and heteroskedasticity (Fally, 2015; Silva and Tenreyro, 2006):

$$\lambda_{i,j,t} = \exp\left(\text{imp FE}_{j,t} + \exp\ \text{FE}_{i,t} + \boldsymbol{\beta} \boldsymbol{y}_{ijt} + \varepsilon_{ijt}\right) \tag{10}$$

The estimated fixed effects map to structural parameters: $\widehat{\text{imp FE}}_{j,t} = S_{j,t}$ and $\widehat{\exp\ \text{FE}}_{i,t} = -S_{i,t} - \theta \exp\ \text{cost}_{i,t}$. Since the multilateral resistance terms cancel, the common export cost is identified as:

$$\widehat{\text{exp cost}}_{i,t} = \frac{\widehat{\text{imp FE}}_{i,t} + \widehat{\text{exp FE}}_{i,t}}{-\theta}$$

I calibrate the trade elasticity $\theta = 2.5$, which falls within the range of empirical estimates in the literature (Boehm et al., 2023; Simonovska and Waugh, 2014).[12] By construction, these estimated export costs are orthogonal to factors captured by the multilateral resistance terms, such as country-level productivity, aggregate prices, and foreign demand shocks (Eaton and Kortum, 2002; Waugh, 2010).

I estimate the gravity equation (10) separately for each year to allow for time-varying coefficients. The primary analysis uses manufacturing data, though the results are robust to the inclusion of all industries.[13] The vector $\boldsymbol{y}_{ijt}$ captures bilateral trade costs $d_{ij,t}$ through a standard suite of gravity controls: (i) the log of distance between the most populated cities; (ii) a UN diplomatic disagreement score; and indicator variables for (iii) contiguous borders, (iv) a common official or primary language, (v) a common language spoken by at least 9% of the population, (vi) historical colonial ties, and (vii) the presence of a free trade agreement. All bilateral controls are sourced from the CEPII Gravity database (Conte et al., 2022).

Firm-level sales volatility measurement. Having constructed export costs, I now turn to measuring firm-level volatility at the country level. To measure country-level idiosyncratic volatility, I utilize within-firm annual domestic sales changes from the World Bank Enterprise Surveys. For consistency with the trade data, the baseline analysis restricts the sample to manufacturing firms. I follow the two-step procedure described in Section 4. First, I isolate firm-specific idiosyncratic shocks, $\varepsilon_{i,j(i),c,t}$, for firm i in industry $j(i)$ and country c at time t. Second, the country-level volatility in year t, $\sigma_{c,t}$, is defined as the cross-sectional standard deviation of these shocks. As discussed in Section 4, estimates based on domestic sales volatility are likely biased toward zero due to measurement error arising from pure demand shocks.

Estimation. With these measures in hand, I estimate the following equation:

$$\widehat{\text{exp costs}}_{c,t} = \beta_0 + \beta_1 \ln \sigma_{c,t} + \beta_2 \ln \frac{GDP_{c,t}}{L_{c,t}} + \beta_3 \ln \text{fin. fric}_{c,t} + \boldsymbol{\beta}_4 h_{c,t} + \gamma_t + e_{c,t} \; ; \qquad (11)$$

[12] Existing studies generally find this elasticity to range between 1 and 5.

[13] Results are qualitatively similar when using a sample of all industries.

the two main coefficients of interest are β_1 and β_2. The former captures the percentage change in estimated export costs for a one percent change in firm-level volatility. The latter captures the analogous relationship with GDP per capita.[14] The additional control, fin. $\text{fric}_{c,t}$, denotes the share of firms declaring access to financial markets as an impediment to growth. The vector $\boldsymbol{h}_{c,t}$ includes entry costs (procedures to register a business), indicators for EU, WTO, and GATT membership, and legal origin. These controls, as the bilateral ones, come from the CEPII Gravity database. γ_t denotes year fixed effects.

Table 2 presents the estimation results for equation (11). Columns 1-3 report findings with export costs as the dependent variable, while Column 4 uses the log of GDP per capita. This last column reveals a negative relationship between firm-level volatility and GDP per capita, consistent with established findings on growth and macroeconomic volatility (Aghion et al., 2010; Ramey and Ramey, 1995).

Table 2: Firm-level Volatility, Development and Exports Costs

	Export costs			GDP per capita
	(1)	(2)	(3)	(4)
ln (GDP per capita)	-0.699***	-0.466***	-0.447***	
	(0.125)	(0.109)	(0.114)	
ln (Firm volatility)		0.575***	0.577***	-0.381***
		(0.102)	(0.101)	(0.120)
ln (Financial frictions)			0.086	-0.316**
			(0.126)	(0.122)
N	126	126	126	126
Adjsuted R^2	0.448	0.591	0.590	0.441
Year FE	✓	✓	✓	✓
Controls	✓	✓	✓	✓

Note: Table reports estimates of equation (11). Export costs are estimated using PPML, following a gravity specification similar to Waugh (2010) (equation 10). Annual trade flows and firm-level volatility used are for manufacturing. Controls include financial access (WBES database), entry costs (number of procedures), and dummies for EU, WTO, GATT membership, and legal origin. Standard errors clustered at the origin country level are in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

[14] I use USD GDP adjusted for purchasing power parity in 2011 dollars from Penn World Tables, divided by that year's total population to construct the GDP per capita

Aggregate Fact 1: Export costs decline with GDP per capita. Column (1) of Table 2 shows that a 1 percent increase in a country's GDP per capita is associated with a 0.7 percent decrease in its average export costs. This negative relationship persists after controlling for firm-level volatility or financial frictions (columns 2 and 3). The financial friction variable is not statistically significant in explaining export cost differences (Column 3), consistent with the findings in Leibovici (2021).

Fact 1 confirms well-established findings (Blum et al., 2019; de Sousa et al., 2012; Waugh, 2010). Since the export cost estimates already account for productivity, prices, and bilateral trade costs, this relationship must reflect factors that correlate negatively with development and positively with export costs.

Aggregate Fact 2: Exports costs increase with firm-level sales volatility. Columns (2) and (3) of Table 2 show that there exists a positive relationship between a country's export costs and its firm-sales volatility, even conditional on the country's level of financial development or GDP per capita. The estimates show that a country with a 1 percent higher firm-level volatility will face, on average, 0.57 percent higher export costs. In terms of trade flows, this translates to a 1.4 log point reduction in exports to each destination on average. To put it differently, moving from the median to the first quartile of the cross-sectional distribution of firms' sales volatility is associated with a decrease in export costs of around 44%, an increase in exports of around 111%. This result is consistent with Proposition 2.

Aggregate Fact 3: Firm-level volatility explains one-third of the export cost-development puzzle. Conditioning on firm-level volatility reduces the export cost-GDP relationship by 33%, and the adjusted R^2 improves by nearly 32% when firm-level volatility is included. This is direct evidence that volatility drives the puzzling correlation between development and export costs.[15]

To address potential biases, I performed several robustness checks discussed in Appendix B.1. These include using different sample restrictions, variables, or statistics to compute firm-level volatility. I also test whether the results are robust when using other methodological procedures. Specifically, I estimate the relationship using total sales to domestic and foreign markets with a border dummy to identify the differential effect of volatility on exports relative to domestic sales. The findings are robust to these alternative specifications.

[15]The two-sided p-value for equal coefficients is 0.036; the one-sided p-value is 0.018.

These aggregate facts reflect equilibrium relationships, yet they provide suggestive evidence that firm-level volatility helps explain cross-country differences in export costs and income. The following sections develop a general equilibrium model to investigate whether productivity volatility can generate these patterns while matching the micro-level evidence.

6 The model

This section develops a small open economy (SOE) general equilibrium model to quantify the proposed mechanism. The SOE framework is well-suited to this analysis as the paper focuses on common export costs—trade frictions that affect all destinations uniformly. By abstracting from a full multi-country general equilibrium, I maintain quantitative tractability while preserving the core insights regarding firm-level cost shocks and markup adjustments.

I focus on the stationary equilibrium of the economy, where the distribution of firms over productivity and customer capital is constant over time.

The economy consists of four agents: a continuum of firms producing differentiated intermediate goods, a representative firm assembling a domestic bundle, a final-good producer, and a representative household. The final consumption and domestic bundle sectors are perfectly competitive, whereas intermediate firms operate under monopolistic competition and face idiosyncratic, persistent shocks.

Domestic consumers. The representative consumer owns firms, supplies labor inelastically, and holds bonds in zero net supply, so trade is balanced. Since the consumer's problem is standard, I omit its full derivation; in steady state, it yields a stochastic discount factor equal to β and zero bond holdings.

Domestic bundle. The domestic bundle D is produced from differentiated intermediate goods according to:

$$\int_{\omega \in \Omega^d} \Upsilon\left(\frac{q^d(\omega)}{D}\right) d\omega = 1, \tag{12}$$

Following Klenow and Willis (2016), $\Upsilon(x)$ is given by:

$$\Upsilon(x) = 1 + (\theta - 1) e^{\frac{1}{\eta}} \eta^{\frac{\theta}{\eta} - 1} \left(\Gamma(\frac{\theta}{\eta}, \frac{1}{\eta}) - \Gamma(\frac{\theta}{\eta}, \frac{x^{\frac{\eta}{\theta}}}{\eta}) \right), \; \theta > 1; \; \eta > 0 \tag{13}$$

where $\Gamma(a,b)$ is the incomplete gamma function. I refer to θ as the price elasticity parameter and η as the super-elasticity parameter. As will be clear later, conditional on θ, η shapes the firm's markup responses to changes in production costs. The producer of the domestic bundle observes intermediate good prices $\{p^d(\omega)\}_{\omega\in\Omega}$ and chooses the intermediate quantities $\{q^d(\omega)\}_{\omega\in\Omega}$ to solve the following problem

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

subject to equations (13), and (12). The solution to this problem yields the following demand for variety ω,

$$\log q(\omega) = \frac{\theta}{\eta}\log\left(-\eta\log\left(\frac{p^d(\omega)}{p^d_c}\right)\right) + \log D \quad \text{if } p^d < p^d_c, \tag{14}$$

where p^d_c is the choke price.Unlike CES demand, variable price elasticity features a choke price p^d_c above which demand is zero (Arkolakis and Morlacco, 2017). Demand becomes increasingly elastic as prices approach p^d_c, while low-price, high-productivity firms face less elastic demand and charge higher markups. The choke price is given by

$$p^c = e^{\frac{1}{\eta}}\frac{\theta-1}{\theta}\frac{P}{\tilde{D}}, \tag{15}$$

where P is the price index for the intermediate goods, defined as $P := \int_\Omega \frac{q(\omega)}{D}p(\omega)d\omega$, and $\tilde{D} := \int_\Omega \Upsilon'(\frac{q(\omega)}{D})\frac{q(\omega)}{D}d\omega$.[16]

In equilibrium, the choke price is determined by the clearing of the market for the domestic bundle, D. The supply of the domestic bundle is implicitly defined by the following aggregation condition:

$$\int \Upsilon\left(\frac{q(z,1)}{D}\right)d\Psi(z,A) = 1 \tag{16}$$

Foreign consumer's problem. Intermediate firms can also sell to foreign importers. The importer takes aggregate foreign demand, Q^*, and foreign prices, P^*, as given.[17] The importer observes the prices of the intermediate goods and solves,

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

[16] See Arkolakis and Morlacco (2017) to see why when $\eta \to 0$ the model converges to CES, and $p^c \to \infty$.

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

s.t.

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

where indirect utility function term $\Upsilon(x)$ is given by equation (13); $A(\omega)$ represents the customer capital that the exporter, producing variety ω, has when selling to this foreign market. α is the elasticity of customer capital to the demand intercept; as shows the following foreign demand function for each variety

$$\log q^*(A,p^*) = \frac{\theta}{\eta}\log\left(-\eta\log\left(\frac{p^*(\omega)}{p^{c*}}\right)\right) + \log A^{\alpha} + \log Q^* \quad \text{for } p^*(\omega) < p^{c*}, \tag{17}$$

note that $A(\omega)$ is a demand shifter, over which firms can invest and grow into the foreign market. As before, p^{c*} denotes the choke price of the foreign economy.[18]

Note that the equation shows how variable markups in the cross-section are consistent with new exporters growing by shifting their demand intercept. The evolution of $A(\omega)$ dictates the new exporters' dynamic export intensity, while the markup depends on the ratio between the firm's price and the choke price of the destination economy. This should be interpreted as capturing the relative customer capital that exporters accumulate abroad compared to their domestic customer base.

Asymmetric market structure. The model assumes that customer capital A governs demand only in foreign markets. This should be interpreted as capturing the relative customer capital that exporters accumulate abroad compared to their domestic customer base.[19] This structure is also consistent with my empirical treatment of the data. Empirically, I measure exporter growth using export intensity (the ratio of foreign to total sales), which captures the expansion of foreign customer capital relative to the domestic one. The calibration targets moments of export intensity dynamics over the exporter life cycle (Table 4), not absolute export levels.

Intermediate goods. Each intermediate firm produces a variety using a linear production function with time-varying labor productivity. At the beginning of each period, firm i observes its productivity z_i (drawn from a Markov process with transition $f(z'|z)$) and customer capital

[18] 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.

[19] Under this interpretation, the adjustment costs in equation (19) reflect the well-documented higher costs firms face when expanding into foreign markets relative to domestic expansion—costs associated with building distribution networks, establishing brand recognition, and navigating unfamiliar regulatory environments (Eaton et al., 2007; Fitzgerald. et al., 2024).

A_i. It then makes static decisions (prices, quantities, labor) and, at the period's end, dynamic decisions (customer capital investment and export entry and exit decisions).[20] 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, a firm's customer capital depends on its market presence; when a firm ceases exporting, it loses the customer capital it has accumulated. Since each variety ω maps to a unique firm, I henceforth index varieties by firm i.

Firms' static problem. The firm chooses the optimal price to maximize its operational profits, as in

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

subject to its production technology, $q_i^* = \frac{l_i z_i}{\tau}$, and demand equation (17).[21] Unlike the standard CES case, by choosing the price to maximize their profits, firms implicitly choose their price elasticity. By staring at equation (17), one can realize that the firms' price elasticity is given by $\xi(p) = -\frac{\theta}{\eta \log(\frac{p}{p^{c*}})}$. The usual argument implies that firms' markups are given by

$$\mu(p) = \frac{\theta}{\theta + \eta \log(\frac{p}{p^{c*}})} \quad \text{for all } p \leq p^{c*}\ ; \tag{18}$$

which are decreasing with firms' prices, and hence more productive firms charge higher markups, consistent with firm-level facts documented previously. [22]

Firms' dynamic problem. Denote next-period variables with an apostrophe. Firms make two dynamic decisions: the exporting decision, denoted by m, and the investment decision to accumulate more customers, denoted by i_i. The export decision is discrete: $m \in \{0, 1\}$. The labor required to invest i_{id} in customer capital is:

$$c(i_i, A_i) = i_i - \frac{\phi}{2}\left(\frac{i_i}{A_i}\right)^2 \tag{19}$$

Firms' customer capital is given by the following two components: a fixed minimum level of customer capital A^{min}, and the accumulated customer capital k_i. They relate to total customer

[20]For tractability and consistency with the empirical analysis, I assume firms can reach all customers in the domestic market.

[21]If $\alpha = 0$ and $\tau = 1$, the model becomes a static model with CES.

[22]The price elasticity equation and the markup equation imply boundaries for the optimal prices such that $\mu(p) \geq 1$, and $\xi(p) \geq 1$for all $p \leq p^{c*}$.

capital as follows:

$$A_i = k_i + A^{min}\ , \tag{20}$$

which evolves according to the following law of motion,

$$k_i' = m\,(i_i + k_i(1-\delta)) \tag{21}$$

Firms cannot sell customer capital and hence cannot make negative investments. Non-exporters ($m = 0$) lose all accumulated customer capital, so $A' = A^{min}$. The firm's dynamic problem is to solve

$$\begin{aligned} V(z_i, A_i) = \max_{m\in\{0;1\}; i_i\in[0;\infty)} \ & \pi^d(z_i, 1) + m(\pi(z_i, A_i) - wf_e) - \\ & - wc(i_i, A_i) + \mathbb{E}\left[\beta V(z_i', A_i')\right] \end{aligned} \tag{22}$$

subject to (19), (20) and (21).

Firm's optimal dynamic behavior. The optimal customer capital the firm decides to have in the next period is given by:

$$\frac{\partial wc(i_i, A)}{\partial A'} \geq \beta \underbrace{\left(1 - Pr(z_i^{'*}|z_i)\right)}_{\text{export probability}} \overbrace{\mathbb{E}_{z_i}\left\{\frac{\partial V(A', z')}{\partial A'}\ |z_i^{'} > z_i^{'*}\right\}}^{\text{Expected marginal return if export}}$$

The condition holds with equality when firms invest. Firms equalize the marginal cost of investment (LHS) with the expected marginal return (RHS). The RHS depends on the probability of exporting next period, $(1 - \Pr(z_i^{\prime *}|z_i))$, and the expected marginal return conditional on exporting—both reduced by uncertainty when profits are concave.

Firms will export if productivity is higher than the productivity threshold $z^*(A)$, given by:

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

The marginal firm is indifferent between exporting and not when operational profits plus the option value of retaining customer capital equal the fixed cost plus investment cost. The option value generates hysteresis in export participation: its presence delays exit, and ignoring it would overstate the negative effects of uncertainty on trade (see for example Alessandria et al., 2015; Merga, 2020).

6.1 Equilibrium

Let $\Psi(z,A)$ denote the stationary distribution of firms over productivity z and customer capital A. A stationary equilibrium consists of: (i) firm value and policy functions $\{V(z,A), A'(z,A), p(z,A), p^*(z,A), m(z,A)\}$; (ii) aggregate quantities $\{Exp, C, D, M\}$; (iii) prices $\{w, P^C, P^D, p^c\}$; and (iv) a stationary distribution $\Psi(z,A)$, such that:

1. Firm policy functions solve (22) given prices;
2. Consumer and final good producer decisions are optimal;
3. Labor and goods markets clear;
4. Trade is balanced;
5. The distribution $\Psi(z,A)$ is stationary: it is consistent with firm policy functions and the productivity transition $f(z'|z)$.

7 Quantitative Results

This section quantitatively assesses the model's ability to capture the firm-level facts and the documented relationships between firm-level volatility, total exports, and GDP per capita. I first discuss the model's parameterization, then present the quantitative predictions of the four models, evaluating the proposed mechanism's relevance.

7.1 Model calibration

Because the model is highly nonlinear, all parameters are calibrated jointly to match targeted moments. However, some parameters have clear empirical counterparts. The parameter values for each model are presented in Table 3. Columns 1 and 2 present the dynamic models with and without variable markups, while Columns 3 and 4 present the static models with and without variable markups. Two parameters are externally calibrated: 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. The consumer's utility function is assumed to be given by $u(c) = \ln(c)$, and 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 normally distributed, with s.d. σ_z. Both ρ and σ_z are set so that model-simulated data yield AR(1) estimates similar to those from Colombian domestic sales data.

The parameters τ and A^{min} are set to match the average export intensity of all exporters and of new exporters specifically. f^e is set to match the share of exporters over the total active firms. The parameters α, ϕ, and δ are set to match the evolution of export intensity over exporters' life cycles.

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	0.04	1.50	0.10	Exporter fixed costs
α	0.70	0.74	0.00	0.00	Customer capital: curvature
ϕ	3.72	14.30	0.00	0.00	Investment adjustment cost
δ	0.24	0.42	1.00	1.00	Customer capital: depreciation
A^{min}	0.01	0.02	1.00	1.00	Customer capital: Initial value
τ	0.44	0.20	0.38	0.61	Iceberg cost

Demand parameters θ and η are calibrated to match the estimated Colombian markup responses (Table 1). The estimated values, $\eta = 4.2$ and $\theta = 2.9$, imply an average markup of 45%, consistent with manufacturing benchmarks. The value of η lies within the 2–10 range established in the literature (Arkolakis and Morlacco, 2017; Edmond et al., 2023; Klenow and Willis, 2016). To discipline these parameters, I replicate the empirical estimation on model-simulated data with two modifications conditional on matching average markups. First, because markups are directly observable in the model, I use them as the dependent variable.[23] Second, I follow the literature by using wage shocks to represent marginal cost changes. Finally, the international choke price, p^{c*},

[23]This bypasses the need for the fixed-effect controls for marginal costs used in the empirical section.

is parameterized to be consistent with foreign demand.[24] Table 4 presents the targeted moments and model fit.

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	-	-

Note: Firms' cumulative growth shows the evolution of new exporters' export intensity over their life cycle; its values correspond to the estimated results shown in column 7 of Table A.5 in the appendix. Average export intensity is calculated using weighted firm-level exports. The standard deviation of domestic sales shocks and their persistence shows the standard deviation of the estimated residual and the estimated coefficient from an AR (1) estimate for firm-level real domestic sales.

7.2 Model implications

I now test each model's ability to explain the empirical facts documented in Sections 4 and 5. The simulations vary the exogenous volatility of firm productivity shocks (σ_z) and solve for new policy functions and general equilibrium at each parameter value.[25] Importantly, σ_z is an exogenous model input, whereas firm-level domestic sales volatility is an endogenous equilibrium outcome—just as in the data. For comparability with the empirical estimates, I report all model predictions against the equilibrium domestic sales volatility.

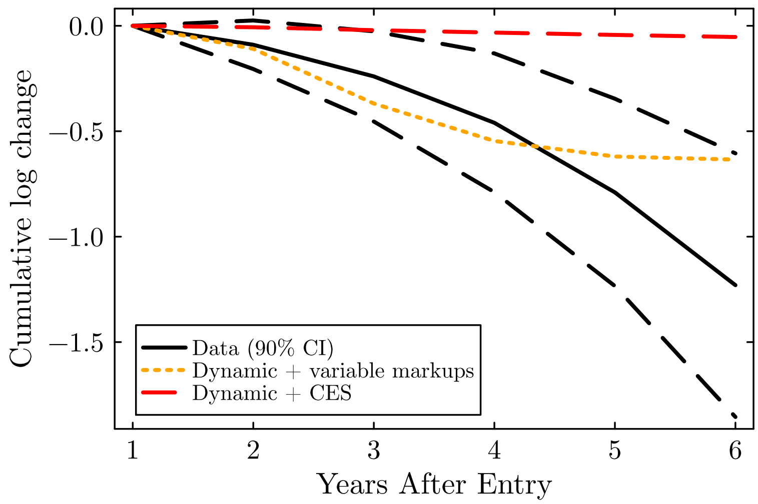
Quantitative result 1: Higher volatility of firms' productivity shocks reduces new exporters' growth. Figure 3 presents, for both dynamic models, the export intensity growth response to higher domestic firm-level volatility. The model with variable markups adequately

[24] I assume the foreign economy shares the same firm distribution and demand parameters (θ, η) as the domestic economy.

[25] To isolate changes in conditional variance, I also adjust the mean μ and persistence ρ of the shock process. Without these adjustments, changes in σ_z would affect average firm productivity.

predicts the relationship between domestic volatility and new exporter growth (yellow dotted line) relative to data estimates (solid black line). The model with constant markups fails to generate the observed pattern. The intuition follows Section 2: variable markups generate concave profits, so higher volatility reduces the expected return to customer acquisition, slowing exporter growth.

Figure 3: Volatility and New Exporters' Growth



Note: The orange dotted line shows the cumulative export intensity response elasticity predicted by the model with new exporters' dynamics and variable markups when the average firm domestic sales volatility increases 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. The model predictions correspond to changes in the firms' productivity volatility. The data results are based on the estimates for Colombian firm-level data presented in column 6 of Table A.6.

Aggregate predictions. Having established that the model matches micro-level dynamics, I now examine its aggregate predictions. To understand the mechanism's relevance, I rewrite total exports as in Section 2, but without assuming i.i.d. productivity shocks. In this case, total exports are:

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

where $\hat{rev}^*(z) := p^*(z)q^*(z,1)$ 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,

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

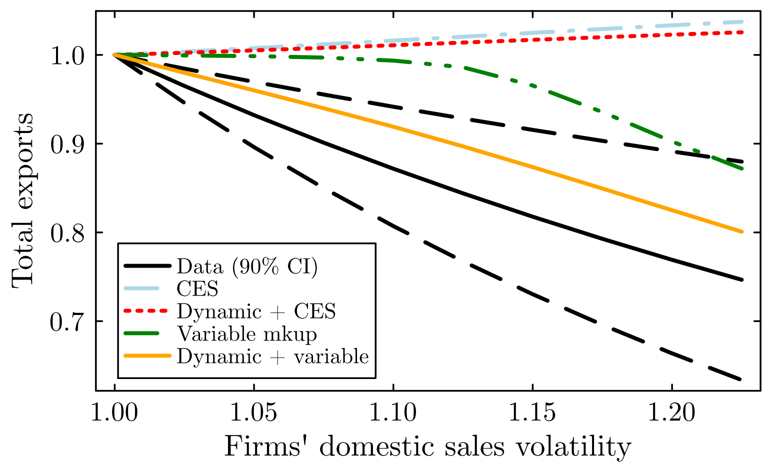
where $\Theta := \mathbb{E}(rev_i^*(z)|z \geq z^*) + \mathbb{C}\mathbf{ov}\left(\frac{A_i^\alpha}{\bar{A}}; rev_i^*(z)|z \geq z^*\right)$, $\psi_z(z,A)$ denotes the conditional probability density function of firms productivity, given their value of customer capital, and $\Psi_A(A)$ is the marginal density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

The previous expression shows that total export reaction to changes in σ_z takes place through the typical intensive and extensive margins. But unlike the static model or the dynamic version with i.i.d. shocks, three sub-margins determine the intensive margin: (i) the dynamic margin, capturing changes in average customer capital; (ii) the static margin, capturing changes in firms' static export decisions (equal to the total intensive margin in static models); and (iii) the misallocation margin (absent in dynamic models with i.i.d. productivity shocks). The latter sub-margin captures changes in the covariance between firms' revenues per customer and their relative level of customer capital. A higher covariance increases exports, as it indicates that firms with higher revenues per customer are reaching relatively more customers.

Quantitative result 2: Higher volatility of firms' productivity shocks reduces total exports. Figure 4 shows the models' quantitative prediction regarding total exports and firms' sales volatility when we change σ_z as previously described. Both models with variable markups are qualitatively consistent with the documented relationship between firm-level volatility and exports. The model without variable markups predicts the opposite relationship. Within the models with variable markups, the model with exporters' dynamics generates a quantitative relationship similar to the one observed in the data. It predicts an elasticity of around 1.09 between domestic volatility and total exports—77% of the point estimate in column (2) of Table 2—and 60% higher than the model without exporter dynamics.

To contextualize this finding, a reduction in firm TFP shock volatility that moves a country from the median to the first quartile of the distribution would result in an 84% increase in exports. [26] This is consistent with the puzzling observation from standard international trade models (e.g. Waugh, 2010): when abstracting from volatility changes, these models estimate higher cross-country export costs for developing economies, consistent with their higher firm-level volatility.

Figure 4: Firm-level Volatility and Exports



Note: Firms' domestic sales volatility refers to the standard deviation of firms' changes in domestic sales both in the model and in the data. The results are driven by underlying changes in firms productivity volatility. The data results are based on Table 2 where export changes are derived from the export costs relationship and translated to total exports via the model's trade elasticity.

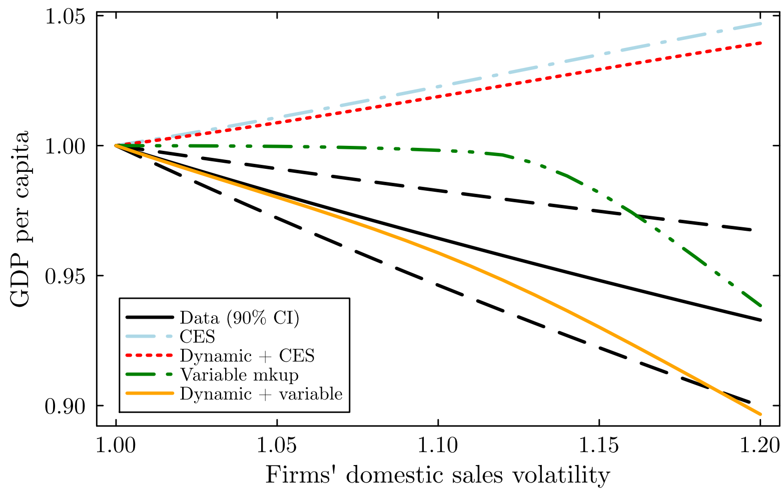
These results resolve the puzzling volatility-exports relationship documented in the literature (Alessandria et al., 2015; Alessandria et al., 2021; Baley et al., 2020), since it shows that abstracting from the existence of variable markups comes at the cost of missing the negative relationship between firm-level volatility and total trade. Similarly, abstracting from exporter dynamics quantitatively biases down the negative volatility-trade relationship.

Quantitative result 3: Higher volatility of firms' productivity shocks reduces GDP per capita. Figure 5 shows the relationship generated in each model between firms' domestic volatility and GDP per capita, induced by changes in the volatility of firms' productivity. Relative to the relationship observed in the data, the two model versions with variable markups outperform those assuming constant elasticity. The former are quantitatively consistent with the conditional moments observed in the data, unlike the latter. This result highlights the relevance

[26] For comparison, if Colombian firms faced Spanish or Danish volatility levels, exports would grow by 33% and 99%, respectively.

of the proposed mechanism, as it is not only quantitatively important for explaining observed trade patterns but also has significant implications for development. Specifically, the benchmark model predicts an elasticity of around -0.5 between domestic sales volatility and GDP per capita. An increase in productivity volatility that moves a country from the first or second quartile to the third quartile of sales volatility reduces GDP per capita by about 35% and 25%, respectively. These represent around 55% of the observed GDP differences between these groups of countries.

Figure 5: Volatility and GDP per capita

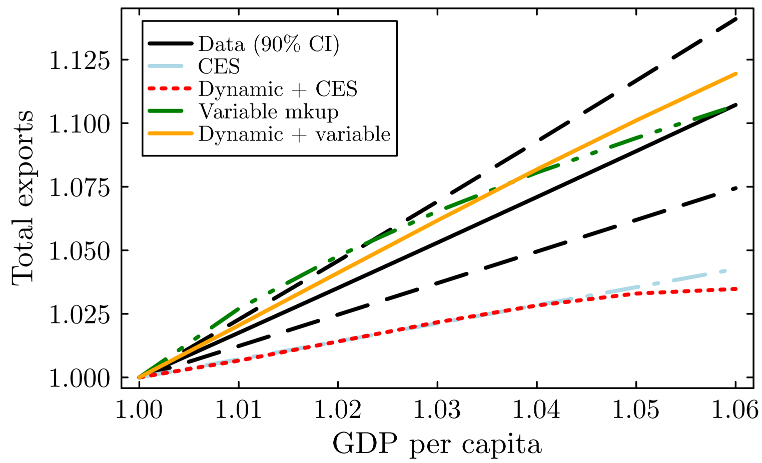


Note: Firms' domestic sales volatility refers to the standard deviation of the residual firms' level idiosyncratic changes in domestic sales both in the model and in the data. The model predictions correspond to changes in the firms' productivity volatility. The data results are based on Table 2

On the other hand, Figure 5 shows that both models with constant markups generate the standard positive volatility-investment relationship pattern and hence predict that GDP increases with the volatility of firms' tfp shocks. This result explains why constant markup models generate a positive GDP-exports relationship due to changes in volatility, despite counterfactual predictions about how volatility affects each variable separately.

Quantitative result 4: Changes in the volatility of firms' productivity shocks generates a positive relationship between exports and GDP per capita. Figure 6 combines these results, showing that all models predict a positive GDP-exports relationship, but only variable markup models generate magnitudes consistent with the data. Constant markup models match the relationship for the wrong reasons: they predict counterfactual effects of volatility on both GDP and exports that offset in the aggregate. The models with variable markups, however, predict magnitudes closer to the data.

Figure 6: GDP per capita and total exports



Note: The model predictions correspond to changes in the firms' productivity volatility. The data results are based on Table 2 where export changes are derived from the export costs relationship and translated to total exports via the model's trade elasticity.

A note on the magnitudes of these effects is warranted. The GDP per capita variation in Figure 6 ranges from 1.0 to 1.06, a range primarily constrained by the modest income responses to volatility shocks in the constant elasticity specification. While these differences are smaller than the total income dispersion observed in the data, this limited range reflects the local nature of the quantitative exercise. Specifically, I vary only the idiosyncratic productivity volatility around the Colombian baseline while holding all other parameters constant.

The model is thus not intended to replicate the full cross-country income distribution, which is driven by a myriad of factors—including technology, institutions, and human capital—beyond firm-level volatility. Instead, the exercise demonstrates that volatility shocks alone generate the correct signs and economically significant magnitudes, mirroring the conditional estimates from Section 5, which control for other development factors. Indeed, the local elasticities implied by the model are consistent with the conditional estimates in Table 2, suggesting that firm-level volatility is a quantitatively relevant margin for trade and development.

8 Conclusion

This paper shows that firm-level productivity volatility is a significant barrier to international trade and development. This finding arises from a general equilibrium model that incorporates two empirically validated features: variable demand elasticity and dynamic export investment. My findings provide a new explanation for two puzzles: the negative relationship between firm-level volatility and exports, and the high export costs faced by developing economies. I also find that cross-country differences in productivity volatility account for a significant share of income differences. Extending the analysis to a full multi-country model is left for future work.

The proposed mechanism reverses the “Oi-Hartman-Abel” effect present in standard frameworks. Higher volatility discourages exporter investment in foreign markets, hindering growth and ultimately reducing exports and income. The model replicates the negative correlation between firm-level volatility and both trade and income, explaining a substantial portion of previously unexplained variation in export costs.

These findings demonstrate that policies promoting macroeconomic and microeconomic stability can be of first-order importance for trade and development. Lastly, the model’s tractability also opens avenues for future research. First, relative to traditional frameworks, it suggests a more prominent role for trade policy uncertainty in suppressing trade and welfare. Second, the framework can be extended to investigate the observed differences in firm distribution and growth across various stages of development.

References

Aghion, P., Angeletos, G.-M., Banerjee, A., & Manova, K. (2010). Volatility and growth: Credit constraints and the composition of investment. *Journal of Monetary Economics*, *57*(3), 246–265.

Alessandria, G., Choi, H., Kaboski, J. P., & Midrigan, V. (2015). Microeconomic Uncertainty, International Trade, and Aggregate Fluctuations, 42.

Alessandria, G., Arkolakis, C., & Ruhl, K. J. (2021). Firm dynamics and trade. *Annual Review of Economics*, *13*, 253–280.

Amiti, M., Itskhoki, O., & Konings, J. (2014). Importers, Exporters, and Exchange Rate Disconnect. *American Economic Review*, *104*(7), 1942–1978.

Arkolakis, C., & Morlacco, M. (2017). Variable Demand Elasticity, Markups, and Pass-Through. *Manuscript, Yale University*, 36.

Baley, I., Veldkamp, L., & Waugh, M. (2020). Can global uncertainty promote international trade? *Journal of International Economics*, *126*, 103347.

Besedeš, T. (2011). Export differentiation in transition economies. *Economic Systems*, *35*(1), 25–44.

Bloom, N. (2013). Fluctuations in uncertainty. *Journal of Economic Perspectives*, *28*(2), 153–176.

Blum, B. S., Claro, S., Dasgupta, K., & Horstmann, I. J. (2019). Inventory Management, Product Quality, and Cross-Country Income Differences. *American Economic Journal: Macroeconomics*, *11*(1), 338–388.

Boehm, C. E., Levchenko, A. A., & Pandalai-Nayar, N. (2023). The long and short (run) of trade elasticities. *American Economic Review*, *113*(4), 861–905.

Conte, M., Cotterlaz, P., Mayer, T., et al. (2022). The cepii gravity database.

de Sousa, J., Mayer, T., & Zignago, S. (2012). Market access in global and regional trade. *Regional Science and Urban Economics*, *42*(6), 1037–1052.

Di Giovanni, J., Levchenko, A. A., & Mejean, I. (2024). Foreign shocks as granular fluctuations. *Journal of Political Economy*, *132*(2), 391–433.

Eaton, J., & Kortum, S. (2002). Technology, Geography, and Trade. *Econometrica*, *70*(5), 1741–1779.

Eaton, J., Eslava, M., Kugler, M., & Tybout, J. R. (2007). Export dynamics in colombia: Firm-level evidence.

Edmond, C., Midrigan, V., & Xu, D. Y. (2023). How costly are markups? *Journal of Political Economy*, *131*(7), 1619–1675.

Esposito, F. (2022). Demand risk and diversification through international trade. *Journal of International Economics*, *135*, 103562.

Fally, T. (2015). Structural gravity and fixed effects. *Journal of international economics*, *97*(1), 76–85.

Fernandes, A. M., Freund, C., & Pierola, M. D. (2015). Exporter behavior, country size and stage of development: Evidence from the exporter dynamics database. *Journal of Development Economics*, *119*, 121–137.

Fitzgerald., D., Haller, S., & Yedid-Levi, Y. (2024). How exporters grow. *Review of Economic Studies*, *91*(4), 2276–2306.

Handley, K., & Limão, N. (2022). Trade policy uncertainty. *Annual Review of Economics*, *14*(1), 363–395.

Hummels, D., & Klenow, P. J. (2005). The Variety and Quality of a Nation's Exports. *American Economic Review*, *95*(3), 704–723.

Klenow, P. J., & Willis, J. L. (2016). Real Rigidities and Nominal Price Changes. *Economica*, *83*(331), 443–472.

Koren, M., & Tenreyro, S. (2007). Volatility and development. *The Quarterly Journal of Economics*, *122*(1), 243–287.

Leibovici, F. (2021). Financial development and international trade. *Journal of Political Economy*, *129*(12), 3405–3446.

Limão, N., & Maggi, G. (2015). Uncertainty and trade agreements. *American Economic Journal: Microeconomics*, *7*(4), 1–42.

Mandelman, F. S. (2013). Monetary and exchange rate policy under Remittance Fluctuations. *Journal of Development Economics*, *102*, 128–147.

Mayer, T., Santoni, G., & Vicard, V. (2023). *The cepii trade and production database*. CEPII.

Melitz, M. (2003). The impact of trade on intra-industry reallocations and aggregate industry productivity. *Econometrica*, *71*(6), 1695–1725.

Merga, R. (2020). Real Exchange Rate Uncertainty Matters. *Mimeo*.

Ramey, G., & Ramey, V. A. (1995). Cross-country evidence on the link between volatility and growth. *The American Economic Review*, *88*(5), 1138–1151.

Ruhl, K. J., & Willis, J. L. (2017). New exporter dynamics. *International Economic Review*, *58*(3), 703–726.

Silva, J. S., & Tenreyro, S. (2006). The log of gravity. *The Review of Economics and statistics*, 641–658.

Simonovska, I., & Waugh, M. E. (2014). The elasticity of trade: Estimates and evidence. *Journal of international Economics*, *92*(1), 34–50.

Steinberg, J. B. (2023). Export market penetration dynamics. *Journal of International Economics*, *145*, 103807.

Waugh, M. E. (2010). International Trade and Income Differences. *American Economic Review*, *100*(5), 2093–2124.

A Appendix

Proofs

Proof of Proposition 1.

Exporters' growth is given by $\ln(\frac{A'}{A})$. The proposition follows from (3) and Jensen's inequality.

Proof of Lemma 1.

The result follows from Jensen's inequality.

Proof of Proposition 2.

Let Exp^{e1} and Exp^{e2} be the total exports of two identical economies, where exporters' revenue functions $r\hat{e}v(z)$ are concave in productivity. In the latter economy, the productivity distribution is a mean-preserving spread of the former.

Lemma 1 implies $Exp^{e1} > Exp^{e2}$. Denote export differences as $\Delta Exp = \ln \frac{Exp^{e1}}{Exp^{e2}} > 0$. Denote the export change predicted by the convex model as $\Delta Exp^{\text{convex model}} < 0$.

Define $\ln \hat{\tau}$ as follows,

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

This implies that we need to reduce the predicted exports in the convex model by $\hat{\tau} > 1$ after a firm's productivity mean preserving spread to match the data.

To see how this translated into higher costs for exporting, denote by mgc the marginal cost of exporting such that

$$\int r\hat{e}v(mgc)dF = Exp^{\text{e2}}$$

This implies that:

$$\int r\hat{e}v^{convex}(mgc)dF = Exp^{convex,e2} > Exp^{e2}$$

Furthermore, assume for simplicity that $Exp^{e1} = Exp^{convex,e1}$. Since revenues are continuous, define $m\hat{g}c_i = \alpha\, mgc_i$ as the estimated marginal cost of exporting in the convex model, such that:

$$\int r\hat{e}v^{convex}(m\hat{g}c)dF = Exp^{e2}$$

Note that α does not vary across firms. It is sufficient to show that $\alpha > 1$ for all firms. To prove it, assume the contrary. We have two cases. The first case is $\alpha = 1$ and hence $\hat{mgc} = mgc$ for all firms. Since $\hat{rev}(\cdot) > 0$ and $\hat{mgc} = mgc$ for all i, we have $\hat{\tau} = 0$, contradicting Lemma 1.

The second case is $\alpha < 1$, which implies $\hat{mgc} < mgc \ \forall\ i$. Since revenues are decreasing in mgc, we have

$$\int \hat{rev}^{convex}(mgc)dF < \int \hat{rev}^{convex}(\hat{mgc})dF$$

By definition of $\hat{mgc}$ this implies $Exp^{convex,e2} < Exp^{e2}$ a contradiction to revenues being convex.

Hence $\alpha > 1$, which implies that $\hat{mgc} > mgc$. We can then define the firm-level iceberg cost as:

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

Proof of Proposition 3.

The revenue change relative to firm productivity is as follows: $\frac{drev(z)}{dz} = \frac{dp}{dz}\left[q + p\frac{\partial q}{\partial p}\right]$. The second difference is given by

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

where $\frac{d^2p}{dz^2} \geq 0$ and $\frac{\partial q}{\partial p} < 0$. Let $\xi < -1$ denote the price elasticity, and let $\varepsilon_{\xi,p} > 0$ denote the elasticity of $|\xi|$ with respect to firm price. The second derivative of quantities with respect to prices is equal to:

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

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

When $\varepsilon_{\xi,p} = 0$, $\frac{d^2rev(z)}{dz^2} > 0$. But if $\varepsilon_{\xi,p} > |\xi| - 1 > 0$ for all z, then $\frac{d^2rev(z)}{dz^2} < 0$.

Online Appendix (For online publication only)

B Cross-country Data and Estimation Robustness

This section provides additional details on the cross-country data and estimation robustness.

B.1 Cross-Country Estimation

Measurement of firm-level volatility. Table A.1 presents the results of estimating equation (11) using different ways of computing firms volatility. Column 1 uses the baseline measure and focuses on manufacturing firms. Column 2 includes all firms regardless of sector. Column 3 restricts to firms reporting zero direct or indirect exports. Column 4 presents the results when firms' volatility is constructed as in the baseline, but using the change in the number of total workers instead of sales. Table A.2 presents analogous results using the inter-quartile range instead of the standard deviation.

One step PPML. I test whether results are robust to alternative estimation methods. Another approach is to estimate the relationship in one step via PPML, including a border dummy:

$$\begin{aligned} sales_{ij,t} = exp\Big\{ & I_{\text{Border}_{i\neq j,t}} + I_{\text{Border}_{i\neq j,t}} \times \Big(\beta_1 \ln \sigma_{i,t} + \beta_2 \ln \frac{GDP_{i,t}}{L_{i,t}} + \beta_3 \ln \text{fin. fric}_{i,t} \\ & + \boldsymbol{\beta_4} \boldsymbol{y}_{ij,t} + \boldsymbol{\beta_5} h_{i,t}\Big) + \beta_6 \ln \sigma_{i,t} + \beta_7 \ln \frac{GDP_{i,t}}{L_{i,t}} + \beta_8 \ln \text{fin. fric}_{i,t} \\ & + \boldsymbol{\beta_9} \boldsymbol{y}_{ij,t} + \boldsymbol{\beta}_{10} h_{i,t} + \gamma_{j,t} + \varepsilon_{ij,t} \Big\}; \end{aligned} \tag{23}$$

where $sales_{ij,t}$ includes both domestic and bilateral sales. The main variable of interest is the one described in the main text when interacted with a border effect dummy $I_{\text{Border}_{i\neq j,t}}$. The dummy equals one when i sells to a foreign country, and zero when sales are domestic, allowing me to identify the differential effect on trade relative to domestic flows. The vector $\boldsymbol{y}_{ijt}$ includes standard gravity controls for each bilateral country pair: (1) log distance between most populated cities (km); (2) UN diplomatic disagreement score; and indicator variables for (3) contiguous borders; (4) common official or primary language; (5) for when at least 9% common language; (6) for past colonial ties; and (7) for when a free trade agreement is in place. Lastly, the vector $h_{i,t}$, denotes a control for firms' entry costs - proxy by the numbers of procedures to register a business- and a set of indicators capturing if the country belongs to the European Union, the World Trade Organization, has GATT membership, and two categorical variables for the origins and the current the legal system type. Finally, $\gamma_{j,t}$ denotes destination-year fixed effects. Table A.3 presents the estimation results. Previous findings remain valid.

B.2 Firm-level Estimation

Estimation of Markup response: Instrumental variable approach

This section provides additional details on the markup estimation procedure and robustness checks.

This section provides additional details on the IV estimation of equation (6). As described in Section 4.1, I instrument the interaction of bilateral exchange rate changes with market share using remittance flows from third countries to Colombia.

The IV strategy requires two assumptions discussed in Section 4.1: remittance flows must affect exchange rates, and conditional on the included fixed effects, remittance shocks must be orthogonal to destination-specific demand conditions.

Results comparing the IV and the OLS estimation are presented in Table A.7. Relative to Table 1 in the main text, this table adds three additional specifications in Columns 5–7. As can be seen, the F-statistic ranges between 65.15 and 108.22 for different specifications. Column 5 presents the results of dropping the firm-destination-product fixed effects. Column 6 shows that the results hold if we condition the sample on those exporters that continue exporting in 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 the benchmark case (column 4) used to calibrate the model is on the conservative side of the estimates.

New exporters' dynamics

This section provides additional details on the estimation of equation (8) and presents robustness checks. I estimate the specification using two dependent variables: (i) total export quantities $\text{export}^q_{i,l,d,t}$, and (ii) export intensity $\frac{\text{export}_{i,l,d,t}}{\text{Tot. sales}_{i,t}}$.[27] To examine price dynamics, I also estimate:

$$\ln p_{i,l,d,t} = \sum_{h=0}^{6} \beta^p_h \mathbb{I}^h_{\{age=h\}} + \gamma_{i,l,t} + \gamma_{d,l,t} + \gamma_{\text{cohorts}} + \varepsilon^p_{i,l,d,t}$$

where β^p_h captures cumulative price changes over the exporter life cycle relative to entry.

[27] Ideally, I would divide by domestic sales of the same product l, but that data is unavailable.

Results are presented in Table A.5. Columns 1–4 use quantities, columns 5–8 use export intensity, and columns 9–10 use prices. The results confirm that exporters grow primarily through demand shifts rather than price adjustments, consistent with Firm-level Fact 2 in the main text.

Volatility and exporter life cycle

Baseline firm's sales volatility measure. Following the approach in Section 4, I exploit a leave-one-out strategy using detailed Colombian firm-level data. As before, firms' i idiosyncratic sales changes are estimated as follows:

$$\Delta \text{dom. sales}_{i,j(i),t} = \gamma_{j(i),t} + e_{i,j(i),t}$$

where Δdom. $\text{sales}_{i,j(i),t}$ is the log change in domestic sales, $\gamma_{j(i),t}$ denotes industry-time fixed effects (with $j(i)$ being firm i's industry), and $e_{i,j(i),t}$ is the idiosyncratic component.

I compute firm i's exposure to domestic firm-level volatility, $\sigma_{i,t}$, as follows. I compute the cross-sectional standard deviation of $e_{j,j(i),t}$ at time t for all firms $j \neq i$ in the same industry. The focus on domestic sales shocks to other firms within the same industry serves two purposes: first, it allows me to avoid the volatility measure being related to the direct effects of foreign demand shocks, and second, it prevents the measure from being related to shocks to the firm itself.

Below, I describe the construction of alternative volatility measures:

Robustness measure 2: A product weighted measure of firms' volatility exposure. The measure of volatility used in Column (8) is constructed as follows:

1. Compute the annual log on one year of the real domestic sales of each firm i, defined as Δdom. sales

2. Compute the cross-sectional standard deviation of Δdom. sales for each year among firms sharing the same 6-digit main export product in category J, then average over time for each product j. Denote this sd_J^{hs6}. Denote this measure by sd_J^{hs6}

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

4. Compute the 6-digit product average share as the average share between 2006 and 2009 for all the firms selling that 6-digit 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 destinations it sells to by estimating:

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

3. Compute the cross-section standard deviation of $\gamma_{i,t}$, for each year t, of those firms other than i with main export products in the 6-digit category that 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:

$$\Delta exp_{i,l,d,t} = \theta_{d,l,t} + \Delta e\hat{x}p_{i,l,d,t} \tag{25}$$

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.

Estimation results. Table A.6 presents the estimation of equation (9). Columns 1 to 7 present the results using the baseline measure for domestic sales volatility. Columns 5 to 7 estimate equation (9) conditional on those exporters with at least five and six 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 firm-level volatility explained above.

The similarity of the documented patterns suggests that the results are not driven by the possible selection due to firms' exit, nor by the measure of volatility used, nor by the dependent variable used to measure customer capital evolution. When I test for all these cases, the documented patterns are similar, and I cannot reject the model's main predictions regarding the effects of volatility on exporters' life cycle evolution.

C Model Algorithm

The model solves for the steady state under different values of σ, with corresponding adjustments to μ and ρ to ensure mean-preserving spreads in productivity volatility.

Given the high nonlinearities of the firm's problem, I solve the model using global methods. First, domestic decisions are static, requiring only the solution for optimal prices. To solve 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 distribution to solve for w and w'. Because I solve for the steady-state distribution, I use the wage as a state variable rather than the full firm distribution, which is computationally infeasible. This is sufficient given the small open economy assumption.

To solve for the economy's aggregate equilibrium, I proceed as follows: When calibrating the model, I set the wage equal to one. I normalize the baseline wage to one. For each change in the volatility parameters, I re-solve for the entire value function, policy functions, and aggregate economy.

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

1. Fix the parameter values of the problem and pre-set ε to a small value.

2. Set a grid space of $(20 \times 85 \times 10)$ 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 (100×120) possible grid points for the state variable. Compute the Markov transition matrix $H(\cdot)$ for the firm distribution, conditional on wage 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.

Appendix Tables

Table A.1: Firm-level Volatility, Development and Exports Costs

	(1)	(2)	(3)	(4)
ln (GDP per capita)	-0.447***	-0.547***	-0.592***	-0.561***
	(0.114)	(0.124)	(0.126)	(0.122)
ln (Firm volatility)^{Baseline}	0.577***			
	(0.101)			
ln (Financial frictions)	0.086	0.077	0.082	0.074
	(0.126)	(0.143)	(0.148)	(0.142)
ln (Firm volatility)$^{\text{All firms}}$		0.499***		
		(0.113)		
ln (Firm volatility)$^{\text{No exporters}}$			0.414***	
			(0.111)	
ln (Firm volatility)$^{\text{workers}}$				0.516***
				(0.105)
N	126	126	126	126
adj. R^2	0.590	0.547	0.526	0.548
Year FE	✓	✓	✓	✓
Controls	✓	✓	✓	

Note: Table reports estimates of equation (11) with varying firm-level volatility measures: manufacturing sample (baseline), all firms sample, non-exporters sample (direct or indirect exports), and worker-based volatility. Export costs are estimated using PPML, following a gravity specification similar to Waugh (2010) (equation (10)). Annual trade flows are used. Controls include financial access (as indicated in the WBES database), entry costs (measured by the number of procedures), and dummies for EU, WTO, GATT membership, and legal origin. Standard errors clustered at the origin country level are in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table A.2: Firm-level Volatility (IQR), Development and Exports Costs

	(1)	(2)	(3)	(4)	(5)
ln (GDP per capita)	-0.684***	-0.383***	-0.392***	-0.447***	-0.424***
	(0.135)	(0.114)	(0.111)	(0.111)	(0.118)
ln (Financial frictions)	0.070	0.065	0.089	0.084	0.068
	(0.159)	(0.122)	(0.123)	(0.129)	(0.127)
ln (Firm volatility)$^{IQR-manuf}$		0.401***			
		(0.060)			
ln (Firm volatility)$^{IQR-all}$			0.419***		
			(0.077)		
ln (Firm volatility)$^{IQR-no\ exp}$				0.388***	
				(0.079)	
ln (Firm volatility)$^{IQR-workers}$					0.460***
					(0.079)
N	126	126	126	126	126
Year FE	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓

Note: Table reports estimates of equation (11) with varying firm-level volatility measures: manufacturing sample (baseline), all firms sample, non-exporters sample (direct or indirect exports), and worker-based volatility. Volatility measures are constructed using the inter-quartile range (IQR). Export costs are estimated using PPML, following a gravity specification similar to Waugh (2010) (equation (10)). Annual trade flows are used. Controls include financial access (as indicated in the WBES database), entry costs (measured by the number of procedures), and dummies for EU, WTO, GATT membership, and legal origin. Standard errors clustered at the origin country level are in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table A.3: One step PPML

	(1)	(2)	(3)	(4)
$\ln(\text{GDP per capita})$	0.259*	0.491***	0.514***	-0.057
	(0.134)	(0.129)	(0.134)	(0.124)
$I_{\text{Border}} \times \ln(\text{GDP per capita})$	0.591***	0.522***	0.539***	0.636***
	(0.146)	(0.144)	(0.148)	(0.133)
$\ln(\text{Firm volatility})^{Baseline}$	-0.783***			
	(0.115)			
$I_{\text{Border}} \times \ln(\text{Firm volatility})^{Baseline}$	-0.255**			
	(0.120)			
$\ln(\text{Firm volatility})^{All}$		-0.650***		
		(0.110)		
$I_{\text{Border}} \times \ln(\text{Firm volatility})^{All}$		-0.234**		
		(0.113)		
$\ln(\text{Firm volatility})^{no\ exp}$			-0.513***	
			(0.100)	
$I_{\text{Border}} \times \ln(\text{Firm volatility})^{no\ exp}$			-0.311***	
			(0.102)	
$\ln(\text{Firm volatility})^{IQR\ manuf.}$				-0.717***
				(0.073)
$I_{\text{Border}} \times \ln(\text{Firm volatility})^{IQR\ manuf.}$				-0.276***
				(0.077)
Observations	26516	26516	26516	27250
Year $\times$ Destination FE	✓	✓	✓	✓
Controls $\times$ I_{Border}	✓	✓	✓	✓

Note: Table presents PPML estimates of equation (23) using annual domestic and trade flows. It presents results using different volatility measures as detailed in Appendix B.1. Gravity controls for each pair include log distance, UN disagreement score, and dummies for contiguous borders, common official language, at least 9% common language, past colonial ties, and free trade agreement. Origin country controls include financial access (WBES), entry costs (procedures), GDP per capita (PPP), and dummies for EU, WTO, GATT, and legal origin. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

Table A.4: Robustness Firm-level 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 2 using different ways of computing firm-level volatility. Standard errors are in brackets and are clustered at the origin country level. $^{*}p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A.5: 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 each year. Standard errors 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. Standard errors cluster at the 6-digit product. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A.6: 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 (9). 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.2. Total tenure refers to the minimum number of years exporters have continuously exported to each market in the sample. Standard errors cluster at the firm level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A.7: 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 1. Continued exporting denotes the case when the sample is restricted to exporters that continue to export in the following year. 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. Standard errors cluster at the destination country. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$