

All Shook Up: International Trade and Firm-level Volatility*

PRELIMINARY AND INCOMPLETE

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Abstract

Despite the large theoretical literature on the macroeconomic dynamics arising from international trade, there is little theoretical research that rationalizes the relationship between a firm's trading patterns and its volatility. Our paper attempts to fill this gap by exploring the relationship between firms' exporting and importing status and firm-level volatility in a dynamic, stochastic, general equilibrium model. We augment the framework with heterogeneous firms and endogenous exporting from Ghironi and Melitz (2005) to allow for international input sourcing. In this framework, we examine the firm-level volatility generated by the model for a cross-section of firm types, which are defined to reflect the rich heterogeneity in firms' international activities. In line with recent empirical evidence on the link between a firm's trade status and its volatility, the model predictions are: (1) Exporters display lower volatility than non-exporters, whereas importers display higher volatility than non-importers. (2) Firms that trade for longer durations display lower volatility than firms switching in and out of international trade. (3) Firms that export to uncorrelated foreign markets are less volatile, whereas firms importing from uncorrelated foreign suppliers are more volatile.

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1 Introduction

A large body of theoretical and empirical literature provides insight into the implications of international trade for macroeconomic dynamics. By contrast, there is little work and a lack of consensus regarding the impact of shocks passed through international trade on firm-level characteristics. Recent work by Kurz and Senses (2016) documents a set of stylized facts on the relationship between firm-level volatility and the trade exposure of a firm.

With the empirical foundations in hand, this paper attempts to fill the gap between the theoretical research and stylized facts in order to rationalize the relationship between a firm's trading patterns and its volatility. We accomplish this through the framework of a dynamic, stochastic, general equilibrium model of international macroeconomics and trade. We augment the framework with heterogeneous firms and endogenous exporting from Ghironi and Melitz (2005, henceforth, GM05) to allow for international input sourcing, like in Zlate (2016). Thus, our model consists of two economies, the North and the South. Each economy includes one representative household and a continuum of firms—with each firm producing a different variety—that are monopolistically competitive and heterogeneous in labor productivity. Both Northern and the Southern firms produce for their domestic market and, similarly to GM05, firms can serve overseas markets through exporting. In addition, the ability to offshore production provides further flexibility, as certain Northern firms can choose to produce in the South and import back to their domestic market.

In this framework, we examine the firm-level volatility generated by the model for a cross-section of firm types, which are defined to reflect the rich heterogeneity in firms' international activities. For this purpose, we define three types of representative firms according to their exporting and importing status and persistence by focussing on different portions of the support interval for firm-specific idiosyncratic productivity. Namely, we define representative firms that are in the immediate vicinity of the endogenous productivity cutoff for exporting or importing, and also representative firms that are well below or well above the corresponding cutoffs. Thus, based on export status, the three representative firms are: the firm that never exports, the firm that sometimes exports, and the firm that always exports. Based on import status, the three representative firms are: the firm that never imports, the firm that sometimes imports, and the firm that always imports. The resulting output is obtained by integrating and taking averages

over the varieties produced and endogenously exported or imported by each representative firm. To compare the model implications for firm-level volatility to those from the data, we simulate the model under various assumptions for the two-country bivariate process of aggregate productivity, and compute model-generated impulse responses and measures of volatility for the output and employment of the three types of exporting/importing firms.

In line with the empirical evidence, the model implies that, first, exporters display lower volatility than non-exporters (at least for output), whereas importers display higher volatility than non-importers. Second, firms that trade for longer durations display lower volatility than firms switching in and out of international trade. Third, firms that export to uncorrelated foreign markets are less volatile (at least for output), whereas firms importing from uncorrelated foreign suppliers are more volatile (at least for employment). The model rationalizes these findings by highlighting the asymmetry in the way that diversification across uncorrelated trading partners affects exporters and importers: While diversification reduces the volatility of exporters, as positive and negative shocks in the domestic and foreign markets offset each other, it enhances the volatility of importers, since disruptions from one single supplier affects the entire production process reliant on complementary inputs.

Taken together, this paper provides a theoretical rationale for the empirical evidence on the link between exporting, importing, and firm-level volatility documented in Kurz and Senses (2016). In addition, our paper adds to the recent body of theoretical literature that rationalizes the impact of firms' decisions to export and/or import on either firm-level or macro-level characteristics. However, most of this theoretical literature is silent on the impact of firms' exporting and importing decisions on firm-level characteristics, although it devotes ample attention to the impact on macro-level variables (see GM05, Alessandria and Choi, 2007; Contessi, 2015; Fattal Jaef and Lopez, 2014; Liao and Santacreu, 2015; Mandelman, 2016; Mandelman and Zlate, 2015; Zlate, 2016). Among the scarce literature on firm-level characteristics, Fillat and Garetto (2015) model the impact of firms' international status on firms' financial performance, with firms engaging in exports and horizontal FDI displaying higher stock returns and earning yields. Fillat, Garetto, and Oldenski (2015) also model the impact of host economy characteristics on the risk premia of multinational firms.

The rest of the paper is organized as follows: Section 2 presents a set of stylized facts relating trade and volatility. Section 3 introduces the baseline model with heterogeneous firms

and describes the firms’ endogenous decisions to export and import. Section 4 translates the model into an equivalent framework with three representative firms defined according to their trade status and persistence. Section 5 presents the calibration. Section 6 discusses the results, including impulse responses and moments describing the link between the firms’ trade status and the volatility of output and employment growth. Section 7 concludes.

2 Stylized Facts on Trading and Volatility

This section presents some basic empirical facts about the relationship between trade and firm-level volatility.¹ As mentioned, previous work by Kurz and Senses (2016) find significant heterogeneity between the employment volatility between trading and non-trading firms, even when accounting for firm-fixed effects. Moreover, there are substantial differences across firms that trade, particularly across dimensions such as products traded, countries traded with, and the time and duration of trade.

The data employed source from the Longitudinal Business Database (LBD) and the Longitudinal Firm Trade Transactions Database (LFTTD). The LBD contains industry identification, age, employment, firm identifiers, and longitudinal links and contains annual data on the universe of all private U.S. business establishments with paid employees from 1976 to present. The LBD allows for a detailed analysis of employment dynamics and of the entry and exit of establishments. Importantly, the longitudinal coverage and annual frequency of the LBD allows for the calculation of firm-level volatility, which necessitates consecutive observations over time for each firm.

We aggregate the establishment data from the LBD to the firm level and link it to the LFTTD for the manufacturing sector. In addition to individual trade transactions of imports and exports, the LFTTD includes information on the products traded (at the 10-digit Harmonized Schedule (HS) level), the nominal value of the transaction, and the destination countries for exports and source countries for imports.

The volatility measures we use capture the variability of growth rates of employment. We calculate the growth rate of employment as the log difference in employment and use this measure to calculate the volatility as the standard deviation of firm employment growth. For

¹The results in this section will be expanded when additional output is disclosed by the Census Bureau.

this section, we employ data spanning 15 years from 1991 to 2005 and calculate firm-level volatility for firms that report positive employment for at least five consecutive years over the full 1991 to 2005 sample period. The resultant firm count is 331,874.

We first delineate the differences in employment volatility for firms that trade and those that do not, and then further differentiate by temporary and permanent trading. We do this for trading in general, that is, either importing or exporting, and also do this for exporters and importers. The results of differentiating organizations by their trade status over volatility can be found in figure 1. The top panel contains the average volatility for traders over four different categories: Non traders, traders (i.e., firms that either import or export at least once over the sample), temporary traders (i.e., organizations that do no trade every period), and permanent traders. The four categories are repeated for exporters and importers in the next two panels of figure 1.

As can be seen in figure 1, traders (either temporary or permanent) are less volatile than non-traders, a result primarily driven by the low volatility of permanent traders. The average volatility results can be further understood when decomposing trade status into importers and exporters. For exporters (panel 2 in figure 1), exporters are less volatile than non-exporters, and while this holds true for both temporary and permanent exporters, permanent exporters tend to be less volatile than temporary exporters. For importers (panel 3 in figure 1), the result is slightly different, with overall importers being more volatile than non-importers, a result primarily driven by temporary importers.

The results in figure 1 imply that export and import status have differing implications for an organization's volatility. Putting this into the context of the transmission of international shocks, trade may allow firms to diversify away from or to become exposed to international volatility that amplifies or attenuates the variability to which the average domestic firm is exposed. We will attempt to delineate these factors in our modeling and results section.

As figure 1 indicates, the amount of time traded has important implications for an organization's volatility. A more stable trade status is directly related to lower volatility. Figure 2 addresses the relationship between a firm's volatility and the time traded more directly. Specifically, we plot the four quartiles of time traded for both exporters (blue bars) and importers (red bars) over the second and third quartiles of trade shares. Trade share is the fraction of exports to shipments for exporters and imports to intermediate inputs for importers. As can

be seen in both panels, there is a monotonic decline in volatility as firms increase the amount of time they trade, for either exports or imports. As with trade status, we will attempt to model such differences. In this case, drawing the distinction between organizations located near the productivity cutoff for trading, and those well above the threshold, that is, permanent traders.

In terms of shocks that importers and exporters are exposed to, Kurz and Senses (2016) find that, *ceteris paribus*, a higher number of countries exported to is correlated with lower volatility, whereas a higher number of countries imported from is correlated with higher volatility. The top and bottom panels in figure 3 address these stylized facts visually.² As can be seen in the top panel of figure 3, as the country count increases, employment volatility is lower for both exporters and importers. The second panel plots the residuals of a regression of volatility on products exported and imported and firm size. Once those factors are controlled for, we see that the behavior of volatility rankings for exporters remains unchanged, that is, a larger country count exported to is correlated with lower volatility. For importers, though, the direction shifts, as a larger number of countries imported from appears related to lower employment volatility. We believe these results reflect the diversification across different demand shocks for exporters and the exposure to foreign shocks in the production process for importers.

Trade can affect firms in various ways. We postulate that trade can allow for firms to diversify or can expose them to international shocks for an extent and duration that should be directly related to dynamics of an organization's productivity process. To make these channels more concrete, we now turn to modeling firm dynamics across differing forms of trade status, time traded, and countries traded with in order to clarify the sources of the aforementioned volatility characteristics.

3 Model with Exporting and Importing Firms

The model builds on the setup with heterogeneous firms, endogenous firm entry, and endogenous exporting in GM05. This setup is augmented with endogenous imports as in Zlate (2016). Thus, the model consists of two economies, the North and the South. Each economy includes one representative household and a continuum of firms that are monopolistically competitive and

²the second panel is not included at this time, as we are awaiting final disclosure of the results from the Census Bureau.

heterogeneous in labor productivity. In both the North and the South, each firm produces a different variety of goods for its domestic market, and some firms also produce domestically to export like in GM05. In addition, some of the Northern firms can choose to produce either domestically or offshore for their home market, like in Zlate (2016). Offshore production results in the firm producing in the South and importing back to the North.

This section describes the problem of the Northern household and firms for the baseline model with financial integration.³ The case for the South looks similar, except for the fact that Southern firms do not produce offshore in the North and thus do not import.

3.1 Household's Problem

The household maximizes expected lifetime utility: $\max_{\{B_{t+1}, x_{t+1}\}} \left[E_t \sum_{s=t}^{\infty} \beta^{s-t} \frac{C_s^{1-\gamma}}{1-\gamma} \right]$, where $\beta \in (0, 1)$ is the subjective discount factor, C_t is aggregate consumption, and $\gamma > 0$ is the inverse of the inter-temporal elasticity of substitution. The budget constraint is:

$$\begin{aligned} & (\tilde{v}_t + \tilde{d}_t) N_t x_t + w_t L + (1 + r_t) B_{N,t} + (1 + r_t^*) Q_t B_{S,t} + T_t \\ & \geq \tilde{v}_t (N_t + N_{E,t}) x_{t+1} + C_t + B_{N,t+1} + Q_t B_{S,t+1} + \frac{\pi}{2} (B_{N,t+1})^2 + \frac{\pi}{2} Q_t (B_{S,t+1})^2, \end{aligned} \quad (1)$$

The household starts every period with share holdings x_t in a mutual fund of N_t firms whose average market value is $\tilde{v}_t$.⁴ It also holds risk-free, country-specific real bonds from the North and the South, $B_{N,t}$ and $B_{S,t}$, denominated in units of the issuing country's consumption basket. The holdings of Southern bonds are converted into units of the Northern basket through the real exchange rate Q_t .⁵ The household receives dividends equal to the average firm profit $\tilde{d}_t$ in proportion with the stock of firms N_t , the real wage w_t for $L = 1$ supplied inelastically, and real rates of return r_t and r_t^* from the North and South-specific bonds.

Every period, the household purchases two types of assets. First, it purchases x_{t+1} shares in a mutual fund of Northern firms, which includes N_t incumbent firms producing either domestically or offshore at time t , and also $N_{E,t}$ new firms that enter the market in period t . (Firm entry is

³"Baseline" refers to the model with fixed labor supply and no capital. Also, "financial integration" refers to the presence of risk-free, country-specific bonds traded internationally.

⁴Since stocks are not traded across countries, the equilibrium condition is $x_t = x_{t+1} = 1$.

⁵The real exchange rate $Q_t = P_t^* \varepsilon_t / P_t$ is the ratio between the price indexes in the South and the North expressed in the same currency, where ε_t is the nominal exchange rate.

discussed in Section 2.2.) On average, each of these firms is worth its market value $\tilde{v}_t$, equal to the net present value of the expected stream of future profits. The household also purchases the risk-free bonds $B_{N,t+1}$ and $B_{S,t+1}$. The budget allows for quadratic costs of adjustment for bond holdings $\frac{\pi}{2}(B_{N,t+1})^2$ and $\frac{\pi}{2}Q_t(B_{S,t+1})^2$, which are rebated to the household as T_t . Parameter π is set at a small value to ensure stationarity for net foreign assets in the presence of shocks.

The consumption basket includes varieties produced by the Northern firms domestically ($\omega \in \Omega_t^{NN}$), varieties produced by the Northern firms offshore and imported ($\omega \in \Omega_t^{NS}$), as well as varieties produced by the Southern exporters ($\omega \in \Omega_t^{SS}$), with the symmetric elasticity of substitution $\theta > 1$:

$$C_t = \left[\underbrace{\int_{z_{\min}}^{z_{V,t}} y_{D,t}(\omega)^{\frac{\theta-1}{\theta}} d\omega}_{\omega \in \Omega_t^{NN}} + \underbrace{\int_{z_{V,t}}^{\infty} y_{V,t}(\omega)^{\frac{\theta-1}{\theta}} d\omega}_{\omega \in \Omega_t^{NS}} + \underbrace{\int_{z_{X,t}^*}^{\infty} y_{X,t}^*(\omega)^{\frac{\theta-1}{\theta}} d\omega}_{\omega \in \Omega_t^{SS}} \right]^{\frac{\theta}{\theta-1}}, \quad (2)$$

As explained in Section 2.3, $[z_{\min}, \infty)$ is the support interval for the idiosyncratic productivity of Northern firms, and only the more productive firms (with productivity above the endogenous cutoff $z_{V,t}$) choose to produce offshore and import back to the North.⁶ Since the number of firms is time-variant and firms re-optimize their offshoring and exporting strategies every period, the composition of the consumption basket changes over time. With the consumption basket C_t set as numeraire, the price index for North is $1 = [\int \rho_t(\omega)^{1-\theta} d\omega]^{\frac{1}{1-\theta}}$, in which $\rho_t(\omega)$ is the real price of each variety and $\omega \in \Omega_t^{NN} \cup \Omega_t^{NS} \cup \Omega_t^{SS}$.

The Euler equations for bonds are:

$$1 + \pi B_{N,t+1} = \beta(1 + r_{t+1})E_t \left[\left(\frac{C_{t+1}}{C_t} \right)^{-\gamma} \right], \quad (3)$$

$$1 + \pi B_{S,t+1} = \beta(1 + r_{t+1}^*)E_t \left[\frac{Q_{t+1}}{Q_t} \left(\frac{C_{t+1}}{C_t} \right)^{-\gamma} \right], \quad (4)$$

with the market-clearing conditions $B_{N,t+1} + B_{N,t+1}^* = 0$ and $B_{S,t+1} + B_{S,t+1}^* = 0$, in which the asterisk denotes holdings by the Southern household of each type of bond. The Euler equation

⁶In the South, $[z_{\min}^*, \infty)$ is the support interval for the idiosyncratic productivity of Southern firms, and $z_{X,t}^*$ is the endogenous productivity cutoff for Southern exporters.

for stocks is below, with the rate of firm exit δ described in Section 2.2:

$$\tilde{v}_t = \beta(1 - \delta)E_t \left[\left(\frac{C_{t+1}}{C_t} \right)^{-\gamma} (\tilde{d}_{t+1} + \tilde{v}_{t+1}) \right] \quad (5)$$

3.2 Firm Entry

Firm entry takes place every period in both the North and the South, as in GM05. In the North, firm entry requires a sunk entry cost equal to f_E units of Northern effective labor, which reflects headquarter costs in the country of origin.⁷ After paying the sunk entry cost, each firm is randomly assigned an idiosyncratic labor productivity factor z , which is drawn independently from a common distribution $G(z)$ with support over the interval $[z_{min}, \infty)$, and which the firm keeps for the entire duration of its life. Thus, $N_{E,t}$ new firms are created every period t and start producing at $t + 1$. However, all existing firms, including the new entrants, are subject to a random exit shock that occurs with probability δ at the end of every period, irrespective of their idiosyncratic productivity. The law of motion for the number of active firms is: $N_{t+1} = (1 - \delta)(N_t + N_{E,t})$.

The potential entrants anticipate their expected post-entry value $\tilde{v}_t$, which depends on the expected stream of future profits $\tilde{d}_t$, the stochastic discount factor, and the exogenous probability δ of exit every period. The forward iteration of the Euler equation for stocks from (5) generates the following expression for the expected post-entry value of the average firm:

$$\tilde{v}_t = E_t \left\{ \sum_{s=t+1}^{\infty} [\beta(1 - \delta)]^{s-t} \left(\frac{C_s}{C_t} \right)^{-\gamma} \tilde{d}_s \right\}. \quad (6)$$

Thus, every period, the unbounded pool of potential entrants face a trade-off between the sunk entry cost and the expected stream of monopolistic profits. In equilibrium, firm entry takes place until the expected value of the average firm is equal to the sunk entry cost: $\tilde{v}_t = f_E \frac{w_t}{Z_t}$.

3.3 Firms' Choice of Markets and Production Strategies

Every period, the active firms N_t choose endogenously the destination market(s) that they serve and the location of production, as follows: (1) All firms serve their home market. For

⁷The sunk entry cost is equivalent to $f_E w_t / Z_t$ units of the Northern consumption basket.

this purpose, the Northern firms can either produce at home or produce offshore and import the resulting output, like in Zlate (2016). Offshoring offers the advantage of a lower cost of production but is subject to fixed and trade costs every period. Importantly, the firms' choice between producing at home or offshore concerns output intended for the home market only, and is not guided by access to the foreign market. (2) A subset of firms from each economy also serve the foreign market. For this purpose, they produce domestically and export subject to a fixed cost as in GM05. Each of these two problems (the offshoring decision of firms serving their home market, and the exporting decision of firms serving the foreign market) are described next.

3.3.1 Importing

Every period, the Northern firm with idiosyncratic productivity z chooses between the two possible production strategies to serve its home market: (a) Produce domestically, with output $y_{D,t}(z) = Z_t z l_t(z)$ as a function of aggregate productivity Z_t , the firm-specific labor productivity z , and domestic labor $l_t(z)$. (b) Alternatively, produce inputs offshore and import the resulting output, which then is used as input in production along with domestic inputs, $y_{V,t}(z) = z [Z_t l_t(z)]^\alpha [Z_t^* l_t^*(z)]^{1-\alpha}$. Thus, the firm producing offshore uses Southern labor $l_t^*(z)$ and becomes subject to the aggregate Southern productivity Z^* , but carries its idiosyncratic labor productivity z abroad.

Under monopolistic competition, the firm with idiosyncratic productivity z solves the profit-maximization problem for the alternative scenarios of domestic and offshore production:

$$\max_{\{\rho_{D,t}(z)\}} d_{D,t}(z) = \rho_{D,t}(z) y_{D,t}(z) - \frac{w_t}{Z_t z} y_{D,t}(z), \quad (7)$$

$$\max_{\{\rho_{V,t}(z)\}} d_{V,t}(z) = \rho_{V,t}(z) y_{V,t}(z) - \frac{\tau w_t^* Q_t}{Z_t^* z} y_{V,t}(z) - f_V \frac{w_t^* Q_t}{Z_t^*}, \quad (8)$$

where $\rho_{D,t}(z)$ and $\rho_{V,t}(z)$ are the prices associated with each of the two production strategies, w_t and w_t^* are the real wages in the North and the South, and Q_t is the real exchange rate. Thus, the cost of producing one unit of output either domestically or offshore varies not only with the cost of effective labor w_t/Z_t and $w_t^* Q_t/Z_t^*$ across countries, but also with the idiosyncratic labor productivity z across firms. In addition, the Northern firms producing offshore incur a fixed

cost equal to f_V units of Southern effective labor, which reflects the building and maintenance of the production facility offshore, and also an iceberg trade cost $\tau > 1$ associated with the importing of goods produced offshore back to the country of origin.⁸

The demand for the variety of firm z produced either domestically or offshore is $y_{D,t}(z) = \rho_{D,t}(z)^{-\theta} C_t$ or $y_{V,t}(z) = \rho_{V,t}(z)^{-\theta} C_t$ respectively, where C_t is the aggregate consumption in the North. Profit maximization implies the equilibrium prices $\rho_{D,t}(z) = \frac{\theta}{\theta-1} \frac{w_t}{Z_t^* z}$ and $\rho_{V,t}(z) = \frac{\theta}{\theta-1} \tau \frac{w_t^* Q_t}{Z_t^* z}$ for the alternative scenarios of domestic and offshore production. The corresponding profits are $d_{D,t}(z) = \frac{1}{\theta} \rho_{D,t}(z)^{1-\theta} C_t$ and $d_{V,t}(z) = \frac{1}{\theta} \rho_{V,t}(z)^{1-\theta} C_t - f_V \frac{w_t^* Q_t}{Z_t^*}$.

When deciding upon the location of production every period, the firm with productivity z compares the profit $d_{D,t}(z)$ that it would obtain from domestic production with the profit $d_{V,t}(z)$ that it would obtain from producing the same variety offshore. As a particular case, we define the productivity cutoff level $z_{V,t}$ on the support interval $[z_{\min}, \infty)$ such that the firm at the cutoff obtains equal profits from producing domestically or offshore:

$$z_{V,t} = \{z \mid d_{D,t}(z) = d_{V,t}(z)\}. \quad (9)$$

The model implies that only the relatively more productive Northern firms find it profitable to produce their varieties offshore. Despite the lower cost of effective labor in the South, only firms with idiosyncratic productivity above the cutoff level ($z > z_{V,t}$) obtain benefits from offshoring that are large enough to cover the fixed and iceberg trade costs. This implication is consistent with the empirical evidence in Kurz (2006), who shows that the U.S. plants and firms using imported components in production are larger and more productive than their domestically-oriented counterparts, as the larger idiosyncratic productivity levels allow them to cover the fixed costs of offshoring.⁹ In addition, the productivity cutoff $z_{V,t}$ responds to fluctuations in the relative cost of effective labor across countries. For any given level of firm-specific productivity, a relatively lower cost of effective labor abroad implies higher profits from offshoring, and therefore leads to a larger fraction of importing firms in equilibrium. This implication is consistent with the empirical evidence on the determinants of offshoring in Hanson, Mataloni, and Slaughter (2005), who show that U.S. multinationals import larger

⁸The fixed offshoring cost is equivalent to $f_V w_t^* / Z_t^*$ units of the Southern consumption basket.

⁹In Melitz (2003), more productive firms also have larger output and revenue.

shares of their foreign affiliates's sales when the latter benefit from lower trade costs and lower wages abroad.

To illustrate the cutoff, Figure 4 shows the per-period profits from domestic and offshore production as functions of the idiosyncratic productivity $z^{\theta-1}$ over the support interval $[z_{\min}, \infty)$, expressed as $d_{D,t}(z) = M_t \left(\frac{w_t}{Z_t} \right)^{1-\theta} z^{\theta-1}$ and $d_{V,t}(z) = M_t \left(\tau \frac{w_t^* Q_t}{Z_t^*} \right)^{1-\theta} z^{\theta-1} - f_V \frac{w_t^* Q_t}{Z_t^*}$, where $M_t \equiv \frac{1}{\theta} \left(\frac{\theta}{1-\theta} \right)^{1-\theta} C_t$ measures demand in the North. The vertical intercept is zero for domestic production; it is equal to the negative of the fixed cost $(-f_V \frac{w_t^* Q_t}{Z_t^*})$ for offshoring. In this framework, the productivity cutoff $z_{V,t}$ exists in equilibrium if the profit function from offshoring is steeper than the profit function from domestic production, $\text{slope} \{d_{V,t}(z)\} > \text{slope} \{d_{D,t}(z)\}$. When this condition is met, offshoring generates larger profits than domestic production for a number of $N_{V,t}$ firms with idiosyncratic productivity along the upper range of the support interval ($z > z_{V,t}$).¹⁰

In equilibrium, the inequality of profit slopes described above is equivalent to $\tau TOL_t < 1$, with the "terms of labor" $TOL_t = \frac{Q_t w_t^* / Z_t^*}{w_t / Z_t}$ defined as the ratio between the cost of effective labor in the South and the North expressed in the same currency. (Note that an appreciation of the terms of labor for the North is equivalent to a decline in TOL_t .) In other words, the existence of the productivity cutoff $z_{V,t}$ requires a cross-country asymmetry in the cost of effective labor, whereby the effective wage in the South must be sufficiently lower than in the North, so that the difference covers the fixed and iceberg trade cost ($\tau > 1$) and thus provides an incentive for some of the Northern firms to produce offshore. The model calibration and the magnitude of macroeconomic shocks ensure that this condition is satisfied every period.

3.3.2 Exporting

In addition to serving their domestic market, firms from each economy can choose to serve the foreign market through exports, as in GM05. In the North, the firm with idiosyncratic productivity z would use an amount of domestic labor $l_{X,t}(z)$ to produce for the Southern market, $y_{X,t}(z) = Z_t l_{X,t}(z)$. The Southern firms that choose to export to the North face a similar problem. Profit maximization implies the following equilibrium price: $\rho_{X,t}(z) = \frac{\theta}{\theta-1} \tau^* \frac{w_t Q_t^{-1}}{Z_t z}$ and profit function: $d_{X,t}(z) = \frac{1}{\theta} \rho_{X,t}(z)^{1-\theta} C_t^* Q_t - f_X \frac{w_t}{Z_t}$ for the Northern exporter

¹⁰A second condition necessary to avoid the corner solution when all firms would produce offshore is $d_{D,t}(z_{\min}) > d_{V,t}(z_{\min})$. It ensures that $z_{V,t} > z_{\min}$ in all periods.

with productivity factor z , where C_t^* is aggregate consumption in South. Producing for the foreign market generates additional profits, but involves a fixed exporting cost equal to f_X units of Northern effective labor, and also an iceberg trade cost τ^* . The model implies that only the subset of Northern firms with idiosyncratic labor productivity above the productivity cutoff $z_{X,t}$ find it profitable to produce in the North and export to the Southern market, as they can afford the fixed and iceberg trade costs of exporting. Thus, the time-varying productivity cutoff for exporters is:

$$z_{X,t} = \inf \{z \mid d_{X,t}(z) > 0\}. \quad (10)$$

To illustrate the exporting productivity cutoff, Figure 5 plots the profit function for exports $d_{X,t}(z) = M_t^* \left(\tau^* \frac{w_t Q_t}{Z_t} \right)^{1-\theta} z^{\theta-1} - f_V \frac{w_t^* Q_t}{Z_t^*}$, where $M_t^* \equiv \frac{1}{\theta} \left(\frac{\theta}{1-\theta} \right)^{1-\theta} C_t^* Q_t$ is a measure of demand in the South. Given the exporting productivity cutoff $z_{X,t}$, only a number of $N_{X,t}$ firms above it obtain positive profits from exporting to the South.

3.4 Aggregation over Heterogeneous Firms

Like in Zlate (2016), the model is solved as an equivalent framework with representative firms defined by the endogenous offshoring and exporting cutoffs. In the North, assuming that the firm-specific labor productivity draws z are Pareto-distributed, with p.d.f. $g(z) = k z_{min}^k / z^{k+1}$ and c.d.f. $G(z) = 1 - (z_{min}/z)^k$ over the support interval $[z_{min}, \infty)$, the average productivity levels of the firms below and above the offshoring cutoffs are:

$$\tilde{z}_{D,t} = \nu z_{min} z_{V,t} \left[\frac{z_{V,t}^{k-(\theta-1)} - z_{min}^{k-(\theta-1)}}{z_{V,t}^k - z_{min}^k} \right]^{\frac{1}{\theta-1}} \quad \text{and} \quad \tilde{z}_{V,t} = \nu z_{V,t}, \quad (11)$$

where the cutoff is $z_{V,t} = z_{min} (N_t / N_{V,t})^{(1/k)}$, with parameters $\nu \equiv \left[\frac{k}{k-(\theta-1)} \right]^{\frac{1}{\theta-1}}$ and $k > \theta - 1$.

Like in GM05, the average productivity of firms above the exporting cutoff is:

$$\tilde{z}_{X,t} = \nu z_{min} \left(\frac{N_t}{N_{X,t}} \right)^{1/k}. \quad (12)$$

Using these average productivity levels, the average prices for the corresponding firms are $\tilde{\rho}_{D,t}$, $\tilde{\rho}_{V,t}$, and $\tilde{\rho}_{X,t}$; the profits are $\tilde{d}_{D,t}$, $\tilde{d}_{V,t}$, and $\tilde{d}_{X,t}$.

3.5 Aggregate Accounting

Under financial integration, aggregate accounting implies that households spend their income from labor, stock, and bond holdings on consumption and investment in new firms:

$$C_t + N_{E,t}\tilde{v}_t + B_{N,t+1} + Q_t B_{S,t+1} = w_t L + N_t \tilde{d}_t + (1 + r_t) B_{N,t} + (1 + r_t^*) Q_t B_{S,t}, \quad (13)$$

$$C_t^* + N_{E,t}^* \tilde{v}_t^* + Q_t^{-1} B_{N,t+1}^* + B_{S,t+1}^* = w_t^* L^* + N_t^* \tilde{d}_t^* + (1 + r_t) Q_t^{-1} B_{N,t}^* + (1 + r_t^*) B_{S,t}^*. \quad (14)$$

The balance of international payments requires that the current account balance (i.e., the trade balance, repatriated profits of offshore affiliates, and income from investments) equals the change in bond holdings:

$$TB_t + \underbrace{N_{V,t} \tilde{d}_{V,t}}_{\text{Repatriated profits}} + \underbrace{r_t B_{N,t} + r_t^* Q_t B_{S,t}}_{\text{Income from bonds}} = \underbrace{(B_{N,t+1} - B_{N,t}) + Q_t (B_{S,t+1} - B_{S,t})}_{\text{Change in bond holdings}}, \quad (15)$$

where the trade balance is given by:

$$TB_t = \underbrace{N_{X,t} (\tilde{\rho}_{X,t})^{1-\theta} C_t^* Q_t}_{\text{Exports}} - \underbrace{N_{V,t} (\tilde{\rho}_{V,t})^{1-\theta} C_t}_{\text{Offshoring imports}} - \underbrace{N_{X,t}^* (\tilde{\rho}_{X,t}^*)^{1-\theta} C_t}_{\text{Regular imports}} \quad (16)$$

Thus, the baseline model with financial integration for the Northern economy is characterized by 18 equations in 18 endogenous variables: N_t , $N_{D,t}$, $N_{V,t}$, $N_{X,t}$, $N_{E,t}$, $\tilde{d}_t$, $\tilde{d}_{D,t}$, $\tilde{d}_{V,t}$, $\tilde{d}_{X,t}$, $\tilde{z}_{D,t}$, $\tilde{z}_{V,t}$, $\tilde{z}_{X,t}$, $\tilde{v}_t$, r_t , w_t , C_t , $B_{N,t+1}$, and $B_{S,t+1}$. Since the Southern firms do not produce in the high-cost North, the Southern economy is described by only 13 equations in 13 endogenous variables; there are no Southern counterparts for $N_{D,t}$, $N_{V,t}$, $\tilde{d}_{V,t}$, $\tilde{z}_{D,t}$ and $\tilde{z}_{V,t}$. Finally, the real exchange rate Q_t and the balance of international payments close the model. In this framework, aggregate output in the North and the South are: $Y_t = C_t + N_{E,t}\tilde{v}_t + TB_t$ and $Y_t^* = C_t^* + N_{E,t}^*\tilde{v}_t^* + TB_t^*$, respectively.

4 Firms Defined by Trade Status and Persistence

The model with heterogeneous firms allows to define three types of representative Northern firms along the dimensions highlighted in Kurz and Senses (2016). Namely, we differentiate

across firms according to their status as traders vs. non-traders; we also distinguish between persistent vs. temporary traders. As such, for either importers and exporters, we define: (1) the representative firm that never trades; (2) the firm that sometimes trades; and (3) the firm that always trades. In this setup, the comparison of traders vs. non-traders concerns firm types (3) vs. (1). The comparison of persistent vs. temporary traders involves types (3) vs. (2).

In this section, when referring to the continuum of heterogeneous firms over which the three representative firms are defined, we refer to firms and varieties interchangeably since each firm produces one variety. Thus, the three representative firms defined according to their importing or exporting status and persistence represent averages taken over the range of heterogeneous firms or varieties.

4.1 Importers

For importers, shown in Figure 4, we set the time-invariant productivity cutoffs z_{IM1} and z_{IM2} at one percent below and one percent above the steady-state value of the endogenous offshoring cutoff $z_{V,t}$. The magnitude of the stochastic shocks to aggregate productivity Z ensures that the endogenous cutoff $z_{V,t}$ moves within the interval (z_{IM1}, z_{IM2}) without breaching its limits. In turn, the time-invariant cutoffs define the three representative firms according to their import status: (1) the firm that never imports, which represents the interval $z < z_{IM1}$; (2) the firm that sometimes imports, defined over $z_{IM1} < z < z_{IM2}$; and (3) the firm that always imports, over $z > z_{IM2}$.

The output of each of these three representative firms is obtained by taking the average productivity and output between the time-invariant cutoffs:

$$\begin{aligned}
Y_{IM_NEV,t} &= \underbrace{\left[\frac{\theta}{\theta-1} \frac{w_t}{Z_t \tilde{z}_{IM_NEV}} \right]^{-\theta}}_{\text{Output produced at home}} C_t, \\
Y_{IM_SOM,t} &= \underbrace{\left(\frac{N_t - N_{IM_NEV,t} - N_{V,t}}{N_{IM_SOM,t}} \right) \left[\frac{\theta}{\theta-1} \frac{w_t}{Z_t \tilde{z}_{IM_SOM}(z < z_{V,t},t)} \right]^{-\theta}}_{\text{Output produced at home when } z < z_{V,t}} C_t + \\
&\quad + \underbrace{\left(\frac{N_{V,t} - N_{IM_ALW,t}}{N_{IM_SOM,t}} \right) \left[\frac{\theta}{\theta-1} \frac{\tau w_t^* Q_t}{Z_t^* \tilde{z}_{IM_SOM}(z > z_{V,t},t)} \right]^{-\theta}}_{\text{Output imported when } z > z_{V,t}} C_t,
\end{aligned}$$

$$Y_{IM_ALW,t} = \underbrace{\left[\frac{\theta}{\theta-1} \frac{\tau w_t^* Q_t}{Z_t \tilde{z}_{IM_ALW}} \right]^{-\theta}}_{\text{Output imported}} C_t,$$

where $N_{IM_NEV,t}$, $N_{IM_SOM,t}$, and $N_{IM_ALW,t}$ are the number of firms (or varieties) between the time-invariant cutoffs z_{IM1} and z_{IM2} . Also, parameters $\tilde{z}_{IM_NEV}$, $\tilde{z}_{IM_SOM}$, and $\tilde{z}_{IM_ALW}$ are the corresponding average productivity levels. Since the cutoffs z_{IM1} and z_{IM2} are time-invariant, the productivity averages between them are also time-invariant.

For the representative firm situated in the vicinity of the importing cutoff $z_{V,t}$, output depends on the share and average productivity levels of varieties produced domestically and offshore. Since the importing cutoff $z_{V,t}$ moves within the interval (z_{IM1}, z_{IM2}) in response to shocks, the share of varieties produced at home and offshore and their average productivity levels also move over time, which enhances the volatility of output for the representative firm around the offshoring cutoff. Thus, $\tilde{z}_{IM_SOM}(z < z_{V,t})$ is the average productivity level over the interval $(z_{IM1}, z_{V,t})$, while $\tilde{z}_{IM_SOM}(z > z_{V,t})$ is the average productivity over $(z_{V,t}, z_{IM2})$.

Employment for each of the three representative firms is:

$$\begin{aligned} L_{IM_NEV,t} &= \frac{Y_{IM_NEV,t}}{Z_t \tilde{z}_{IM_NEV}}, \\ L_{IM_SOM,t} &= \underbrace{\left(\frac{N_t - N_{IM_NEV,t} - N_{V,t}}{N_{IM_SOM,t}} \right) \left[\frac{\theta}{\theta-1} \frac{w_t}{Z_t \tilde{z}_{IM_SOM}(z < z_{V,t})} \right]^{-\theta} \frac{C_t}{Z_t \tilde{z}_{IM_SOM}(z < z_{V,t})}}_{\text{Labor hired at home for } z < z_{V,t}} + \\ &\quad + \underbrace{\left(\frac{N_{V,t} - N_{IM_ALW,t}}{N_{IM_SOM,t}} \right) \left[\frac{\theta}{\theta-1} \frac{\tau w_t^* Q_t}{Z_t^* \tilde{z}_{IM_SOM}(z > z_{V,t})} \right]^{-\theta} \frac{C_t}{Z_t^* \tilde{z}_{IM_SOM}(z > z_{V,t})}}_{\text{Labor hired abroad for } z > z_{V,t}}, \\ L_{IM_ALW,t} &= \underbrace{\frac{Y_{IM_ALW,t}}{Z_t^* \tilde{z}_{IM_ALW}}}_{\text{Labor hired abroad}}. \end{aligned}$$

4.2 Exporters

In Figure 5, we also set the time-invariant productivity cutoffs z_{EX1} and z_{EX2} at one percent below and one percent above the steady-state value of the exporting cutoff $z_{X,t}$, which moves within the interval without breaching it. As such, we define three representative firms according to their export status: (1) the firm that never exports, (2) the firm that sometimes exports, and

(3) the firm that always exports. The output of each representative firm is obtained by taking averages over the support interval for idiosyncratic productivity z in between the time-invariant cutoffs:

$$\begin{aligned}
Y_{EX_NEV,t} &= \underbrace{\left[\frac{\theta}{\theta-1} \frac{w_t}{Z_t \tilde{z}_{EX_NEV,t}} \right]^{-\theta}}_{\text{Output sold at home}} C_t, \\
Y_{EX_SOM,t} &= \underbrace{\left[\frac{\theta}{\theta-1} \frac{w_t}{Z_t \tilde{z}_{EX_SOM,t}} \right]^{-\theta}}_{\text{Output sold at home}} C_t + \\
&\quad + \underbrace{\left(\frac{N_{X,t} - N_{EX_ALW,t}}{N_{EX_SOM,t}} \right) \left[\frac{\theta}{\theta-1} \frac{\tau^* w_t Q_t^{-1}}{Z_t \tilde{z}_{EX_SOM}(z > z_{X,t},t)} \right]^{-\theta} \frac{C_t^* Q_t}{\tilde{z}_{EX_SOM}(z > z_{X,t},t)}}_{\text{Output exported when } z > z_{X,t}}, \\
Y_{EX_ALW,t} &= \underbrace{\left[\frac{\theta}{\theta-1} \frac{w_t}{Z_t \tilde{z}_{EX_ALW,t}} \right]^{-\theta}}_{\text{Output sold at home}} C_t + \underbrace{\left[\frac{\theta}{\theta-1} \frac{\tau^* w_t Q_t^{-1}}{Z_t \tilde{z}_{EX_ALW,t}} \right]^{-\theta}}_{\text{Output exported}} C_t^* Q_t,
\end{aligned}$$

where $N_{EX_NEV,t}$, $N_{EX_SOM,t}$, and $N_{EX_ALW,t}$ are the number of firms (or varieties) between the time-invariant cutoffs; $\tilde{z}_{EX_NEV}$, $\tilde{z}_{EX_SOM}$, and $\tilde{z}_{EX_ALW}$ are the corresponding average productivities levels, which are time-invariant; and $\tilde{z}_{EX_SOM}(z > z_{X,t},t)$ is the average productivity level over the interval $(z_{X,t}, z_{EX2})$, which moves with the endogenous exporting cutoff.

For the representative exporting firm situated around the exporting cutoff $z_{X,t}$, output consists of varieties produced for the domestic market, some of which will also be exported. Thus, all varieties within (z_{EX1}, z_{EX2}) are sold domestically irrespective of the exporting cutoff; however, the share of varieties above the exporting cutoff are also exported, namely those within $(z_{X,t}, z_{EX2})$. The time variation in the share and average productivity level of varieties above the cutoff enhances the volatility of output for the representative firm situated around the exporting cutoff.

Employment for each of the three representative firms is:

$$\begin{aligned}
L_{EX_NEV,t} &= \frac{Y_{EX_NEV,t}}{Z_t \tilde{z}_{EX_NEV,t}}, \\
L_{EX_SOM,t} &= \underbrace{\left[\frac{\theta}{\theta - 1} \frac{w_t}{Z_t \tilde{z}_{EX_SOM,t}} \right]^{-\theta} \frac{C_t}{Z_t \tilde{z}_{EX_SOM,t}}}_{\text{Labor hired for output sold at home}} + \\
&\quad + \underbrace{\left(\frac{N_{X,t} - N_{EX_ALW,t}}{N_{EX_SOM,t}} \right) \left[\frac{\theta}{\theta - 1} \frac{\tau^* w_t Q_t^{-1}}{Z_t \tilde{z}_{EX_SOM}(z > z_{X,t},t)} \right]^{-\theta} C_t^* Q_t}_{\text{Labor hired for output exported when } z > z_{X,t}}, \\
L_{EX_ALW,t} &= \frac{Y_{EX_ALW,t}}{Z_t \tilde{z}_{EX_ALW,t}}.
\end{aligned}$$

In the presence of shocks, the growth of output and employment for each type of representative firm is computed as $grY_t = \ln Y_t - \ln Y_{t-1}$ and $grL_t = \ln L_t - \ln L_{t-1}$.

5 Calibration

We use a standard quarterly calibration by setting the subjective rate of time discount $\beta = 0.99$ to match an average annualized interest rate of 4 percent. The coefficient of relative risk aversion is $\gamma = 2$. Following GM05, the intra-temporal elasticity of substitution is $\theta = 3.8$ and the probability of firm exit is $\delta = 0.025$. The quadratic adjustment cost parameter for bond holdings is $\pi = 0.0025$. The Pareto distribution parameter k , the iceberg trade cost τ , and the fixed costs of offshoring (f_V) and exporting (f_X and f_X^*) are calibrated so that the model in steady state matches the importance of offshoring for the Mexican economy, as illustrated by three empirical moments: (1) The maquiladora value added represents about 20 percent of Mexico's manufacturing GDP (Bergin, Feenstra, and Hanson, 2009) compared to 15 percent in the model in steady state. (2) The maquiladora sector provided about 55 percent of Mexico's manufacturing exports on average from 2000 to 2006 (INEGI, 2008) compared to about 61 percent in the model. (3) The maquiladora sector accounts for about 25 percent of Mexico's manufacturing employment (Bergin, Feenstra, and Hanson, 2009) and 20 percent in the model. To this end, I set $k = 4.2$, $\tau = 1.2$, $f_V = 0.095$, $f_X = 0.040$, and $f_X^* = 0.025$.¹¹ Without loss of

¹¹The resulting exports-to-GDP ratios in steady state are 27 percent for the North and 41 percent for the South. In the South, offshoring exports represent 61 percent of total exports and 25 percent of GDP.

generality, the lower bound of the support interval for firm-specific productivity in the North and the South is $z_{min} = z_{min}^* = 1$.

To obtain an asymmetric cost of effective labor across countries in steady state, the sunk entry cost, which reflects headquarter costs sensitive to the regulation of starting a business in the firms' country of origin, is set to be larger in the South than in the North ($f_E^* = 4f_E$ and $f_E = 1$). As a result, the steady-state output, the number of firms, the labor demand, and the effective wage are relatively lower in the South. The calibration reflects the considerable variation in the monetary cost of starting a business across economies, which was 2.8 times higher in Mexico than in the United States in purchasing power parity terms in 2010 (World Bank, 2011). The asymmetric sunk entry costs, along with the values for k , τ , f_V , f_X , and f_X^* discussed above, generate a steady-state value for the terms of labor that is less than unit ($TOL = \frac{Qw^*/Z^*}{w/Z} = 0.75$). In other words, the steady-state cost of effective labor in the South is 75 percent of the cost of effective labor in the North. Thus, the calibration provides an incentive for some of the Northern firms to produce offshore in steady state.

6 Results

6.1 Impulse Responses

To understand the behavior of the endogenous productivity cutoffs $z_{V,t}$ and $z_{X,t}$ that drive the firms' importing and exporting decisions, we compute impulse responses for key variables to a transitory one-percent increase in aggregate productivity in the North. Aggregate productivity follows the autoregressive process $\log Z_{t+1} = \rho \log Z_t + \xi_t$, with persistence $\rho = 0.9$.

As shown in Figure 6, the shock to aggregate productivity in the North causes firm entry and the number of established firms to increase. Firm entry puts upward pressure on the real wage in the North, which causes the terms of labor to appreciate (i.e., the cost of effective labor in the North to increase relative to the South), as shown by the terms of labor falling below the steady state. Due to the cost of effective labor appreciating in the North, the exporting cutoff $z_{X,t}$ rises and the fraction of exporting firms N_X/N declines before returning to their steady-state levels. Also, the importing cutoff $z_{V,t}$ falls on impact and persists below its steady state (despite a short-lived recovery), which implies that the fraction of importing firms N_V/N

increases.

Since the firms (or varieties) situated around the productivity cutoffs are most affected by the shocks, output fluctuates by more for the firms that "sometimes export" and "sometimes import" than for the firms that never or always do so. Indeed, in Figure 7, the impulse responses show more sizeable movements in the output of the representative firms in the middle than on the sides of the productivity spectrum.

6.2 Moments

Table 1 presents the moments from model simulations based on the assumption that aggregate productivities Z_t and Z_t^* follow the bivariate autoregressive process:

$$\begin{bmatrix} \log Z_t \\ \log Z_t^* \end{bmatrix} = \begin{bmatrix} \rho_Z & \rho_{ZZ^*} \\ \rho_{Z^*Z} & \rho_{Z^*} \end{bmatrix} \begin{bmatrix} \log Z_{t-1} \\ \log Z_{t-1}^* \end{bmatrix} + \begin{bmatrix} \xi_t \\ \xi_t^* \end{bmatrix}, \quad (17)$$

with the persistence parameters ρ_Z and $\rho_{Z^*} < 1$, spillovers ρ_{ZZ^*} and $\rho_{Z^*Z} \geq 0$, and normally-distributed, zero-mean technology shocks ξ_t and ξ_t^* .

The bivariate productivity process is calibrated like in Backus, Kehoe, and Kydland (1992, henceforth BKK92), with the symmetric persistence and spillovers are $\rho_Z = \rho_{Z^*} = 0.906$ and $\rho_{ZZ^*} = \rho_{Z^*Z} = 0.088$, the variance of innovations is $\text{var}(\xi_t) = \text{var}(\xi_t^*) = 0.00852^2$, and the correlation of innovations is $\text{corr}(\xi_t, \xi_t^*) = 0.258$. In an alternative case, the correlation of innovations is set at negative the value from BKK92, namely $\text{corr}(\xi_t, \xi_t^*) = -0.258$.

In Table 1, we report the standard deviations of output and employment growth for the three representative Northern firms defined according to their trade status.¹²

For output growth, the standard deviations in Panel B are generally in line with the empirical regularities presented in Section 2. First, the firm that always exports is less volatile than the firm that never exports (rows 6 vs. 4). The firm that always imports is more volatile than the non-importer, but the difference is very small (rows 9 vs. 7). Like in the data, diversification reduces the volatility of exporters but increases the volatility of importers.

Second, for the persistence of international trade, the firm that sometimes exports/imports is more volatile than the firm that always exports/imports (rows 5 vs. 6 and 8 vs. 9). Thus,

¹²These results are preliminary.

proximity to the productivity cutoffs enhances the volatility of temporary exporters/importers relative to that of firms that trade consistently.

Third, regarding the effect of diversification, the exporting firm (row 6) is *more* volatile when it trades with a foreign destination that is positively correlated with the home economy (column 1) than negatively correlated (column 2). As such, export diversification across uncorrelated destinations reduces volatility, since positive shocks to foreign demand may offset negative shocks at home. Unlike in the data, the importing firm (row 9) is also *more* volatile when it relies on foreign sources that are positively correlated with the home economy (column 1) than negatively correlated (column 2).

These results also hold for employment growth, presented in Panel C, although with some exceptions. Unlike in the data, the volatility of firms than always export exceeds that of firms who do not (rows 12 vs. 10); and export diversification across uncorrelated markets does not reduce volatility (row 12, columns 1 vs. 2). However, consistent with the data, importers are more volatile than non-importers (rows 15 vs. 13); firms around the cutoffs are more volatile than those further above (rows 11 vs. 12 and 14 vs. 15); and diversification across uncorrelated sources enhances the volatility of importers (row 15).

In next steps, we will study the impact of diversification across import sources on firm-level volatility in a setup that allows for complementarity between domestic and imported inputs. We will also study the impact of international trade on the volatility of firms that export and import simultaneously. Diversification across a larger number of trade partners will be modeled explicitly rather than proxied by calibrating a negative correlation of shocks. Finally, we will document the impact of the prevalence of exporting and importing firms on aggregate volatility.

7 Conclusion

This paper is predicated upon a set of stylized facts presented in Kurz and Senses (2016) which point to considerable heterogeneity in the volatility of firms that differ in terms of the level of engagement in international trade, the type of products they trade, and the characteristics of their trading partners. In particular, Kurz and Senses (2016) find that importers experience higher levels of volatility compared to non-trading firms. This relationship is mainly driven by firms that switch in and out of importing. Firms that only export experience lower levels

of volatility. These results are complemented with findings that indicate firm-level volatility increases with a larger share of exports and imports and is depended on the number of products traded and the number of countries traded with.

In contrast to the large body of theoretical and empirical literature on international trade's implications for macroeconomic dynamics, there is little theoretical work regarding the transmission of international shocks to firm-level volatility. Our paper attempts to fill this gap by exploring the relationship between firms' exporting and importing status and firm-level characteristics—namely the volatility of output and employment—in a dynamic, stochastic, general equilibrium model of international macroeconomics and trade. We augment the heterogeneous firms and endogenous exporting framework of GM05 to allow for international input sourcing. More specifically, we examine the firm-level volatility generated by the model for a cross-section of firm types, which are defined to reflect the rich heterogeneity in firms' international activities.

In line with the empirical evidence, the model predictions are: (1) Exporters display lower volatility than non-exporters (at least for output), whereas importers display higher volatility than non-importers. (2) Firms that trade for longer durations display lower volatility than firms switching in and out of international trade. (3) Firms that export to uncorrelated foreign markets are less volatile (at least for output), whereas firms importing from uncorrelated foreign suppliers are more volatile (at least for employment). The model rationalizes these findings by highlighting the asymmetry in the way that diversification across uncorrelated trading partners affects exporters and importers: While diversification reduces the volatility of exporters, as positive and negative shocks in destination markets offset each other, it enhances the volatility of importers, since disruptions from one single supplier affects the entire production process reliant on complementary inputs.

8 List of References

References

- [1] Alessandria, George and Horag Choi. 2007. "Do sunk costs of exporting matter for net export dynamics?" *Quarterly Journal of Economics*, 122(1): 289-336.

- [2] Backus, David K.; Patrick J. Kehoe; and Finn E. Kydland, 1992. "International real business cycles." *Journal of Political Economy*, 100(4): 745-775.
- [3] Contessi, Silvio. 2015. "Multinational firms' entry and productivity: Some aggregate implications of firm-level heterogeneity." *Journal of Economic Dynamics and Control*, 61(2015): 61-80.
- [4] Fattal Jaef, Roberto N. and Jose Ignacio Lopez. 2014. "Entry, trade costs and international business cycles." *Journal of International Economics*, 94: 224-238.
- [5] Fillat, Jose L. and Stefania Garetto. 2015. "Risk, returns, and multinational production." *Quarterly Journal of Economics*, 130(4): 2027-2073.
- [6] Fillat, Jose L.; Stefania Garetto; and Lindsay Oldenski. 2015. "Diversification, cost structure, and the risk premium of multinational corporations." *Journal of International Economics*, 96: 37-54.
- [7] Ghironi, Fabio and Marc J. Melitz. 2005. "International trade and macroeconomic dynamics with heterogeneous firms." *Quarterly Journal of Economics*, 120(3): 865-915.
- [8] Hanson, Gordon H.; Raymond J. Mataloni; and Matthew J. Slaughter. 2005. "Vertical production networks in multinational firms." *Review of Economics and Statistics*, 87(4): 664-678.
- [9] Kurz, Christopher. 2006. "Outstanding outsourcers: A firm- and plant-level analysis of production sharing." FEDs Working Paper No. 2006-04.
- [10] Kurz, Christopher and Mine Z. Senses. 2016. "Importing, exporting, and firm-level employment volatility." *Journal of International Economics*, 98: 160-175.
- [11] Liao, Wi and Ana Maria Santacreu. 2015. "The trade comovement puzzle and the margins of international trade." *Journal of International Economics*, 96: 266-288.
- [12] Mandelman, Federico. 2016. "Labor market polarization and international macroeconomic dynamics." *Journal of Monetary Economics*, forthcoming.

- [13] Mandelman, Federico and Andrei Zlate. 2016. "Offshoring, low-skilled immigration, and labor market polarization." Federal Reserve Banks of Atlanta and Boston, mimeo.
- [14] Melitz, Marc. 2003. "The impact of trade on intra-industry reallocations and aggregate industry productivity." *Econometrica*, 71(6): 1695-1725.
- [15] Zlate, Andrei. 2016. "Offshore production and business cycle dynamics with heterogeneous firms." *Journal of International Economics*, forthcoming 2016.

Table 1: Moments

		TFP calibration as in BKK92	
		$corr(\varepsilon, \varepsilon^*) > 0$	$corr(\varepsilon, \varepsilon^*) < 0$
A.	St. dev. (%), aggr. variables, levels	(1)	(2)
1.	Y	0.97	0.92
2.	C (relative to Y)	0.67	0.55
3.	N_E (relative to Y)	3.52	4.37
B.	St. dev. (%), output growth		
	Exporters:		
4.	grY_{EX-NEV} (never)	0.46	0.36
5.	grY_{EX-SOM} (sometimes)	5.31	4.16
6.	grY_{EX-ALW} (always)	0.43	0.33
	Importers:		
7.	grY_{IM-NEV} (never)	0.46	0.36
8.	grY_{IM-SOM} (sometimes)	11.39	9.24
9.	grY_{IM-ALW} (always)	0.47	0.37
C.	St. dev. (%), employment growth		
	Exporters:		
10.	grL_{EX-NEV} (never)	0.51	0.62
11.	grL_{EX-SOM} (sometimes)	4.79	3.93
12.	grL_{EX-ALW} (always)	0.58	0.72
	Importers:		
13.	grL_{IM-NEV} (never)	0.51	0.62
14.	grL_{IM-SOM} (sometimes)	9.11	7.41
15.	grL_{IM-ALW} (always)	0.66	0.83
D.	International correlations, levels		
16.	Y, Y^*	0.42	-0.08
17.	$Y, TB/Y$	-0.18	-0.14
18.	Z, Z^*	0.31	-0.20

Figure 1
Volatility and Firm Export Status

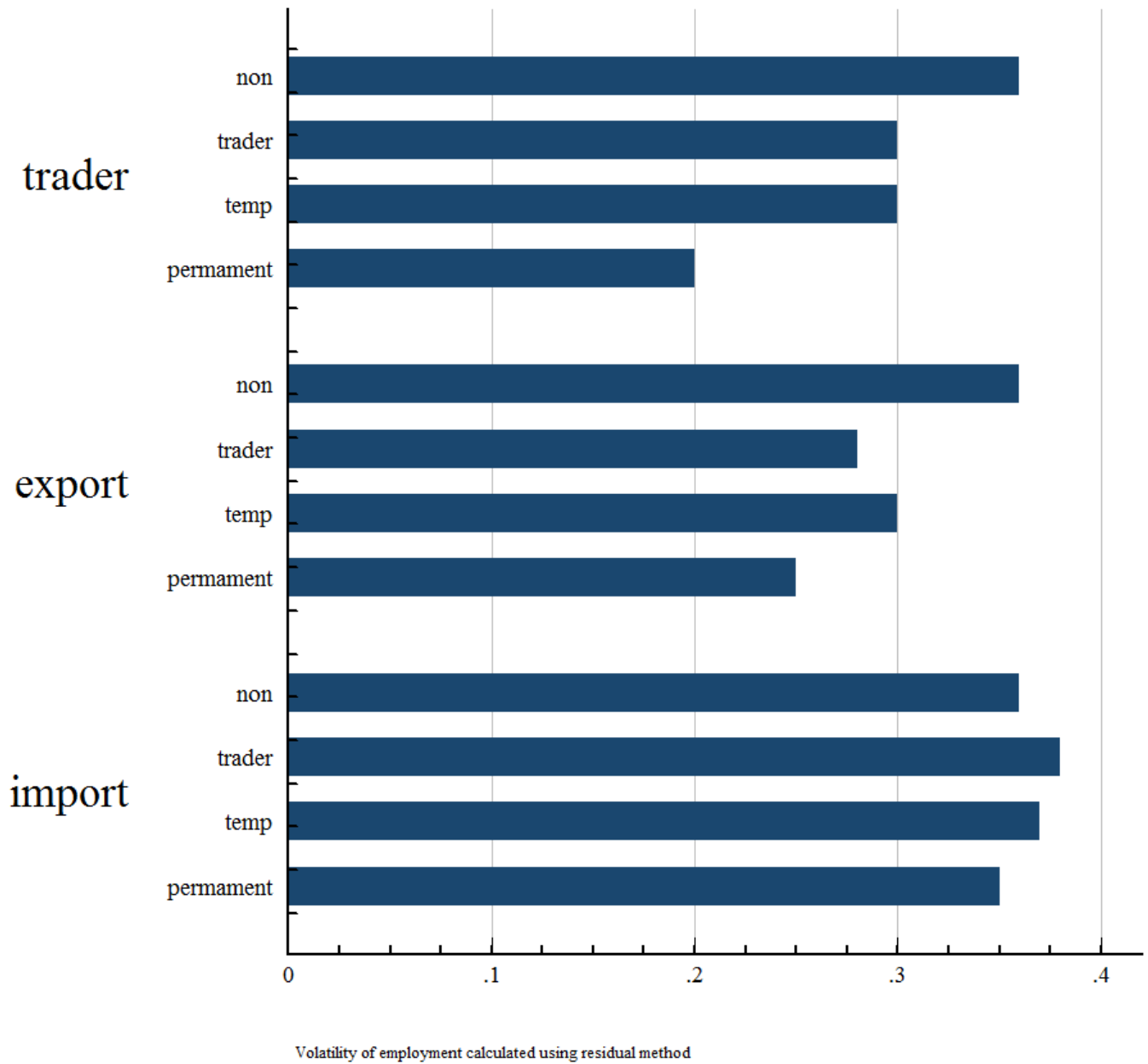


Figure 2
Volatility and Time Traded

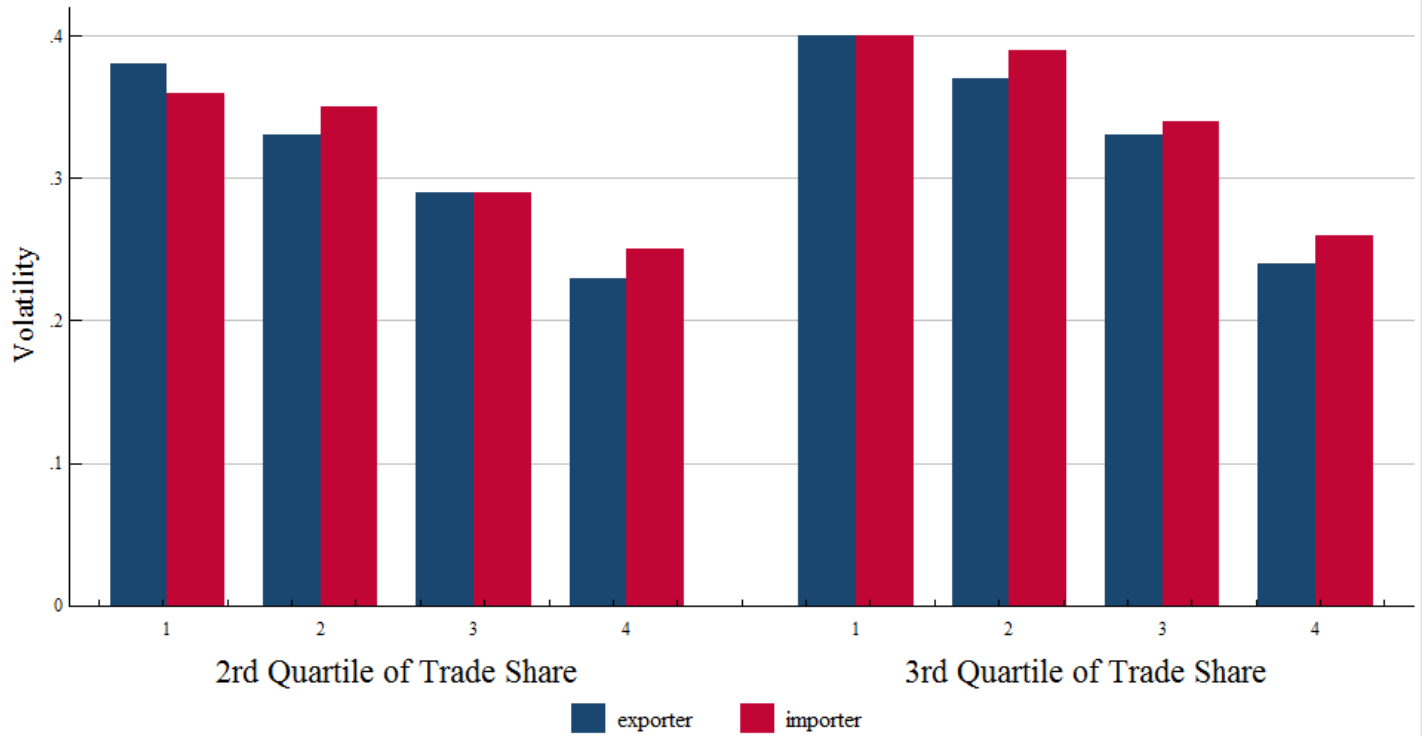


Figure 3
Volatility and Countries Traded With

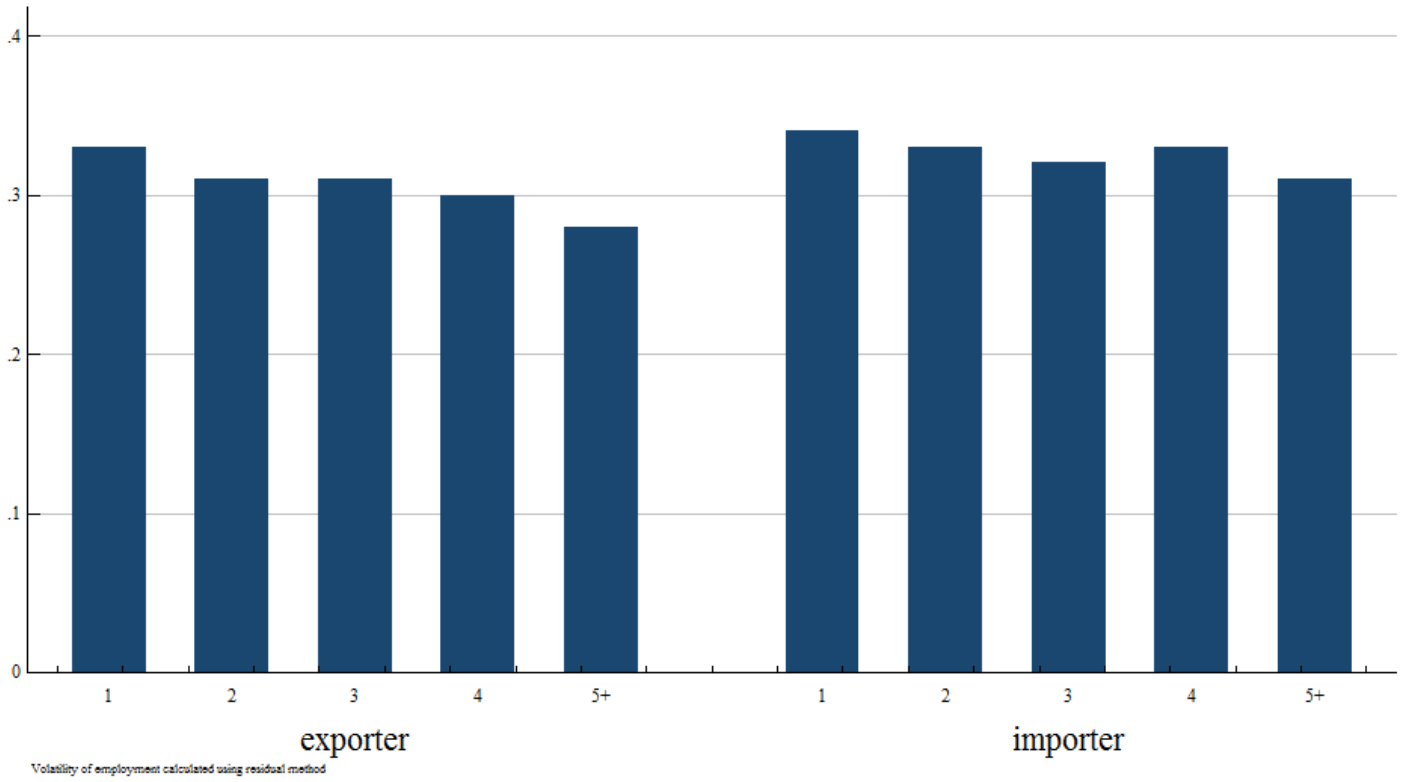


Table 1: Moments

		TFP calibration as in BKK92	
		$corr(\varepsilon, \varepsilon^*) > 0$	$corr(\varepsilon, \varepsilon^*) < 0$
A.	St. dev. (%), aggr. variables, levels	(1)	(2)
1.	Y	0.97	0.92
2.	C (relative to Y)	0.67	0.55
3.	N_E (relative to Y)	3.52	4.37
B.	St. dev. (%), output growth		
	Exporters:		
4.	grY_{EX-NEV} (never)	0.46	0.36
5.	grY_{EX-SOM} (sometimes)	5.31	4.16
6.	grY_{EX-ALW} (always)	0.43	0.33
	Importers:		
7.	grY_{IM-NEV} (never)	0.46	0.36
8.	grY_{IM-SOM} (sometimes)	11.39	9.24
9.	grY_{IM-ALW} (always)	0.47	0.37
C.	St. dev. (%), employment growth		
	Exporters:		
10.	grL_{EX-NEV} (never)	0.51	0.62
11.	grL_{EX-SOM} (sometimes)	4.79	3.93
12.	grL_{EX-ALW} (always)	0.58	0.72
	Importers:		
13.	grL_{IM-NEV} (never)	0.51	0.62
14.	grL_{IM-SOM} (sometimes)	9.11	7.41
15.	grL_{IM-ALW} (always)	0.66	0.83
D.	International correlations, levels		
16.	Y, Y^*	0.42	-0.08
17.	$Y, TB/Y$	-0.18	-0.14
18.	Z, Z^*	0.31	-0.20

Figure 1
Volatility and Firm Export Status

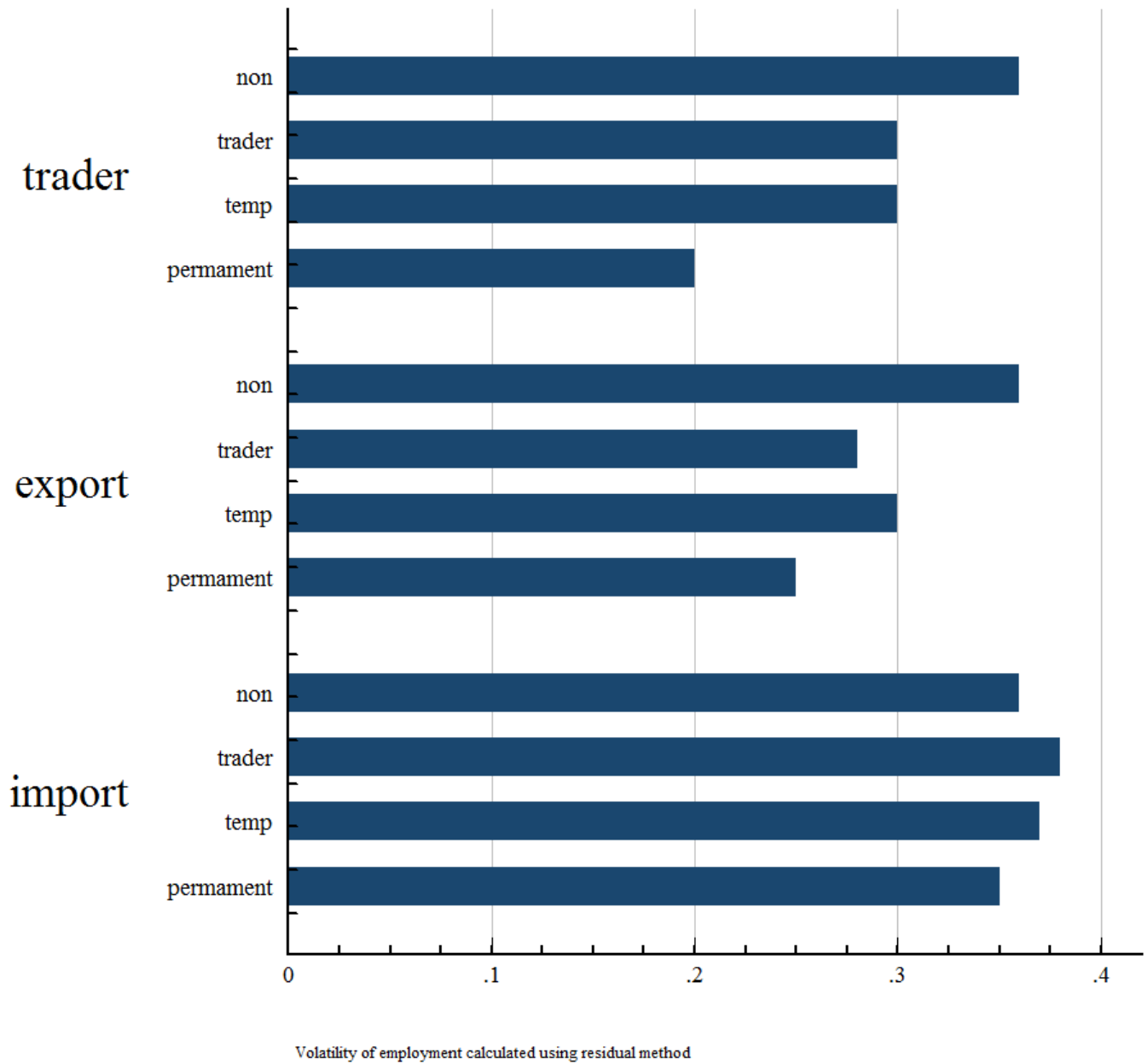


Figure 2
Volatility and Time Traded

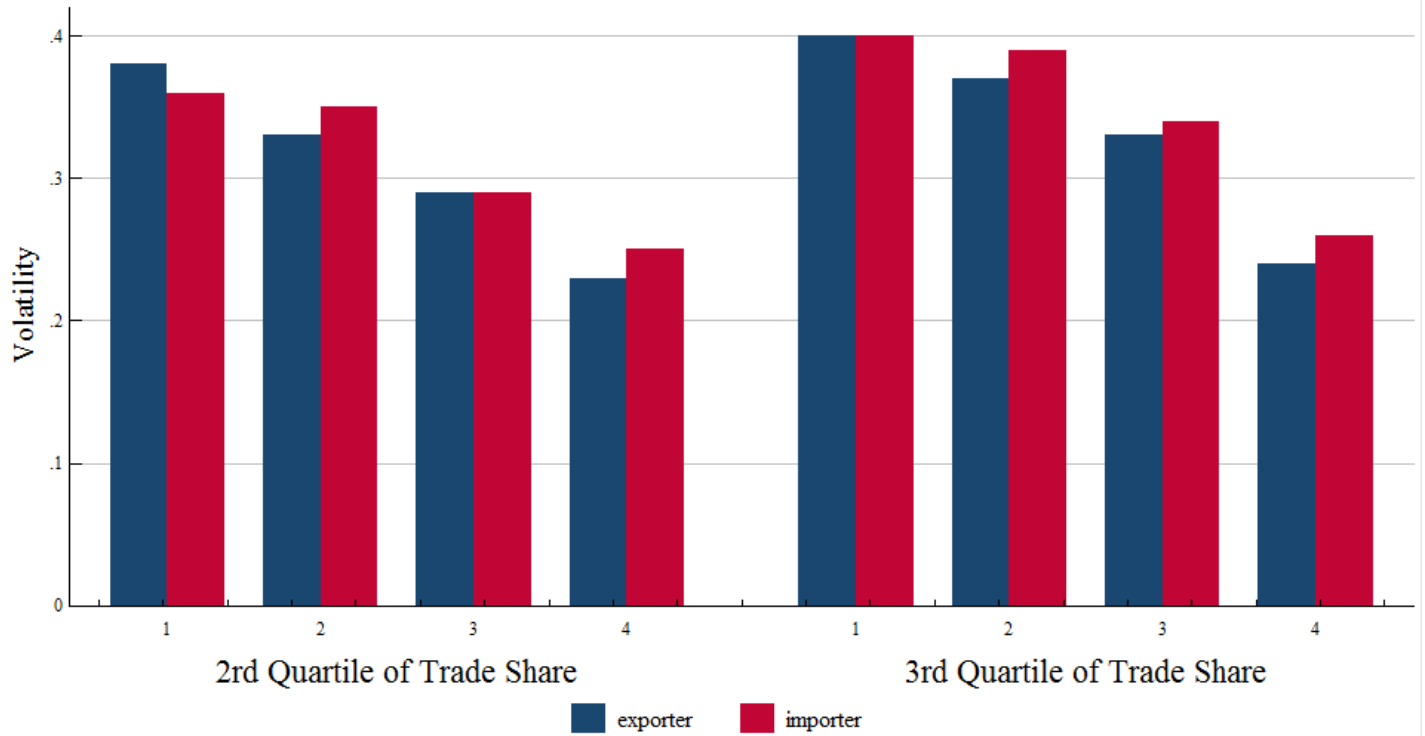


Figure 4: Importing firms.

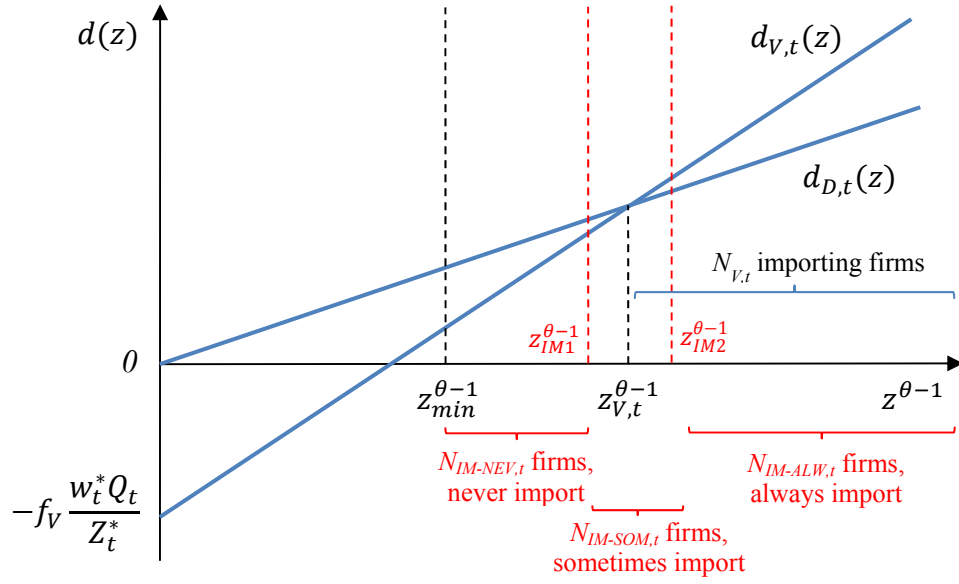


Figure 5: Exporting firms.

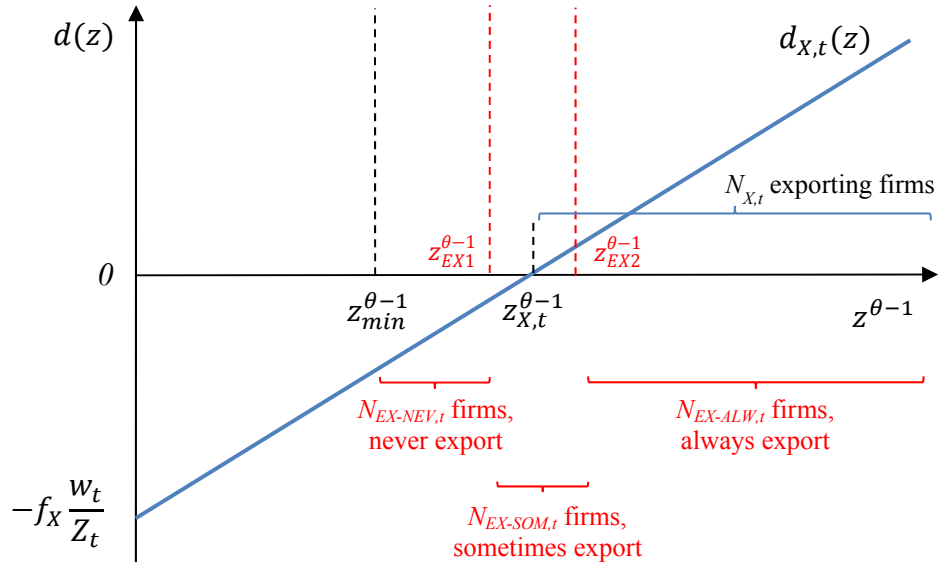


Figure 6: Impulse responses: the exporting and importing productivity cutoffs.

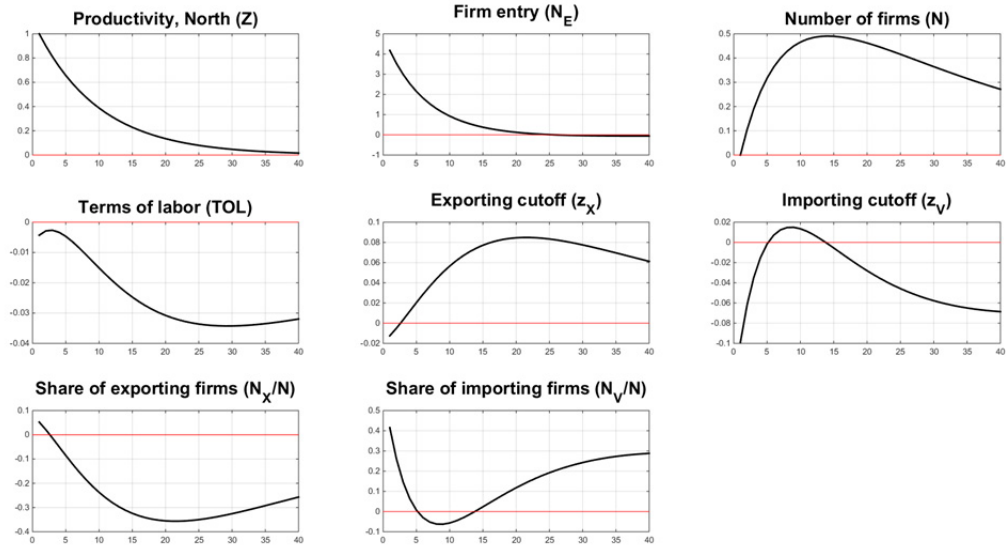


Figure 7: Impulse responses: the output of representative firms.

