Banco de México

Documentos de Investigación

Banco de México

Working Papers

N° 2019-05

Firm Export Dynamics and the Exchange Rate: A Quantitative Exploration

Bernabe Lopez-Martin
Banco de México

March 2019

La serie de Documentos de Investigación del Banco de México divulga resultados preliminares de trabajos de investigación económica realizados en el Banco de México con la finalidad de propiciar el intercambio y debate de ideas. El contenido de los Documentos de Investigación, así como las conclusiones que de ellos se derivan, son responsabilidad exclusiva de los autores y no reflejan necesariamente las del Banco de México.

The Working Papers series of Banco de México disseminates preliminary results of economic research conducted at Banco de México in order to promote the exchange and debate of ideas. The views and conclusions presented in the Working Papers are exclusively the responsibility of the authors and do not necessarily reflect those of Banco de México.

Documento de Investigación
2019-05

Working Paper
2019-05

Firm Export Dynamics and the Exchange Rate: A Quantitative Exploration

Bernabe Lopez-Martin†
Banco de México

Abstract: We develop a quantitative theoretical model of firm dynamics to analyze key determinants of the elasticity of exports with respect to the exchange rate. The model incorporates mechanisms that determine the firms? capacity to react when the profitability of exports change due to fluctuations in the exchange rate. The framework allows for a quantitative assessment of different mechanisms: distribution costs represent the most important factor, as well as the exogenous and gradual growth dynamics of new exporters, and the currency denomination of sunk-entry costs into the foreign market. The different versions of the model are evaluated by contrasting the behavior of simulated variables with empirical estimates and evidence found in the literature. In addition, we present an assessment of the effects on the intensive and extensive margins of exports.
Keywords: export dynamics, hysteresis, exchange rates, heterogeneous firms, exchange rate pass-through
JEL Classification: F12, F41

Resumen: En este documento se desarrolla un modelo teórico dinámico de firmas con el objetivo de analizar los determinantes clave de la elasticidad de las exportaciones con respecto al tipo de cambio. El modelo incorpora mecanismos que determinan la capacidad de las firmas para reaccionar ante cambios en la rentabilidad de las exportaciones generados por fluctuaciones en el tipo de cambio. Este marco permite una evaluación cuantitativa de diferentes mecanismos: los costos de distribución representan el factor de mayor importancia, así como el crecimiento exógeno y gradual de los nuevos exportadores, y la moneda que denomina los costos hundidos de entrada al mercado extranjero. Distintas versiones del modelo son evaluadas contrastando el comportamiento de las variables simuladas con estimaciones empíricas y evidencia encontrada en la literatura. Así mismo, se presenta un análisis de los efectos sobre de los márgenes intensivos y extensivos de las exportaciones.
Palabras Clave: dinámica de exportaciones, histéresis, tipo de cambio, firmas heterogéneas, traspaso del tipo de cambio

† Dirección General de Investigación Económica, Banco de México. Email: bernabe.lopez@banxico.org.mx.

1 Introduction

How do international trade flows respond to fluctuations in exchange rates? The understanding of the impact of exchange rates on international trade is critical for economic policy given its potential influence on economic activity and its role in the adjustment process of current account balances.[1] Furthermore, its relevance also becomes apparent considering the consequences that could result from ill-designed government initiatives (Auboin and Ruta, 2013). The empirical evidence linking exchange rate depreciations and aggregate exports is often misinterpreted and researchers frequently caution against instrumenting policies to exploit this relationship. For example, Freund and Pierola (2012) find that export surges in developing countries tend to be preceded by a large real depreciation, while in developed countries this relationship is not statistically significant. They cautiously warn about the extent to which policy-induced depreciations may be used as a means of promoting export growth.

The issue has also garnered significant attention in academia. The response of aggregate exports to movements in real exchange rates has been found to be rather limited (a review of the literature is provided below). This evidence has guided the calibration of models of international business cycles, where a relatively low elasticity of substitution between domestic and foreign goods, governed by the *Armington elasticity*, is typically considered to replicate comovements of relative prices and quantities at the business cycle frequency. In stark contrast, applied general equilibrium models require a relatively large elasticity of substitution to explain the growth in trade volumes that result from changes in tariffs. Ruhl (2008) coins the term *international elasticity puzzle* to describe this apparent inconsistency.

Research has made progress in identifying mechanisms that reconcile these seemingly contradictory findings regarding the elasticity of trade. Ruhl (2008) constructs a model where cyclical fluctuations are caused by temporary shocks, in the business cycle tradition, while tariff modifications are permanent in nature. His model features heteroge-

[1] For a discussion of these issues see IMF (2015, Ch. 3). An additional example of the relevance of the topic is the attention given to the debate on whether currency manipulation is equivalent to trade protection.

neous firm productivity and a cost to enter the foreign market. Entry costs interact with firm-level heterogeneity to partition firms into exporters and non-exporters (Baldwin and Krugman, 1989; Dixit, 1989). A non-exporting firm compares the expected future gains of exporting to the cost of entering the foreign market. The reaction of this *extensive margin of exports* will depend on whether changes in the gains of accessing the new market are perceived to be temporary, as is the case of exchange rate fluctuations, or relatively permanent, which is the case for changes in tariffs.

This article contributes to the literature and policy discussions by exploiting a theoretical model of firm dynamics to provide a quantitative analysis of different determinants of the elasticity of exports with respect to the exchange rate. The model considers the micro-foundations of export supply functions by incorporating features that shape firm-level production and investment decisions, and their response to exchange rate fluctuations. We examine and contrast the different mechanisms that shape the relationship of exports and the exchange rates at the aggregate and firm levels, and assess their contributions through the *intensive* and *extensive* margins of exports, recognizing their interrelation.

Distribution costs represent an important proportion of the final price to consumers. Burstein et al. (2003) document that distribution costs are large for the average consumer good, representing more than 40 percent of the retail price in the US.[2] Berger et al. (2009) find overall distribution wedges of around 50-70% for U.S. data during 1994-2007. For a sample of 21 industrialized economies, Goldberg and Campa (2010) document that distribution margins of household consumption goods are in the range of 30-50 percent of the purchase price. Distribution services are intensive in local factors and hence non-tradable, thus creating a natural wedge between the prices of tradable goods across countries (Burstein et al., 2003; Corsetti et al., 2008), and reducing the changes in the profitability of exports generated by fluctuations in the exchange rate. In my quantitative model, I find that distribution costs have a significant impact on the exchange rate elas-

[2] Distribution costs include transportation across countries, wholesale and retail services, marketing and advertisement and local transportation services. Burstein et al. (2003) report the distribution margin for six OECD economies: Canada, France, Germany, Italy, Japan and the UK. For consumption goods these margins range from 35% in France to 50% in Japan (the average including the estimate for the US is 42.8%).

ticity of exports, even under a conservative calibration approach for the magnitude of distribution costs. Furthermore, the literature focusing on the exchange rate pass-through to prices has already emphasized the importance of distribution costs (e.g., Corsetti et al., 2008), with implications for how currency fluctuations affect inflation and therefore the conduct of monetary policy.

We exploit the model to evaluate the quantitative relevance of additional mechanisms: gradual exporter growth, imported intermediate inputs, entry and fixed per-period costs of access to the foreign market denominated in local or foreign currency. Considering a model with a variety of mechanisms is key to provide a proper assessment of their relative quantitative importance. An exhaustive evaluation of different versions of the model is carried out by contrasting the behavior of aggregate variables obtained from model simulations against empirical results in the literature. Additionally, firm-level regressions from simulations are compared with firm-level empirical estimations, using both results from the literature and a firm-level data set from Mexico.

The rest of this article is organized as follows. In Section 2, we provide a review of the related empirical and theoretical literatures. In Section 3 the theoretical framework is described. In Section 4, we discuss different mechanisms that are at work in the model. The parameters and the calibration procedure are discussed in Section 5. Section 6 presents the quantitative analysis and the main results. We conclude with some final comments.

2 Relation to the Literature

For the sake of clarity in the discussion of the literature, in this section we divide the literature in two parts: empirical evidence and theoretical mechanisms, although some articles provide contributions in both dimensions.

2.1 Empirical Evidence

A number of articles provide an empirical analysis of the relationship between exchange rates and exports with different types of data. Freund and Pierola (2012) use country-level data to estimate the impact of real exchange rates on exports. They find that depreciations only stimulate exports in developing countries. Their results imply that a 10 percentage point increase in currency competitiveness leads to approximately 3-7 percentage point export growth. Bussière et al. (2016) exploit data on bilateral trade flows, covering 5 thousand products and more than 160 trading partners during 1995-2012. Results depend on the specification, with the median elasticity across economies typically in the range of 0.35-0.50, although these include non-significant coefficients and a wide dispersion in estimates.

The relationship between exchange rates and exports has also been empirically studied with firm-level data. Fitzgerald and Haller (2018) exploit firms and customs micro-data for Ireland to estimate how export entry and exit, as well as the export revenue of incumbent exporters respond to changes in tariffs and fluctuations in real exchange rates. In their estimations, although entry into export markets is several times more responsive to tariffs relative to real exchange rates, the absolute level of entry responses to both variables is modest. Furthermore, they do not find statistically significant responses of firm exit from foreign markets to either variable. Their estimates translate into an elasticity of aggregate exports with respect to real exchange rates of 0.50 on impact, and between 0.60 and 0.80 in the long run. These estimates are consistent with the elasticities summarized by Ruhl (2008). Dekle et al. (2010) estimate an elasticity in the range of 0.41 to 0.77, with a preferred estimate of 0.77, using firm-level data from Japan, and reconcile their firm-level estimates with an aggregate elasticity of 0.65. Tang and Zhang (2012) and Li et al. (2015), using Chinese data, estimate firm-level elasticities in the range of 0.25 to 0.45. Furthermore, Li et al. (2015) find evidence that distribution costs and the proportion of imported inputs reduce the quantity responsiveness of exports with respect to exchange rate fluctuations. Campa (2004) estimates a firm level elasticity of approximately 0.70 for Spain, his estimates translate into an aggregate elasticity of 0.80. Fabling and Sanderson (2015) find limited elasticities at both the extensive and intensive margins in the case of

New Zealand.

The role of heterogeneity at the firm-level has also been examined. Berman et al. (2012) use firm-level data for France and document that the average exporter increases its export volumes by 4 percent in front of a 10 percent depreciation (the range of estimates for the elasticity is 0.40 to 0.70, with 0.40 being their preferred estimate).[3] They find evidence that higher performance firms tend to absorb exchange rate movements in their markups, reducing the sensitivity in their export volumes. They show that, although this behavior is consistent with different mechanisms, the evidence points in favor of models that emphasize the relevance of distribution costs.[4] Berthou and Dhyne (2018) estimate the exchange rate elasticity using a micro-level dataset for 11 European countries for the period 2001-2011. The benchmark average microeconomic elasticity ranges from 0.50 to 0.80. In line with the results in Berman et al. (2012), the elasticity from the least productive firms is higher than for the most productive firms. These results will be used to evaluate the performance of different versions of the theoretical model.

2.2 Theoretical Mechanisms

The first generation of models that provided microeconomic foundations for trade dynamics at the firm level formalized the idea that large shocks to the exchange rate could have persistent effects on international trade (Baldwin and Krugman, 1989; Dixit, 1989). These frameworks analyze the decision to export in environments that feature uncertainty in exchange rates and sunk entry costs that must be incurred in order to gain access to the foreign market and per-period fixed costs to maintain that access.[5] The existence of sunk entry costs implies that the decision to supply the foreign market is forward looking. In these models, *hysteresis* refers to an effect that persists after the cause that brought it

[3]In the aggregate, the elasticity of volumes with respect to the exchange rate is 0.95, with 0.08 and 0.87 attributed to the extensive and intensive margins, respectively (their Table XII).

[4]The elasticity of demand for an exporter falls with a real exchange rate depreciation. A depreciation implies a fall in the import price in the currency of the country of destination, while distribution costs are not affected by a depreciation. Therefore, the share in the price paid by the consumer that depends on the export price falls, reducing the elasticity of demand perceived by the firm with respect to its export price.

[5]Firms that are not exporting face the costs of establishing distribution channels, learning and complying with bureaucratic procedures, adapting their products and packaging for foreign markets, etc. (see Roberts and Tybout, 1997; Das et al., 2007).

about has been removed (Dixit, 1989): a temporary appreciation in the exchange rate, if sufficiently large, induces foreign firms to enter a domestic market. Given that entry costs are sunk, not all of the new entrant firms will leave the market when exchange rates revert to original levels (Baldwin and Krugman, 1989). Posterior research provided inference and a quantitative estimation of these effects (e.g., Roberts and Tybout, 1997; Campa, 2004; Das et al., 2007; Rho and Rodrigue, 2016; Ruhl and Willis, 2017).

To account for the quantitatively different responses of trade flows to changes in tariffs and fluctuations in exchange rates, Fitzgerald and Haller (2018) argue that the key feature necessary in standard models of international trade and international business cycles is forward-looking investment in customer base. The nature of tariffs makes them more predictable relative to real exchange rates, therefore firms will optimally increase investment in their customer base by a larger extent in response to favorable changes in tariffs than in response to favorable movements in real exchange rates, resulting in export revenue being more responsive to tariffs in line with empirical findings. The mechanisms they propose builds on a growing literature in macroeconomics and international trade on the importance of the customer base of firms. Alessandria et al. (2015) embed a dynamic model of export participation into a small-open-economy framework to account for the the gradual expansion of exports in emerging markets following large devaluations (average depreciations of 40-50 percentage points). Their results emphasize the importance of high interest rates and less impatience of the representative household associated with those events. This reduces incentives to invest in expanding exports quickly or strongly, dampening export growth and generating a relatively more gradual net export dynamics.

A series of articles analyze how financial frictions and balance-sheet effects contribute to determine the reaction of exports with respect to exchange rate fluctuations (Pratap and Urrutia, 2004; Chaney, 2016; Kohn et al., 2017; Salomao and Varela, 2018). Similarly, Cooper and Haltiwanger (2006), among others, have already stressed the role of capital adjustment costs for understanding the behavior of investment both at the firm and at the aggregate level: to the extent that firms face costs of adjusting capital, this could potentially represent an obstacle to adjusting the scale of production in response to changes in the profitability of serving the foreign (or domestic) market (see Rho and Rodrigue, 2016; Liu, 2015; Riaño, 2011).

Recent work by Lewis (2017) examines three mechanisms: price rigidities, strategic complementarities and intermediate inputs. He concludes that even with significant price frictions, the model is incapable of matching trade-flows responses to exchange rate movements (see also the discussion in Kohn et al., 2017), while imported intermediates are an unlikely source explanation of their dynamics. His thorough empirical analysis centers on U.S. sectoral commerce data. Similarly, Fitzgerald et al. (2017) conclude that price rigidities and markup adjustment are not sufficient to account for the insensitivity of exports to real exchange rates, and point to the role of the accumulation of customer base in foreign markets.

3 Theoretical Framework

The theoretical framework is a dynamic model of heterogeneous firms that consider the decision to enter a foreign market. Firms are subject to two sources of uncertainty: fluctuations in exchange rates and idiosyncratic productivity shocks. The analysis is at the industry level and thus the process for the exchange rate is taken as exogenous (e.g., Dixit, 1989; Das et al., 2007; Ruhl and Willis, 2017; Lewis, 2017, etc.).[6] To understand firm-level responses it is convenient to think of firms as solving two interrelated problems. The static problem consists of the maximization of profits by the firm in a given period, taking as given its productivity level and stock of capital. Firms combine labor, capital, and imported and domestically sourced intermediate inputs to produce a unique variety of goods. The firm faces two dynamic decisions: accumulation of capital for production

[6] In the literature, the *exchange-rate disconnect puzzle* points to the volatility of exchange rates and their apparent disconnection from fundamentals. Obstfeld and Rogoff (2000) argue that to understand exchange rate volatility, we need to consider models that account for the high volatility observed in asset markets. Some recent examples in this direction, giving emphasis to financial factors, are found in Gabaix and Maggiori (2015) and Itskhoki and Mukhin (2017). The latter emphasizes that monetary and productivity shocks cannot be the key drivers of the exchange rate, if a model is to feature the *disconnection* properties. They also argue that their framework can be used as a theoretical foundation for a vast empirical literature that relies on exchange rate variation for identification.

and the decision to supply the foreign market. Each of these dynamic decisions faces trade-offs, which we describe below.

3.1 Foreign and Domestic Demand

There is a domestic and a foreign market, which are assumed to be segmented so that different prices can be charged by the firm in each market. In the foreign market the firm faces a demand function given by $b \cdot q_x^{\nu-1} = p_x$, where b is a parameter, p_x is the price in foreign currency and q_x is the quantity of the good supplied to the foreign market. Export revenues in domestic currency will be determined according to an exchange rate ε. Similarly, $u \cdot q_d^{\nu-1} = p_d$ is the domestic demand function, with parameter u, domestic price p_d and domestic quantity q_d. This demand function can be derived from a CES utility function where parameter ν determines the elasticity of substitution between the different varieties of goods.[7]

3.2 Production Technology

Firms combine labor, capital and imported and domestically-sourced intermediate inputs to produce a unique variety of goods. Present investment determines capital one period in advance: this results in capital being fixed at the beginning of any given period. In contrast, the levels of labor and intermediate inputs are decided after observing the firm-idiosyncratic productivity shock and the exchange rate at the beginning of each period. The specification for the production function is standard (e.g., Gopinath and Neiman, 2014; Ramanarayanan, 2017), where total output of the firm is determined by:

$$q = e^a \left(k^\alpha \, l^{1-\alpha}\right)^{1-\mu} x^\mu$$

where a is a stochastic productivity variable, which will be modelled as an AR(1) process. A CES aggregator x combines a bundle of intermediate inputs produced domestically z

[7] Parameters b and u can be interpreted as the *strength* of demand. With CES utility functions, the strength of demand would be determined by the CES price index and total consumer expenditures.

and another bundle of imported intermediate inputs m:

$$x = (z^\rho + m^\rho)^{1/\rho}$$

where the elasticity of substitution between the bundles of imported and domestically produced inputs is $1/(1-\rho)$.[8]

In models with linear production functions, the resulting constant marginal cost of production separates the export decision from the domestic production decision (Ruhl and Willis, 2017). In the presence of decreasing returns to scale (as is our case given the fixed level of capital at the beginning of each period), the export and domestic production decisions are interrelated (for more discussion and empirical evidence on capacity constraints see Soderbery, 2014; Ahn and McQuoid, 2017).

3.3 Distribution Costs

Supplying a unit of a good requires ϕ_d units of distribution services in terms of domestic labor to reach the final consumer in the domestic market and ϕ_x units of foreign labor to reach the final consumer in the foreign market. Total distribution costs, in domestic currency, are then be given by:

$$h(q_d, q_x, \varepsilon) \;=\; \phi_d \cdot q_d \cdot w + \phi_x \cdot q_x \cdot \varepsilon \cdot w^*$$

where w and w^* are the domestic and foreign wages, respectively.

We let h denote the fraction of output that is allocated to the foreign market, then we can rewrite total distribution costs in the following manner:

$$h(q_d, q_x, \varepsilon) \;=\; q \cdot ((1-h) \cdot \phi_d \cdot w + h \cdot \phi_x \cdot \varepsilon \cdot w^*)$$

[8] A series of articles endogenize, for different purposes, the intensive and extensive margins of imports of intermediate inputs (e.g., Kasahara and Lapham, 2013; Amiti et al., 2014; Gopinath and Neiman, 2014; Halpern et al., 2015; Ramanarayanan, 2017; Blaum, 2018). A stylized fact of this literature is that the largest exporters are the largest importers, this could further affect how aggregate exports react to exchange rates. Additionally, the elasticity of substitution between domestic and imported intermediate inputs may vary across industries (e.g., Burstein et al., 2008).

We follow Burstein et al. (2003) and Corsetti et al. (2008) in considering that distribution costs are in terms of the non-tradable goods (to be more specific, in our case in terms of local labor in each market). In terms of the quantitative analysis of the model, we will consider different parameterizations to evaluate the role of distribution costs.

3.4 Static Problem of the Firm

The firm supplying the foreign and domestic markets maximizes profits, taking as given the exchange rate ε, its capital stock k, its idiosyncratic productivity level a, and the previously described demand functions:

$$
\begin{aligned}
\pi_x(a,k,\varepsilon) = \max_{\{z,\,m,\,l,\,q_d,\,q_x\}} & \; q_d \cdot p_d + \varepsilon \cdot p_x \cdot q_x - w \cdot l - p_m \cdot m \cdot \varepsilon - p_z \cdot z - h(q_d, q_x, \varepsilon) \\
\text{s.t.} \quad & q_d + q_x = e^a \left(k^\alpha\, l^{1-\alpha}\right)^{1-\mu} x^\mu
\end{aligned}
$$

where p_m and p_z are the prices of the imported and domestic input bundles, respectively (the price of the foreign input basket is in terms of foreign currency). We can rewrite this problem using h as the share of total production that is exported by the firm and using the demand functions for each market:

$$
\begin{aligned}
\pi_x(a,k,\varepsilon) = \max_{\{z,\,m,\,l,\,h\}} & \; u \cdot q_d^\nu + b \cdot \varepsilon \cdot q_x^\nu - w \cdot l - p_m \cdot m \cdot \varepsilon - p_z \cdot z - h(q_d, q_x, \varepsilon) \\
\text{s.t.} \quad & q_d + q_x = h\, q + (1-h)\, q = e^a \left(k^\alpha\, l^{1-\alpha}\right)^{1-\mu} x^\mu
\end{aligned}
$$

For a firm that is not exporting, the problem is simply modified by setting h equal to zero, we will denote these profits as $\pi_n(a,k,\varepsilon)$.

3.5 Dynamic Problem: Preliminaries

The exogenous state variables for the firm are $\{a, \varepsilon\}$, the idiosyncratic productivity level a follows a stochastic process $\Lambda(a' \,|\, a)$ and the exchange rate follows a stochastic process $\Gamma(\varepsilon' \,|\, \varepsilon)$, both with a Markov structure. The endogenous state variables are the stock of capital k and the export status of the firm. The firm supplying only the domestic market faces a sunk entry cost if it wants to enter the foreign market, this implies that the decision to export is dynamic in nature. Additionally, there is a per-period fixed cost of exporting which, depending on the parameterization of the model, generates exit from the foreign market when a firm does not find it optimal to continue to export.

There is a large and exogenously fixed number of (possibly) risk-averse firms (Riaño, 2011; Kohn et al., 2016), where each firm produces a differentiated product as previously described and maximizes expected lifetime utility:[9]

$$\mathbb{E}\left[\sum_{t=0}^{\infty} \beta^t \, u(d_t)\right] \quad \text{with} \quad u(d_t) = \frac{d_t^{1-\sigma}}{1-\sigma}$$

where $d = \pi(\,\cdot\,) - i - c(i, k)$ are the dividends of the firm and i is investment in capital (profits depend on the export status of the firm), and $c(i, k)$ are capital adjustment costs, we describe these next.

3.6 Capital Adjustment Costs

The stock of capital is decided by the firm one period in advance and evolves according to a standard law of motion:

$$k_{t+1} = (1 - \delta)\, k_t + i_t$$

where δ it the rate of depreciation of capital and i_t is investment in period t.

Investment in capital for production is subject to adjustment costs. The baseline specification builds on Cooper and Haltiwanger (2006), which allows us to assess both convex and non-convex adjustment costs as well as partial irreversibility, necessary to reproduce relationships between investment and fundamentals that are similar to those documented in the literature. This type of model features have been extensively used in different applications including the literature on trade and firm dynamics (e.g., Riaño, 2011; Liu, 2015; Rho and Rodrigue, 2016). As is well understood from this literature, the different types of adjustment costs will allow the model to match a set of moments related to investment:

[9] Risk aversion dampens the response of investment to, for example, productivity shocks (Riaño, 2011).

for example, the fraction of observations with negative investment, spike rates of negative and positive investment (i.e., episodes of investment rates in excess of 20 percent), asymmetry in investment rates, etc.[10]

The irreversibility of investment projects caused by a lack of thick secondary markets for capital goods can act as another form of adjustment cost (Cooper and Haltiwanger, 2006). This problem could be specially acute in developing economies. For example, Riaño (2011) argues that manufacturing firms in Colombia seldom divest capital by selling in secondary markets. Gelos and Isgut (2001) exploit firm-level data for Colombia and Mexico and find that irreversibilities play a more important role than in more-advanced economies, while fixed costs of investment do not seem to be important. Irreversibility is incorporated in the specification of the price of investment $p(i,k)$, which would depend on whether there are capital purchases or sales (e.g., capital is sold at a lower price relative to the price at which it was purchased).[11] One implication will be that firms will not react as strongly, in terms of investment, to shocks that improve profitability. We describe the specification of adjustment costs in the calibration section.[12]

3.7 New Exporter Dynamics: Gradual Export Growth

We consider in our baseline model that foreign demand parameter b grows over time. This will allow the model to replicate the observation that new exporters initially export relatively small amounts and their foreign sale volumes grow gradually (Eaton et al., 2007; Cebreros, 2016; Ruhl and Willis, 2017). This dependence of exports on *foreign-market tenure* can be attributed to different mechanisms. Rauch and Watson (2003) argue that if the foreign market buyer faces uncertainty in terms of the capacity of the supplier to successfully fulfill a large order, then a partnership will start with relatively smaller orders and later graduate to larger ones. They provide supportive empirical evidence as well as

[10] This is not free of empirical challenges. Cooper and Haltiwanger (2006) warn that identifying inaction in investment at the micro-level can be difficult, considering the heterogeneity in capital assets and the associated heterogeneity in adjustment costs.

[11] In addition to specifications considered in the literature it is plausible that the cost of capital in foreign currency, at least in part, could act to some extent as a deterrent of investment in front of a depreciation in domestic currency.

[12] Distribution costs are estimated to be considerably lower for investment goods (see Corsetti et al. 2008), for simplicity we do not incorporate them in the baseline model.

a theoretical model to formalize this idea.

Aeberhardt et al. (2014) and Araujo et al. (2016) explore the role of contract enforcement and learning about the reliability of their trade partners. Timoshenko (2015) and Cebreros (2016) attribute the dynamic behavior to a learning process of firms in foreign markets, Arkolakis (2015) emphasizes market penetration costs, while Eaton et al. (2014) study jointly search costs of identifying potential clients and customer learning. Fitzgerald et al. (2017) propose a model where the accumulation of customer base is endogenous, to analyze its influence on the elasticity of exports with respect to the exchange rate. Consistent with results from these models, once we introduce a gradual dynamic process in the model, the role of sunk costs is reduced significantly. The specification for this simple process is explained in the calibration section and basically follows Ruhl and Willis (2017). With this extension the state variables in the model are $s = \{a, b, k, \varepsilon\}$, and the export status of the firm.

3.8 Dynamic Problem of the Firm

We can now proceed to write the dynamic problem of the firm in a recursive manner, the export status will be denoted by a subscript in the value function of the firm. We group state variables $s = \{a, b, k, \varepsilon\}$, the value of a non-exporting firm is written as follows:

$$v(s) = \max_{\{k'\}} u(\,\cdot\,) + \beta\,(1-\omega) \sum_{\{\varepsilon',\,a'\}} \Gamma(\varepsilon'\,|\,\varepsilon)\,\Lambda(a'\,|\,a)\;\max\{v(s'), v_{nx}(s')\}$$

where utility values dividend $d(a, k, i, \varepsilon)$ of the non-exporting firm, $v_{nx}(s')$ is the value of a *new exporter*, ω is the exogenous death rate of firms and β is the discount parameter. A firm may enter the foreign market many times during its existence, we label a firm as a *new exporter* every time it starts to export.

The dynamic problem of the firm with access to the foreign market is written in the following manner:

$$v_x(s) = \max_{\{k'\}} u(\,\cdot\,) + \beta\,(1-\omega) \sum_{\{\varepsilon',\,a'\}} \Gamma(\varepsilon' \,|\, \varepsilon)\,\Lambda(a' \,|\, a)\,\max\{v(s'), v_x(s')\}$$

where utility values the dividend $d_x(a, k, i, \varepsilon, b) - \varepsilon \cdot c_x$, c_x is the per-period fixed cost of access to the foreign market. The difference between new exporters and incumbents is that the former faces a sunk cost of entry into the foreign market denoted $\varepsilon \cdot c_s$ (otherwise these two problems are equivalent). In the baseline specification per-period fixed costs and the sunk cost of entry into the foreign market are in the foreign currency.

4 Model Mechanics

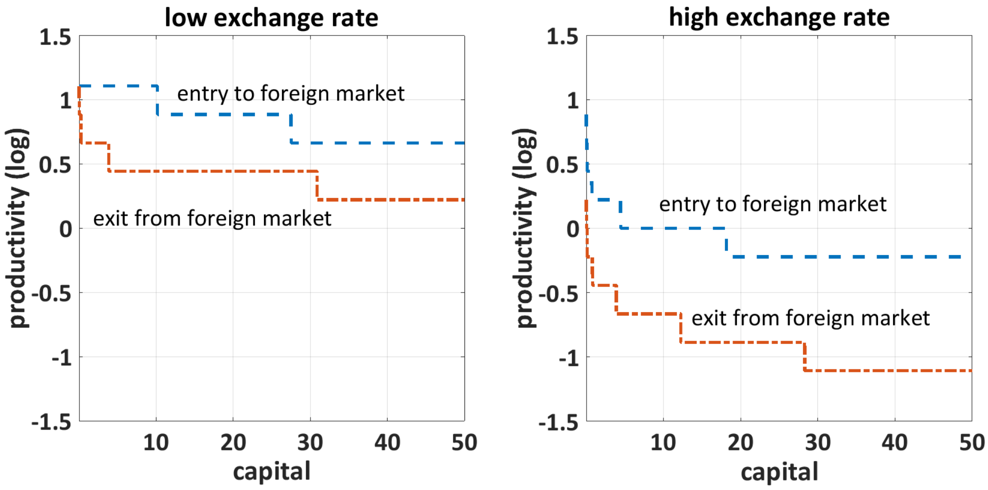
In this section, a brief review of the *hysteresis* mechanism is presented. Additionally, a brief discussion of how distribution costs interact with firm productivity, resulting in heterogeneous responses of exports to fluctuations in the exchange rate. This provides a description of key mechanisms of the model, which will contribute to the interpretation of the results in the quantitative analysis below.

4.1 Hysteresis Revisited

A standard property of models with sunk-costs of entry into the foreign market is that firms with a particular productivity level (and in the case of our model, physical capital as well) may be exporters or not depending on the history of their shocks (Baldwin and Krugman, 1989; Dixit, 1989; Riaño, 2011). We can illustrate this result as in Figure 1. Each panel depicts, for a given level of the exchange rate, the entry and exit decisions as a function of firm productivity (exogenous) and production capital (endogenous).

A firm that is not supplying the foreign market will wait for a sufficiently high level of idiosyncratic productivity to pay the sunk cost necessary to export (the blue line in each panel). However, this is not the productivity level below which producers exit the foreign market. The firm will continue to export until productivity falls below the exit level (the

Figure 1. Foreign Market Entry and Exit Decisions.



red line in each panel).

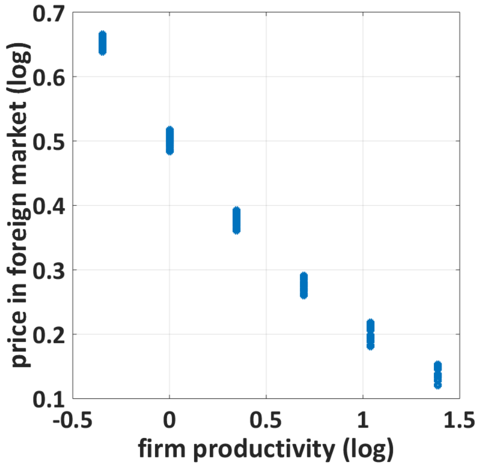
With sunk costs of exporting, the level of productivity that induces a firm to enter the export market is greater than the level that would lead to its exit. This results in an area where the exporter-status of the firm depends on the history of shocks (in our model, both shocks to productivity and exchange rates). The panel on the right in Figure 1 shows that for a higher (more depreciated) exchange rate, the firm will enter the foreign market at a lower level of idiosyncratic productivity, given that higher exchange rates increase the profitability of exporting (although increasing the cost of imported intermediate inputs, the fixed costs in foreign currency and foreign distribution costs). Gradual exporter growth reinforces hysteresis: firms that have remained in the export market for several periods and have increased their foreign demand will be reluctant to exit given the additional loss reentry involves in terms of losing accumulated foreign demand (Ruhl and Willis, 2017).

4.2 Productivity and the Exchange Rate Elasticity

Firms with higher productivity have lower export prices (see Figure 2, constructed with model simulations). In the presence of distribution costs, this implies that a larger share of the final consumer price does not depend on the export price set by the firm.

A depreciation increases the share of the consumer price which does not depend on the price of the exporter. This reduces the elasticity of demand, allowing firms to increase

Figure 2. Firm Productivity and Export Prices



their markup, but specially for the higher productivity firms that initially have lower elasticity.[13] This mechanism will be tested in our model, both qualitatively and quantitatively.

5 Parameters and Calibration

We separate the parameters of the model into two sets: the first one includes the parameters related to the static problem of the firm, and a second group related to the dynamic problem of the firm. A significant number of the parameters are standard and are therefore obtained from the literature.

5.1 Baseline Parameters: Static Problem of the Firm

The share of intermediate inputs in the production function is determined by μ. A value of 2/3 is used by Gopinath and Neiman (2014), which is consistent with the input-output table for Argentina. Ramanarayanan (2017) sets the average share of expenditures on intermediate goods as a fraction of gross output equal to 0.525, calculated for Chile using the annual industrial survey (his production function features a technology with decreasing returns to scale). Zhang (2017) uses data from the manufacturing census of Colombia: the

[13]Berman et al. (2012) discuss alternative mechanisms that generate this result, at least qualitatively. We follow their discussion in this brief section.

estimates for the share of inputs in the production function are in the range of 0.54-0.65, depending on the industry. Estimates of foreign and domestic value added by industry for Mexico are provided by De La Cruz et al. (2011). We start with a value of 2/3 for μ. The share parameter for capital α is set to 1/3, which is standard. Parameter ρ determines the elasticity of substitution between imported and domestic input baskets, a value of 0.75 is taken from Gopinath and Neiman (2014), and is within the range of estimates by Zhang (2017) for different industries in Colombia.

Table 1. Static Problem: Baseline Parameters.

description of parameter (predetermined)	parameter	value
elasticity of demand function	ν	0.80
share of intermediate inputs in production	μ	2/3
share of capital in production	α	1/3
elasticity of subst. across input baskets	ρ	0.75
domestic market demand (normalization)	u	1.00
description of parameter (calibration)	**parameter**	**value**
foreign market demand (min. level)	b	0.45
distribution costs	ϕ	2.75

The elasticity of the demand function is governed by parameter ν, which is set to 0.80 in accordance with the literature (e.g., Kohn et al. 2016; Ruhl and Willis, 2017). Quantitative exercises in Alessandria et al. (2015) suggest this parameter affects the elasticity of exports with respect to the exchange rate. The domestic demand parameter u can be normalized, while b is calibrated by targeting an average export to total sales ratio of exporting plants in the range of 0.135-0.165 (Kohn et al., 2016; Riaño, 2011; Ruhl and Willis, 2017).

In the baseline parameterization of the model distribution costs represent 45 percent of the retail price (with ϕ equal to 2.75, for both market destinations). This proportion is approximately at the lower bound of the range of estimates in Burstein et al. (2003), which include Argentina, the US, and a group of 6 additional OECD economies, and is close to the mid-range of the estimates of distribution margins of the purchase price of household consumption goods across 21 industrialized economies documented by Goldberg and Campa (2010). Berger et al. (2009) find that overall distribution wedges are around 50-70% for U.S. data during 1994-2007.[14]

5.2 Baseline Parameters: Dynamic Problem of the Firm

A period in our model is a year. We set an exogenous death rate of firms ω of 0.025, this is in line with the range of estimates of the death rate for relatively large firms. For example, Ramanarayanan (2017) sets the exogenous exit rate of firms at 0.029. The discount parameter β is set so that the total *effective discount* considering the exogenous death rate $\beta \cdot (1-\omega)$ is 0.90 as in Riaño (2011) and Das et al. (2007), models that emphasize financial constraints set lower discount parameters (e.g., a value of 0.83 in Kohn et al., 2016). The parameter σ that governs risk aversion is 1.5, within the range of values in the literature (Kohn et al., 2016; Riaño, 2011).

As is standard, the set of parameters jointly determine the different moments of model-simulated data.[15] For example, Ruhl and Willis (2017) explain that the sunk cost of entering the foreign market directly affects the rate at which firms start exporting (sometimes referred to as the *starter rate*), but also has an influence on the rate at which firms stop supplying the foreign market (the *stopper rate*): the reason is that the higher barrier to entry implies that only relatively more productive firms will enter the foreign markets, making them less likely to exit. Therefore, the sunk cost of entry into the foreign market c_s and the fixed per-period cost of exporting c_x are set to match the mean proportion of firms that export and the rate at which firms stop supplying the foreign market.[16] These

[14]The *distribution wedge* captures everything that encompasses the gap between the retail price and the price at the dock including both profit margins and local distribution costs. Interestingly, their regression results using individual item data show a lack of relationship between changes in these wedges and exchange rates. This issue is beyond the scope of this article.

[15]While certain moments in the data may be particularly informative about a set of parameters, it is generally not possible to uniquely identify a parameter from one particular empirical moment.

[16]There are more complex approaches to specifying these costs. For example, in Ruhl (2008) and Kohn et al. (2016) the entry cost is correlated with firm productivity, this allows to better reproduce the size distribution of exporting plants, by generating a number of small exporting firms.

costs are in terms of foreign goods and therefore vary with exchange rate fluctuations.[17]

Table 2. Dynamic Problem: Baseline Parameters.

description of parameter	parameter	value
risk aversion	σ	1.500
discount	β	0.923
exogenous firm destruction rate	ω	0.025
autocorrelation firm productivity	ρ_a	0.700
volatility firm productivity	σ_a	0.350
autocorrelation exchange rate	ρ_ε	0.700
volatility exchange rate	σ_ε	0.100
capital depreciation rate	δ	0.069
capital convex adjustment cost	γ	0.040
capital irreversibility	p_s	0.900
sunk cost of entry into foreign market*	c_s	0.016
per-period cost of access foreign market*	c_x	0.015

*denotes calibrated parameters.

There are two sources of uncertainty in the model: firm idiosyncratic productivity and the exchange rate. We consider that these variables evolve according to independent and discretized AR(1) processes. The autocorrelation parameter and the standard deviation of shocks for firm productivity are 0.70 and 0.35, which are well within the range of values commonly used in the literature on firm dynamics. For the exchange rate process, we set these parameters at 0.70 and 0.10, respectively. I estimate this process with annual data

[17] Chaney (2016) discusses the importance of the assumption that the entry cost into the foreign market is denominated in foreign labor. He emphasizes the evidence in Goldberg and Campa (2010), which shows that between 50 to 70 percent of the costs of entering the foreign markets are denominated in foreign currency. Interestingly, Dixit (1989), analyzing the problem of Japanese firms exporting to the U.S. market, assumed that foreign-market entry and exit costs are in dollars (the foreign currency for these firms), which he judged to be the reasonable assumption. We explore the quantitative consequences of this assumption in the exercises below.

on the real exchange rate for Mexico for the period 1996-2016.[18]

The model allows us to consider different types of convex and non-convex adjustment costs following Cooper and Haltiwanger (2006), Riaño (2011) and Rho and Rodrigue (2016). Traditional investment models assume convex costs of adjustment, the following quadratic cost specification is standard:

$$(\gamma/2) \cdot (i/k)^2 \cdot k$$

We set a value of 0.04 for γ, which is at the lower bound of the range in Cooper and Haltiwanger (2006). This cost reduces the responsiveness of investment with respect to shocks.

In the baseline model the non-convex component of adjustment costs consists of transaction costs, which is introduced as a gap between the buying and selling price of capital. This could be attributed to capital specificity and/or a *lemons problem*, or thinness of secondary markets for capital in general. Riaño (2011) makes the extreme assumption that investment is completely irreversible, arguing that secondary markets for capital goods are particularly thin in developing economies. We consider a minor level of irreversibility by assuming that the selling price is 90 percent of the price at which capital goods are bought, which is a more modest cost than in Liu (2015). Gelos and Isgut (2001) find evidence that irreversibilities play a more important role in Colombia and Mexico than in more-advanced economies, while fixed costs of investment do not seem to be important.[19] With these parameter values we obtain an *inaction rate of investment* of 0.20, which is standard in the literature.[20] We will evaluate the quantitative role of these adjustment costs. The capital depreciation rate is 0.069, which is standard.

[18]Pratap and Urrutia (2004) estimate a higher volatility of 0.145 and a similar persistence parameter for the period 1989-2002 (I obtain similar results for that period). As in their case, I use a CPI-based measure of the real multilateral (111 countries) exchange rate for Mexico, computed by Banco de México.

[19]Interestingly, although they recognize the possibility of financial constraints, they do not find evidence that cash flows affect investment patterns.

[20]Additionally, the programs allow for the possibility of fixed costs of investment as well as an opportunity cost of investment: when the firm adjusts capital there can be a proportional loss of profits. This form of adjustment implies that investment becomes more costly during periods of high profitability which can, for example, contribute to moderate the increase in investment when the exchange rate depreciates.

We set a linear grid of 10 values for b, the foreign demand for firms that begin exporting is determined by the lowest level $\underline{b}$ and in every period that the firm continues to export b increases to the next level. We show results for a grid of $b \in [0.450, 0.600]$. With these values the ratio of exports to total sales for new exporters is 0.066 and the average ratio for all exporting firms is 0.127, similar to Ruhl and Willis (2017).

6 Quantitative Analysis

The theoretical framework is sufficiently rich to analyze the evolution of aggregate variables as well as their behavior at the firm-level.[21] In this section, we simulate the model and estimate the elasticity of aggregate exports with respect to fluctuations in the exchange rate, as well as the impact on aggregate entry and exit rates and prices. Then, we use simulated panels to contrast the performance of the model at the firm-level with empirical work in the literature.

6.1 The Exchange Rate and Aggregate Exports

The main result of interest is the elasticity of aggregate exports with respect to the exchange rate.[22] In the baseline calibration the elasticities of aggregate exports with respect to the exchange rate are 0.659 and 0.835, in terms of their value in foreign currency and quantities, respectively (Table 3). We then show, in each column respectively, the quantitative importance of removing or modifying different components of the model. For each exercise, we recalibrate the sunk-cost of entry into the foreign market and the fixed per-period cost of access,[23] while leaving the remaining parameters unmodified. In the second column, for example, we consider a version of the model with no distribution costs, which results in an almost threefold increase in the estimated elasticities. Quantitatively, this is

[21]The Appendix describes the solution algorithms for the model as well as the approach for the simulation exercises.

[22]All aggregate series are in logarithms and filtered using the HP methodology. Empirical studies find that most of the response of trade to exchange rate movements materialize within the first year (e.g., Leigh et al., 2017; Tang and Zhang, 2012), this is consistent with our simulations.

[23]When different combinations provide similar results for the target moments, we report the most conservative result in terms of our elasticity of interest.

the most important channel in determining the exchange rate elasticity of exports.

In terms of quantitative relevance, distribution costs are followed by the dynamic foreign demand component and by the currency in which sunk-costs and fixed per-period costs of access to the foreign market are denominated. Imported intermediate inputs are not as relevant as distribution costs for a number of reasons. First, although both are in the currency of the foreign market, imported intermediate inputs can be substituted for the domestic equivalent (to some extent, depending on the elasticity of substitution), while foreign distribution services cannot be substituted. Second, the weight of distribution of costs is larger than that of the intermediate input bundle, as previously discussed.[24] Third, foreign distribution services are only necessary for exported units, while imported intermediate inputs are necessary for the production of all produced units.

Table 3. Regressions on the Exchange Rate: Aggregate Exports.

distribution costs	yes	**no**	yes	yes	yes	yes
dynamic foreign demand	yes	yes	**no**	yes	yes	yes
market costs in for. currency	yes	yes	yes	**no**	yes	yes
imported inputs	yes	yes	yes	yes	**no**	yes
extensive margin	yes	yes	yes	yes	yes	**no**
elasticity of exports: value	0.659	1.737	1.218	1.380	0.932	0.550
elasticity of exports: quantity	0.835	2.348	1.337	1.567	1.206	0.750

The intuition behind the role of the denomination of market access costs is straightforward: if denominated in the foreign currency, the entry of firms to the foreign market when there is a depreciation, for example, will be partially muted. The last column in the table shows the importance of considering (or removing) the extensive margin in our model. This exercise simply consists, starting from the baseline parameterization, in setting the sunk-cost of entry and the per-period fixed cost to zero (this results in all firms

[24]Greenaway et al. (2010) find evidence of the role of imported intermediate inputs in moderating the impact of exchange rate fluctuations on firm-level exports in the UK.

becoming exporters). As explained in the literature, the impact of entry at the aggregate level is expected to be modest given that firms that enter the export market due to a depreciation are initially relatively small (see Campa, 2004; Eaton et al., 2007; Ruhl, 2008; Berman et al., 2012). The result from the theoretical model is consistent with the empirical literature.

6.2 Foreign-Market Entry and Exit

In this section we study the impact of fluctuations in the exchange rate on foreign market entry and exit rates (Table 4). For comparison, Berman et al. (2012) find that following a 10 percent depreciation with respect to the currency of a particular country, the probability of exporters to enter this market increases by 2 percentage points. Li et al. (2015), using firm-level data for China, find even more modest effects: they estimate that a 10 percent appreciation reduces the probability of entry by 0.6 percent and the probability of continuing in the export market by 1.1 percent (see Section 2.1, and Tang and Zhang, 2012).

Table 4. Regressions on the Exchange Rate:
Entry and Exit Rates into Foreign Market.

distribution costs	yes	**no**	yes	yes	yes	yes
dynamic foreign demand	yes	yes	**no**	yes	yes	yes
market costs in for. currency	yes	yes	yes	**no**	yes	yes
imported inputs	yes	yes	yes	yes	**no**	yes
extensive margin	yes	yes	yes	yes	yes	**no**
coefficient: exit rate	-0.015	-0.199	-0.361	-0.377	-0.135	—
coefficient: entry rate	0.001	0.113	0.125	0.347	0.125	—

The results in our baseline model simulations are comparable to the modest impact of the exchange rate on foreign-market entry and exit rates typically estimated in the literature. The largest increase in this sensitivity is found when sunk-costs and per-period fixed cost of access to the export market are in domestic currency, which affects both entry and exit rates. Considering a dynamic foreign demand potentially affects how entry-exit react to exchange rate movements. With the current parameterizations, the change in the reaction of exit rates is larger than the change we document for entry rates, the reason is that in the calibration we are considering for this version of the model fixed per-period costs are more important than the sunk-cost of entry (results vary depending on their relative importance).

6.3 Exchange-Rate Pass-Through to Domestic Prices

The model allows us to study the impact of exchange rates on prices. For example, we can define the price index of domestic firms (both exporters and non-exporters) in the domestic market in a standard manner:

$$P_d = \left[\int p_d(i)^{\frac{\nu}{\nu-1}}\, di \right]^{\frac{\nu-1}{\nu}}$$

Introducing costs of distribution in the model reduces the pass-through of the exchange rate into the prices of domestic firms in the domestic market to almost a third (Table 5). When removing imported intermediate inputs the pass-through is almost eliminated: for non-exporters the exchange rate is not relevant in their price decisions. For exporters their price in the domestic market can be affected through their export decision, given that capital is fixed for that period. However, quantitatively the effect of this channel is small, in part due to the relatively small weight of capital in the production function.

Table 5. Regressions on the Exchange Rate:

Pass-Through to Domestic Prices.

distribution costs	yes	**no**	yes	yes	yes	yes
dynamic foreign demand	yes	yes	**no**	yes	yes	yes
market costs in for. currency	yes	yes	yes	**no**	yes	yes
imported inputs	yes	yes	yes	yes	**no**	yes
extensive margin	yes	yes	yes	yes	yes	**no**
pass-t.: domestic index	0.119	0.293	0.120	0.121	0.002	0.123
pass-t.: avg. dom. price	0.137	0.280	0.137	0.140	0.002	0.144

The literature has already emphasized the role of imported inputs use and distribution margins in determining the exchange rate pass-through (see Corsetti et al., 2008; Goldberg and Campa, 2010; Amiti et al., 2014).[25] The low pass-through for tradable goods in our baseline calibration is in line with the range of values typically estimated (e.g., Burstein and Gopinath, 2014).[26]

6.4 Simulations and Firm-Level Regressions: Export Quantities

We take the evaluation of the quantitative framework one step further by contrasting the firm-level empirical analysis found in the literature with simulations from the different versions of our theoretical model. In Table 6, we estimate the empirical model proposed by Li et al. (2015), to explain export quantities at the firm-level (see their equation (3) and results in their Tables 4-6). In addition to the exchange rate, this specification includes an interaction term of the exchange rate and a lagged measure of productivity.[27]

[25] A complementary literature has emphasized the role of price rigidities in being conducive to a reduced exchange rate pass-through to consumer prices (e.g., Devereaux and Yetman, 2010).

[26] Estimates for the exchange rate pass-through for Mexico, with microeconomic data, are provided by Kochen and Samano (2016). To be accurate, once again, the exercise presented in this section refers to the pass-through of the exchange rate to consumer prices of domestically produced tradable products. In the Appendix, model estimations of the pass-through to foreign prices are provided. As a point of reference, Goldberg and Campa (2010) estimate an average exchange rate pass-through into the total consumer price index (CPI) for 21 OECD economies, with an average of 0.15 (their Table 7), although with significant dispersion in their estimates across countries.

[27] In this section our measure of firm productivity is firm TFP, but we also estimate these equations and report the results with output per worker in the Appendix. Berman et al. (2012) conduct estimations

Li et al. (2015) introduce the lagged value of productivity to account for the possibility that it may be endogenous to price and quantity variations. Consistent with the results in Li et al. (2015), Berman et al. (2012) and Berthou and Dhyne (2018), the coefficient on the interaction term is negative, indicating that more productive firms have lower volume responses (first column in Table 6). Furthermore, the estimations in Table 6 show that this results depends on the inclusion of distribution costs in the theoretical model.[28]

Table 6. Firm-Level Simulations and Regressions:
Firm Heterogeneity and Responses to RER: Export Quantities.

distribution costs	yes	**no**	yes	yes	yes	yes
dynamic foreign demand	yes	yes	**no**	yes	yes	yes
market costs in for. currency	yes	yes	yes	**no**	yes	yes
imported inputs	yes	yes	yes	yes	**no**	yes
extensive margin	yes	yes	yes	yes	yes	**no**
Δ exch. rate	0.795	2.199	0.825	0.775	1.258	0.899
Δ exch. rate $*$ firm TFP	-0.298	0.033	-0.339	-0.234	-0.490	-0.460
lag firm TFP	0.103	0.257	0.029	0.086	0.091	0.008
Δ firm TFP	1.156	2.697	0.949	1.123	1.097	1.278

Notes: variables in logs, all coefficients significant at 1% level,
TFP: firm productivity. Firm fixed effects included.

6.5 Aggregate Dynamic Responses of Exports

We employ the model to describe the aggregate dynamic responses of exports to exchange rate shocks. In this section we analyze the impulse response functions for appreciations

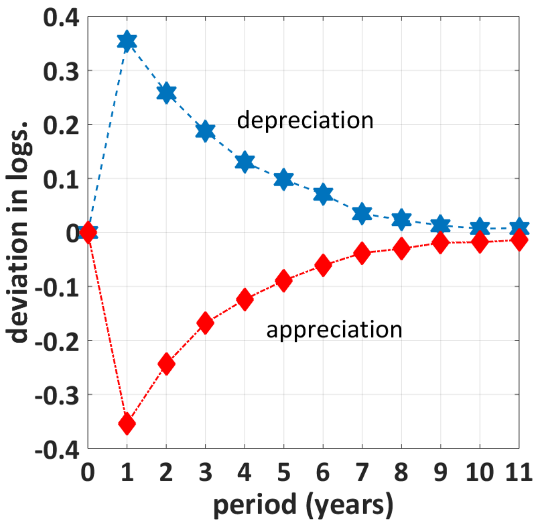
with both measures of productivity. The methodology and criteria for this exercise is also described in the Appendix.

[28] We are also able to estimate, for example, linear probability models for entry and exit in the foreign market a the firm-level, our conclusions are similar to those found for aggregate entry and exit rates: the impact of exchange rates is small in the baseline model and they are relatively largest in the version of the model with entry and per-period costs in domestic currency.

and depreciations of similar magnitude (Figure 3).[29]

Figure 4 exhibits the impulse response functions for the baseline model (the methodology is described in the Appendix). The effects of an exchange shock are highly persistent: after 11 periods the exchange rate, on average, reverts to its long-run average, while aggregate exports are still 20 percent above their long-run average for a depreciation of 35 percent on impact.

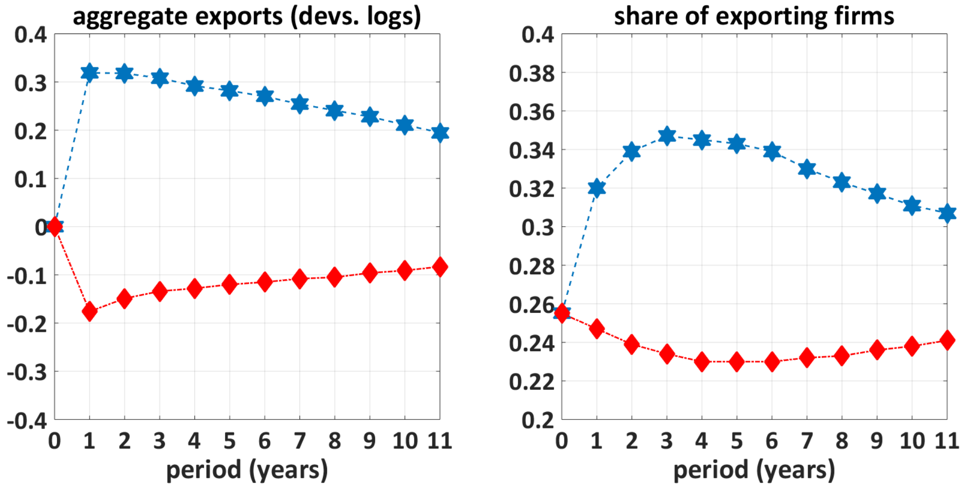
Figure 3. Impulse Response Functions: Exchange Rates



In the baseline model the impact of the exchange rate is asymmetric as shown in Figure 4, which is mainly explained by the asymmetric reaction of the extensive margin. This is in line with the discussions in the pioneering work of Baldwin and Krugman (1989) and Dixit (1989). In turn, the asymmetric reaction of the extensive margin is mostly accounted for by the entry of firms into the foreign market after a depreciation of the exchange rate (from approximately a share of 0.26 of firms to 0.32 upon impact of the exchange rate shock), while an appreciation does not influence this margin significantly.

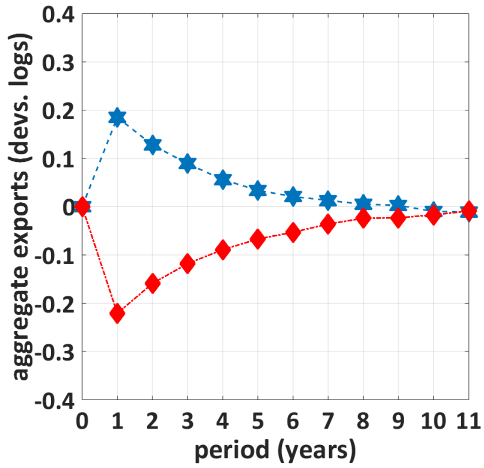
[29] Exchange rate fluctuations of the magnitude considered for the impulse response functions have a low probability given the parameters utilized. Nevertheless, sizable changes in the exchange rate serve the purpose of illustrating the mechanisms in the model. Kohn et al. (2017) consider a devaluation of approximately 40% to match the episode of Mexico in 1994 and, similar to the evolution of the exchange rate we are considering in this section, four years after the devaluation the real exchange rate is still 10% above its pre-devaluation level. However, they consider that the shocks follow a deterministic path and are fixed after the fourth period.

Figure 4. Impulse Response Functions:
Aggregate Exports and Share of Exporters Baseline Model



We carry out the same exercise in a version of the model without an extensive margin and therefore no dynamic foreign demand. As can be seen in Figure 5, the asymmetry in the response of aggregate exports is eliminated.[30]

Figure 5. Impulse Response Functions:
Aggregate Exports in Alternative Model



7 Conclusions

I develop a theoretical model of firm dynamics to provide a quantitative analysis of different determinants of the elasticity of exports with respect to the exchange rate. The

[30]The relative importance of entry costs and the dynamic foreign demand component depend on the parameterization of the model. Different exercises show that irreversibility in capital investment, down to levels of $1/2$, is not quantitatively relevant to generate this asymmetry.

model incorporates several features that affect the ability of firms to exploit changes in the profitability of exports generated by fluctuations in the exchange rate. The framework allows for a quantitative assessment of different mechanisms: while distribution costs are the single most important factor, the dynamics of new exporters are also relevant as well the currency in which sunk-entry costs into the foreign market and fixed per-period costs of exporting are denominated. In terms of the ability of the model to replicate the pass-through of the exchange rate to domestic prices typically estimated in the literature, distribution costs and imported intermediate inputs are crucial, while other mechanisms are not quantitatively relevant.

Certainly, there are numerous alternative channels that potentially contribute to determine the reaction of exports with respect to fluctuations in the exchange rate. First, there is evidence that product quality, in addition to firm productivity, is an important factor influencing firm-export possibilities. In particular, preference for quality is found to be increasing in high-income destinations. Given that improving product quality implies a costly investment, this may act as an impediment to a rapid increase exports in front of an exchange rate depreciation (for discussions and related references see Brooks, 2006; Crino and Epifani, 2012).

Second, as countries become more integrated in the global production process, a currency depreciation only improves the competitiveness of a fraction of domestic value added embodied in the value of exports, but raises the cost of imported inputs. Ahmed et al. (2015) exploit a panel data-set covering 46 countries over the period 1996-2012 and find suggestive evidence that the elasticity of manufacturing exports to the real effective exchange rate has decreased over time. Their findings would also indicate that participation in global value chains has contributed to reduce this elasticity. However, they report that the results are sensitive to the methodology as well as the sample size and composition and the period of observation (their findings are challenged by Leigh et al., 2017).

Third, the complementarity of tradable goods with services and goods with a high non-tradable component may have a quantitatively important role in determining the elasticity of demand of imported goods against changes in the exchange rates. For example, the American Automobile Association provides annual reports of operating and ownership costs for different types of vehicles. In one year these costs exceed $1/4$ of the price of a new unit.[31] A similar case could be made for other durable goods, such as computers. These issues could motivate further research.

[31]These costs include, among others: maintenance, insurance, financial charges, depreciation (it is not clear whether costs such as parking are included).

8 References

Aeberhardt, R., I. Buono and H. Fadinger (2014). "Learning, incomplete contracts and export dynamics: Theory and evidence from French firms," *European Economics Review*, 68, pp. 219-249.

Ahmed, S., M. Appendino and M. Ruta (2015). "Global value chains and the exchange rate elasticity of exports," *B.E. Journal of Macroeconomics*, 17 (1), pp. 1-24.

Ahn, J. and A.F. McQuoid (2017). "Capacity Constrained Exporters: Identifying Increasing Marginal Cost," *Economic Inquiry*, 55 (3), pp. 1175-1191.

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

Alessandria, G., S. Pratap and V. Yue (2015). "Export Growth and Aggregate Dynamics in Large Devaluations," WP.

Araujo, L., G. Mion and E. Ornelas (2016). "Institutions and export dynamics," *Journal of International Economics*, 98, pp. 2-20.

Arkolakis, C. (2015). "A Unified Theory of Firm Selection and Growth," *Quarterly Journal of Economics*, 131 (1), pp. 89-155.

Auboin, M. and M. Ruta (2013). "The relationship between exchange rates and international trade: a literature review," *World Trade Review*, 12 (3), pp. 577-605.

Baldwin, R. and P. Krugman (1989). "Persistent Trade Effects of Large Exchange Rate Shocks," *Quarterly Journal of Economics*, 104 (4), pp. 635-654.

Berger, D., J. Faust, J.H. Rogers and K. Steverson (2009). "Border Prices and Retail

Prices," Board of Governors of the Federal Reserve System, International Finance Discussion Papers #972.

Berman, N., P. Martin and T. Mayer (2012). "How do Different Exporters React to Exchange Rate Changes?" *Quarterly Journal of Economics*, 127 (1), pp. 437-492.

Berthou, A. and E. Dhyne (2018). "Exchange Rate Movements, Firm Level Exports and Heterogeneity," Banque de France, WP #660.

Blaum, J. (2018). "Global Firms in Large Devaluations," WP.

Brooks, E.L. (2006). "Why don't firms export more? Product quality and Colombian plants," *Journal of Development Economics*, 80 (1), pp. 160-178.

Burstein, A.T. and G. Gopinath (2014). "International Prices and Exchange Rates," Handbook of International Economics, Volume 4.

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

Burstein, A.T., C. Kurz, L. Tesar (2008). "Trade, production sharing, and the international transmission of business cycles," *Journal of Monetary Economics*, 55 (4), pp. 775-795.

Bussière, M., G. Gaulier and W. Steingrass (2016). "Global Trade Flows: Revisiting the Exchange Rate Elasticities," Banque de France, Document de Travail #608.

Campa, J.M. (2004). "Exchange rates and trade: How important is hysteresis in trade?" *European Economic Review*, 48 (3), pp. 527-548.

Cebreros Zurita, C.A. (2016). "The Rewards of Self-Discovery: Learning and Firm Exporter Dynamics," Banco de México WP N2016-08.

Chaney, T. (2016). "Liquidity Constrained Exporters," *Journal of Economic Dynamics and Control*, 72 (C), pp. 141-154.

Cooper, R.W. and J.C. Haltiwanger (2006). "On the Nature of Capital Adjustment Costs," *Review of Economic Studies*, 73 (3), pp. 611-633.

Corsetti, G., L. Dedola and S. Leduc (2008). "High exchange-rate volatility and low pass-through," *Journal of Monetary Economics*, 55 (6), pp. 1113-1128.

Crino, R. and P. Epifani (2012). "Product, Quality and Export Behaviour," *The Economic Journal*, 122 (565), pp. 1206-1243.

Das, S., M.J. Roberts and J.R. Tybout (2007). "Market Entry Costs, Producer Heterogeneity, and Export Dynamics," *Econometrica*, 75 (3), pp. 837-873.

De La Cruz, J., R.B. Koopman, Z. Wang (2011). "Estimating Foreign Value-added in Mexico's Manufacturing Exports," U.S. International Trade Commission, Office of Economics W.P. N2011-04A.

Dekle, R., H. Jeong and H. Ryoo (2010). "A Re-Examination of the Exchange Rate Disconnect Puzzle: Evidence from Firm Level Data," WP.

Devereaux, M.B. and J. Yetman (2010). "Price adjustment and exchange rate pass-through," *Journal of International Money and Finance*, 29 (1), pp. 181-200.

Dixit, A. (1989). "Hysteresis, Import Penetration, and Exchange Rate Pass-Through," *Quarterly Journal of Economics*, Vol. CIV (2), pp. 205-228.

Eaton, J., M. Eslava, M. Kugler and J. Tybout (2007). "Export Dynamics in Colombia: Firm Level Evidence," NBER WP 13531.

Eaton, J., M. Eslava, D. Jinkins, C.J. Krizan and J. Tybout (2014). "A Search and Learning Model of Export Dynamics," WP.

Fabling, R. and L. Sanderson (2015). "Exchange rate fluctuations and the margins of exports," New Zealand Treasury, WP 15/08.

Fitzgerald, D., Y. Yedid-Levi and S. Haller (2017). "Can Sticky Quantities Explain Export Insensitivity to Exchange Rates?" WP.

Fitzgerald, D. and S. Haller (2018). "Exporters and Shocks," *Journal of International Economics*, 113 (C), pp. 154-171.

Freund, C. and M.D. Pierola (2012). "Export Surges," *Journal of Development Economics*, 97 (2), pp. 387-395.

Gabaix, X. and M. Maggiori (2015). "International Liquidity and Exchange Rate Dynamics," *The Quarterly Journal of Economics*, 130 (3), pp. 1369-1420.

Gelos, R.G. and A. Isgut (2001). "Fixed Capital Adjustment: Is Latin America Different?" *Review of Economics and Statistics*, 83 (4), pp. 717-726.

Goldberg, L.S. and J.M. Campa (2010). "The Sensitivity of the CPI to Exchange Rates: Distribution Margins, Imported Inputs, and Trade Exposure," *The Review of Economics and Statistics*, 92 (2), pp. 392-407.

Gopinath, G. and B. Neiman (2014). "Trade Adjustment and Productivity in Large Crises," *American Economic Review*, 104 (3), pp. 793-831.

Greenaway, D., R. Kneller and X. Zhang (2010). "The Effects of Exchange Rates on Firm Exports: The Role of Imported Intermediate Inputs," *The World Economy*, 33 (8), pp. 961-986.

Halpern, L., M. Koren and A. Szeidl (2015). "Imported Inputs and Productivity," *American Economics Review*, 105 (12), pp. 3660-3703.

Iacovone, L. (2008). "Exploring Mexican Firm Level Data," WP.

IMF (2015). *World Economic Outlook*, International Monetary Fund, October 2015.

Itskhoki, O. and D. Mukhin (2017). "Exchange Rate Disconnect in General Equilibrium," Working Paper 23401, National Bureau of Economic Research.

Kasahara, H. and B. Lapham (2013). "Productivity and the decision to import and export: Theory and evidence," *Journal of International Economics*, 89 (2), pp. 297-316.

Kochen, F. and D. Samano (2016). "Price-Setting and Exchange Rate Pass-Through in the Mexican Economy: Evidence from CPI Micro Data," Banco de México Research Document N2016-13.

Kohn, D., F. Leibovici and M. Szkup (2016). "Financial Frictions and New Exporter Dynamics," *International Economic Review*, 57 (2), pp. 453-486.

Kohn, D., F. Leibovici and M. Szkup (2017). "Financial Frictions and Export Dynamics in Large Devaluations," WP.

Lewis, L.T. (2017). "How Important are Trade Prices for Trade Flows?" *IMF Economic Review*, 65 (3), pp. 471-497.

Li, H., H. Ma and Y. Xu (2015). "How do exchange rate movements affect Chinese exports? - A firm-level investigation," *Journal of International Economics*, 97 (1), pp. 148-161.

Liu, Y. (2015). "Capital Adjustment Costs: Implications for Domestic and Export Sales Dynamics," WP.

Obstfeld, M. and K. Rogoff (2000). "The Six Major Puzzles in International Macroeconomics: Is There a Common Cause?" NBER-Macroeconomics Annual, 15 (1), pp. 339-390.

Pratap, S. and C. Urrutia (2004). "Firm dynamics, investment, and debt portfolio: balance sheet effects of the Mexican crisis of 1994," *Journal of Development Economics*, 75 (2), pp. 535-563.

Rauch, J.E. and J. Watson (2003). "Starting small in an unfamiliar environment," *International Journal of Industrial Organization*, 21 (7), pp. 1021-1042.

Rho, Y. and J. Rodrigue (2016). "Firm-Level Investment and Export Dynamics," *International Economic Review*, 57 (1), pp. 271-304.

Ramanarayanan, A. (2017). "Imported inputs, irreversibility, and international trade dynamics," *Journal of International Economics*, 104 (C), pp. 1-18.

Riaño, A. (2011). "Exports, investment and firm-level sales volatility," *Review of World Economics*, 147 (4), pp. 643-663.

Roberts, M.J. and J.R. Tybout (1997). "The Decision to Export in Colombia: An Empirical Model of Entry with Sunk Costs," *American Economic Review*, 87 (4), pp. 545-564.

Ruhl, K.J. and J.L. Willis (2017). "New Exporter Dynamics," *International Economic*

Review, 58 (3), pp. 703-725.

Ruhl, K.J. (2008). "The International Elasticity Puzzle," WP.

Salomao, J. and L. Varela (2018). "Exchange Rate Exposure and Firm Dynamics," WP.

Soderbery, A. (2014). "Market size, structure and access: Trade with capacity constraints," *European Economic Review*, 70 (C), pp. 276-298.

Tang, H. and Y. Zhang (2012). "Exchange Rates and the Margins of Trade: Evidence from Chinese Exporters," *CESifo Economic Studies*, 58, pp. 671-702.

Tauchen, G. (1986). "Finite State Markov-Chain Approximation to Univariate and Vector Autoregressions," *Economic Letters*, 20 (2), pp. 177-181.

Timoshenko, O.A. (2015). "Learning versus sunk costs explanations of export persistence," *European Economics Review*, 79 (C), pp. 113-128.

Zhang, H. (2017). "Static and dynamic gains from costly importing of intermediate inputs: Evidence from Colombia," *European Economic Review*, 91-C, pp. 118-145.

A Decomposition of Export Growth

Following Eaton et al. (2007) we can compute period by period how changes in total exports reflect the contributions of incumbent firms, entrants and exiters. We start from the change in total exports in any given period:

$$\frac{X_t - X_{t-1}}{(X_t + X_{t-1})/2}$$

where X_t denotes total exports in period t. Growth can be decomposed into three parts, the first part is the contribution of continuing firms:

$$\left[\frac{\sum_{j\in C_t}(x_{j,t} + x_{j,t-1})/2}{(X_t + X_{t-1})/2}\right]\left[\frac{\sum_{j\in C_t}(x_{j,t} - x_{j,t-1})}{\sum_{j\in C_t}(x_{j,t} + x_{j,t-1})/2}\right]$$

where $x_{j,t}$ are exports by firm j in period t. The term C_t represents the set of continuing firms (the firms that exported in periods t and in the previous period $t-1$). The contribution of incumbents equals the share of exports of continuing firms over the two periods, multiplied by the growth in their export revenues.

In the baseline model the share of exports of continuing firms has an average over time of 0.942, while the average of the second term, representing their growth in their export revenues is 0.006. When we remove the dynamic foreign demand component from the model, the value of 0.006 turns to -0.050 (Table A): in this version firms enter the foreign market when they benefit from a positive productivity shock, but these shocks exhibit mean reversion (there is another significant difference in terms of the contribution from entering firms which we comment on below).

The second part represents the contribution of entrants to export growth:

$$\frac{NEN_t \cdot \bar{x}_{t-1}}{(X_t + X_{t-1})/2} + \frac{\sum_{j\in EN_t}(x_{j,t} - \bar{x}_{t-1})}{(X_t + X_{t-1})/2}$$

where EN_t represents the set of firms that exported in period t but not in period $t-1$ and NEN_t represents the number of entrants. The contribution of entry is expressed as the sum of two terms: the growth of exports implied by the increase in the number of exporter if new firms had the same average foreign sales as those of the average firm in the previous period, and the difference between exports of entrants and those of the average firm in the previous period. The means of these two terms in the baseline model are 0.073 and -0.019, respectively. Again there is a notable difference in the version of the model where the dynamic foreign demand component is removed: the value of -0.019 turns to 0.021: in the model with growing foreign demand, new exporters start exporting relatively small amounts, explaining the lower (and negative) term in the baseline specification.

The last term is the contribution by exiting firms:

$$-\frac{NEX_t \cdot \bar{x}_{t-1}}{(X_t + X_{t-1})/2} - \frac{\sum_{j \in EX_t}(x_{j,t-1} - \bar{x}_{t-1})}{(X_t + X_{t-1})/2}$$

where EX_t represents the set of firms that exported in period $t-1$ and not in period t, while NEX_t is the number of exiting firms. As in the case of entry, the contribution of exit is itself decomposed into two terms: the sum of the reduction that would have occurred if exiting firms had the export revenues of the average exporter in the previous period, and a term that considers the relative size of exiting firms (usually exiting firms are relatively small).

In the baseline model, the means of these two terms are 0.048 and -0.015, respectively. This first component, with an average contribution of 0.048, simply implies there is a loss of exports from the exiting firms, the second component reflects the fact that on average the foreign sales of exiting firms is smaller than the average exports of firms.

Table A. Decomposition of Export Growth.

distribution costs	yes	**no**	yes	yes	yes	yes
dynamic foreign demand	yes	yes	**no**	yes	yes	yes
market costs in for. currency	yes	yes	yes	**no**	yes	yes
imported inputs	yes	yes	yes	yes	**no**	yes
extensive margin	yes	yes	yes	yes	yes	**no**
continuing firms: share	0.942	0.914	0.855	0.904	0.944	1.000
continuing firms: growth	0.006	-0.018	-0.050	0.014	0.007	0.000
entering firms: fixed average	0.073	0.130	0.168	0.124	0.071	—
entering firms: *relative term*	-0.019	-0.014	0.021	-0.040	-0.018	—
exiting firms: fixed average	0.048	0.132	0.143	0.118	0.070	—
exiting firms: *relative term*	-0.015	-0.049	-0.022	-0.025	-0.016	—

We note that in our model there is no long-run growth in total exports, so that the average growth rate of exports is expected to be zero.

B Description of Solution and Simulation Algorithms

The theoretical model is solved via value function and policy function iteration (the combination of these algorithms increases the speed of convergence, as is well known). The state space is discretized. The AR(1) processes for the exchange rate and the idiosyncratic firm productivity shocks are discretized and the Markov transition matrices $\Gamma(\varepsilon' \mid \varepsilon)$ and $\Lambda(a' \mid a)$ are constructed following the method described in Tauchen (1986). A linear grid with 10 values is specified for the foreign demand value b (the calibration approach has already been described), while for production capital k we specify a grid with 500 points.

To compute aggregate moments and regressions with aggregate series, the model is simulated 50 times, each with 100 thousand firms and 300 periods (a period represents a year).

The first 100 periods of the series are discarded and thus not considered in the computation of statistics, to avoid dependence on initial conditions. Aggregate series for exports and prices are in logarithms, and the Hodrick-Prescott filter is applied to all aggregate series.

In a similar manner, to compute the impulse response functions we simulate the model 100 times, each with 100 thousand firms and 300 periods (again the first 100 periods are discarded). When the exchange rate is at its long-run average (i.e., equal to 1), in the next period a shock is introduced. This means we select the level of the exchange rate as either a large depreciation or a large appreciation, depending on the *event* we want to analyze, to a specific point on its grid starting from a particular level of the exchange rate. After this shock we let the exchange rate evolve according to its Markov transition matrix (i.e., using a random number generator). A condition is specified so that at least 50 periods have to pass before we consider a new event (the amount of periods between events is, therefore, random). Each simulation may provide, at most, 4 events. Endogenous variables evolve according to their respective policy functions. For the impulse response functions more simulations are needed relative to the aggregate moments and regressions, since we need a sufficiently large number of *events* (either significant appreciations or depreciations) to compute the average impulse response function. This average impulse response function is what we report for each variable (see for example the average evolution of the exchange rate in Figure 3). The number of periods shown in the Figures of the main text is selected as those that are enough for the exchange rate to return to its long-run average.

For the firm-level regressions using model simulations we simulate 8,000 firms for 300 periods. We then construct a panel using 51 years, all coefficients except one result statistically significant at the 1% level (Table 6 and C).

C Simulations and Firm-Level Regressions

In Table C we repeat the estimations of Table 6, replacing TFP with output per worker.

Qualitatively our conclusions are unchanged.

Table C. Firm-Level Simulations and Regressions:
Firm Heterogeneity and Responses to RER: Export Quantities.

distribution costs	yes	**no**	yes	yes	yes	yes
dynamic foreign demand	yes	yes	**no**	yes	yes	yes
market costs in for. currency	yes	yes	yes	**no**	yes	yes
imported inputs	yes	yes	yes	yes	**no**	yes
extensive margin	yes	yes	yes	yes	yes	**no**
Δ exch. rate	0.758	1.888	0.887	0.663	1.365	1.370
Δ exch. rate $*$ firm RpW	-0.050	0.317	-0.132	-0.075	-0.255	-0.460
lag firm RpW	-0.360	-1.709	-0.551	-0.427	-0.352	-0.510
Δ firm RpW	-0.003†	0.362	0.054	0.036	0.022	0.050

Notes: variables in logs, coefficients significant at 1% level, † not significant.
RpW: revenues per worker. Firm fixed effects included.

D Simulations and Firm-Level Regressions: Mexico

We exploit firm level data from Mexico to provide an additional assessment of our theoretical framework with an alternative specification. We use the Annual Industrial Survey (*Encuesta Anual de la Industria Manufacturera*, in Spanish) produced by the national statistics institute INEGI, for the period 2009-2015 (for a detailed description of this database see Iacovone, 2008). The data-set does not include *maquiladoras*. In this Appendix, we explore an alternative specification relative to the one in the main text. Export revenues and physical capital are deflated using the industrial price index, similar to Rho and Rodrigue (2016). An important restriction of this dataset is that it does not include export prices or quantities.

In the spirit of Berman et al. (2012), Li et al. (2015), and Berthou and Dhyne (2018), we include an interaction term of the real exchange rate with (deflated) revenues per worker.

In the data regression we include controls for the industrial sector at the 3 digit level. Additionally we include the volatility of the real exchange rate and the EMBI sovereign interest rate spread, both with negative signs and statistically significant at the 10% level (all results and alternative specifications explored are available upon request). All regressions include a constant term.

The simulation procedure was described in this Appendix. Note, in particular, that the last version of the theoretical model has almost 400 thousand firms since this version does not include an extensive margin (and it takes one period for new firms to start exporting). In the regressions with simulated data there are no significant changes when considering firm fixed effects. The R-squared is particularly high in the version of the model with no dynamic foreign demand: in this version of the model there is one less state variable that determines the export supply function, while remaining state variables are considered in the regression. In the model version in the second column there is no variation in the variable revenues per worker

We have also estimated logit models with the firm-level data to evaluate the impact of the exchange rate on the extensive margin: there was no statistically significant role or entry or exit. The level of capital and the ratio of imported inputs of production had statistically significant, robust, and positive effect on entry, and statistically significant, robust, and negative effect on exit (results available upon request). As has been previously discussed, the literature finds a small or no role for the exchange rate in determining entry and exit into foreign markets, which is consistent with our baseline theoretical model.

Table D. Firm-Level Simulations and Regressions:

Firm Heterogeneity and Responses to RER: Export Revenues.

	theoretical model						data
distribution costs	yes	**no**	yes	yes	yes	yes	–
dynamic foreign demand	yes	yes	**no**	yes	yes	yes	–
market costs in for. curr.	yes	yes	yes	**no**	yes	yes	–
imported inputs	yes	yes	yes	yes	**no**	yes	–
extensive margin	yes	yes	yes	yes	yes	**no**	–
exchange rate	0.93	4.42	1.52	0.76	1.31	1.68	1.11^{*}
exch. rate $*$ rev. per worker	-0.46	-0.95	-0.03	-0.25	$-0.01^{\dagger}$	$0.00^{\dagger}$	-0.40^{*}
physical capital	3.11	0.57	-0.07	2.99	2.89	1.84	0.56^{***}
revenues per worker	0.51	—	0.92	0.55	0.52	1.15	2.05^{**}
R-squared (overall)	0.66	0.44	0.97	0.59	0.66	0.80	0.47
N. observations	102,459	111,594	130,681	91,863	145,791	397,694	16,492

Notes: variables in logs, all theoretical model coefficients significant at 1% level, except † (not significant).

E Exchange-Rate Pass-Through to Foreign Prices

We present a complementary exercise to the exchange rate pass through to domestic prices presented in Table 5. In the same manner, we can compute the elasticity of the price index and the average price of exported goods (in foreign currency), in the foreign market (Table E).

Table E. Regressions on the Exchange Rate:
Pass-Through to Foreign Prices.

distribution costs	yes	**no**	yes	yes	yes	yes
dynamic foreign demand	yes	yes	**no**	yes	yes	yes
market costs in for. currency	yes	yes	yes	**no**	yes	yes
imported inputs	yes	yes	yes	yes	**no**	yes
extensive margin	yes	yes	yes	yes	yes	**no**
pass-t.: export price index	-0.196	-0.564	-0.121	-0.213	-0.304	-0.236
pass-t.: avg. export price	-0.232	-0.542	-0.122	-0.205	-0.331	-0.286

As in the case of domestic prices distribution costs and intermediate inputs have a significant role in determining the exchange rate pass-through.