Multi-Product Firms and Exchange Rate Fluctuations*

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Abstract

This paper studies the effect of exchange rate shocks on export behavior of multi-product firms. We construct a model illustrating how firms adjust their prices, quantities, product scope, and sales distribution across products in the event of exchange rate fluctuations. In response to a real exchange rate depreciation, firms increase markups for all products, but markup increases decline with firm-product specific marginal costs of production. We find robust evidence for our theoretical predictions using Brazilian customs data containing destination-specific and product-specific export sales and quantities. The sample period covers 1997-2006, during which Brazil experienced a series of drastic currency fluctuations.

JEL classification: F12, F41

Keywords: Multi-product firms, exchange rate pass-through, product ladder, local distribution costs.

1 Introduction

The relatively muted response of consumer import prices to exchange rate fluctuations is a stylized fact that has intrigued economists for many years.[1] Understanding this phenomenon is crucial to many issues faced by policy-makers, since the degree of exchange rate pass-through has implications for how currency devaluations affect inflation and hence the conduct of monetary policy. Furthermore, it may also have important effects on the welfare of exporting firms, importing firms, and consumers. Since there is a symmetry on how import tariffs and exchange rates affect domestic prices, the study of the determinants of exchange rate pass-through may also shed light on how and to what extent domestic prices react to trade liberalization. Finally, understanding exchange rate pass-through is interesting in itself because it helps us understand how firms set prices and how they react to shocks.

The study of exchange rate pass-through in international macroeconomics has for a long time focused on aggregate cross-country data. However, due to the increasing availability of firm- and product-level export and import transaction data, many authors have begun to analyze firm level responses in order to understand the determinants of incomplete exchange pass-through. This strand of the literature started with Feenstra, Gagnon and Knetter (1993) and Goldberg and Verboven (2001) studying price behavior in the international car market, and is experiencing a recent surge with the availability of official customs data. These usually cover all international transactions of a given country and provide researchers with an unprecedented level of detail.[2] This change in focus to firm level data is not surprising given that in the past decade, the international trade literature established firms as the

[1]For examples, see Goldberg and Knetter (1997), Burstein, Neves, and Rebelo (2003), Campa and Goldberg (2005), Campa, Goldberg, and Gonzalez-Minguez (2006), Devereux, Engel, and Tille 1999, and Devereux and Engel (2002) among others.

[2]Examples of this recent literature include, Itskhoki, Gopinath and Rigobon (2008) who study currency choice as a determinant of pass-through, Itskhoki and Gopinath (2009) who study the relationship between the frequency of price adjustment and pass-through, and Berman, Mayer and Martin (2011) who study how different exporters react to exchange rate movements.

primary agents of international commerce.[3] Firms that participate in international trade are heterogeneous in productivity, produce multiple products and often exhibit heterogeneous productivity across different products. In this paper, we explicitly model the effect of exchange rate shocks on the pricing decisions of heterogeneous multi-product exporters and empirically explore implications of within- and across-firm heterogeneity in explaining exchange rate pass-through using detailed transaction-level customs data from Brazil.

Our model illustrates how heterogeneous firms adjust their prices, quantities and product scope in the event of an exchange rate depreciation, and how the degree of price and quantity responses varies across products within firms. The two key features of the model are: 1) Each firm faces a product ladder, i.e. there is a core product that the firm is most efficient at producing (the firm's "core competency") and the firm is less efficient at producing products further away from it; and 2) Each firm pays a local per-unit distribution cost, which implies that markups vary depending on how far the product is from the firm's core competency. Within a given firm, optimal markups are higher for products closer to the core competency. For these products, the production costs are relatively low, so that distribution costs constitute a significant fraction of consumer prices, leading to lower perceived demand elasticity and hence higher markups.

Theoretically, we show that in response to an exchange rate depreciation, producer price increases are more pronounced for products closer to the core competency, i.e., those with greater productivity. The reason is that local per-unit distribution costs imply different degrees of markups depending on the firms' product-specific productivities. Also, firms expand their product scope, and their sales distribution across different products becomes less skewed in response to a real exchange rate depreciation. These two results imply that following a devaluation, the importance of non-core (less efficient) products relative to core products increases in firms' export baskets, leading to a within-firm reallocation of resources towards less efficient use.

[3] See Melitz (2003), Bernard, Redding and Schott (2011), Nocke and Yeaple (2006), and Mayer, Melitz, and Ottaviano (2011) among others.

We test the model's predictions on rich Brazilian customs data. Spanning the period from 1997 to 2006, during which Brazil experienced a series of major exchange rate fluctuations, the dataset has very detailed information at the firm, product, and destination levels. That allows us to use exchange rate variation as well as firm-, product-, and destination-specific information in order to analyze how firms respond to exchange rate movements. We find that the responses of prices, quantities, firm scope, and sales distributions to exchange rate fluctuations are consistent with the theoretical predictions. Our key finding is that the relative position of a product within a firm is a statistically and economically significant determinant of producer price responsiveness to real exchange rate shocks. This result is robust to different measures of within-firm heterogeneity, and after controlling for a rich set of firm, industry and country characteristics. Firm productivity - proxied by a set of firm characteristics - also plays a key role in determining exchange rate pass-through.

The paper is structured as follows. Section 2 discusses the related literature, section 3 describes the theoretical model and its predictions, section 4 presents the empirical analysis, and section 5 concludes the paper.

2 Related Literature

Our paper is mostly related to Berman, Martin, and Mayer (2011), who study optimal price responses to exchange rate movements for French firms. While their model also features local per-unit distribution costs as the main driver of heterogeneous price responses, the analysis focuses on single-product firms and therefore on how high-productivity firms react differently from low-productivity firms. However, most firms participating in international trade produce multiple products. By allowing firms to produce more than one product, we are able to obtain additional results, namely on how firms change their product range and how price responses differ from product to product within a firm. Our empirical results also confirm the key conclusion of Berman, Martin, and Mayer (2011) that in response to a real exchange rate depreciation, more productive firms increase producer prices further than less productive firms.

Regarding multi-product firms, our study is similar to Mayer, Melitz and Ottaviano (2011), whose primary focus is to understand how export market conditions, such as market size and degree of competition, affect firms' relative sales distribution across products. We adopt their deterministic formulation of product ladders to show how the relative sales distribution across products changes in response to exchange rate movements. Bernard, Redding, and Schott (2011) characterize an alternative formulation to a product ladder, in which firm-product specific preferences are stochastic. While we use the approach taken by Mayer, Melitz and Ottaviano (2011), our results are independent of whether we use a deterministic or stochastic formulation for product ladders.

Mayer, Melitz and Ottaviano (2011) incorporate non-homothetic demand in their framework in order to allow for endogeneity of markups. In our setup, endogenous markups arise due to the presence of local distribution costs, even though the demand structure is derived from CES preferences. However, our theoretical and empirical results demonstrate that firms skew their relative export sales towards less efficient use when facing softer market competition (e.g., after a currency depreciation), a result consistent with Mayer, Melitz and Ottaviano (2011). All of our theoretical predictions would be unchanged if we used non-homothetic preferences in our framework. However, CES preferences allow for an analytically tractable framework where we can explicitly demonstrate how distribution and transportation costs affect producer price elasticities as well as empirically test these predictions.

There is a significant body of literature which analyzes how non-tradable distribution costs affect international pricing decisions. Burstein, Eichenbaum, and Rebelo (2005) argue that large declines in real exchange rates associated with devaluations stem mainly from the slow price adjustments of nontradable goods and services. Our paper is closer to Atkeson and Burstein (2008), who show that the presence of trade costs and imperfect competition with variable markups can explain deviations from relative purchasing power parity, and these two features of their model are essential in generating firms' pricing-to-market behavior.

Finally, our paper is related to the literature on incomplete exchange rate pass-through. Auer and Chaney (2009) present a model with goods of different qualities and consumers with heterogeneous preferences for quality. They find that exchange rate shocks are imperfectly passed through to prices and that the pass-through is greater for low-quality goods than for high-quality goods. Hellerstein (2008) studies manufacturers' and retailers' pass-through of nominal exchange rate movements in the beer market and estimates a structural econometric model to quantify the extent to which a nominal exchange rate shock affects domestic and foreign firms' profits and consumer surplus. In our model, the elasticity of producer prices with respect to the exchange rate depends on per-unit local distribution costs. Hence, in our empirical work we allow price responses to vary according to distribution margins, in a manner similar to Campa and Goldberg (2010). Also, we control for the heterogeneity of producer price responses according to important destination characteristics (such as nominal exchange rate volatility of destination countries, market potential, etc.) to assess the importance of within-firm heterogeneity in explaining price responsiveness, following the empirical international macroeconomics literature (for example, Campa and Goldberg (2005)).

3 Model

We present a model in which heterogeneous firms in the Home country export to a variety of destinations. As our empirical section uses data from Brazil, we use "Home" to refer to Brazilian firms. Firms can export a number of products to a given destination, with the firm-product specific productivity depending on how far the product is from the firm's core expertise. We analyze how an exchange rate shock affects firms' optimal price and quantity responses as well as the number of products exported. An individual firm's decisions cannot affect exchange rate movements. Hence, we treat such movements as exogenous from the point of view of the firm.

3.1 Setup

The representative agent in country (destination) c has utility

$$U_c = \left(\int_X x_c(\varphi)^{1-\frac{1}{\sigma}} d\varphi \right)^{\frac{1}{1-\frac{1}{\sigma}}} \tag{1}$$

where $x_c(\varphi)$ is the consumption of product φ in country c and X denotes the set of traded products. The elasticity of substitution among products is $\sigma > 1$.

Each firm has one product corresponding to its core competency; this is the product which it is most efficient at producing. The productivity associated with this "core product" is a random draw θ from a common and known distribution $G(\theta)$ with bounded support on $[0, \overline{\theta}]$; each firm is therefore indexed by θ. We use m to denote the rank of the product in increasing order of distance from the firm's core competency, with m=0 referring to the core product. The productivity of a firm with core competency θ in producing product m for country c is given by

$$\varphi\left(m, \theta\right) = \theta \omega_{c\theta}^{-m}, \; \omega_{c\theta} > 1 \tag{2}$$

The above expression defines a firm's competency ladder, where $\omega_{c\theta}$ characterizes the length of the ladder.[4] Products with higher m are further away from the core competency, and the firm is relatively less efficient at producing these products. We denote the total number of products exported by a firm to any destination c (firm scope) as $n_c(\theta)$. Firms employ one unit of labor at Home to produce $\theta \omega_{c\theta}^{-m}$ units of any variety φ. The wage rate at Home is w.

Each firm faces a distribution cost for each unit of any product it exports to destination c. This cost is meant to capture all expenses associated with delivering the product to a customer after the product has left Home. Per unit distribution costs in country c are measured as η_c units of labor hired in country c.

Because of the presence of local distribution costs, per unit costs depend

[4]Our main results are independent of whether the length of the ladder $\omega_{c\theta}$ depends on country c characteristics or firm characteristics θ.

on both Home and destination wage rates. Let w_c be the wage rate in country c, and ε_c be the nominal exchange rate between Home and country c expressed in Home currency per country c's currency. Therefore, an increase in ε_c is a depreciation in Home's currency vis-a-vis country c's. We call $q_c \equiv \frac{w_c \varepsilon_c}{w}$ the real exchange rate between Home and country c.

Firms face a fixed cost F_c in exporting to destination c. These fixed costs are the same for all firms and products and only depend on the country of destination c. In addition, there is an iceberg transport cost $\tau_c > 1$.

3.2 Optimal pricing

In units of country c's currency, the consumer price of product $\varphi(m, \theta)$ is given by

$$\frac{p_c\left(\varphi\left(m,\theta\right)\right)\tau_c}{\varepsilon_c} + \eta_c w_c \tag{3}$$

where $p_c(\varphi(m,\theta))$ is the producer price of the good exported to c expressed in Home's currency. The first term corresponds to the good's price at country c's dock expressed in country c's currency, and the second term captures the distribution cost incurred in country c. The quantity demanded in country c of this product is

$$x_c(\varphi) = Y_c P_c^{\sigma-1} \left(\frac{p_c(\varphi(m,\theta))\tau_c}{\varepsilon_c} + \eta_c w_c \right)^{-\sigma} \tag{4}$$

where Y_c is the income of country c and P_c is the price index in country c.

For a firm-product specific productivity φ, the cost in the Home currency of producing $x_c(\varphi)\tau_c$ units and selling them in country c is $\frac{w x_c(\varphi)\tau_c}{\varphi} + F_c$, which implies exporting profits of $\pi_c(\varphi) = \left(p_c(\varphi) - \frac{w}{\varphi}\right) x_c(\varphi)\tau_c - F_c$.

Given the number of products, the first-order condition of optimal pricing is

$$x_c(\varphi)\tau_c \left(1 - \left(p_c(\varphi) - \frac{w}{\varphi} \right) \frac{\sigma \tau_c}{p_c(\varphi)\tau_c + \eta_c w_c \varepsilon_c} \right) = 0 \tag{5}$$

leading to the producer price of

$$p_c(\varphi) = \frac{\sigma}{\sigma - 1}\left(1 + \frac{\eta_c q_c \varphi}{\sigma \tau_c}\right)\frac{w}{\varphi} = m_c(\varphi)\frac{w}{\varphi} \tag{6}$$

Note that the markup, $m_c(\varphi)$, is higher than the usual monopolistic competition markup due to the presence of local distribution costs. Also, the markup increases with the real exchange rate and with the firm-product specific productivity level φ.[5] For a more productive firm (high θ), for a product closer to the firm's core competency (low m, given θ), or for a depreciated real exchange rate (high q_c), a large share of the final consumer price does not depend on the producer price, resulting in a lower perceived elasticity of demand and hence higher markups.

3.3 Firm Scope

To determine the number of products, note that a firm with productivity θ earns profits $\pi_c(\varphi(n_c, \theta))$ from its marginal product, where $\pi_c(\varphi(n_c(\theta), \theta))$ equals

$$Cwq_c w_c^{-\sigma} Y_c P_c^{\sigma-1}\left(\frac{\tau_c}{\theta \omega_{c\theta}^{-n_c(\theta)+1} q_c} + \eta_c\right)^{1-\sigma} - F_c, \tag{7}$$

where C is a positive constant that only depends on σ. These profits decrease in $n_c(\theta)$. A product further from the core has a higher variable cost. Thus, a firm earns higher profits on products closer to its core competency.

A firm with productivity θ produces $n_c(\theta)$ products, where $n_c(\theta)$ is the largest integer for which (7) is positive. If (7) is positive only for the top product, then the firm is a single-product firm producing only its top product. If the firm-specific productivity θ is so low that it does not earn positive profits even from its top product, then that firm does not export to destination c.

[5] Berman, Martin and Mayer (2011), Bergin and Feenstra (2001, 2002, 2009) and Atkeson and Burstein (2008) have similar predictions on markups.

3.4 Key Predictions

Here we present the key predictions from our theoretical mechanism.

Producer price and quantity response: Producer prices increase following a real depreciation. From (6) it is clear that the markup increases with real exchange rate through the impact of the real exchange rate on the local distribution cost component. The producer price elasticity is given by

$$\frac{\eta_c q_c \varphi}{\sigma \tau_c + \eta_c q_c \varphi} \tag{8}$$

The producer price elasticity with respect to real exchange rates is less than 1; thus real exchange rate depreciation reduces the price faced by consumers, despite the producer price increase. Hence the quantity response to a real exchange rate depreciation is positive.

Note that the producer price elasticity is specific to each firm and to each product. In fact, (8) increases in both firm-specific and product-specific productivity. Hence, in response to a real exchange rate devaluation, more productive firms increase prices more than less productive firms. Moreover, multi-product firms increase producer prices more for products closer to the core competency than for those further away. Due to firms' higher efficiency at producing core products and to local distribution costs, production costs account for a relatively small fraction of the consumer price. Consequently, the perceived demand elasticity is lower, leading to higher markups. This translates into higher price increases for these products as a result of a depreciation.

For single-product firms, since the price response is stronger for more productive firms, the quantity response is weaker for those firms. Similarly, for multi-product firms, the quantity response is weaker for products closer to the core competency than for those further away.

Moreover, the producer price elasticity increases in per-unit distribution costs and decreases with transportation costs. This follows from the markup, $m_c(\varphi)$, which is increasing in distribution costs and falling with transportation costs.

In addition to price responses, the theoretical model yields the following implications regarding firm scope adjustment, and changes in relative sales.

Firm scope: A firm (weakly) increases its number of products exported to destination c in response to a depreciation. The intuition for this result is the following. Before the depreciation, profits for all exported products are positive and are decreasing with the distance of the product from the firm's core competency. The product furthest away from the core competency, or the "marginal product," is the last product that yields positive profits (the next product yields negative profits, reducing total profits). When the depreciation occurs, profits increase for all products, including the pre-depreciation next-to-marginal product, which may now make positive profits. As a result, the firm has an incentive to expand the range of products further down the ladder.

Changes in relative sales: Consider two products of a firm, where product 1 is higher up in the product ladder than product 2, i.e. $\varphi_1 > \varphi_2$. Then the ratio of the sales of product 1 to the sales of product 2 decreases in response to an exchange rate depreciation.[6] The shift in the relative sales distribution following a depreciation is due to the fact that price increases are not homogeneous across products within firms. Since price increases are more pronounced for products closer to the core competency, quantity responses for these products are relatively muted, leading to an increase in sales that is proportionately smaller than an increase in sales of products further away from the core competency. Thus, in the presence of endogenous markups, a real exchange rate depreciation implies a within-firm reallocation of resources towards less efficient use. Relative sales also become less skewed in response to a decrease in transportation costs. Similarly, an increase in transportation costs and/or a real exchange appreciation imply tougher competition in export markets which induces a firm to skew its export sales towards its best performing products, in a manner similar to Mayer, Melitz and Ottaviano (2011).[7]

[6] See appendix for derivation.

[7] Mayer, Melitz and Ottaviano (2011) allow for endogenous markups through non-homothetic demand. In our set up, local distribution costs give rise to endogenous markups. All of our results go through with the specification of markup endogeneity à la Mayer, Melitz and Ottaviano (2011).

4 Empirical Analysis

4.1 Data

Here we describe the primary sources of data that we use. In this paper we only use data from manufactured products (those attached to NAICS 2-digit industries 15 to 37).

4.1.1 Secex - Customs Data

These records describe every legally registered export transaction from Brazilian firms. For each transaction, the available information includes exporting firm (establishment level), identified by its unique 14-digit identifier $CNPJ$ (Cadastro Nacional de Pessoa Jurídica); the exported good at the 8-digit level NCM (Nomenclatura Comum do Mercosul); country of destination; value of the transaction in US$; number of units and/or weight (in kg) of the shipment; and year and month of the transaction. The same type of data is also available for import transactions.

The data present both weight and quantity columns. For some transactions only weight or quantity is reported, and for others both are reported. In order to choose in what unit unit-values are computed, we construct for every product-destination pair a most frequently reported unit throughout the sample period. We compute unit values dividing total sales of product i, from firm j, to destination c at time t by the total quantity of product i, from firm j, to destination c at time t. While Secex is available since 1990, there is no information on quantities until 1996, which makes it impossible to compute unit-values. Therefore, we only use data from 1997 to 2006, which is a period when Brazil suffered several shocks in its exchange rate.

4.1.2 RAIS

These records consist of all legally registered Brazilian firms. Every year, firms are required by law to report data on each of their establishments and employees as well as several firm-specific variables. In particular, we construct measures of skill composition, number of employees, and distribution of wages for each firm. Firms are identified by their unique registry number (CNPJ), therefore we merge Secex and RAIS in order to obtain firm-level information for exporters. Unfortunately, RAIS does not provide information on domestic sales, revenue, capital, or other balance-sheet variables. Consequently, we cannot construct standard variables to proxy for TFP, such as revenue per worker. For that reason, we proxy for TFP using firm size, skill composition, average hourly wages, and importance of imported inputs.

4.1.3 Aggregate (economy-wide and sector-level) data sources

We obtain data on exchange rates, population, price indices and GDP for different destinations from the Penn World Table (PWT). Information on several aggregate variables is available in PWT from 1950 to 2007 for 190 countries. We use foreign supply potential variables from Head and Mayer (2004) for years 1997 to 2006 as a measure of destination-specific market size. The construction of the measures of supply potential is discussed in greater details in Redding and Venables (2004).[8] Finally, we use data on average distribution margins from Campa and Goldberg (2010) as a measure of the importance of distribution costs at the sector level.

4.1.4 Descriptive Statistics

The firm-level data that we use is very comprehensive and well-suited to empirically explore the hypotheses of the theoretical mechanism we present in this paper. In addition, Brazil underwent major real exchange rate fluctuations over the period of our study, which makes this dataset particularly attractive to study the questions at hand. Figure 1 illustrates the time path of the monthly nominal exchange rate between the Brazilian real and the US dollar. The currency was pegged to the dollar until early 1999 when it faced a sharp

[8]The supply potential measures take into account the distances of a country from other major markets as well as its GDP. For example, even if Netherlands and New Zealand have similar GDP, Netherlands has a higher supply potential because of its central location in Europe.

depreciation. After that, it faced another period of sharp depreciations in 2002 due to uncertainty in Argentina as well as increasing uncertainty vis-a-vis presidential candidate Lula's economic policies prior to taking office. Soon after president Lula became president and brought continuity to his predecessor's sound economic policies, the currency started to appreciate gradually. Figure 2 shows the evolution of the annual real exchange rate with respect to the dollar - which is the frequency we will be working with in this paper - and Figure 3 shows the annual variation in the real exchange rate, which depreciated 45% between 1998 and 1999.

Next, we highlight a few important characteristics of the firm-level dataset. An important contribution of our paper is to highlight how within-firm heterogeneity shapes firms' responses to real exchange rate shocks. We model within-firm heterogeneity as a deterministic product ladder within a firm. The empirical counterpart of a theoretical product in our dataset is an 8-digit level NCM code. In Table 1 we illustrate a few examples of NCM codes. For example, in the eyeglass industry the different products in the data are plastic eyeglass frames, metal eyeglass frames, safety eyeglasses, sunglasses, telescopes, binoculars, etc. These product categories in the data are sufficiently different for them to correspond to the theoretical notion of distinct products and allow for the possibility of different firms having core expertise in different products.

Ours is the first paper to study the multi-product aspect of firms in determining exchange rate pass-through. Most firms export more than one product in the dataset. Guided by our model, we define a multi-product firm as a firm-destination-year triplet with strictly more than one product sold. A single product firm in a given year is defined as a firm-destination-year triplet with only one product sold. We compare multi-product and single-product firms in Table 2. Multi-product firms account for nearly half of the firms in the data. However, they account for approximately two thirds of total employment and almost three quarters of total export value. The last column "fraction of unit-value observations" looks at the share of unit-values in our dataset that come from multi-product firms and single-product firms. Approximately 90% of unit value observations are associated with multi-product firms. Overall, the average number of products exported by a firm to a given country is 53.8, while the median number of products is 11, as seen in Table 3 which lists the top 10 export industries in Brazil.

Comparing different industries, we can see that there is a significant degree of heterogeneity across industries.[9] In the "Food and Beverages" industry (NAICS 15) the median number of products exported by a given firm to a given destination is 3, whereas in the "Assembly of Automotive Vehicles" industry (NAICS 34) the median number of products exported by a given firm to a given destination is 39.

Consistent with our key modeling assumption, we observe great heterogeneity across products within firms, as Table 4 shows. On average, for a given firm, the revenue generated by the product with the highest revenue is approximately three times greater than the revenue generated by the product with the second highest revenue. In fact, the revenue generated by the top product is at least twice as large as the revenue generated by the sum of all the other products. This evidence is consistent with the product-ladder assumption in the theoretical model.

Finally, it is informative to display some descriptive statistics related to Brazilian firms' destinations. The median number of destinations is equal to 10 in a given year, the 25th percentile is equal to 4 destinations and the 75th percentile is equal to 22 destinations. Table 5 shows the top 10 export destinations over the 1997-2006 period. They account for 60% of all manufactured goods exports from Brazil, with the United States and Argentina accounting for more than one third of total exports.

4.2 Econometric Analysis

4.2.1 Response of Prices and Quantities to Real Exchange Rates

In this section, we first test our model's key predictions concerning producer prices. The two key predictions are that (1) producer prices increase following

[9] Products are attached to industries using a correspondence table from NCM codes to 2-digit NAICS industries at `http://www.ibge.gov.br/concla/cl_corresp.php?sl=3`

a real depreciation, and (2) producer prices increases are more pronounced for more productive firms, and within-firm for products closer to the core competency. We estimate the following reduced-form regression to test the first prediction:

$$\ln p_{ijct} = \mu_{ijc} + \varphi(t) + \beta \ln (RER_{ct}) + X_{jt-1}\gamma + Z_{ct}\delta + \varepsilon_{ijct} \tag{9}$$

where p_{ijct} is the producer price in 2006 R$ charged by firm j for product i in destination c in year t, μ_{ijc} is a product-firm-destination fixed effect, $\varphi(t)$ is a 5th degree time polynomial, RER_{ct} is the real exchange rate of country c in year t with respect to Brazil, Z_{ct} is a vector of characteristics of destination c in year t, X_{jt-1} is a vector of firm j's characteristics in year $t-1$, and ε_{ijct} is an error term.

The coefficient β captures the long-run response (in the co-integration sense) of the producer price to real exchange rate fluctuations and is the key parameter to be estimated. We estimate (9) using the fixed effects estimator. For each triplet ijc, β is identified by the correlation between the deviations of prices to the mean log-price of ijc across time and deviations of $\ln (RER_{ct})$ to the mean of each country c across time. The real exchange rates RER_{ct} are assumed to follow an exogenous process, as this is a partial equilibrium model.

We control for a flexible time trend with the time polynomial term in the regression. The firm characteristics that we control for include log of firm size measured by number of employees ($\ln(Emp_{jt-1})$), fraction of skilled (high school completed or higher) workers in the firm ($Skill_{jt-1}$), log of the average wage paid in the firm ($\ln(\bar{w}_{jt-1})$) and a measure of importance of imported inputs relative to total wage bill at the firm level ($\ln(Imp_{jt-1})$, where Imp_{jt-1} is given by $1 + \frac{Total\ Imports\ of\ Firm\ j\ in\ year\ t-1}{Wage\ Bill\ of\ Firm\ j\ in\ year\ t-1}$). All of these characteristics are empirically established indicators of a firm's latent productivity.[10] All these variables are lagged in order to avoid correlation between contemporaneous shocks to prices and contemporaneous innovations to firm-level characteristics.

The quantity counterpart of producer price responsiveness follows natu-

[10] See Verhoogen (2008), Kugler and Verhoogen (2009), and Kugler and Verhoogen (2011).

rally. From (8), the elasticity of producer prices with respect to real exchange rates is less than one, hence the consumer price falls and the quantity exported increases following a real exchange rate depreciation. We estimate the following reduced form regression to test this prediction:

$$\ln Q_{ijct} = \mu_{ijc} + \varphi(t) + \beta \ln (RER_{ct}) + X_{jt-1}\gamma + Z_{ct}\delta + \varepsilon_{ijct} \qquad (10)$$

Table 6 reports the results concerning the responsiveness of producer price and quantity to real exchange rates. The coefficient estimate for log real exchange rate is positive and significant in both cases. Increases in the real exchange rate (real depreciations) are associated with increases in producer prices and quantity exported. The producer price elasticity is estimated to be of approximately 0.24, which implies an exchange rate pass-through to import prices abroad (in the destination's currency) of around 0.76, before local distribution costs (which further attenuate the pass-through to consumers).

The estimated import price elasticity obtained using similar firm-level French data is of 0.83 (see Berman, Martin, and Mayer (2011)). Similarly to our study, this elasticity is also before local distribution costs and is remarkably close to our estimate. Using country- and industry-level data for OECD countries, Campa and Goldberg (2005) obtain an elasticity of 0.64 (Campa and Goldberg (2005)). They also show that the United States have a pass-through of 0.4, which is significantly lower than in other countries in the OECD.

The positive responsiveness of producer prices to exchange rate movements is robust when we estimate equation (9) for each industry. Interestingly, Figure 4 shows a high degree of heterogeneity of producer price responsiveness for different industries. Such heterogeneity is further investigated below.

Next we present more detailed results regarding price adjustments for products within a given firm. The model predicts that the response of producer prices to a real depreciation is greater for products closer to the firm's core competency than for those further away. To test this prediction we estimate the following equation:

$$\ln p_{ijct} = \mu_{ijc} + \varphi(t) + \beta_1 \ln(RER_{ct}) + \beta_2 \ln(RER_{ct}) \times Ladder_{ijct} + \ln(RER_{ct}) \times X_{jt-1}\beta_3 + X_{jt-1}\gamma + Z_{ct}\delta + \varepsilon_{ijct} \quad (11)$$

In order to test how different firms adjust prices for different products following exchange rate movements, we interact $\ln(RER_{ct})$ with variables indicating the relative position of the product within the firm and with firm-level variables that proxy for productivity.

$Ladder_{ijct}$ is a variable that indicates the relative position of good i among those sold by firm j to destination c in year t. The relative position is based on sales of each product of a given firm, to a given destination at a given year. Given a firm-destination-year triplet, the product with highest volume of sales is the core product ($m = 0$), the product with second highest volume of sales is the next to core product ($m = 1$), and so on and so forth. It is easy to show that ranking products according to sales is consistent with the model outlined in the previous section: given a firm-destination pair, products with higher sales are those with higher productivity and hence closer to the core competency.

The following "ladder" variables are used: $Bottom_{ijct}$ is an indicator for whether product i is below the median ranking for sales of firm j to country c in year t; $NotCore_{ijct}$ is an indicator for whether product i is **NOT** the product with highest sales of firm j to country c in year t - i.e., it is not the core product for triplet jct; $Second_{ijct}$ is an indicator for whether product i is the second product with highest sales of firm j to country c in year t[11]; and $Ranking_{ijct}$ is the sales ranking of product i among the products sold by firm j to country c in year t (with lower rank associated with products with higher export sales).

We also allow the responsiveness of producer price to real exchange rate movements to depend on firm productivity, since our theoretical model predicts that producer price elasticity is also higher for firms with higher productivity.

[11] For specifications using this variable, only products ranked first or second are kept.

We use log of firm size, fraction of skilled workers in the firm, log of the average wage paid in the firm, and a measure of importance of imported inputs relative to the total wage bill as proxies for productivity. These variables are appropriately lagged in order to avoid correlation with the error term. For instance, current prices depend on current productivity, but productivity is unobserved. Current levels of employment and wages may immediately react to shocks in productivity, leading to current errors being correlated with current firm-level variables.

Table 7 presents the results from the estimation of (11). The prediction on the product ladder is strongly confirmed and very robust to the specification of the ladder variable. For all four specifications of the ladder, we observe that firms' producer price response is significantly lower for products further away from their core expertise. The magnitude of the product ladder is also economically important. For example, we observe that, all else equal, for products below median sale (of firm j to country c in year t) producer price responsiveness is 9 percentage points lower than for products with above median sales; this is an economically important magnitude in view of the overall price elasticity of 0.24 (obtained from the estimated β parameter in Table 6).

We also confirm the prediction that following a depreciation, more productive firms - measured by bigger size, higher fraction of skilled workers, or paying higher wages - increase markups to a greater extent than less productive firms. This set of results lend support to a similar result found in Berman, Martin and Mayer (2011) concerning heterogeneous responses of firms to real exchange rate shocks.[12]

We also find that the higher the ratio between imports of inputs and the wage bill of the firm, the higher the response of prices to a depreciation will be. This may reflect the fact that importers are more productive and hence increase markups further, but it also reflects the fact that following a depreciation, costs

[12] Berman, Martin and Mayer (2011) restrict their sample to only single product firm-destination-year triplets. To compare our results more directly with theirs we estimated a similar regression restricting our sample to only single-product firms. Our results with regard to firm productivity being a strong determinant of producer price responsiveness are not as robust in this restricted sample. Results are available upon request.

of imported inputs increase, leading to an increase in prices.

Theoretically, we attribute the heterogeneity in price responses to productivity dispersion across firms and within-firm productivity dispersion across products. Table 7 confirms our predictions in the data. However, there are additional reasons for heterogeneity in producer price responses across firms - firms may operate in very different industries, or export to very different destinations. These different industries may have very different local distribution costs, and different destinations may have different transportation costs. From our theoretical model, (8) illustrates that the producer price elasticity with respect to real exchange rates increases with distribution costs and decreases with transportation costs. Also, in our model we make the simplifying assumption that all firms price their products in the Home currency. However, the pass-through can also vary according to destination characteristics, such as market size or exchange rate volatility. These factors potentially affect exporters' currency invoicing decisions, and in the presence of price stickiness, may affect the producer price elasticity.[13] In order to allow for the possibility of producer price responsiveness to vary according to several industry and destination characteristics, we estimate the following equation:

$$\begin{aligned} &\ln p_{ijct} = \mu_{ijc} + \varphi(t) + X_{jt-1}\gamma + Z_{ct}\delta + \\ &\beta_1 \ln(RER_{ct}) + \beta_2 \ln(RER_{ct}) \times Ladder_{ijct} + \ln(RER_{ct}) \times X_{jt-1}\beta_3 + \\ &\ln(RER_{ct}) \times Dest_{ct}\beta_4 + \beta_5 \ln(RER_{ct}) \times \ln(DISTMG_{ind(i)}) + \varepsilon_{ijct} \end{aligned} \tag{12}$$

We continue to allow price responses to vary depending on the relative position of a good in the product ladder of a given firm (captured by the term $Ladder_{ijct}$) and on the productivity of firms (captured by the term X_{jt-1}). We include two other lagged measures of firm performance as additional measures of firm productivity: number of products exported by firm j to country c in year $t-1$ (denoted by $NUMPROD_{jct-1}$) and number of export destinations of firm j in year t (denoted by $NUMDEST_{jt-1}$). These are proxies for pro-

[13]See Bhattarai (2009) for empirical evidence and literature survey.

ductivity since our model implies that the number of products sold by a firm to a given destination increases with productivity. Likewise, the number of destinations also increases with the productivity of the firm.

In addition, we allow destination characteristics (denoted by $Dest_{ct}$) to affect producer price responsiveness. In the destination characteristics, we include the distance between the largest city in Brazil and the largest city in country c (denoted by $Dist_c$) as our measure of transport cost, market potential of country c in year t (denoted by $MKTPOT_{ct}$) as our measure of market size, and log variance of the annual real exchange rate between country c's currency and the US dollar (denoted by $XRATVOL_c$) as our measure of exchange rate volatility. Market potential is constructed in Head and Mayer (2004). This measure is essentially a country's market size weighted by its bilateral distances from other countries, where the weighting attempts to control for the country's accessibility from other markets. Market potential is used instead of GDP because market potential should better approximate the degree of competition at the destination's market. Mayer, Melitz and Ottaviano (2011) use this measure for a similar purpose.

We also allow the price responsiveness to vary according to distribution margins at the two-digit industry level (denoted by $DISTMG_{ind(i)}$). Each 8-digit product i is assigned to a two-digit industry according to a correspondence table that maps NCM codes to NAICS industries. Distribution margins are meant to capture the components of the consumer price that are not included in the producer price. We use the measure constructed in Campa and Goldberg (2010), which is calculated from input-output tables of various countries and consists of transportation and storage costs as well as wholesaler and retailer charges.

Table 8 confirms our key prediction that product ranking is a major determinant of variability in producer price responsiveness, and hence exchange rate pass-through. Even after controlling for heterogeneity contributed by a host of firm, industry and country characteristics, all four measures of the ladder continue to be statistically and economically significant determinants of price responses to real exchange rate shocks. At the firm level, in addition to firm size and average wages, the number of products exported also emerge as an important determinant of producer price response to exchange rate movements.

An increase in bilateral distance and hence associated transportation costs reduces producer price responsiveness, consistent with our theoretical model. An increase in distribution costs, as predicted by (8), increases producer price responsiveness via its impact on the local component of per unit costs; however, the result is not statistically significant. This last finding is not surprising, given the difficulty in measuring distribution costs.

Our empirical results with regard to exchange rate volatility and market potential confirm the empirical evidence and economic intuition from the endogenous currency invoicing literature. Higher exchange rate volatility and smaller market potential are associated with a smaller chance of local currency pricing, and hence a smaller response of producer prices to real exchange rates.

The empirical results in this section firmly establish that product ranking is a key component of producer price responsiveness to real exchange rate fluctuations. We now proceed to empirically test the remaining set of predictions of our theoretical model.

4.2.2 Response of Product Scope to Real Exchange Rates

Our theoretical mechanism predicts an increase in product scope following a real exchange rate depreciation. We test this prediction by estimating the following equation:

$$\ln(1 + NUMPROD_{jct}) = \mu_{jc} + \varphi(t) + \beta \ln(RER_{ct}) + X_{jt-1}\gamma + Z_{ct}\delta + \varepsilon_{ijct} \quad (13)$$

where $NUMPROD_{jct}$ measures the number of products exported by firm j to country c in year t, and μ_{jc} is a firm-destination fixed effect. We use two different samples to test the robustness of our predictions. In the first sample we only include firm-destination pairs that sell at least one product in every single period of the dataset (this only accounts for the intensive margin of product scope). In the second sample, for each firm-destination pair we record the first and the last year of positive export sales. These are the periods during which each firm-destination pairs are "active" in our sample. We only keep observations for periods during which the firm-destination pair is active, including periods of zero sales. As opposed to the first sample, the second sample includes both the intensive margin of product scope (firms increasing and decreasing the number of products exported to a given destination), and the extensive margin of firms exiting a given destination in a given year, possibly due to exchange rate movements.

We report the results in Table 9. In both samples, product scope does increase in response to depreciation, confirming the prediction of the model.[14]

4.2.3 Response of Skewness of Sales Distribution to Real Exchange Rates

In this section, we test our model's predictions concerning the response of relative sales to real exchange rate fluctuations. From our theoretical model, a real exchange rate depreciation leads to weaker market competition and, in response, firms focus their economic activities on products further away from their core expertise. Thus, skewness of export sales falls in response to real exchange rate depreciation. We test this prediction by estimating equation:

$$\ln Skewness_{jct} = \mu_{jc} + \varphi(t) + \beta \ln (RER_{ct}) + X_{jt-1}\gamma + Z_{ct}\delta + \varepsilon_{ijct} \qquad (14)$$

where $Skewness_{jct}$ is measured by either sales of the core product relative to sales of the second-most important product of firm j in country c in year t (denoted by $\left(\frac{R^1_{jct}}{R^2_{jct}}\right)$) or sales of the core product relative to sales of the rest of

[14]In order to be fully rigorous, we would need to estimate a tobit model for equation (13). However, the maximum likelihood estimation of tobit models with fixed effects introduces an incidental parameters problem (see Greene (2004)). Since the OLS estimator of β is biased towards zero, and we find statistically significant positive estimates for this parameter, we only report results using OLS.

the products of firm j in country c in year t (denoted by $\left(\frac{R^1_{jct}}{\sum\limits_{k\neq 1} R^k_{jct}}\right)$), and μ_{jc} is a firm-destination fixed effect.

Table 10 reports the results. In both cases skewness decreases in response to a depreciation. The results are statistically significant when the second measure of skewness is used.

The results obtained estimating 13 14 empirically confirm our theoretical result that following an exchange rate depreciation, firms reallocate resources towards less efficient use. This is consistent with the key finding of Mayer, Melitz and Ottaviano (2011).

5 Robustness Exercises

In this section, we investigate the robustness of our results regarding the heterogeneity of producer price responsiveness to exchange rate movements.

Our first exercise restricts our sample to firm-product-destination triplets that are always active, getting rid of the extensive margin of adjustment. The extensive margin can be a source of incomplete exchange rate pass-through to the extent that a depreciation moves the Melitz export productivity threshold up, inducing less efficient firm-product pairs to start exporting. That phenomenon alone could potentially explain aggregate producer price responsiveness to exchange rates, even if producers did not adjust markups following exchange rate movements (see Campos (2010)). However, Table 11 shows that even after restricting the sample to firm-product-destination triplets that are always active throughout 1997 to 2006, more productive firms tend to increase producer prices more than less productive firms following a devaluation. Within firms, products closer to the core face larger increases in producer prices following a devaluation.

Our second exercise investigates whether the product ladder result is robust across industries. Equation (11) is separately estimated for each NAICS 2-digit industry. Results are reported in Table 12 and are shown to be remarkably robust across industries.

Next, we investigate alternative specifications for the $Ladder_{ijct}$ variables in regression (11). In our previous specifications, we allowed the ranking of a given product within a given firm and destination to vary over time. In the next two exercises we use $Ladder_{ijct}$ variables that are constant over time. The specifications in Table 13 keep only multi-product firms and use only products that were **ALWAYS** core and that were **NEVER** core for a given firm in a given destination. Therefore, we have a fixed ranking, avoiding products changing positions in the ladder in the regressions. The coefficient on the $NeverCore_{ijc}$ variable is still statistically and economically significant.

Another specification for the ladder variable computes rankings at the firm-destination level. For each firm-destination pair, we compute total sales of each product from 1997 to 2006. Rankings are based on these total sales and do not vary over time. Results using this new definition for rankings are shown in Table 14 - note that the ladder variables no longer display time subscripts. Results remain robust, except for when we compare the core product with the second product.

As a last robustness test, we estimate regression (11) with 2 lags in real exchange rates:

$$\begin{aligned}
&\ln p_{ijct} = \mu_{ijc} + \varphi(t) + X_{jt-1}\gamma + Z_{ct}\delta + \\
&\beta_{10} \ln(RER_{ct}) + \beta_{11} \ln(RER_{ct-1}) + \beta_{12} \ln(RER_{ct-2}) + \\
&(\beta_{20} \ln(RER_{ct}) + \beta_{21} \ln(RER_{ct-1}) + \beta_{22} \ln(RER_{ct-2})) \times Ranking_{ijct} + \\
&(\ln(RER_{ct})\, \beta'_{30} + \ln(RER_{ct-1})\, \beta'_{31} + \ln(RER_{ct-2})\, \beta'_{32}) \times X_{jt-1} + \varepsilon_{ijct}
\end{aligned} \tag{15}$$

The long-run response of producer prices to real exchange rates is obtained summing the coefficients $\beta_0 + \beta_1 + \beta_2$.[15] Table 15 displays these long-run responses. Our results are still robust to this specification and notion of long-run.

We also estimate a similar version of equations (13) and (14) in order

[15] This notion of long-run is distinct from the notion of long-run relationship in the co-integration sense and are not necessarily related.

to obtain the long-run responses of product scope and skewness of sales to exchange rate fluctuations:

$$\ln(1 + NUMPROD_{jct}) = \mu_{jc} + \varphi(t) + \beta_0 \ln(RER_{ct}) + \beta_1 \ln(RER_{ct-1}) + \beta_2 \ln(RER_{ct-2}) + X_{jt-1}\gamma + Z_{ct}\delta + \varepsilon_{ijct} \tag{16}$$

$$\ln\left(\frac{R^1_{jct}}{R^2_{jct}}\right) = \mu_{jc} + \varphi(t) + \beta_0 \ln(RER_{ct}) + \beta_1 \ln(RER_{ct-1}) + \beta_2 \ln(RER_{ct-2}) + X_{jt-1}\gamma + Z_{ct}\delta + \varepsilon_{ijct} \tag{17}$$

Tables 16 and 17 show the long-run estimates of the last two equations.

In conclusion, our results regarding the across- and within-firm heterogeneity of producer price responses to fluctuations in real exchange rates are robust to the specification of the ladder variables used. The results are also present even when analyzing each industry in isolation and are robust to the notion of long-run used.

6 Conclusion

We build a theoretical model to explain how multi-product firms adjust prices in response to exchange rate fluctuations. When there is an exchange rate depreciation, firms increase their product range and raise producer prices. The increase in producer prices is greater for products with high sales than for those with low sales, a consequence of local distribution costs. As a result, firms' sales distributions become less concentrated in products with the highest sales. We empirically test the model's implications on Brazilian customs data and find that firms' responses to exchange rate movements are consistent with the theoretical predictions.

The theoretical mechanism of this paper has implications for the lack of sensitivity of aggregate exports to real exchange rate movements. In our model, in response to a real exchange rate depreciation there is a within-firm reallocation of resources towards less efficient use and, hence, sales of products further from the core product increase more.[16] While multi-product firms dominate international trade, these firms export their top products relatively more in the presence of fixed costs of exporting. Thus, the theoretical mechanism from our simple model would imply a muted response of aggregate exports to real exchange rate shocks. We leave assessing the quantitative implications of our mechanism in understanding the exchange rate disconnect puzzle in a more quantitatively relevant model for future work.

[16] Similarly, across firms, less efficient firms increase their sales relatively more in response to a real exchange rate depreciation.

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Tables

Table 1: Examples of NCM codes

NCM	Description
64011000	Waterproof shoes made of rubber or plastic with metal toe protector
64019100	Waterproof shoes made of rubber or plastic covering the knees
64019200	Waterproof shoes made of rubber or plastic covering the ankles
64019900	Other seamless waterproof shoes made of rubber or plastic
64021200	Shoes for ski and snowboard made of rubber or plastic
64021900	Shoes for other sports made of rubber or plastic
64029100	Other shoes made of rubber or plastic covering the ankles
64031200	Shoes for ski and snowboard made of leather
64031900	Shoes for other sports made of leather
90031100	Plastic eyeglasses frames
90031910	Metal eyeglasses frames
90031990	Eyeglasses frames, other materials
90039010	Eyeglass hinges
90039090	Other parts for eyeglasses frames
90041000	Sunglasses
90049010	Eyeglasses for correction
90049020	Safety eyeglasses
90049090	Other eyeglasses for protection or similar articles
90051000	Binoculars
90058000	Telescopes
90059010	Parts and accessories of binoculars
90059090	Parts and accessories of telescopes

Table 2: Single- versus Multi-Product Firms

	Fraction of Exporters	Fraction of Employment	Fraction of Export Value	Fraction of Unit-Value Obs.
Single-Product Firms	0.48	0.35	0.24	0.11
Multi-Product Firms	0.52	0.65	0.76	0.89

Table 3: Top 10 Export Industries

2-digit NAICS	Industry Description	Fraction of Total Export Value	Median # of Products
15	Food and Beverages	0.23	3
27	Metallurgy	0.15	9
34	Assembly of Automotive Vehicles	0.14	39
24	Chemicals	0.08	7
29	Machinery and Equipment	0.08	19
35	Other Transportation Equipment	0.06	7
32	Electronic Components	0.04	19
21	Pulp, Paper and Paper Products	0.03	8
19	Leather Products and Shoes	0.03	3
31	Electrical Machinery	0.02	29
	All	1.00	11

Table 4: Relative Importance of Products In Firm Export Sales

	Median
Export Value 1st / Export Value 2nd	3.36
Export Value 1st / Total Export Value of the Rest	2.42

Table 5: Top 10 Destinations for Manufactured Products

Destination	Percentage of Exports
United States	24.5
Argentina	10.1
Netherlands	4.7
Mexico	4.2
Germany	3.5
Japan	3.0
Chile	2.9
Russia	2.5
Great Britain	2.4
Belgium	2.4

Table 6: Response of Producer Prices and Quantities to Exchange Rates

	(1) Prices	(2) Quantities
$\ln(RER_{ct})$	0.2353***	0.2354***
	[0.021]	[0.054]
$\ln(Emp_{jt-1})$	0.0118	0.1137***
	[0.008]	[0.031]
$Skill_{jt-1}$	0.0112	0.1273**
	[0.029]	[0.064]
$\ln(\bar{w}_{jt-1})$	0.0740***	0.0176
	[0.023]	[0.048]
$\ln(Imp_{jt-1})$	0.0561***	0.0220
	[0.020]	[0.039]
$\ln(PCGDP_{ct})$	0.0504	0.9617***
	[0.032]	[0.111]
Observations	2239401	2241078
R-squared	0.943	0.935

Robust standard errors clustered at the firm level in brackets
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 7: Responsiveness of Producer Prices to Real Exchange Rates along the Product Ladder

	(1) Bottom/Top	(2) Core/Not Core	(3) First/Second	(4) Log Ranking
$\ln(RER_{ct})$	-0.0137	-0.0120	0.1213***	-0.0587
	[0.064]	[0.065]	[0.037]	[0.071]
$\ln(RER_{ct}) \times Bottom_{ijct}$	-0.0934***			
	[0.019]			
$\ln(RER_{ct}) \times NotCore_{ijct}$		-0.0669***		
		[0.010]		
$\ln(RER_{ct}) \times Second_{ijct}$			-0.0360***	
			[0.008]	
$\ln(RER_{ct}) \times \ln(Ranking_{ijct})$				-0.0445***
				[0.008]
$\ln(RER_{ct}) \times \ln(Emp_{jt-1})$	0.0204***	0.0216***	0.0121***	0.0307***
	[0.008]	[0.008]	[0.005]	[0.008]
$\ln(RER_{ct}) \times Skill_{jt-1}$	0.0801*	0.0843*	0.0883***	0.0755*
	[0.045]	[0.045]	[0.026]	[0.041]
$\ln(RER_{ct}) \times \ln(\bar{w}_{jt-1})$	0.0386**	0.0410**	0.0072	0.0581***
	[0.019]	[0.019]	[0.013]	[0.021]
$\ln(RER_{ct}) \times \ln(Imp_{jt-1})$	0.0488***	0.0492***	0.0264**	0.0496***
	[0.016]	[0.016]	[0.011]	[0.016]
Observations	2239401	2239401	820312	2239401
R-squared	0.943	0.943	0.977	0.943

Robust standard errors clustered at the firm level in brackets
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 8: Decomposition of Producer Price Responsiveness

	(1) Top/Bottom	(2) Core/NotCore	(3) First/Second	(4) LogRanking
$\ln(RER_{ct})$	0.8661***	0.9571***	0.7495***	0.9291***
	[0.307]	[0.306]	[0.203]	[0.293]
$\ln(RER_{ct}) \times Bottom_{ijct}$	-0.1010***			
	[0.025]			
$\ln(RER_{ct}) \times NotCore_{ijct}$		-0.0945***		
		[0.012]		
$\ln(RER_{ct}) \times Second_{ijct}$			-0.0494***	
			[0.012]	
$\ln(RER_{ct}) \times \ln(Ranking_{ijct})$				-0.0480***
				[0.014]
$\ln(RER_{ct}) \times \ln(Emp_{jt-1})$	0.0231**	0.0250***	0.0113*	0.0334***
	[0.009]	[0.009]	[0.006]	[0.011]
$\ln(RER_{ct}) \times Skill_{jt-1}$	-0.0728	-0.0684	-0.0801*	-0.0691
	[0.069]	[0.069]	[0.042]	[0.070]
$\ln(RER_{ct}) \times \ln(\bar{w}_{jt-1})$	0.0418*	0.0448*	0.0394**	0.0529*
	[0.025]	[0.025]	[0.018]	[0.028]
$\ln(RER_{ct}) \times$	0.0160***	0.0185***	0.0298***	0.0259***
$\ln(1 + NUMPROD_{jct-1})$	[0.006]	[0.006]	[0.008]	[0.007]
$\ln(RER_{ct}) \times$	-0.0012	-0.0022	-0.0037	-0.0092
$\ln(1 + NUMDEST_{jt-1})$	[0.006]	[0.006]	[0.004]	[0.007]
$\ln(RER_{ct}) \times \ln(Imp_{jt-1})$	0.0340	0.0342	0.0139	0.0375*
	[0.022]	[0.022]	[0.013]	[0.022]
$\ln(RER_{ct}) \times \ln(MKTPOT_{ct})$	0.0595***	0.0582***	0.0577***	0.0512***
	[0.010]	[0.010]	[0.007]	[0.010]
$\ln(RER_{ct}) \times \ln(DIST_c)$	-0.1710***	-0.1753***	-0.1385***	-0.1622***
	[0.024]	[0.024]	[0.017]	[0.029]
$\ln(RER_{ct}) \times \ln(DISTMG_{ind(i)})$	0.0296	0.0216	0.0197	0.0087
	[0.057]	[0.057]	[0.045]	[0.053]
$\ln(RER_{ct}) \times XRATVOL_c$	-2.5830***	-2.6048***	-2.3586***	-2.4651***
	[0.325]	[0.321]	[0.177]	[0.378]
Observations	1275305	1275305	470490	1275305
R-squared	0.948	0.948	0.977	0.948

Robust standard errors clustered at the firm level in brackets
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 9: Response of Number of Products to Exchange Rates

	(1) Sample of firm-destination pairs that were always selling at least one product	(2) Sample of firm-destination pairs from the period of first to last export sale
$\ln(RER_{ct})$	0.0962***	0.1624***
	[0.016]	[0.010]
$\ln(Emp_{jt-1})$	0.1041***	0.0535***
	[0.012]	[0.006]
$Skill_{jt-1}$	0.1181***	0.0680***
	[0.040]	[0.020]
$\ln(\bar{w}_{jt-1})$	0.0499*	-0.0152
	[0.027]	[0.019]
$\ln(Imp_{jt-1})$	0.0279*	0.0091
	[0.017]	[0.009]
$\ln(PCGDP_{ct})$	0.1929***	0.2352***
	[0.034]	[0.020]
Observations	82402	600503
R-squared	0.853	0.728

Robust standard errors clustered at the firm level in brackets
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 10: Response of Skewness of Sales to Exchange Rates

	(1)	(2)
	Dependent Variable	
	$\ln\left(\frac{R^1_{jct}}{R^2_{jct}}\right)$	$\ln\left(\frac{R^1_{jct}}{\sum_{k\neq 1} R^k_{jct}}\right)$
$\ln(RER_{ct})$	-0.0449	-0.0744**
	[0.030]	[0.033]
$\ln(Emp_{jt-1})$	0.0016	-0.0281**
	[0.011]	[0.013]
$\ln(\bar{w}_{jt-1})$	-0.0201	-0.0453
	[0.033]	[0.037]
$Skill_{jt-1}$	-0.0383	-0.0585
	[0.049]	[0.055]
$\ln(Imp_{jt-1})$	0.0181	0.0064
	[0.019]	[0.021]
$\ln(PCGDP_{ct})$	-0.0803	-0.1373**
	[0.064]	[0.068]
Observations	268883	268883
R-squared	0.652	0.687

Robust standard errors clustered at the firm level in brackets
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 11: Firm-Product-Destination Triplets Always Active

	(1) Top/Bottom	(2) Core/NotCore	(3) Top/Bottom	(4) Top/Bottom
$\ln(RER_{ct})$	-0.1908**	-0.1994**	-0.0265	-0.2440**
	[0.097]	[0.098]	[0.070]	[0.114]
$\ln(RER_{ct}) \times Bottom_{ijct}$	-0.0809***			
	[0.022]			
$\ln(RER_{ct}) \times NotCore_{ijct}$		-0.0415**		
		[0.020]		
$\ln(RER_{ct}) \times Second_{ijct}$			-0.0212	
			[0.017]	
$\ln(RER_{ct}) \times \ln(Ranking_{ijct})$				-0.0267**
				[0.011]
$\ln(RER_{ct}) \times \ln(Emp_{jt-1})$	0.0371***	0.0377***	0.0257***	0.0454***
	[0.011]	[0.010]	[0.008]	[0.013]
$\ln(RER_{ct}) \times Skill_{jt-1}$	0.1520**	0.1515**	0.0937**	0.1345**
	[0.060]	[0.060]	[0.044]	[0.057]
$\ln(RER_{ct}) \times \ln(\bar{w}_{jt-1})$	0.0340	0.0348	0.0108	0.0441
	[0.029]	[0.029]	[0.021]	[0.031]
$\ln(RER_{ct}) \times \ln(Imp_{jt-1})$	0.0549*	0.0552*	0.0527**	0.0554**
	[0.029]	[0.028]	[0.021]	[0.027]
$\ln(Emp_{jt-1})$	0.0605***	0.0605***	0.0363***	0.0601***
	[0.014]	[0.014]	[0.010]	[0.014]
$Skill_{jt-1}$	0.0140	0.0140	-0.0349	0.0106
	[0.047]	[0.047]	[0.042]	[0.047]
$\ln(\bar{w}_{jt-1})$	0.1309***	0.1313***	0.1162***	0.1386***
	[0.037]	[0.037]	[0.022]	[0.037]
$\ln(Imp_{jt-1})$	0.1039***	0.1039***	0.0912***	0.1042***
	[0.035]	[0.035]	[0.017]	[0.035]
$\ln(PCGDP_{ct})$	0.0742	0.0739	0.0267	0.0734
	[0.056]	[0.057]	[0.033]	[0.056]
Observations	207403	207403	93998	207403
R-squared	0.901	0.901	0.941	0.901

Robust standard errors clustered at the firm level in brackets
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 12: Product Ladder By Industry

NAICS	$Bottom_{ijct}$	$NotCore_{ijct}$	$\ln(Ranking_{ijct})$	Obs.
15	-0.0552***	-0.0530***	-0.0307***	138619
16	0.0425	-0.1107	-0.0064	668
17	-0.0818***	-0.0746***	-0.0569***	85244
18	-0.0859***	-0.1164***	-0.0905***	114700
19	-0.0439**	-0.0723***	-0.0464**	86307
20	-0.0490	-0.0669*	-0.0657**	40521
21	-0.1311*	-0.0525	-0.0495	17827
22	-0.2073*	0.0313	-0.0687	26386
23	0.0371	0.0073	0.0128	2763
24	-0.0575***	-0.0271	-0.0505***	197587
25	-0.1369***	-0.0835**	-0.0663***	118014
26	-0.0570**	-0.0374	-0.0289**	90681
27	-0.0434*	-0.0184	-0.0012	74092
28	-0.1061***	-0.0831***	-0.0371**	203896
29	-0.0444	-0.0512**	-0.0231*	430887
30	-0.7278***	-0.3414***	-0.3816***	14697
31	-0.1431***	-0.1078**	-0.0603**	183468
32	-0.3403***	-0.1446**	-0.1605***	46166
33	-0.1894**	-0.1131*	-0.1107**	97283
34	-0.0423	-0.0794**	-0.0344*	157936
35	-0.1954	-0.1773*	-0.1217**	9146
36	-0.1047***	-0.0889***	-0.0632***	102513

Robust standard errors clustered at the firm level in brackets

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 13: Always Core Products vs. Never Core Products

	(1)
	AlwaysCore/NeverCore
$\ln(RER_{ct})$	0.0072
	[0.096]
$\ln(RER_{ct}) \times NeverCore_{ijc}$	-0.0938***
	[0.036]
$\ln(RER_{ct}) \times \ln(Emp_{jt-1})$	0.0295***
	[0.011]
$\ln(RER_{ct}) \times Skill_{jt-1}$	0.0785
	[0.072]
$\ln(RER_{ct}) \times \ln(\bar{w}_{jt-1})$	0.0343
	[0.036]
$\ln(RER_{ct}) \times \ln(Imp_{jt-1})$	0.0491
	[0.030]
$\ln(Emp_{jt-1})$	0.0065
	[0.012]
$Skill_{jt-1}$	-0.0083
	[0.049]
$\ln(\bar{w}_{jt-1})$	0.0740**
	[0.038]
$\ln(Imp_{jt-1})$	0.0207
	[0.016]
$\ln(PCGDP_{ct})$	0.0305
	[0.058]
Observations	801376
R-squared	0.963

Robust standard errors clustered at the firm level in brackets
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 14: Ranking Using Total Sales Over The Whole Period

	(1) Top/Bottom	(2) Core/NotCore	(3) First/Second	(4) LogRanking
$\ln(RER_{ct})$	-0.0249	-0.0146	0.1145***	-0.0457
	[0.064]	[0.065]	[0.035]	[0.066]
$\ln(RER_{ct}) \times Bottom_{ijc}$	-0.1108***			
	[0.019]			
$\ln(RER_{ct}) \times NotCore_{ijc}$		-0.0539***		
		[0.020]		
$\ln(RER_{ct}) \times Second_{ijc}$			0.0126	
			[0.016]	
$\ln(RER_{ct}) \times \ln(Ranking_{ijc})$				-0.0231***
				[0.008]
$\ln(RER_{ct}) \times \ln(Emp_{jt-1})$	0.0200***	0.0210***	0.0074*	0.0252***
	[0.008]	[0.007]	[0.004]	[0.007]
$\ln(RER_{ct}) \times Skill_{jt-1}$	0.0798*	0.0826*	0.0859***	0.0763*
	[0.045]	[0.045]	[0.025]	[0.042]
$\ln(RER_{ct}) \times \ln(\bar{w}_{jt-1})$	0.0370*	0.0403**	0.0117	0.0492**
	[0.019]	[0.019]	[0.013]	[0.020]
$\ln(RER_{ct}) \times \ln(Imp_{jt-1})$	0.0489***	0.0491***	0.0229**	0.0494***
	[0.016]	[0.016]	[0.010]	[0.016]
$\ln(Emp_{jt-1})$	0.0115*	0.0115*	0.0104**	0.0111
	[0.007]	[0.007]	[0.005]	[0.007]
$Skill_{jt-1}$	-0.0003	0.0002	-0.0533**	-0.0000
	[0.027]	[0.027]	[0.022]	[0.027]
$\ln(\bar{w}_{jt-1})$	0.0696***	0.0696***	0.0738***	0.0726***
	[0.022]	[0.022]	[0.014]	[0.020]
$\ln(Imp_{jt-1})$	0.0495***	0.0495***	0.0329***	0.0497***
	[0.018]	[0.018]	[0.008]	[0.018]
$\ln(PCGDP_{ct})$	0.0517	0.0512	-0.0004	0.0519*
	[0.032]	[0.032]	[0.021]	[0.031]
Observations	2208556	2208556	707493	2208556
R-squared	0.942	0.942	0.972	0.942

Robust standard errors clustered at the firm level in brackets

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 15: Product Ladder - Specification with Lags

	Top/Bottom	Core/NotCore	LogRanking
$\ln(RER_{ct})$	-0.0200	-0.0163	-0.0662
	[0.0710]	[0.0727]	[0.0781]
$\ln(RER_{ct} \times Ladder_{ijct})$	-0.0907***	-0.0720***	-0.0485***
	[0.0213]	[0.0101]	[0.0124]
$\ln(RER_{ct}) \times \ln(Emp_{jt-1})$	0.0243***	0.0258***	0.0364***
	[0.0084]	[0.0081]	[0.0083]
$\ln(RER_{ct}) \times Skill_{jt-1}$	0.0745	0.0774*	0.0619
	[0.0459]	[0.0456]	[0.0422]
$\ln(RER_{ct}) \times \ln(\bar{w}_{jt-1})$	0.0260	0.0293	0.0491***
	[0.0201]	[0.0202]	[0.0213]
$\ln(RER_{ct}) \times \ln(Imp_{jt-1})$	0.0332*	0.0337*	0.0333*
	[0.0177]	[0.0178]	[0.0185]

Robust standard errors clustered at the firm level in brackets
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 16: Number of Products - With Lags

	(1) Sample of firm-destination pairs that were always selling at least one product	(2) Sample of firm-destination pairs from the period of first to last export sale
$\beta_0 + \beta_1 + \beta_2$	0.0655***	0.0830***
	[0.0191]	[0.0132]

Robust standard errors clustered at the firm level in brackets
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 17: Skewness of Sales - With Lags

	Value1/Value2	Value1/ValueRest
$\beta_0 + \beta_1 + \beta_2$	-0.0382	-0.0538
	[0.0370]	[0.0403]

Robust standard errors clustered at the firm level in brackets
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Figures

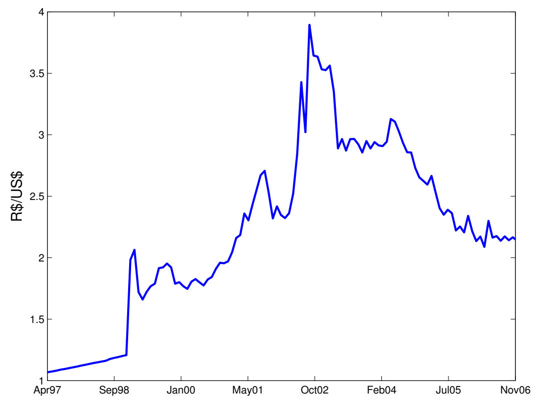

Figure 1: Evolution of the Monthly Nominal Exchange Rate R$/US$, Jan1997-Dec2006

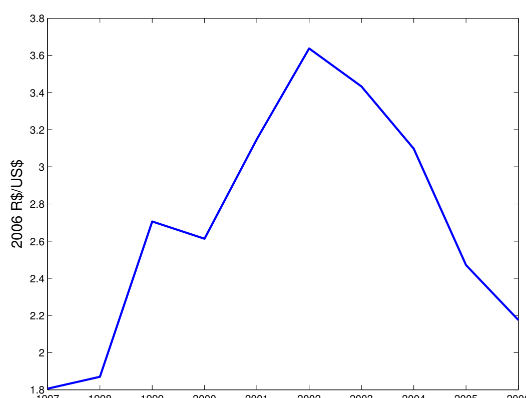

Figure 2: Evolution of the Annual Real Exchange Rate 2006 R$/US$, 1997-2006

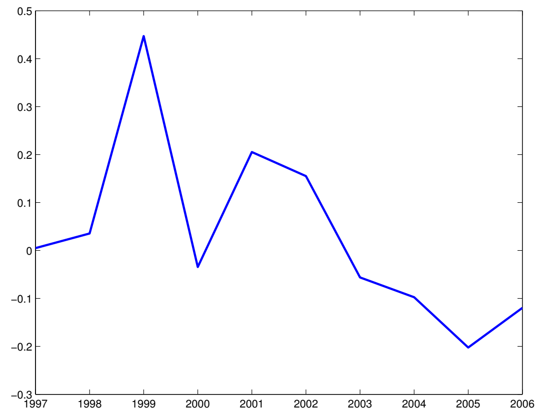

Figure 3: Annual Variation in the Real Exchange Rate 2006 R$/US$, 1997-2006

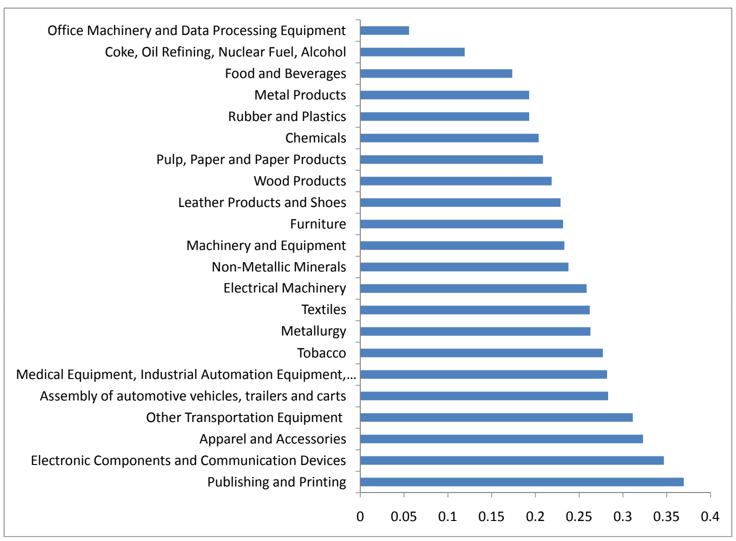

Figure 4: Producer Price Responsiveness to Exchange Rates by Industry

Appendix - Skewness of Sales

The import price is given by

$$\frac{p_c(\varphi)\tau_c}{\epsilon_c} = \frac{\sigma w_c}{\sigma - 1}\left(\frac{\tau_c}{\varphi q_c} + \frac{\eta_c}{\sigma}\right) \tag{18}$$

and the consumper price in destination c is given by

$$\frac{p_c(\varphi)\tau_c}{\epsilon_c} + \eta_c w_c = \frac{\sigma w_c}{\sigma - 1}\left(\frac{\tau_c}{\varphi q_c} + \eta_c\right) \tag{19}$$

Sales for a product φ measured in producer currency is therefore

$$\left(\frac{\sigma}{\sigma - 1}\right)^{1-\sigma} \frac{w}{\varphi} w_c^{-\sigma} Y_c P_c^{\sigma-1}\left(1 + \frac{\eta_c q_c \varphi}{\sigma \tau_c}\right)\left(\frac{\tau_c}{\varphi q_c} + \eta_c\right)^{-\sigma} \tag{20}$$

Relative sales of product φ_1 vis-a-vis product φ_2, $\varphi_1 > \varphi_2$, is given by

$$\frac{\left(1 + \frac{\eta_c q_c \varphi_1}{\sigma \tau_c}\right)\left(\frac{\tau_c}{\varphi_1 q_c} + \eta_c\right)^{-\sigma}\left(\frac{1}{\varphi_1}\right)}{\left(1 + \frac{\eta_c q_c \varphi_2}{\sigma \tau_c}\right)\left(\frac{\tau_c}{\varphi_2 q_c} + \eta_c\right)^{-\sigma}\left(\frac{1}{\varphi_2}\right)} \tag{21}$$

We show that the derivative of (21) w.r.t the real exchange rate, q_c, is

$$(\sigma - 1)(\varphi_2 - \varphi_1)\frac{\eta_c \tau_c^2 \sigma\left(\eta_c + \frac{\tau_c}{\varphi_1 q_c}\right)^{-\sigma}\varphi_2\left(\tau_c(1+\sigma) + \eta_c q_c\right)}{\left(\eta + \frac{\tau_c}{\varphi_2 q_c}\right)^{-\sigma}\varphi_1\left(\tau_c + \varphi_1 q_c \eta_c\right)\left(\tau_c + \varphi_2 q_c \eta_c\right)\left(\tau_c \sigma + \varphi_2 q_c \eta_c\right)^2} < 0 \tag{22}$$

since $\sigma > 1$ and $\varphi_2 < \varphi_1$. Thus, real exchange rate depreciation leads to a reduction in the skewness of sales within a firm.