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Abstract

This paper investigates the impact of market structure on the joint determination of exchange rate pass-through and currency of invoicing in international trade. A novel feature of the study is the focus on market share of firms on both sides of the market—that is, exporting firms and importing firms. A model of monopolistic competition with heterogeneous firms has the following set of predictions: a) exchange rate pass-through should be non-monotonic and U-shaped in the market share of exporting firms, but monotonically declining in the market share of importers; b) exchange rate pass-through should be lower, the higher is local currency invoicing of imports; and c) producer currency invoicing should be related non-monotonically and U-shaped to exporter market share, and monotonically declining in importing firms' market share. We test these predictions using a new and large micro data set covering the universe of Canadian imports over a six-year period. The data strongly support all three predictions.

JEL classification: F3, F4
Bank classification: Exchange rates; Inflation and prices; Market structure and pricing

Résumé

Nous analysons l'effet de la structure de marché sur le choix du degré de transmission des variations du taux de change et la monnaie de facturation retenue dans les échanges internationaux. L'originalité de l'étude est l'intérêt porté aux deux côtés du marché, c'est-à-dire aux exportateurs et aux importateurs. Le modèle de concurrence monopolistique à entreprises hétérogènes utilisé aboutit à une série de prévisions : a) la relation entre la transmission des variations du taux de change et la part de marché des exportateurs devrait être non monotone et donner lieu à une courbe en U; en ce qui concerne la part de marché des importateurs, la relation décroît de façon monotone; b) la transmission des variations du taux de change devrait être faible lorsque les importations sont plus susceptibles d'être facturées dans la monnaie de l'importateur; c) la facturation dans la monnaie des producteurs devrait donner lieu à une relation non monotone avec la part de marché des exportateurs et à une courbe en U, ainsi qu'à une relation constamment décroissante avec la part de marché des importateurs. Ces prévisions sont vérifiées à l'aide d'un nouvel ensemble de microdonnées sur toutes les importations canadiennes effectuées en six ans. Les données confirment largement chacune des trois prévisions.

Classification JEL : F3, F4
Classification de la Banque : Taux de change; Inflation et prix; Structure de marché et fixation des prix

Non-Technical Summary

Motivation and Question

Understanding how movements in the nominal exchange rate affect import prices has long been one of the most discussed and studied areas in international economics. Exchange rate pass-through relates to the measurement of the degree to which exchange rate movements are transmitted into import prices and then through to consumer prices. Having reliable estimates of exchange rate pass-through—and a deepened understanding of the underlying mechanisms that determine it—are crucial for the conduct of monetary policy, since pass-through can affect short-run inflation. In this paper, we derive estimates of exchange rate pass-through to import prices using highly disaggregated trade data, and then explore the role that the market power of the firms involved in trade—the importers and exporters—plays in the determination of pass-through. Furthermore, in the presence of sticky trade prices, the currency of invoicing matters for pass-through, and we study the intricate relationship between importer and exporter market share, currency invoicing, and exchange rate pass-through.

Methodology

We develop a model of monopolistic competition and trade that accounts for market power on both sides of the trade transaction, and makes several predictions about the connection between market share, the currency of invoicing and pass-through. Namely, the model predicts a U-shaped relationship between the market share of exporters and exchange rate pass-through, while the relationship between importer market share and pass-through will be decreasing monotonically. It also predicts similar relationships between currency choice and market shares. We then test the predictions of the model using highly disaggregated unit price data consisting of the universe of imports for nine product types in Canada from 2002 to 2008. In the process, we derive estimates of overall pass-through, and individual estimates for the nine product types.

Key Results and Contributions

First, pooling all nine products, we estimate pass-through to be approximately 59 percent—that is, a 1 percent depreciation (appreciation) of the Canadian dollar is associated with a 0.59 percent increase (decrease) in import prices. We also find a significant amount of variation in pass-through across each of the nine products, ranging from 82 percent for apparel to only 21 percent for vegetable products. Next, we test the predictions of the model. We find strong evidence of a U-shaped relationship between exporter market share and pass-through, and a negative relationship between importer market share and pass-through. We also find that similar patterns exist in the determination of the currency of invoice. Finally, we explore how market shares may be related to changes in pass-through over time. Running rolling regressions, we find evidence of large swings in the degree of pass-through over a relatively short time period. At the same time, the percentage of imports accounted for by large market-share importers and exporters increased. It is therefore possible that these trends in the shift of import market share to larger firms played some role in the fluctuations in pass-through.

1. Introduction

The relationship between exchange rates and goods prices has been one of the most discussed and studied areas in international economics. A large part of the core theory of international trade and macroeconomics depends on assumptions about how prices, both at the retail level and "at the dock," respond to changes in exchange rates. One central concept in both the theory and empirical work on this topic is that of exchange rate pass-through. This pertains to the question of how much of an exchange rate change is reflected in domestic currency goods prices (when various controls are applied). There is a very large literature on exchange rate pass-through, both at the level of the individual firm and at a more aggregate level of imports, with the robust finding that pass-through to import prices is less than complete.[1]

Fundamentally, the degree of aggregate pass-through will depend on the market power of the firms involved in trade, since this will determine who will absorb movements in the exchange rate.[2] In this paper, we explore how pass-through is determined by the market share of the firms on both sides of the trade transaction—the exporters and the importers. We develop a model of monopolistic competition and trade that accounts for the decisions of both exporters and importers, and that makes clear predictions about the relationship between exchange rate pass-through, market share and the currency of invoice. We then test the predictions of the model using unique micro data.

A number of recent papers have linked pass-through with the market share of exporters. Berman, Martin and Mayer (2012) and Amiti, Itskhoki and Konings (2014) find that under certain conditions, pass-through monotonically decreases in exporter market share using French and Belgian firm-level data, respectively. Feenstra, Gagnon and Knetter (1996) and Garetto (2014) emphasize a U-shaped relationship between exporter market share and pass-through supported by estimates on car-price data sets. Auer and Schoenle (2015) also show that the response of import prices to exchange rate changes is U-shaped in exporter market share using micro data from the Bureau of Labor Statistics.[3]

What distinguishes our paper from these existing micro studies is: (i) the development of a model of exchange rate pass-through that accounts for market power on both sides of the trade transaction; (ii) the use of an extremely large and disaggregated data set representing a wide range of goods and information on both importers and exporters to test the predictions of the model; (iii) the finding of not only a U-shaped relationship between pass-through and exporter market share, but also of a negative relationship between importer market share and pass-

[1] See, for example, Knetter (1989), Campa and Goldberg (2005), and Burstein and Gopinath (2013).

[2] This perspective is developed in Dornbusch (1987) and more recently Atkeson and Burstein (2008).

[3] Since micro price data from the Bureau of Labor Statistics do not include information on the sales of individual firms, Auer and Schoenle infer market share indirectly from relative prices.

through; and (iv) the exploration of the role of the currency of invoice in these relationships. The link between pass-through and importer market share is a particularly important contribution to the literature: we show that while the distribution of market shares of exporters has changed little over time, the market share of large importers increased over the sample period and this may be related to observed variations in overall pass-through.

In our model, exporters differ in cost efficiency (or productivity), which translates into differences in their market shares in equilibrium. Importers also differ in size and, critically, in their demand elasticity. An important building block in our model is that importers with a larger cost advantage, and thus larger market share, have a higher elasticity of demand for the product purchased from each exporter.

The model predicts a U-shaped relationship between pass-through and exporter market share. Very small or very large exporters (in terms of their share of the market) have little concern over the impact of increasing their price on their share of the total market, and they will pass-through most of any exchange rate movements into their sales price. Exporters in the middle range, however, are more concerned with the effects of price changes on their share of the market, and will tend to have lower rates of pass-through.[4]

On the importer side, given the opportunity to invest (at a cost) in more flexible technologies, high-productivity importers will have a higher elasticity of demand. The result is that exchange rate pass-through is lower for sales to importers with a higher market share (or, equivalently, those with high productivity, low cost structure and hence a higher elasticity of demand for imported goods). The higher the elasticity of demand of the importer, the more an exporter's market share will vary if it passes through exchange rate shocks. Therefore, conditional on the market share of the exporter, pass-through will be lower for sales to larger importers (with higher market share).

How does this relate to the determination of invoicing currency? Engel (2006) and Gopinath, Itskhoki and Rigobon (2010) construct models where a firm's desired or unrestricted rate of pass-through (pass-through following a price change) will determine its choice of invoice currency. The higher the desired pass-through, the more likely will the exporting firm be to choose its own currency (or U.S. dollars, in most of our data) for invoicing, while firms desiring low pass-through will be more likely to invoice in the importer's currency (Canadian dollars in our study). Since our focus is on unrestricted exchange rate pass-through (after a price change), our model predicts a particular relationship between the market share of both exporters and importers on the invoice currency. The model implies that the use of the U.S. dollar in invoicing should be non-monotonic and U-shaped in its relationship to exporter market share, and negatively related

[4]For constant-elasticity-of-substitution preferences, this point was originally made in Feenstra, Gagnon and Knetter (1996), and more recently by Auer and Schoenle (2015).

to importer market share.

We test these predictions on a highly disaggregated data set on Canadian import prices. The data include the universe of Canadian imports over a six-year period from 2002 to 2008. The rich nature of the data allows us to investigate how exchange rate pass-through differs for different categories of imports, currencies of invoice and types of firms, as well as a number of other features of import prices. We focus on nine product types that are representative of nearly 40 percent of all Canadian imports (by value) in any given month, and we use unit values (shipment value divided by the number of units) as a proxy for price. In order to overcome some of the issues related to using unit values—in particular, errors in measuring quantities and variation in products even within very narrowly defined product codes—we use a very specific definition for a product. That is, products are specific to an importing firm, exporting firm, 10-digit Harmonized System (HS10) product code, country of origin, country of export, currency and unit of measurement.

We start by measuring overall pass-through and find that it is approximately 59 percent—that is, a 1 percent depreciation (appreciation) of the Canadian dollar is associated with a 0.59 percent increase (decrease) in import prices. We also derive estimates for each of the nine products and find that there is significant variation in the degree of pass-through: from 82 percent for apparel to only 21 percent for vegetable products. Pass-through estimates for all other products fall within this range. We note that the use of detailed micro data to estimate pass-through overcomes many of the pitfalls associated with the use of aggregated data to measure pass-through. This is of particular concern when measuring pass-through in Canada, since in the construction of the Canadian import price index, some of the price data sampled are from other countries (mainly the United States) and incorporated into the index based on arbitrary assumptions regarding the degree of pass-through (Bailliu, Dong and Murray, 2010).

We then look into the relationship between pass-through and market share. We find strong evidence of a U-shaped relationship between pass-through and exporter market share, and a downward-sloping relationship between pass-through and importer market share. In addition, we look at the interactions between importers and exporters of the same and different size, and find that the pass-through and exporter/importer market shares relationships still hold when we explicitly control for the size of the trading partner. Moreover, as the theoretical model suggests, we estimate rates of exchange rate pass-through that are substantially higher for U.S.-dollar- and euro-priced goods than for Canadian-dollar-priced goods.

Putting these two relationships together, we test a simple model of endogenous choice of invoicing currency, using a logit specification. Consistent with the theory, our test results confirm that there is also a U-shaped relationship between exporter market share and the probability of invoicing in U.S. dollars, and that importers with larger market share have a higher probability

of paying in Canadian dollars.

Finally, we explore how changes in market shares may be related to changes in overall pass-through over time. Using rolling regressions, we track pass-through over time and, despite the relatively short sample period, find large swings in pass-through. We then consider the role of changes in market shares in influencing pass-through dynamics. While the distribution of exporter market share changes very little over time (other than a slight increase in the market share of larger exporters in the first year of the sample), the market share of the larger importers increases substantially in the sample, and we conjecture that this relates to the decline in pass-through observed in the latter half of the sample.

In a broad sense, our paper contributes to the large empirical and theoretical literature on the size of exchange rate pass-through and its other determinants. It is an almost universally recognized fact that at all levels of aggregation, exchange rate pass-through is less than full. Early studies by Krugman (1987) and Froot and Klemperer (1989) suggested this was due to the presence of strategic forces leading firms to engage in "pricing-to-market." Later literature proposed that slow nominal price adjustment and local currency pricing may be responsible for partial pass-through both at the import price level and the level of retail prices (Devereux, Engel and Storgaard, 2004). Recently, many studies of exchange rate pass-through have availed themselves of more detailed micro data sets of goods prices. However, it has been difficult to obtain comprehensive matched data on currency of invoicing, market structure and goods prices. Studies using U.S. micro data—for example, Gopinath and Rigobon (2008), Gopinath, Itskhoki and Rigobon (2010) and Auer and Schoenle (2015)—are very informative, but it is likely that the United States may be quite a special case (albeit an important one) due to the central nature of the U.S. dollar in international trade settlement and invoicing (Goldberg and Tille, 2008). There is a growing literature using data for other countries. Fitzgerald and Haller (2013) look at pass-through using Irish data, Amiti, Itskhoki and Konings (2014) make use of Belgian data, and Cravino (2014) uses Chilean data.

Our contribution to this literature is to show the relationship between market structure and pass-through, stressing that market share of both exporting *and* importing firms is a crucial feature in the joint determination of exchange rate pass-through and the currency of invoicing.

The paper proceeds as follows. Section 2 presents the theoretical discussion. Section 3 describes the data and provides summary statistics. In section 4, we present the empirical model and test the predictions of the theoretical model. Section 5 provides a discussion of the possible links between changes in market share over time and observed variations in pass-through. Section 6 concludes.

2. Theoretical Discussion

In this section we explore the determinants of exchange rate pass-through into import prices in a model of monopolistic competition. This will help to frame the empirical analysis of the following sections.

Consider a model of an importing country where there are many different sectors (or markets). Within each sector there are a number of distinct sellers (exporters, or vendors), and a separate number of distinct buyers (importers). Each exporter is assumed to produce and sell a unique product, and some of each product is purchased by all the separate importers. Exporters differ in cost efficiency and in equilibrium this will translate into differences in market share of sales in the sector. Importers are assumed to be intermediaries who purchase a basket of goods from exporters and with these produce a retail product for domestic final consumers (who are not modelled here). Importers also differ in size, again due to differences in cost advantage. This difference in cost also translates into differences in demand elasticity for importing firms. Our maintained assumption is that importers with larger cost advantage have a higher elasticity of demand for the product of each seller. The theoretical foundations for this assumption are developed in Appendix A, where we construct a simple model of sequential decision-making in which importers can choose from a menu of technologies in advance, with each technology constituting a means of producing the retail good using imported intermediate inputs, and technologies differ in their elasticity of substitution between intermediate inputs. When import prices are not known in advance, a technology with a higher elasticity of substitution offers higher expected profits to the retailer/importer. But the ex ante costs of choosing a technology are higher, the higher the elasticity of substitution. Importers with higher exogenous productivity (or lower costs) will choose more-elastic technologies. As a result, larger importers will have a higher ex post elasticity of demand for each product.

Assume that in each sector there are N products, each of which is sold by a unique exporter, and M importing firms. Thus, there are N firms on the supply side of the market, M firms on the demand side and N products sold within each market. Each exporter $i \in N$ sells product i to all M importers. We assume that N may be relatively small, so that exporters set prices strategically. In addition, exporters can perfectly price discriminate, so they set a separate price for each importer. Importers are assumed to be price takers in their input markets. Each importer j has a demand for the imported intermediate good i which satisfies:

$$x_{ij} = {p_{ij}}^{-\rho_j} {p_j}^{\rho_j - \eta} X_j, \tag{2.1}$$

where p_{ij} is exporter i's price for importer j, evaluated in importer's currency, and p_j is the

sectoral or market price index for importer j (also in importer currency).[5] As we noted, it is assumed that N is small enough that firm i takes into account the impact of its pricing decision on the sectoral price index. In addition, as discussed above, we allow for the inner demand elasticity ρ_j to be specific to the importer, while assuming that the elasticity of demand across markets η is the same for all importers. As is usual, we assume that $\rho_j > \eta$, so that the elasticity of demand for individual goods is greater than the elasticity of demand for the sectoral composite good. In addition, we assume that $\rho_j > 1$ and $\eta > 1$. Finally, we allow for importers to be different in total size or market share, as reflected in the scale factor X_j. As shown in Appendix A, the distribution of importer market shares will be determined by the distribution of productivity among importing firms in the production of goods for retail sale using the basket of products that they purchase from exporters. The sectoral price index for importer j is defined as

$$p_j = \left[\sum_{i=1}^{N} p_{ij}^{1-\rho_j}\right]^{(\frac{1}{1-\rho_j})}. \tag{2.2}$$

Firm i's production technology can be represented by a cost function in terms of the exporter currency:

$$c(y_{ij}, w_i, a_i), \tag{2.3}$$

where y_{ij} represents sales to importer j, w_i represents a vector of input costs and a_i is a scalar measure of technology. In addition, we will restrict attention to the case of constant returns to scale, so that marginal cost is independent of sales. Thus,

$$c(y_{ij}, w_i, a_i) = y_{ij}\phi(w_i, a_i), \tag{2.4}$$

and we assume that $\phi(w_i, a_i)$ is increasing in all elements of w_i, and $\phi''(w_i, a_i) \leq 0$.

2.1. Pass-Through and Market Shares

If prices are fully flexible, the currency in which the firm sets its price is irrelevant. Thus, without loss of generality, say the firm sets its price in the importer's currency (local currency). The exporter's profit is then defined as

$$\sum_{j}^{M} p_{ij}x_{ij} - \sum_{j}^{M} y_{ij}e_i\phi(w_i, a_i), \tag{2.5}$$

[5]Here, we maintain the assumption of constant demand elasticity ρ_j. We also explored the exchange rate pass-through implications under alternative specifications where the firm's elasticity of demand was variable. The implications for pass-through and the relationship between pass-through and buyer or seller market share were similar to the results discussed below.

where e_i is the exchange rate for product i (the importer currency price of a unit of exporter currency), and in equilibrium $x_{ij} = y_{ij}$.

If the exporter sets its price freely, its profit maximizing price is given by

$$p_{ij} = \frac{\epsilon_{ij}}{\epsilon_{ij} - 1} e_i \phi(w_i, a_i), \tag{2.6}$$

where ϵ_{ij} is defined as the firm's demand elasticity, given by

$$\epsilon_{ij} = -\frac{d\log(x_{ij})}{d\log(p_{ij})} = \rho_j - (\rho_j - \eta)\left[\frac{p_{ij}}{p_j}\right]^{1-\rho_j}. \tag{2.7}$$

The share of firm i's sales to importer j, relative to all of j's purchases in the sector, is defined as

$$\left[\frac{p_{ij}}{p_j}\right]^{1-\rho_j} = \frac{p_{ij}x_{ij}}{\sum_{i=1}^{N} p_{ij}x_{ij}} \equiv \theta_{ij}(w_i, a_i). \tag{2.8}$$

Firm i's share is negatively related to its price, relative to the price index of importer j. Under an innocuous regularity condition, θ_{ij} is negatively related to the firm's input cost w_i and positively related to the firm's productivity a_i. Given this notation, we can define the elasticity of demand for sales to importer j as $\epsilon(\theta_{ij}) = \rho_j - (\rho_j - \eta)\theta_{ij}$, and this elasticity is decreasing in the firm's market share, given that $\rho_j > \eta$.

If the firm's price is fully flexible, we can obtain the implied pass-through from the exchange rate to its price as follows. Taking a log approximation from (2.6), we obtain the expression:

$$\frac{d\log p_{ij}}{d\log e_i} = \frac{1}{1+\omega} + \frac{\omega}{(1+\omega)(1-\theta_{ij})}\sum_{k\neq i}\theta_{kj}\frac{d\log p_{kj}}{d\log e_i} + \frac{1}{1+\omega}\hat{\phi}_i\frac{d\log w_i}{d\log e_i}, \tag{2.9}$$

where $\hat{\phi}_i \equiv \frac{\phi_i w_i}{\phi}$, and $\omega = -\frac{d\log(\mu)}{d\log(p_{ij})}$ is the elasticity of the markup to the firm's price. We can calculate this elasticity as follows:

$$\omega = \frac{(\rho_j - \eta)(\rho_j - 1)\theta_{ij}(1-\theta_{ij})}{\epsilon(\theta_{ij})(\epsilon(\theta_{ij}) - 1)}. \tag{2.10}$$

The predictions for exchange rate pass-through from (2.9) depend on the elasticity of the markup, the extent to which firm i's competitors for importer j face the same exchange rate as firm i, and the extent to which firm i's domestic cost is affected by changes in the exchange rate. Focusing on the last item, we may decompose the term $\hat{\phi}_i\frac{d\log w_i}{d\log e_i}$ in (2.9) in the following way. We assume that changes in the exchange rate do not directly affect either the exporter currency prices of inputs in the exporter's country, the prices of local inputs into the good in the importer's currency or the price of imported intermediate goods that the exporter purchases from third countries. Assume also that the share of local (importing country) inputs in the good

is γ_1, the share of third-country intermediate imported inputs is γ_2 and the sensitivity of the exchange rate of the country where intermediate inputs are purchased relative to the importing country's exchange rate is φ. It follows that

$$\hat{\phi}_i \frac{d \log w_i}{d \log e_i} = -(\gamma_1 + \gamma_2 \varphi). \tag{2.11}$$

Then from (2.9), we have

$$\frac{d \log p_{ij}}{d \log e_i} = \frac{1 - \gamma_1 - \gamma_2 \varphi}{1 + \omega}. \tag{2.12}$$

Since $\rho_j > \eta$, $\omega > 0$, (2.12) implies that exchange rate pass-through is less than unity. This is first due to the presence of 'local' inputs, as measured by γ_1, and second due to intermediate imported goods whose currencies track those of the importing country currency as captured by the terms $\gamma_2 \varphi$. But even for $\gamma_1 = \gamma_2 \varphi = 0$, pass-through would be less than unity because the firm's optimal markup depends on its market share, captured by the $\omega > 0$ term. A rise in the firm's price reduces its market share, and since a fall in market share means a higher demand elasticity, an exchange rate shock will reduce the firm's optimal markup.

The magnitude of exchange rate pass-through is itself a function of the exporter's market share. From (2.10), we have that

$$\frac{d\omega}{d\theta_{ij}} = \frac{\eta(\eta - 1)\theta_{ij}^2 - \rho_j(\rho_j - 1)(1 - \theta_{ij})^2}{\epsilon(\theta_{ij})^2(\epsilon(\theta_{ij}) - 1)^2}. \tag{2.13}$$

If θ_{ij} is close to zero, this is negative, while for θ_{ij} close to unity, it is positive. Hence, the relationship between pass-through and exporter market share is non-monotonic. Intuitively, for θ_{ij} equal to zero or unity, the firm is either infinitesimal relative to the market, or is a monopoly firm in the sector, and the markup is a constant, determined only by the elasticity of demand. In between these two extremes, the firm's markup is endogenous, and increasing in θ_{ij}. Exchange rate pass-through depends not on the markup itself, but on the elasticity of the markup ω, which is itself a function of the 'elasticity of the elasticity' of demand for the firm's good in sector j. For very low θ_{ij}, the elasticity of the markup with respect to price is increasing in θ_{ij}. As the firm moves from being an infinitesimal part of the market to having some non-negligible share of sales, it will become more concerned with the effect of its pricing on its market share, and thus will limit its price response to exchange rate increases, since its markup elasticity is increasing in θ_{ij}. But as θ_{ij} increases further, the firm has a higher and higher share of the market and becomes less concerned with the impact of its price changes on its market share. In this range, the elasticity of the markup is decreasing in θ_{ij}, and so exchange rate pass-through is declining in θ_{ij}. Hence, the relationship between exchange rate pass-through and exporter market share is theoretically ambiguous.

How does pass-through depend on the size of the importing firm j? Formula (2.10) does

not depend on the size of sales, since we have assumed that exporters produce with constant returns to scale.[6] But pass-through will in general depend on the own elasticity of demand ρ_j. As discussed above, our maintained hypothesis is that larger importers have a higher elasticity of demand. How does this affect the degree of exchange rate pass-through? Again using the definition of (2.10), we may establish that

$$\frac{d\log\omega}{d\log\rho_j} = \Gamma\left[\frac{(\rho_j-1)^2}{(\rho_j-\eta)^2} - \theta_{ij}(\theta_{ij}(1-\frac{1}{\eta})+\frac{1}{\eta})\right], \tag{2.14}$$

where $\Gamma > 0$.[7]

Since we have assumed that $\rho_j > \eta > 1$, and $0 \leq \theta_{ij} \leq 1$, the expression in square brackets on the right-hand side of (2.14) is positive. Hence, ω is increasing in ρ_j for all values of θ_{ij} between 0 and 1, and therefore exchange rate pass-through is decreasing in ρ_j. Thus, exchange rate pass-through is systematically lower for sales to importers with a higher elasticity of demand. The intuition for this is clear. When the firm raises its price in response to an exchange rate shock, its concern for a reduced market share will limit the degree of pass-through. But the firm's market share will fall more, the higher is the elasticity of demand. Hence, while a high elasticity of demand does not in itself lead to lower pass-through, the combination of a high elasticity and strategic price adjustment with variable market share implies a lower exchange rate pass-through.

If, as we have discussed above, importing firms that have a larger share of the market have higher elasticity of demand, then (2.14) implies that exchange rate pass-through should be lower, the larger the importing firm's share of the market. Thus, we have a set of joint predictions concerning exchange rate pass-through and market share. Holding the importer market share constant, the relationship between pass-through and exporter market share should be U-shaped, declining for low market shares, and increasing for high market shares. On the other hand, for a given exporter market share, a rise in the importer's market share should lead to a decline in exchange rate pass-through. In our empirical analysis below we see that these predictions are supported.

Figure 1 illustrates the relationship between the exchange rate pass-through term $\frac{1}{1+\omega}$ (for clarity of exposition, we assume that $\gamma_1 = \gamma_2\varphi = 0$) and the firm's share of market j, θ_{ij}, assuming that $\rho_j = 5$ and $\eta = 2$ (this is the low-elasticity scenario). As described above, exchange rate pass-through begins at unity when $\theta_{ij} = 0$, but falls to around 0.7 for intermediate values of θ_{ij}. As $\theta_{ij} \to 1$, pass-through becomes complete again. It is important to note that the fact that

[6] When exporters face increasing marginal cost of production, pass-through will be less than unity, since a rise in price will coincide with a fall in marginal costs. If the elasticity of marginal cost is increasing in production, then pass-through will be lower for larger importing firms in this case as well.

[7] $\Gamma = \frac{\eta(\rho_j-\eta)^2\theta_{ij}(1-\theta_{ij})}{(\epsilon(\epsilon-1))^2}$.

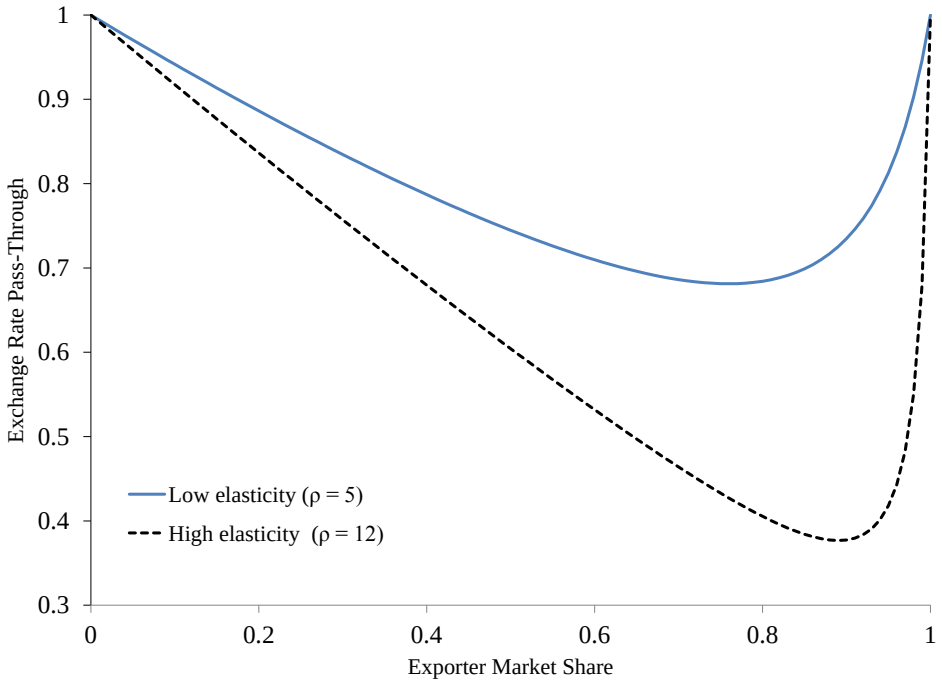

Figure 1: Exchange Rate Pass-Through and Market Share

pass-through is essentially complete for infinitely small market-share firms and for monopoly firms is a result of assuming that $\gamma_1 = \gamma_2\varphi = 0$. However, in reality it is likely that these parameters are greater than 0, and therefore pass-through for extreme values of θ_{ij} will not necessarily be complete.

Figure 1 also illustrates the relationship between pass-through and θ_{ij} for a higher elasticity, $\rho_j = 8$. Again, for $\theta = 0$ or 1, pass-through is unaffected. But in intermediate ranges of θ_{ij}, pass-through may fall quite dramatically as a result of the higher demand elasticity. In Figure 1, the lowest value of exchange rate pass-through falls from 0.7 in the initial case of $\rho_j = 5$ to just below 0.4 when $\rho_j = 8$.

In this discussion, we have taken the price of other firms in the industry as given in evaluating the degree of exchange rate pass-through for a particular firm i. In Appendix B, we show that these results are robust to an extension to an industry equilibrium where other competing firms increase their prices, even if their costs are not directly affected by the exchange rate shock.[8]

How do these results relate to the measure of exchange rate pass-through that can be obtained from the data? Equation (2.9) is a comparative static expression from an optimal pricing relationship in a static model. But in repeated observations over a firm's sales to a particular

[8]See Amiti, Itskhoki and Konings (2015) for a recent examination of strategic complementarities in price setting across firms using micro data in an open economy environment.

market, the empirical equivalent to measured pass-through based on (2.9) is the regression coefficient of the firm's log price on the log exchange rate. This measures the relationship between the firm's price and the exchange rate, holding all other controls fixed. Thus, we can equate the empirical equivalent of the left-hand side of (2.9) with

$$\frac{\text{cov}(\Delta \log p_{ijt}, \Delta \log e_{it})}{\text{var}(\Delta \log e_{it})}.$$

2.2. Sticky Prices and the Choice of Invoicing Currency

As we discuss below, our data on import prices include the currency in which the transaction is invoiced, whether it is U.S. dollars, Canadian dollars or the currency of a third country. If prices are fully flexible, it should not matter in which currency the transaction is invoiced, since the exporting firm can adjust its price in the importer's currency or in its own currency to achieve its desired markup over costs. With preset prices, however, exchange rate pass-through will depend a lot on the currency of invoicing. If prices are set in the producer's currency (PCP), then pass-through is high, since final-goods prices in the importing country will adjust one-for-one with exchange rates. But if prices are set in the local currency (LCP), the pass-through is much lower.

As we make more clear below, our measure of exchange rate pass-through is akin to being conditional on a price change. Hence, by construction, we do not observe pass-through that is triggered purely by exchange rate movements without any price adjustments undertaken by the producing firms. In this case, it might seem that the invoicing currency would be irrelevant to the measured degree of exchange rate pass-through. But if, in fact, sellers are subject to some short-term price rigidity, then the invoicing currency will matter, even for the degree of pass-through that takes place after a price change.

Engel (2006) shows a close relationship between the determinants of pass-through for the firm with flexible prices, and the choice of currency of price-setting for the sticky-price firm. In particular, he shows that a firm that would desire a large exchange rate pass-through elasticity under flexible prices is more likely to choose PCP if it must set the nominal price in advance. Gopinath, Itskhoki and Rigobon (2010) extend Engel's result to a model of Calvo staggered pricing. They show that the critical determinant of the currency of pricing is what they define as "medium run pass-through," which measures the pass-through of exchange rate changes to a firm's price after it has an opportunity to adjust its price.

The implication of these theories is that the causality in the empirical relationship between currency of invoicing and exchange rate pass-through should be in the reverse direction. A firm observed to have higher exchange rate pass-through is more likely to invoice transactions in its own currency (PCP), while a firm with low pass-through is more likely to invoice in Canadian

dollars. Gopinath, Itskhoki and Rigobon (2010) show that if a firm's short-run price flexibility is constrained by a Calvo price adjustment process, then it will follow LCP (PCP) when the empirical exchange rate pass-through coefficient is less than (greater than) 0.5. Thus, in terms of our notation, we should anticipate that a given firm will invoice in local currency when

$$\frac{\text{cov}(\Delta \log p_{ijt}, \Delta \log e_{it})}{\text{var}(\Delta \log e_{it})} < 0.5. \tag{2.15}$$

The empirical implication of this condition is that sectors or goods with pass-through below 0.5 should be characterized by Canadian-dollar invoicing, whereas those with pass-through higher than 0.5 should have transactions invoiced in the currency of the exporting country. In general, we will find this prediction supported in our data.[9] From a broader perspective, condition (2.15) implies that there should be a significant difference in pass-through measures between Canadian-dollar invoiced goods and non-Canadian-dollar invoiced goods. This prediction is also strongly supported by our estimates.

In Figure 2 we illustrate how the relationship between pass-through and currency choice will also depend on the market shares of firms involved in trade. We see that for exporters of all market shares trading with low-elasticity importers, transactions will always be priced in the producer's currency (or U.S. dollars). However, for transactions with bigger, more-productive and hence higher-elasticity-of-demand importers, there are exporters with certain market shares that will opt to price their goods in the destination market currency. That is, their desired pass-through will be low enough that (2.15) will hold.

The interesting implication is that there will be a U-shaped relationship between the probability of PCP and exporter market share, and an overall negative relationship between the probability of PCP and importer market share (assuming, in both cases, that at least some importing firms have a high enough ρ). We test these predictions in the data and find strong support for both. For very high market-share importers trading with very high market-share exporters, we would expect transactions to be priced in the producer's currency, which could mean the relationship between the probability of PCP and importing firm market share is non-linear. However, we find little empirical evidence in support of this in the data.

[9]While the expression (2.15) indicates 0.5 as the cut-off threshold for the relationship between pass-through and the currency of invoicing, it is based on an assumption that short-term price stickiness represents the only factor determining the choice over currency of invoice. In reality, there are likely many legal and institutional features of trade relationships that impact on the invoicing decision. As a result, we should not take the 0.5 threshold as an exact prediction in the empirical investigation.

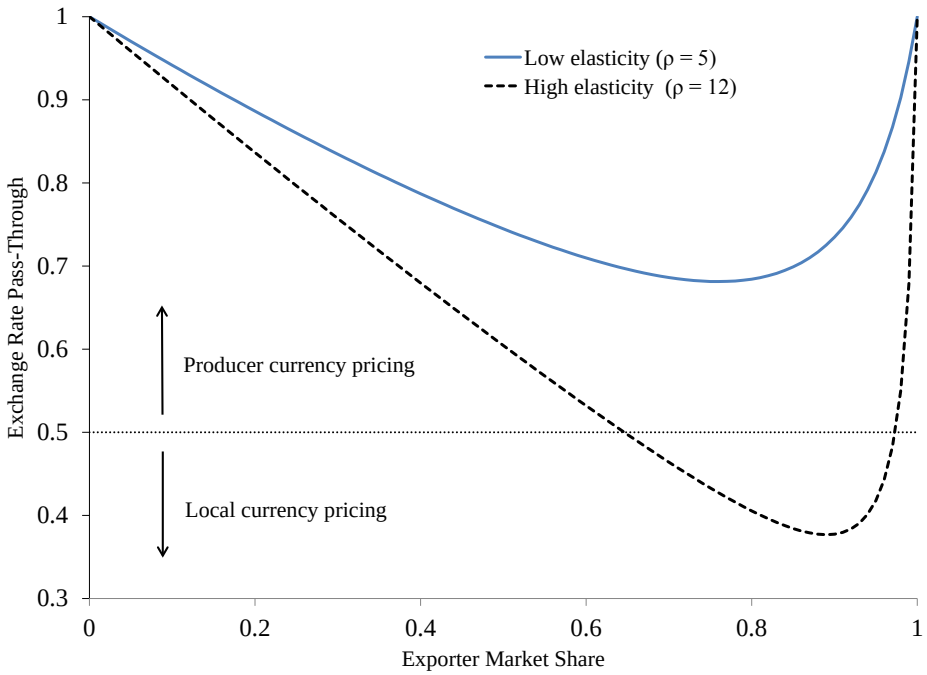

Figure 2: Exchange Rate Pass-Through, Market Share and Currency Choice

3. Data

3.1. Customs Data

We use data from the Canadian Border Services Agency (CBSA) that contain information on every single commercial import/shipment into Canada from September 2002 to June 2008.[10] The data, collected by the CBSA and housed at Statistics Canada, contain information on the total value of each shipment, the number of units shipped, the 10-digit Harmonized System (HS) product code for the good, an importing firm identifier, an exporting firm/vendor identifier, the country in which the good was produced, the country from which the good was finally exported directly to Canada, and several other pieces of information that are important for the analysis of exchange rate pass-through.

As a proxy for prices, we use unit values defined as total shipment value divided by the number of units.[11] The shipment values are reported in the currency of invoice, and if this

[10]This data set is similar to the Argentine import customs data used by Gopinath and Neiman (2014).

[11]There are several issues that arise from using unit values as a proxy for prices, such as the fact that even though the 10-digit HS codes are quite fine, there may still be more than one distinct product in each code, and therefore observed price changes may be due to compositional changes within the 10-digit HS code, rather than changes in the true, underlying prices of individual goods. Moreover, there may be measurement errors in the number of units. These issues are discussed by Berman, Martin and Mayer (2012) and Amiti, Itskhoki and Konings (2014), who use similar data. In section 3.2, we provide a very specific definition of a product that can

is different than Canadian dollars, a Canadian-dollar value is reported using the value of the bilateral exchange rate at the time the good crossed the border. While goods come across the border on a daily basis, we are not provided with an exact date that a given shipment crossed the border and are provided only with the month in which the import entered Canada. In the empirical analysis below, for shipments priced in Canadian dollars, we match the unit values with the monthly bilateral exchange rate between Canada and the country of export. Therefore, for goods priced in non-Canadian dollars, we have a transaction-specific (or day-specific) exchange rate, and for those priced in Canadian dollars, we have a monthly bilateral exchange rate. In the next subsection, we explain how we convert these transaction data into monthly data for the analysis of exchange rate pass-through.

As for the importing firm identifier, we are provided with a scrambled business number (for confidentiality reasons) that allows us to track a single Canadian buyer over time. Aside from this, we have limited information about the buyer other than the province in which it is located. On the exporter side, we have a vendor identifier, which allows us to track a single exporter over time. What we do not know is whether this vendor is a producer or an intermediary—the identifier is built from the company name provided on the customs sheet, which refers to the company ultimately responsible for shipping the good to the border.

Along with reporting the number of units shipped, the data set reports what the units are for each shipment. Examples of the unit of measurement include "number," "kilograms" and "litres." When tracking a unit price over time, we take into account the unit of measurement.

Finally, the data set provides a value for duty code, which, among other things, lets us know whether a reported import represents a transaction among affiliated companies (intrafirm trade). For our analysis, we drop all of these imports, since we want to focus on interfirm trade, and the model presented above reflects this fact.[12]

3.2. Panel Design: Defining Monthly Prices

To measure exchange rate pass-through, it is important that we have a set of goods whose prices we can track over time. In our data, we can observe many imports of the same good in the same month, and these 10-digit HS (HS10) goods can arrive in Canada from different countries and be purchased by different companies in Canada. Therefore, in the raw data there is no way to track the price of a single good over time. To create a price that can be tracked over time and used to analyze pass-through, we combine price observations in order to define a good price that is specific to an importing firm (f), exporting firm (v), HS10 product (pr), country of origin

be tracked over time that addresses these issues, to some extent, but the empirical results that we present should be interpreted with the understanding of these possible data limitations.

[12]See Neiman (2010) for an analysis of pass-through and intrafirm trade.

(o), country of export (ex), currency (c), unit of measurement (u) and time (t). For clarity of exposition, let $s = \{f, v, pr, o, ex, c, u\}$. We define the price of good s in month t as

$$P_{st} = \Sigma_{l=1}^{n}(\alpha_{lst} \cdot P_{lst}), \tag{3.1}$$

where l is an individual transaction (or import) and α_{lst} is a weight, defined as the relative shipment size to total shipments of the good s. That is,

$$\alpha_{lst} = \frac{Shipment_{lst}}{\Sigma_{l=1}^{n} Shipment_{lst}}, \tag{3.2}$$

where $Shipment_{lst}$ is the number of units in each shipment and n is the total number of imports of good s in a single month.

In addition, since we have a transaction-specific exchange rate for those goods priced in currencies other than the Canadian dollar (the exchange rate can vary depending on what day of the month a good crosses the border), we can create a *st*-specific exchange rate in a manner similar to the way we created a *st*-specific price. For those goods priced in Canadian dollars, there is no implied exchange rate in the data. We therefore match these observations with the monthly bilateral exchange rate between the Canadian dollar and the currency of the exporting country. With this definition of a *st*-specific price, we now have "collapsed" or "condensed" data for each product that we use in the empirical analysis of exchange rate pass-through. In what follows, we refer to the raw data as shipment data, and the monthly condensed data as product-level data. We can also use the value of the shipments (in Canadian dollars) to create weighted statistics.

3.3. Summary Statistics

In any given month, we observe approximately five million shipments (we have data for 71 months and the total data set has just under 400 million observations). However, for many of these shipments, either the number of units in the shipment or the unit of measurement is not available. Both of these pieces of information are needed to calculate the unit value and create a time series for a single good. For this reason, we select a subset of products representing a wide range of goods that have this information reported for at least 85 percent of the observed shipments.

The nine product groupings or sectors, along with information on the currency of invoice, are presented in Table 1. The products range from commodities (e.g. vegetable products), to light manufacturing goods (e.g. textiles), to heavy manufacturing goods (e.g. industrial machinery).[13] As for the currency of invoice, overall, 88.0 percent of weighted imports and 86.0

[13]In Table 1, the products are defined as a range of HS2 codes. However, within these ranges, some specific

percent of the shipments are invoiced in U.S. dollars. For Canadian dollars, these numbers are 8 and 4.5 percent, and they are 2.9 and 5.6 percent for euro-priced goods, respectively. The high U.S.-dollar share of overall imports is in line with what has been found in other data sets that contain information on the currency of invoice. Across the nine product categories, we see that there is some variation in the currency of invoice. For example, in terms of the total value of imports, at one extreme only 64.6 percent of food and beverage imports are priced in U.S. dollars (with a significant portion, 33.3 percent, priced in euros), while at the other end 93.3 percent of vegetable product imports are priced in U.S. dollars.

Table 1: Summary Statistics — Currency of Invoice

		Currency of Invoice (%) (by value)			Currency of Invoice (%) (by shipments)			
	HS Code	USD	CAD	EUR	USD	CAD	EUR	Obs.
Overall	—	**88.0**	**8.0**	**2.9**	**86.0**	**4.5**	**5.6**	**37,397,388**
Vegetable products	07-14	93.3	6.0	1.1	95.9	2.1	0.8	6,075,397
Food and beverage	16-22	64.6	1.6	33.3	74.6	5.8	13.9	3,091,614
Chemical products	28-35	86.9	9.7	1.6	83.3	12.4	1.5	2,955,658
Textiles	50-60	82.1	12.2	4.5	89.5	3.6	5.6	3,488,820
Apparel	61-62	88.3	6.5	3.6	66.9	6.3	14.8	6,681,865
Footwear	64	83.1	4.4	11.9	78.6	5.8	13.8	856,652
Metal products	72-81	91.1	6.9	1.7	93.2	2.5	2.2	6,093,213
Industrial machinery	84	88.7	6.3	3.9	93.1	3.9	1.9	5,198,218
Consumer electronics	85	86.1	11.2	1.0	93.6	2.1	1.8	2,955,951

Given that we have both importing and exporting firm identifiers in our data, we can calculate import market shares for both groups. To do this, we must decide the level of aggregation at which we define market share. After experimenting with a number of definitions, we decided that defining market share at the six-digit HS (HS6) level was the suitable level of aggregation. That is, either for exporters or importers, we define market share as a given firm's share of the import market, in terms of value, within a given HS6 product category. Therefore, a single firm can have multiple market shares if they export or import multiple products (across the HS6 classifications). Our definition of market share is also calendar-year specific, and so a firm's market share can vary over time.

In Table 2, we present the share of overall imports accounted for by firms in different market share quintiles. More specifically, based on each firm's share of the importer market at the HS6 level, we place them into quintile bins (that is, all firms with market share between 0 and 20 percent are assigned to the first quintile bin, those with 20 to 40 percent in the second quintile bin, and so on). We then calculate the total value of imports accounted for by the firms in the

HS2 and HS4 products are dropped due to too many missing observations.

different quintile bins. Both in terms of value and number of products imported (product level), importers and exporters in the first quintile of the market share distribution account for the majority of imports. However, in terms of value, the other quintiles account for a non-negligible portion of imports—for example, importers in the third, fourth and fifth quintiles collectively account for nearly 20 percent of imports.

Table 2: Currency of Invoice by Market Share

Import Market Share Quintile	Value Weighted				Product Level			
	Share of	Currency of Invoice (%)			Share of	Currency of Invoice (%)		
Importers	Imports (%)	USD	CAD	EUR	Imports (%)	USD	CAD	EUR
1	66.8	89.6	6.2	2.9	95.8	85.3	6.3	5.9
2	13.6	89.3	7.6	2.5	2.0	85.8	6.9	6.0
3	7.7	71.7	21.0	6.5	1.7	34.0	32.1	29.6
4	4.7	78.5	19.6	1.2	0.3	64.4	27.4	6.0
5	7.3	93.3	4.4	0.5	0.1	87.7	8.3	3.0
Exporters								
1	76.2	87.2	8.1	3.5	98.2	84.2	6.8	6.4
2	12.2	91.4	6.8	1.2	1.2	87.0	10.3	1.9
3	4.5	87.9	9.7	1.2	0.4	85.7	11.7	1.8
4	2.6	90.2	8.8	0.8	0.1	89.8	6.7	2.7
5	4.6	90.4	7.4	0.5	0.0	84.4	11.8	3.0

Table 2 also reports the currency of invoice by market share quintile. For exporters, the share of imports in U.S. dollars is fairly constant across the market share quintiles, falling within 87 and 91 percent, and the share of Canadian-dollar- and euro-priced goods varies very little, as well. What is interesting is the relationship between the market share of importers and the currency of invoice. In terms of value, only about 6 percent of imports by importers in the first quintile of market share are priced in Canadian dollars. However, 21 percent of the value of imports by the third quintile are priced in Canadian dollars, and roughly 20 percent for the fourth quintile. This number drops to 4 percent for the fifth quintile. There is a similar pattern for the product-level measures of imports. In the next section, we take these stylized facts into account when testing the implications of the model.

4. Empirical Analysis

4.1. Exchange Rate Pass-Through

We start the empirical analysis by obtaining a measure of overall pass-through, and pass-through estimates for each product/sector. To do so, we use the following micro-price pass-through regression:

$$\triangle_\tau p_{st} = c + \beta_e \triangle_\tau e_{st} + Z'_{st}\gamma + \epsilon_{st}, \tag{4.1}$$

where $\triangle_\tau p_{st} = ln(P_{st}) - ln(P_{s\tau})$ is expressed in Canadian dollars and τ represents the last period in which this price is observed (we have a very specific definition of a good price, and a good will not necessarily be imported every period). Similarly, $\triangle_\tau e_{st}$ is the cumulative change in the log of the nominal exchange rate over the duration for which subsequent imports of good s are observed. Z_{st} includes controls for the cumulative change in the foreign consumer price level, the Canadian consumer price level, Canadian GDP, and fixed effects for every s product and month t. Note that this is a similar set of control variables to that used by Gopinath, Itskhoki and Rigobon (2010), and given that we are looking at cumulative changes in variables over time, this set-up is similar to the medium-run pass-through regressions in that paper. Finally, ϵ_{st} is an error term.

Table 3 presents the results for overall pass-through and for each of the nine products/sectors, individually, with and without weights. That is, we run the regressions using the product-level data, weighting the observations by the total value of monthly shipments for each product s—weighted results—and without value weights—unweighted results.[14] The overall estimate of exchange rate pass-through (pooling all products together) is approximately 59 percent using value weights, and 48 percent without weights.

These estimates offer valuable insights into the overall degree of pass-through to import prices in Canada. The Canadian aggregate import price index is constructed in such a way that some of the price data are sampled from other countries (mainly the United States). The strong assumptions regarding the degree of pass-through made in this process can create a mechanical relationship between aggregate prices and the exchange rate, resulting in an upward bias on any reduced-form pass-through estimates.[15] Our estimates are not subject to such a bias, since we work with transaction-level data.

In addition to the overall pass-through estimates, we also see that there is a significant amount of variation across the products/sectors. At one extreme, in terms of value-weighted results, the pass-through coefficient for apparel is 0.826 and significant at the 1% level. At the other end, the pass-through coefficient for vegetable products is 0.214, and it, too, is significant at the 1% level. The other pass-through point estimates fall within this range, with pass-through for footwear and industrial machinery exhibiting high pass-through at 0.744 and 0.752, respectively, and metal products at the lower end with a point estimate of 0.422. Most of these results are

[14] Table C.1 in Appendix C presents the pass-through estimates for all the products pooled together, along with the coefficients on the other variables.

[15] For details on Statistics Canada assumptions regarding pass-through, see http://www.statcan.gc.ca/pub/13-604-m/13-604-m2009062-eng.htm#Note5.

in line with the finding that for many other countries, pass-through is incomplete. However, the amount of variation across products that we estimate is surprising.

Table 3: Exchange Rate Pass-Through Estimates

	Product Level		Value Weighted		
	$\hat{\beta}_e$	(s.e.)	$\hat{\beta}_e$	(s.e.)	Obs.
Overall	**0.484*** **	**(0.004)**	**0.593*** **	**(0.027)**	**7,993,402**
Vegetable products	0.298***	(0.009)	0.214***	(0.037)	959,319
Food and beverage	0.454***	(0.011)	0.552***	(0.076)	585,693
Chemical products	0.419***	(0.010)	0.642***	(0.088)	642,768
Textiles	0.546***	(0.011)	0.671***	(0.034)	606,482
Apparel	0.625***	(0.007)	0.826***	(0.026)	1,528,634
Footwear	0.587***	(0.018)	0.744***	(0.037)	175,342
Metal products	0.302***	(0.006)	0.422***	(0.043)	2,090,899
Industrial machinery	0.662***	(0.009)	0.752***	(0.064)	975,483
Consumer electronics	0.653***	(0.013)	0.710***	(0.099)	428,782

Note: The pass-through coefficients for the specific products are obtained using interaction terms, and therefore there is only one set of coefficients for the other explanatory variables. Each regression includes HS10 product and time fixed effects. We restrict the sample to price changes within the -100% to +100% range. The standard errors have not been clustered. We experimented with a number of different levels of clustering (different levels of HS good, as well as clustering at the importer and exporter levels), and the level of significance for the estimates of interest did not change.

4.2. Exchange Rate Pass-Through and the Currency of Invoice

We next test some of the implications of the model. We start with pass-through and the currency of invoice. As documented in Table 1, there is some variation within products/sectors when it comes to the currency of invoice. The model predicts that pass-through rates will be associated with different currency types: exporters that desire lower pass-through to the import price will price in Canadian dollars (CAD); those that desire higher pass-through will price in foreign currency. To test these hypotheses, we use a similar set-up as in (4.1), but we introduce dummy variables for whether a specific product is priced in Canadian dollars (D_{CAD}), U.S. dollars (D_{USD}), or euros (D_{EUR}), and include a full set of interaction terms with the exchange rate:

$$\begin{aligned}\triangle_\tau p_{st} =& c + \alpha_1 D_{CAD} + \alpha_2 D_{USD} + \alpha_3 D_{EUR} + \beta_1 \triangle_\tau e_{st} + \beta_2[\triangle_\tau e_{st} \cdot D_{CAD}] \\ &+ \beta_3[\triangle_\tau e_{st} \cdot D_{USD}] + \beta_4[\triangle_\tau e_{st} \cdot D_{EUR}] + Z'_{st}\gamma + \epsilon_{st}.\end{aligned} \tag{4.2}$$

The coefficient β_1 will pick up the degree of pass-through for goods priced in currencies other than Canadian and U.S. dollars, and euros (this is understood to be a very small set of goods).

Pass-through to Canadian-dollar-priced goods will be $\beta_C = \beta_1 + \beta_2$, to U.S.-dollar-priced goods it will be $\beta_U = \beta_1 + \beta_3$ and to euro-priced goods it will be $\beta_E = \beta_1 + \beta_4$.

Table 4 presents the results of the estimation. Note that these results are from product level regressions (unweighted), to better reflect the assumptions and mechanisms presented in the model.[16] The first set of columns shows the estimates and the standard errors, while the last three show the difference between the estimates and indicate whether that difference is statistically significant. The results are generally in line with the predictions of the model. For all products/sectors, pass-through is higher for U.S.-dollar-priced goods than for Canadian-dollar-priced goods, and in all but one case (vegetable products) the difference between the two estimates is both large and statistically significant. The largest difference between the two pass-through rates is for footwear, where the pass-through estimate for U.S.-dollar goods is 0.702 and for Canadian-dollar goods it is 0.078 (and not significant). For most products/sectors the rate of pass-through is also higher for euro-priced goods than for Canadian-dollar-priced goods. For example, in food and beverage products, the pass-through estimate for euro goods is 0.684, which is larger and significantly different from the Canadian-dollar estimate.

Table 4: Pass-Through and Currency Choice

	CA Dollar		US Dollar		Euro		Difference		
Product	β_C	(s.e.)	β_U	(s.e.)	β_E	(s.e.)	β_C - β_U	β_C - β_E	β_U - β_E
Overall	0.137***	(0.01)	0.502***	(0.01)	0.497***	(0.01)	-0.37***	-0.36***	0.01
Vegetable products	0.300***	(0.04)	0.325***	(0.01)	0.547***	(0.06)	-0.07	-0.25***	-0.22***
Food and beverage	0.020	(0.03)	0.481***	(0.02)	0.684***	(0.03)	-0.46***	-0.66***	-0.20***
Chemical products	0.128***	(0.04)	0.459***	(0.02)	0.521***	(0.06)	-0.32***	-0.39***	0.06
Textiles	0.096**	(0.05)	0.587***	(0.02)	0.484***	(0.04)	-0.49***	-0.39***	0.10***
Apparel	0.123***	(0.02)	0.623***	(0.01)	0.484***	(0.02)	-0.50***	-0.36***	0.14***
Footwear	0.078	(0.06)	0.702***	(0.02)	0.562***	(0.04)	-0.62***	-0.48***	0.14***
Metal products	0.193***	(0.03)	0.451***	(0.01)	0.255***	(0.04)	-0.26***	-0.06	0.20**
Industrial machinery	0.211***	(0.04)	0.597***	(0.01)	0.589***	(0.06)	-0.39***	-0.38***	0.01
Consumer electronics	0.169***	(0.06)	0.620***	(0.02)	0.740***	(0.08)	-0.45***	-0.57***	-0.12

Note: The pass-through coefficients for the different products are obtained using interaction terms, and therefore there is only one set of coefficients for the other explanatory variables. Each regression includes HS10 product and time fixed effects. We restrict the sample to price changes within the -100% to +100% range. The standard errors have not been clustered. We experimented with a number of different levels of clustering (different levels of HS good, as well as clustering at the importer and exporter levels), and the level of significance for the estimates of interest did not change.

Given that the U.S. dollar is the most common currency in Canadian imports, it is not surprising that the coefficient estimates for U.S.-dollar transactions are closest to the overall pass-through estimates presented in Table 3. Nevertheless, there is some variation in currency within products/sectors.

[16]The model outlines the micro mechanisms that influence firm pricing behavior. The unweighted regressions are better suited to capture these mechanisms, since the estimates reflect the decisions of any given firm, rather than putting extra weight on firms with high values of imports, as does the weighted regression set-up.

4.3. Exchange Rate Pass-Through and Market Share

We next test the other predictions of the model: there exists a U-shaped relationship between exporter market share and exchange rate pass-through, and a monotonically decreasing relationship for importer market share. Exporting firms with low market share are usually small firms that charge a small markup. As a result, they have little room to adjust their markup, and hence their price, in the face of exchange rate movements. For this reason, they must pass movements in the exchange rate on to the importing firm, meaning pass-through will be high. As market share increases, so do firm size and markups. This gives the exporting firm more room to adjust its markup and price to market, to maintain market share, which implies lower pass-through. However, once firms have sufficient market share, they no longer need to adjust their foreign currency price to maintain market share, and therefore pass-through increases. This all results in a U-shaped relationship between pass-through and exporter market share. For importers, the larger the firm (in terms of market share), the higher the elasticity of demand and the lower the pass-through. To test these hypotheses, we run the following regression:

$$\triangle_\tau p_{st} = c + \alpha MS_{ht} + \beta_0 \triangle_\tau e_{st} + \beta_1[\triangle_\tau e_{st} \cdot MS_{ht}] + \beta_2[\triangle_\tau e_{st} \cdot MS_{ht}^2] + Z'_{st}\gamma + \epsilon_{st}, \qquad (4.3)$$

where MS_{ht} refers to the market share (as defined in section 3.3) of either an exporter or importer h (i.e. $h \in \{f, v\}$) at time t. This term, along with a squared term, is interacted with the exchange rate to capture the degree of curvature in the pass-through–market share relationship.

The results are presented in Table 5. The coefficient estimates for β_0, β_1 and β_2 can be used, along with varying market shares, to map out the pass-through–market share relationship. In this set-up, the coefficient on the cumulative log change in the exchange rate, β_0, represents the degree of pass-through if market share is zero. We start, in column (I), by including only a single interaction term for exporter market share. The coefficient on the exchange rate–market share interaction term is negative and significant at the 10% level, suggesting some evidence of a negative relationship between exporter market share and pass-through. In column (II), we include an interaction term between the exchange rate and market share squared. The coefficient on the linear interaction terms is negative and significant at the 1% level, while the coefficient on the non-linear interaction term is positive and significant at the 5% level. This is evidence of a U-shaped relationship.

For importers, there is strong evidence of a negative relationship between pass-through and market share. In column (III), the coefficient on the linear interaction term is negative and significant at the 1% level. In column (IV), we include a non-linear term for importers just to be consistent with what was done on the exporter side. We see that the coefficient on the linear interaction term is positive, but not statistically significant, and the coefficient on the non-linear term is negative and significant. We take this as further evidence that the negative relationship

Table 5: Market Share and Pass-Through

	(I)	(II)	(III)	(IV)	(V)
Exchange rate	0.486***	0.487***	0.488***	0.486***	0.489***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Exporter market share	-0.007***	-0.007***			-0.005*
	(0.003)	(0.003)			(0.003)
ER·(Exporter market share)	-0.099*	-0.290***			-0.224**
	(0.056)	(0.111)			(0.113)
ER·(Exporter market share)^2		0.402**			0.390*
		(0.201)			(0.202)
Importer market share			-0.005***	-0.005**	-0.004*
			(0.002)	(0.002)	(0.002)
ER·(Importer market share)			-0.122***	0.078	-0.111***
			(0.034)	(0.078)	(0.036)
ER·(Importer market share)^2				-0.397***	
				(0.140)	
Constant	0.003**	0.003**	0.003**	0.003**	0.003**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Obs.	7,993,402	7,993,402	7,993,402	7,993,402	7,993,402
R^2	0.003	0.003	0.003	0.003	0.003

Note: Each regression includes HS10 product and time fixed effects. We restrict the sample to price changes within the -100% to +100% range. The standard errors have not been clustered. We experimented with a number of different levels of clustering (different levels of HS good, as well as clustering at the importer and exporter levels), and the level of significance for the estimates of interest changed very little.

is monotonic. Finally, in column (V) we include both exporter and importer market share in the same regression and find that the results hold. That is, we observe a U-shape response for exporters and a decreasing relationship for importers.

To get an idea of the magnitude of these relationships, in Figure 3 we use the coefficients from columns (II) and (III) to plot market share against pass-through for importers and exporters. We see in this figure that there is a U-shaped relationship for exporters—and that pass-through is roughly in the 0.4 to 0.6 range depending on exporter market share—and a downward-sloping relationship for importers—where pass-through goes from just below 0.5 for small market share importers to below 0.4 for large market share importers. Note that for the exporter pass-through–market share relationship, the fact that the y-axis intercept is less than 1 provides some evidence that either $\gamma_1 > 0$ or $\gamma_2\varphi > 0$, or both.

So far, we have not controlled for the market share of the trading partner. The coefficient estimates presented above are meant to reflect the effect of increasing the market share of either an importer or exporter, holding all else constant, including the market share of their trading partner. However, the coefficients are estimated off of information on exporters (importers)

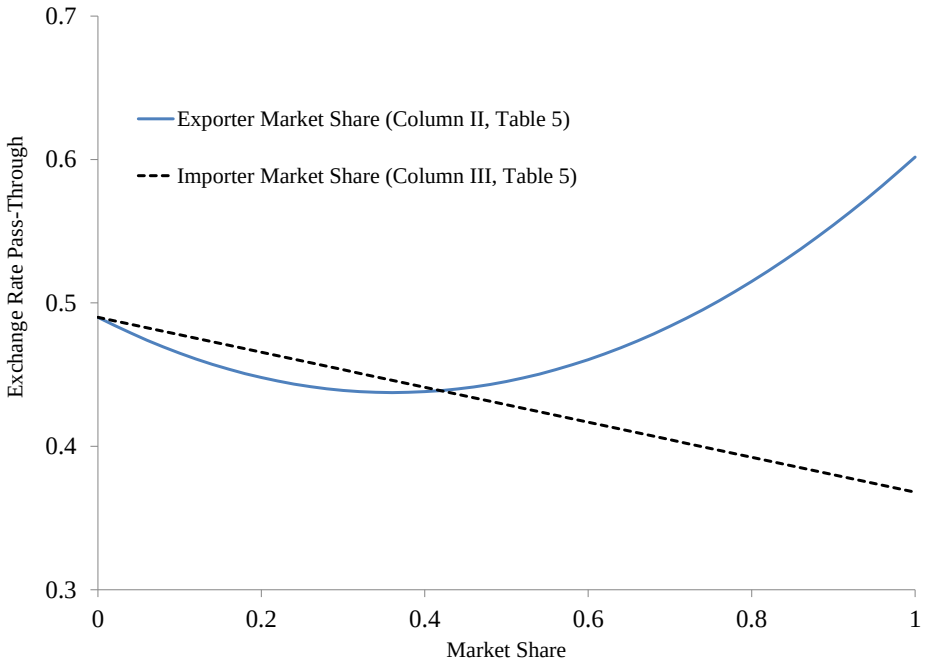

Figure 3: Exchange Rate Pass-Through and Market Share

trading with importers (exporters) of varying market shares. In Table 6, we present results for when we hold the market share of the trading partner relatively constant. More specifically, we look at pass-through across exporters (importers) of different market shares trading with importers (exporters) within quintiles of the market share distribution. We focus mainly on the case where the trading partner falls within the first quintile of the market share distribution.

When holding the importer market share quintile constant at the first quintile, we see that as we increase the market share of the exporter, pass-through at first increases (from 0.486 to 0.582 from the first to second quintile), then drops to 0.438, before eventually increasing to 1.232 for the fifth quintile. While not completely U-shaped, there is some evidence of a U shape, which is in line with the predictions of the model. When holding the exporter market share constant at the first quintile, we see that as we increase importer market share, exchange rate pass-through generally decreases (there is a slight increase from the first to the second quintile, but these coefficients are not statistically different from each other). This accords with the prediction of the model that the relationship between importer market share and pass-through is negative.

4.4. Market Share and the Currency of Invoice

Our model makes the further prediction that exporting firms that prefer lower pass-through to import prices will choose to invoice in the currency of the destination country, while those that prefer higher pass-through will choose their own currency or the U.S. dollar. Furthermore,

Table 6: Cross-Market Shares and Pass-Through

		Importer Market Share Quintile				
		1	2	3	4	5
Exporter Market Share Quintile	1	0.486***	0.489***	0.430***	0.256***	0.282**
		(0.004)	(0.030)	(0.028)	(0.072)	(0.121)
		[7,559,207]	[132,492]	[121,261]	[14,458]	[4,817]
	2	0.582***	0.514***			
		(0.047)	(0.063)			
		[60,047]	[35,954]			
	3	0.438***		0.649***		
		(0.096)		(0.123)		
		[16,082]		[10,130]		
	4	0.785***			0.131	
		(0.164)			(0.168)	
		[4,955]			[4,441]	
	5	1.232***				0.277
		(0.269)				(0.178)
		[1,500]				[3,503]

Note: Off-diagonal (other than when either the exporter or importer market is in the first quintile) estimates are excluded, because the regressions have very few observations and therefore the coefficients are insignificant and difficult to interpret. Each regression includes HS10 product and time fixed effects.

we show that this is related to the market share of firms. On the one side, as small exporters increase their market share, they are more likely to price in the destination market currency; but at a certain point, when market share is large enough, an increase in market share makes it more likely for them to price in the producer currency. This is a reflection of the mechanisms that determine the U-shaped pass-through and market share relationship. On the other side, holding the market share of the exporter constant, an increase in importer market share will invariably lower the degree of pass-through and hence increase the chances that imports are invoiced in the local (destination market) currency.

We have some initial evidence, from Table 2, that importers with larger market share are more likely to pay in Canadian dollars (the exception being those firms in the top quintile, where the share of goods priced in Canadian dollars drops). To test these hypotheses more formally, we use a logit model to estimate how market share affects the probability of invoicing in different currencies. Specifically, we estimate the following equation:

$$\Pr(USD_{st}) = \frac{\exp(v_{st})}{1 + \exp(v_{st})}, \tag{4.4}$$

where

$$v_{st} = c + \beta \Delta_\tau e_{st} + \alpha MS_{ht} + Z_{st}^{'}\gamma + \epsilon_{st}.$$

USD_{st} is a variable that is equal to one if a good is invoiced in U.S. dollars, and zero if the price

is set in Canadian dollars (because these two currencies account for over 90 percent of shipments, for clarity we restrict the analysis to them). Again, MS_{ht} refers to the market share of either the exporter or importer at time t. The set of control variables, Z_{st}, is the same as in (4.1).

Table 7 presents the results from the logit regressions.[17] In columns (I) and (II), we include only exporter market share in the regressions, and find that when only the linear term is included, the estimated coefficient is negative and statistically significant, indicating that the higher the market share of the exporter, the lower the probability of it being priced in U.S. dollars. To test for non-linearity, in column (II) we include a squared exporter market share term. And while the coefficient on the linear term remains negative and statistically significant, the coefficient estimate on the squared term is positive and significant, indicating that the non-linear relationship also applies to currency choice. It suggests that as small market share firms increase their market share, they become more likely to price in Canadian dollars. At a certain point, when market share is large enough, an increase in market share leads to an increase in the probability of pricing in U.S. dollars. This result is consistent with the market share and pass-through results and supports the predictions of the model.

Column (III) presents the results for importer market share and we see that the coefficient on market share is negative and significant. This means that the larger the market share of any given importer, the more likely that importer is to pay in Canadian dollars. This result is consistent with the predictions of the model and is reflected, in part, in Table 2. However, the data presented in Table 2 also suggest that importers with very high market share (in the fifth quintile) primarily pay in U.S. dollars. In column (IV) of Table 7, we test for any further evidence of this non-linearity by including a squared importer market share term in the regression, but find that the linear and squared terms are both negative, implying a monotonic relationship between importer market and currency of invoicing.

It is possible that the very high market share importers are more likely to be trading with very high market share exporters, who are at the upper right-hand side of the U-shaped pass-through curve and are more likely to price in U.S. dollars (regardless of the market share of their trading partner). There is evidence of this in Table 6: looking at the number of observations in the regression results in the vertical column 5 (the fifth quintile of the importer market share), very large importers are almost as likely to transact with an exporter in the fifth quintile (there are 3,503 monthly transactions) as they are with small exporters in the first quintile (there are 4,817 transactions). Alternatively, we can see that smaller market share importers are much more likely to trade with small market share exporters than with exporters of similar market

[17]Because our definition of a product includes the currency in which it is priced, there is no variation in currency over time for individual products. Therefore, we rely primarily on cross-sectional variation to identify the relationship between currency choice and market share.

share. For example, there are 121,261 transactions between importers in the third quintile and exporters in the first quintile, compared to 10,130 transactions between importers and exporters that are both in the third quintile.

Table 7: Market Share and Currency of Invoice (logit model)

	(I)	(II)	(III)	(IV)	(V)
Exchange rate	-9.502***	-9.503***	-9.481***	-9.485***	-9.493***
	(0.054)	(0.055)	(0.055)	(0.055)	(0.055)
Exporter market share	-1.668***	-4.543***			-4.272***
	(0.019)	(0.047)			(0.048)
(Exporter MS)^2		5.387***			5.319***
		(0.088)			(0.087)
Importer market share			-0.898***	-0.170***	-0.387***
			(0.015)	(0.035)	(0.017)
(Importer MS)^2				-1.241***	
				(0.054)	
Constant	3.302***	3.345***	3.299***	3.281***	3.355***
	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)
Obs.	7,290,235	7,290,235	7,290,235	7,290,235	7,290,235
pseudo-R^2	0.103	0.104	0.102	0.102	0.104

Note: The dependent variable, USD_{st}, is equal to one if a good is priced in U.S. dollars, and zero if priced in Canadian dollars. Each regression includes HS2 product and time fixed effects. We restrict the sample to price changes within the -100% to +100% range.

Finally, in column (V) we include the market share of both exporters and importers in the same regression. We find that the results hold: there is a U-shaped relationship between exporter market share and the probability of pricing in U.S. dollars, whereas importer market share is negatively related to the probability of pricing in U.S. dollars (or, alternatively, importer market share is positively related to the use of Canadian dollars for invoicing).

5. Discussion: Market Share and Pass-Through Over Time

There is a literature on the evolution of exchange rate pass-through to prices. In particular, several studies have looked into whether exchange rate pass-through to import prices may have declined in recent years in industrialized countries (Marazzi and Sheets, 2007; Bouakez and Rebei, 2008; Dong, 2012). In this section, we explore how changes in market shares over time may be related to changes in aggregate pass-through over time. We start by running weighted rolling regressions to get an estimate of pass-through over time. Specifically, we run the regression (4.1) on 12-month windows, moving up one month at a time. Our price-change data set covers 70 months; therefore, the rolling-window method allows us to derive 58 pass-through estimates. We present the value-weighted pass-through estimates in Figure 4, with the dates on the horizontal

axis referring to the point at which the start of the rolling window is January of the given year. The large swings in pass-through over a relatively short period of time are striking. At the start of the sample period, pass-through is just over 50 percent. By around 2004, pass-through has increased to just under 80 percent. Pass-through then declines and hovers around 50 percent from 2006 onwards.

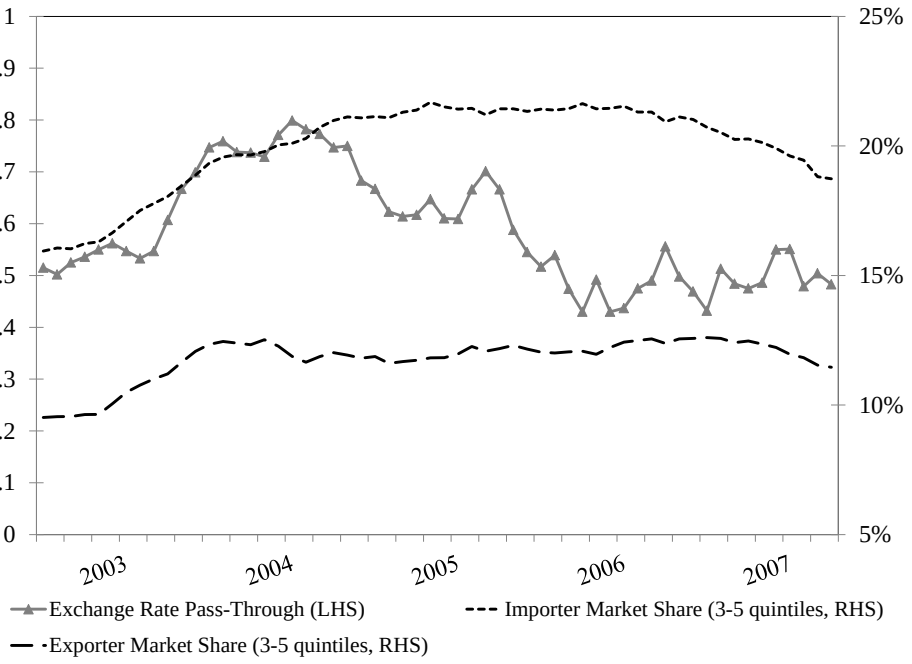

Figure 4: Exchange Rate Pass-Through and Market Share Over Time

Also in Figure 4, we present the share of the total value of imports accounted for by importers and exporters that fall within the third to fifth quintiles of the market share distribution. Again, for comparison purposes, these numbers are calculated by applying the same rolling windows used in the pass-through regressions. The third to fifth quintiles were selected for the importers to reflect the point at which there is strong evidence that pass-through is lower for larger importers. We can see that the share of imports accounted for by larger importers increased from about 16 percent at the start of the sample to almost 21 percent by 2005, before decreasing slightly at the end of the sample to 19 percent. While there is not a perfect coincidence of the increase in market share of large importers and the decrease in measured pass-through, the general trends suggest that the larger the market share of large importers, the lower is overall pass-through.

As for exporters, given the fact that there is a U-shaped relationship between pass-through and market share, it is unclear how to best group exporters. Nevertheless, we add together the market share quintiles three through five to be consistent with what we have done on the importer side. Figure 4 shows that the share of imports accounted for by larger exporters (in

terms of market share) increased slightly in about the first year of the sample—from roughly 10 to 12 percent—but then stayed relatively flat. The increase at the start of the sample could be associated with the initial increase in overall pass-through if market share is shifting toward larger exporters that are located on the upward-sloping section of the U-shaped relationship between pass-through and market share.

In general, our estimates from Tables 5 and 6 suggest that changes in market share alone are not enough to explain the large observed changes in exchange rate pass-through over time. Nevertheless, the general trends in both importer and exporter share do suggest that they may have played a role in overall pass-through.

6. Conclusions

In this paper, we have developed a model of trade pricing where pass-through of exchange rates to import prices and the choice of currency invoicing depends on the market structure, and in particular the market share of both exporting and importing firms. The model implies that both pass-through and currency invoicing should be non-monotonically related to exporter market share, in a U-shaped relationship, while pass-through and currency of invoicing should be strictly negatively related to importer market share.

Our detailed micro data allow us to measure the import market share, by value of shipment, of all exporting and importing firms in Canada over a six-year period, as well as the unit price and currency of invoice for each of these transactions. The predictions of the model for exchange rate pass-through, and the relationship between both pass-through and invoicing patterns to exporter and importer market share, are strongly supported by our empirical tests. The implications of the results suggest that industry composition and market structure are critical ingredients in understanding exchange rate pass-through. More generally, trends that are visible regarding the concentration of importer size and market share in the Canadian data may have important implications for the sensitivity of domestic prices to exchange rate fluctuations in the future.

Appendix A. A Model of Elasticity Choice

Here we sketch out a simple framework to motivate the argument that importing firms may have differences in their technologies for producing retail goods, and can choose among different technologies in advance, subject to a cost. Technologies differ with respect to the elasticity of substitution between imported retail intermediates. We assume that there is uncertainty over intermediate-good prices, so that a greater ability to substitute between intermediates will increase expected profits for retailers. We assume that there are two periods. In period 0, the importer may, at a cost, choose the elasticity of substitution of its technology. In period 1,

given the technology, and realized intermediate prices, the importer purchases intermediates, repackages them using its technology, and sells them to retail consumers.

Consider period 1 first. To simplify matters, assume that there are just two inputs into the production of retail goods. Thus an importer purchases from two separate exporters inputs x_1 and x_2, at prices p_1 and p_2. The importer is a price taker in its input market, so takes the prices p_1 and p_2 as given. The importer then packages the intermediate goods into a retail good for final sale according to the technology:

$$y = A\left[v^{\frac{1}{\rho}} x_1^{1-\frac{1}{\rho}} + (1-v)^{\frac{1}{\rho}} x_2^{1-\frac{1}{\rho}}\right]^{\frac{1}{1-\frac{1}{\rho}}}. \tag{A.1}$$

The elasticity of substitution across imported inputs is ρ. The parameter A is a measure of the importer's technology.

Given this, the importer's cost function is

$$\left[v p_1^{1-\rho} + (1-v) p_2^{1-\rho}\right]^{\frac{1}{1-\rho}} \frac{y}{A}. \tag{A.2}$$

Assuming that the importer is a monopolist in retail with demand elasticity λ, then the price is a markup $\frac{\lambda}{\lambda-1}$ over marginal costs, and equilibrium profits can be written as

$$\Delta\left(\left[v p_1^{1-\rho} + (1-v) p_2^{1-\rho}\right]^{\frac{1}{1-\rho}} \frac{1}{A}\right)^{1-\lambda}, \tag{A.3}$$

where $\Delta > 0$.

For a given ρ, importers with higher productivity will have lower prices and higher retail sales, which implies that they will have a higher share of the market for the purchase of each imported input.

In period 0, prices p_1 and p_2 are not known, so the importer's expected profit is written as

$$E_0\Pi(\rho, A) = E_0\Delta\left(\left[v p_1^{1-\rho} + (1-v) p_2^{1-\rho}\right]^{\frac{1}{1-\rho}} \frac{1}{A}\right)^{1-\lambda}. \tag{A.4}$$

Here we explicitly account for the fact that expected profits will depend on the importer's elasticity of substitution across intermediate imports and on its productivity.

Assume that the cost that the importer incurs for choosing an elasticity of substitution ρ is as follows:

$$C(\rho) = \xi\rho^2 + \kappa. \tag{A.5}$$

In period zero, the importing firm will then choose ρ to maximize:

$$\text{Max}_\rho E_0\Pi(\rho, A) - \xi\rho^2 - \kappa, \tag{A.6}$$

where we have assumed there is no discounting.

Using standard theory, we can show that the expected profits function is convex in p_1 and p_2. This is a familiar result from the theory of production—the firm can always adjust inputs in response to variations in input cost in order to do better than responding linearly, so the cost function is concave in the input prices, which implies that the profit function is convex in input prices. But then the expected profit function becomes more convex, the higher is the elasticity of substitution. Hence, expected profits are increasing in ρ. Since expected profits are also increasing in A, this leads to the result that the optimal ρ is greater for firms with higher A. The implication is that more-productive firms, or firms that can repackage goods for retail more productively, will have a higher final retail sales level, and therefore a higher import share of any particular intermediate input good. They will also have a more-elastic technology for substitution across different intermediate import goods.

Figure A.1 gives a simple illustration of the determination of optimal ρ for a high A firm and a low A firm. It is assumed that p_1 is certain, but p_2 is uncertain at period 0. Firms share a similar technology adoption cost given by (A.5). This is represented by the cost-of-adoption curve. Both firms have expected profit functions increasing in ρ, but the more-productive (high A) firm's expected profit always lies above that of the less-productive firm. As a consequence, the optimal ρ is always higher for the more-productive firm. In this environment, we would then expect that firms with a higher market share should have a higher elasticity of substitution across intermediate inputs.

Appendix B. Exchange Rate Pass-Through in Industry Equilibrium

In the main text, we examined the relationship between market share and pass-through of a single firm when the exchange rate changes. But in an industry equilibrium, we would expect that other firms would increase their prices, even if their costs are not directly affected by the exchange rate, since a rise in the price of firm i will affect the relative price of their export good in market j. To incorporate this, we now allow for all other $N-1$ firms in the industry to adjust their prices to firm i's price change, but assuming that they are not directly affected by the exchange rate. We assume that all firms in the industry besides firm i are symmetric, so they have market share $\frac{1-\theta_{ij}}{N-1}$. Their price change following a currency i depreciation is determined by the condition:

$$\frac{d\log p_{kj}}{d\log e_i} = \frac{\omega_k}{(1+\omega_k)(1-\theta_{kj})}\sum_{z\neq k}\theta_{zj}\frac{d\log p_{zj}}{d\log e_i}. \tag{B.1}$$

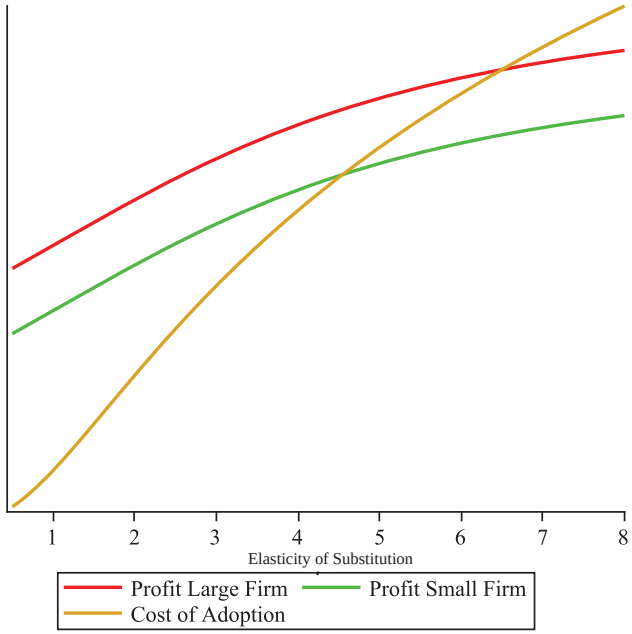

Figure A.1: Choice of Elasticity of Substitution

We see that because there is no direct effect of the exchange rate on firm k's costs, for any firm $k \neq i$, then prices of firm k will only adjust to the extent that firm i's pass-through is non-zero, and firm k's pass-through will depend on firm i's overall market share. Hence it must be that for θ_{ij} close to zero, or close to unity, pass-through for firm k will be zero. In the first case, firm i has complete pass-through, but is so small that it has a negligible effect on other firms' prices. In the second case, firm i has most of the market, and the other firms are so small that their concern with market share is negligible (i.e. ω_k will be very small). This suggests, then, that any rival firm k will also have a non-monotonic relationship between their price response and firm i's market share, but going in the other direction; pass-through rises for θ_{ij} between zero and unity, but is zero at the boundaries.

Figure B.1 illustrates this result for $N = 2$, so there are only two firms in the industry. The first point to note from the figure is that we still obtain the essence of the results from Figure 1 in the main text. Even when rival firms respond, there is still a substantial U-shaped relationship between pass-through and market share for the firm experiencing the exchange rate shock. The scale of the pass-through response is approximately the same as in the case without a response from rival firms. This is shown by the comparison in Figure B.1 of the case with and without price adjustment on the part of firms k. The second point to note in Figure B.1 is that all other firms will have an inverse U-shaped relationship between pass-through and θ_{ij}. Their pass-through is highest for intermediate values of θ_{ij}. We note also that the relationship between firm i's pass-through and firm k's pass-through has distinctly separate phases. For low levels of θ_{ij}, firm i and firm k's pass-through move in opposite directions in response to a rise

in i's market share—thus, we can think of price responses as being strategic substitutes. For intermediate levels of θ_{ij}, both firm i and firm k's pass-through is declining in θ_{ij}, so there is a situation of strategic complementarity. Finally, for θ_{ij} close to unity, firm i's pass-through has passed its minimum in θ_{ij} and is rising, while firm k's pass-through continues to decline in θ_{ij}, so that again pass-throughs are strategic substitutes.

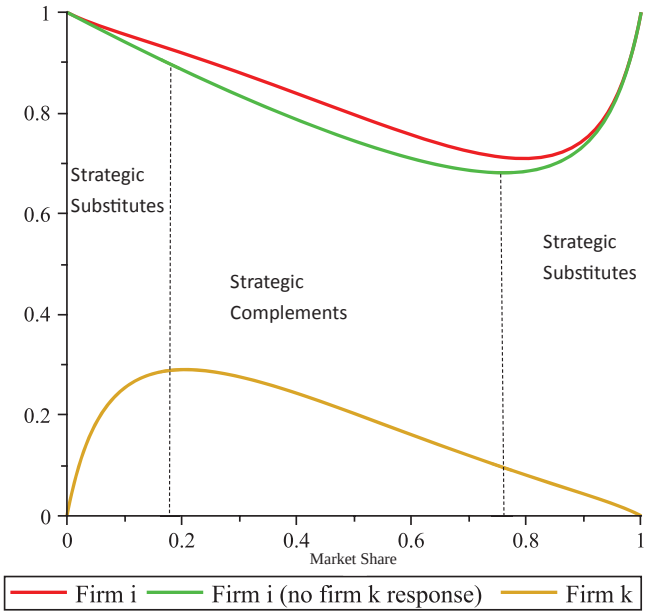

Figure B.1: Exchange Rate Pass-Through and Market Share with Two Firms ($N = 2$)

Figure B.2 shows the joint process of firm i and other firms' pass-through when there are four firms in the industry, so that $N = 4$. In this case, the pass-through response of other firms has the same characteristic as in the two-firms case, but for identical elasticities of demand, the quantitative response of the other firms is significantly smaller. In this case, the relationship between pass-through and θ_{ij} is essentially the same as in Figure 1 in the main text, where we ignored the response of other firms in the market.

Finally, Figure B.3 returns to the $N = 2$ case, but as in Figure 1, illustrates the pass-through response for the baseline case and the high-elasticity case. Again, we see that firm i's pass-through will be reduced in the case of a large (high-elasticity) importing firm. But, interestingly, the results for pass-through of other firms go in the opposite direction. That is, in selling to a large importer, there should be a higher price adjustment for firms not directly affected by the exchange rate shock than in the case of a smaller importer. While this implication may seem surprising, it is quite intuitive. With a higher demand elasticity, firms in an industry will have prices that are closer to one another. So a cost shock that leads to an increase in one firm's price will be more closely imitated by other firms, the higher is the elasticity of demand.

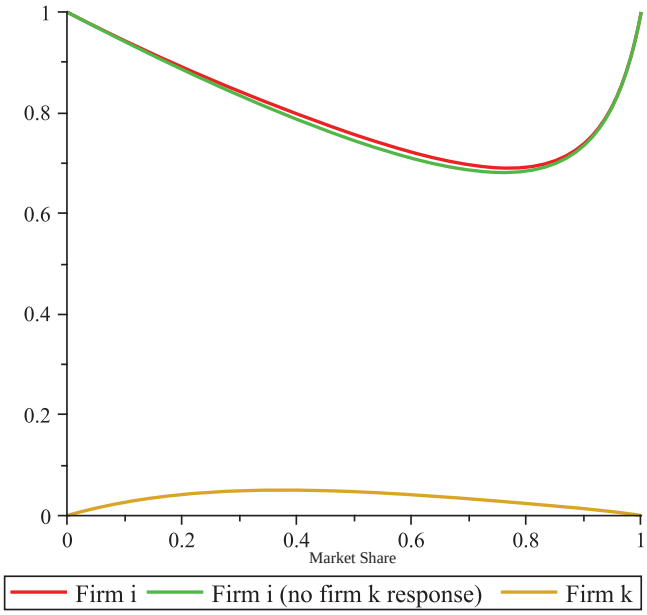

Figure B.2: Exchange Rate Pass-Through and Market Share with Four Firms ($N = 4$)

Given the relationship between size and elasticity, this leads to the implication that pass-through for non-directly affected firms will be *higher*, the larger the market share of importers.

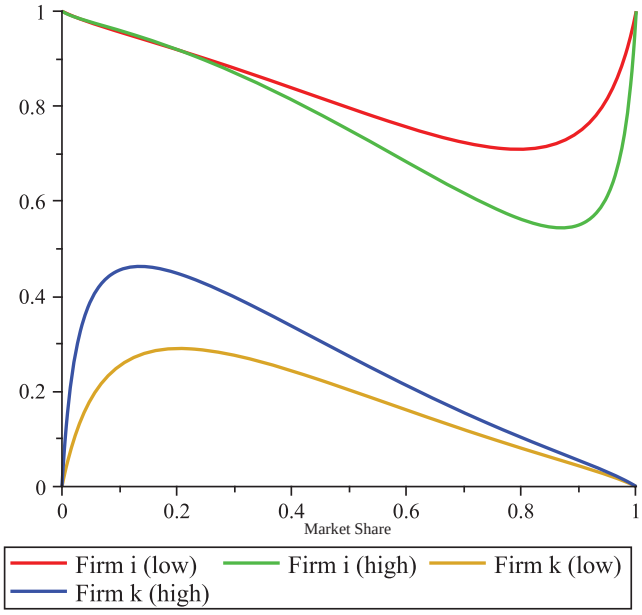

Figure B.3: Exchange Rate Pass-Through and Market Share

Table C.1: Overall Exchange Rate Pass-Through

	Value-Weighted		Product Level	
	Estimate	(s.e.)	Estimate	(s.e.)
Exchange rate (β)	0.592***	(0.027)	0.484***	(0.004)
Exporter CPI	0.038	(0.097)	0.073***	(0.016)
Canadian CPI	1.233***	(0.318)	0.311***	(0.041)
Canadian GDP	0.641**	(0.250)	0.735***	(0.033)
Obs.	7,993,402		7,993,402	
R^2	0.017		0.003	

Note: Each regression includes product and time fixed effects. We restrict the sample to price changes within the -100% to +100% range.

Appendix C. Overall Pass-Through Estimates

Table C.1 presents all the coefficient estimates from the overall pass-through regressions. The coefficient estimates on the cumulative changes in exporter CPI, Canadian CPI and GDP are positive, which is as expected.

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