Exchange Rate Pass-Through, Currency of Invoicing and Market Share

September 2015

Michael B. Devereux, Wei Dong, Ben Tomlin[☆]

Abstract

We explore the role of product market structure on exchange rate pass-through and currency of invoicing in international trade, using very detailed transaction-level data on Canadian imports over a six-year period. A novel feature of the analysis is the importance of market share on both sides of the trading relationship—that of the exporting and importing firms. We find that both exchange rate pass-through and the currency of invoicing are dependent on the size (or market share) of both importers and exporters. Very small or very large exporters have higher rates of pass-through and tend to price in the exporters' currency; while it is the opposite for exporters in the middle range. By contrast, for larger importers, pass-through is lower and destination currency invoicing is more prevalent. Thee findings are consistent with a simple model of trade pricing under monopolistic competition with endogenous markups and heterogeneity in firm size (on both sides of the transaction).

JEL Classification: F3, F4

Keywords: Exchange rate pass-through, market share, currency of invoicing, trade

[☆]We thank Greg Bauer, Douglas Campbell, Andreas Fischer, Doireann Fitzgerald, Kim Huynh, Narayana Kocherlakota, Oleksiy Kryvtsov, Gregor Smith and numerous seminar and conference participants for their comments. We also thank Beiling Yan and Danny Leung at Statistics Canada for their help in preparing and interpreting the data, and Ian Hodgson and Monica Mow for their research assistance. The results have been institutionally reviewed to ensure that no confidential information is revealed. The views expressed in this paper are those of the authors and no responsibility for them should be attributed to the Bank of Canada. Devereux: University of British Columbia, devm@mail.ubc.ca. Dong: Bank of Canada, wdong@bankofcanada.ca. Tomlin: Bank of Canada, btomlin@bankofcanada.ca.

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]

The degree of aggregate pass-through will depend on the market power of the firms involved in trade, since this should determine how markups adjust to exchange rate changes and which party will absorb movements in the exchange rate. At the same time, both theoretical and empirical studies have established that pass-through depends on the currency in which imported goods are invoiced.[2] In this paper, we explore how pass-through and currency of invoicing are jointly determined by the market share of the firms on both sides of the international trade transaction—the exporters and the importers. fIn particular, in the vast literature on exchange rate pass-through, there is very little evidence that links pass-through to importer characteristics, and we address this gap by documenting the important role of importer market share in driving pass-through and currency of invoicing.[3]

We explore these issues using a highly disaggregated data set on Canadian import prices that covers the universe of imports over a six-year period from 2002 to 2008. This data set is unique not only in its scope and product detail, but also in the fact that it allows us to identify the importer and the exporter on each side of a trade transaction. From this, we are able to compute the market share of the importers and exporters. We find strong evidence that both exchange rate pass-through and the share of exporting country currency invoicing have a non-monotonic and U-shaped relationship with the market share of the exporting firm. On the other hand, pass-through and the share of producer currency invoicing are negatively related to the market share of the importing firm. 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

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

[2] See Engel (2006) and Gopinath Itskhoki and Rigobon (2010).

[3] Goldberg and Tille (2013) consider the role of both the exporter and importer in the determination of currency of invoicing in a theoretical bargaining model. Goldberg and Tille (2014) link the size of trade transactions to the currency of invoicing and find that larger transactions are more likely to be priced in the destination currency. Friberg and Wilander (2008) provide some survey evidence that importers play a role in the determination of the currency of invoicing.

market-share relationships still hold when we explicitly control for the size of the trading partner.

Variable markups and heterogeneous firms can emerge in a number of different models. We develop a model of trade with monopolistic competition that accounts for the decisions of both exporters and importers. The model provides a simple framework to illustrate the inter-relationship between exchange rate pass-through, market share and the choice of invoicing currency. In the 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. An implication of the model is that 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 consequently 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]

The model can also capture the importance of importers for exchange rate pass-through. 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 importers with higher market share.

How does this relate to the determination of the invoicing currency? Engel (2006) and Gopinath, Itskhoki and Rigobon (2010) construct models where a firm's desired 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).[5] Building on this, 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 to importer market share.

Our paper contributes to the large empirical and theoretical literature on the size of exchange

[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).

[5]Gopinath (2015) discusses the important role of currency invoicing in exchange rate pass-through and shows that there can be important policy implications from asymmetries across countries in the degree of pass-through.

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.

A number of recent papers have linked pass-through with the market share of exporters.[6] 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.[7]

What distinguishes our paper from these existing micro studies is: (i) the finding 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; and (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 provide evidence. 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 has increased over the sample period and this may be related to observed variations in overall pass-through.

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

[7] 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.

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 results. 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 with endogenous markups and heterogenous size of exporting and importing firms. The model provides an analytical framework for understanding the relationship between market structure, pass-through and currency of invoicing, which helps to guide our empirical work.

Consider an importing country where there are many different sectors (or markets). Within each sector there are a number of distinct sellers (exporters), 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 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. 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. 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.[8] 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, 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 $\rho_j > 1$, $\eta > 1$ and $\rho_j > \eta$, so that the elasticity of demand for individual goods is greater than the elasticity of demand for the sectoral composite good. Finally, we allow for importers to be different in total size or market share, as reflected in the scale factor X_j. The sectoral price index for importer j is defined as

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

Exporting 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 $\phi_{11}(w_i, a_i) \leq 0$.

2.1. Pass-Through and Market Shares

In terms of the importing firm's currency, the exporter's profit is then defined as

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

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

[8] 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.

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 $\rho_j > \eta$. [9]

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

[9] We note that there is a distinction between the elasticity of demand for any importing firm j, defined before as the primitive ρ_j, and the elasticity of demand facing an exporter, which depends upon both the primitive parameter ρ_j as well as the firm's market share, which will depend on the firm's costs relative to its competitors.

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 ω term. A rise in the firm's price reduces its market share, and since a fall in exporter market share means a higher demand elasticity, an exchange rate shock will reduce the firm's optimal markup.

The second term in (2.9) captures the indirect impact on firm markup due to competitor price adjustment. As a first step, we take the prices of other firms in the industry as given.

Turning to the first term, 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.[10] 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

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

where $\Gamma > 0$.[11]

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 importing firm's elasticity of demand. Hence, while a high importer 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

[10] 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.

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

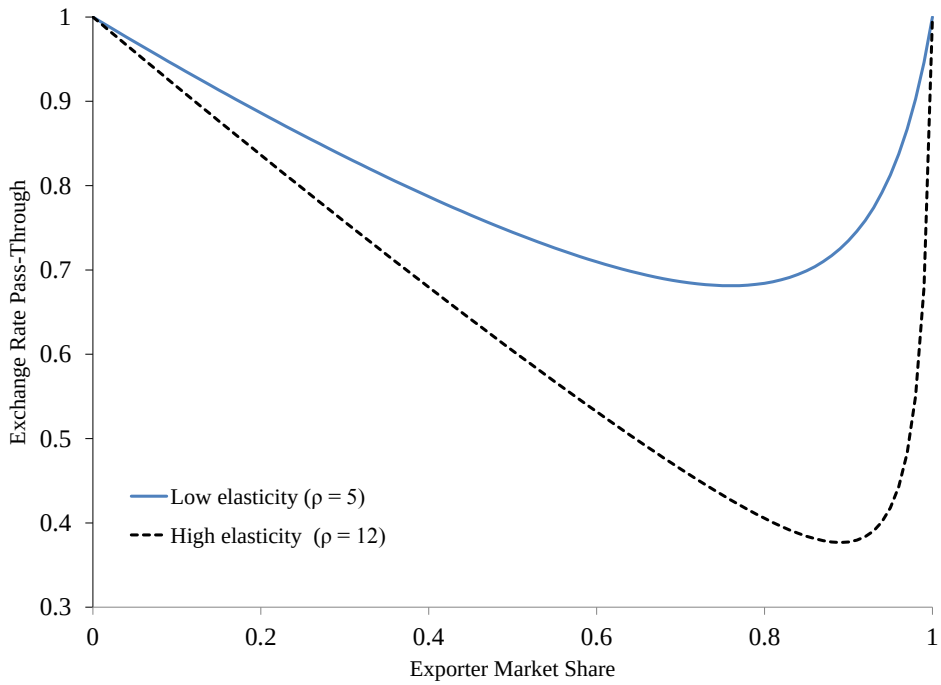

Figure 1: Exchange Rate Pass-Through and Market Share

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 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, $\rho_j = 12$. 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 $\rho_j = 12$.

In this discussion above, 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.[12]

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 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 in the short-run will depend substantially on the currency of invoicing. If prices are set in the producer's currency (PCP), then short-run 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

[12]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.

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.[13] 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, even conditional on a price change. 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 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 explore these predictions in the data and find strong support for both.

[13] 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.

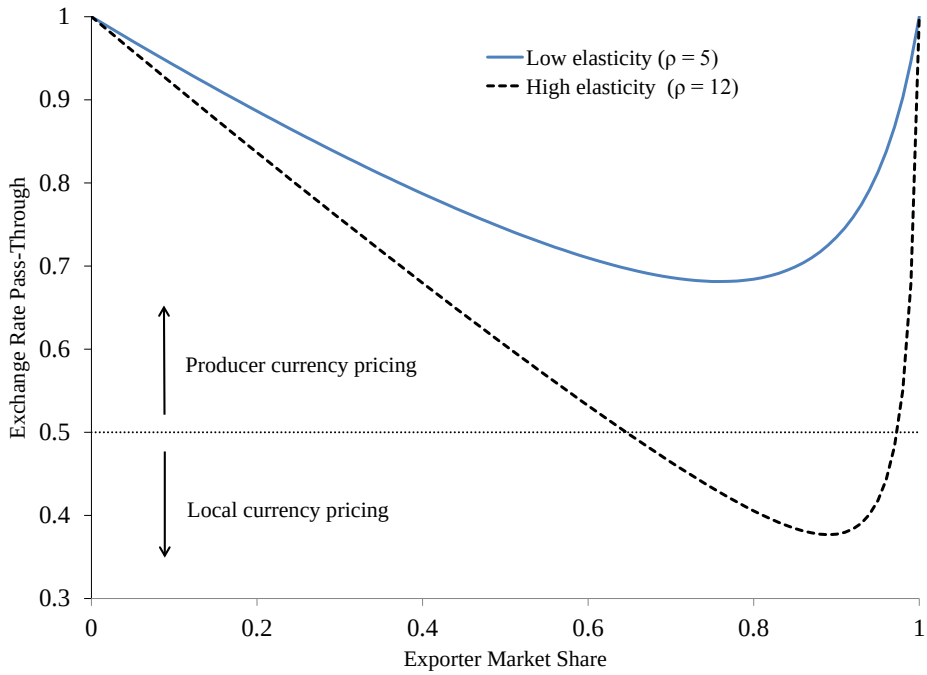

Figure 2: Exchange Rate Pass-Through, Market Share and Currency Choice

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.

3. Data

3.1. Customs Data

We use data from the Canadian Border Services Agency (CBSA) that contain information on every commercial import/shipment into Canada from September 2002 to June 2008.[14] 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

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

number of units.[15] The shipment values are reported in the currency of invoice, and if this 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 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 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 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.[16] More information on data construction, how importers and exporters are identified, how the country of origin and export are determined, and how the data can be accessed for replication are provided in Appendix C.

[15] 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 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.

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

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 (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).[17] As for the currency of invoice, overall, 88.0 percent of weighted imports and 86.0 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 invoiced 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 invoiced 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

[17] In Table 1, the products are defined as a range of HS2 codes. However, within these ranges, some specific HS2 and HS4 products are dropped due to too many missing observations.

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 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 Imports (%)	Currency of Invoice (%)			Share of Imports (%)	Currency of Invoice (%)		
Importers		USD	CAD	EUR		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 exploring 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, from the product level data and the value weighted data.[18] The overall estimate of exchange rate pass-through (pooling all products together) is approximately 59 percent using value weights, and 48 percent using shipment weights. [19]

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.[20] Our estimates are not subject to such a bias, since we

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

[19]This estimate of unconditional pass-through between 0.5 and 0.6 is comparable to those in the literature when one allows for the different features of currency invoicing. For instance, Gopinath et al. 2010 find an unconditional pass-through estimate for US imports equal to 0.22, but given that a much higher fraction of imports into Canada are not invoiced in domestic currency, in contrast to the US market, a significantly higher unconditional pass-through estimate is to be expected.

[20]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.

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 is significant at the 5% 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 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*** **	**(0.010)**	**0.593*** **	**(0.030)**	**7,993,402**
Vegetable products	0.298***	(0.033)	0.214**	(0.092)	959,319
Food and beverage	0.454***	(0.023)	0.552***	(0.046)	585,693
Chemical products	0.419***	(0.018)	0.642***	(0.112)	642,768
Textiles	0.546***	(0.017)	0.671***	(0.039)	606,482
Apparel	0.625***	(0.012)	0.826***	(0.027)	1,528,634
Footwear	0.587***	(0.027)	0.744***	(0.048)	175,342
Metal products	0.302***	(0.013)	0.422***	(0.052)	2,090,899
Industrial machinery	0.662***	(0.014)	0.752***	(0.070)	975,483
Consumer electronics	0.653***	(0.025)	0.710***	(0.094)	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 are clustered at the HS10 level.

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

We next explore 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, to better reflect the assumptions and mechanisms presented in the model.[21] 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, for 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.

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.

4.3. Exchange Rate Pass-Through and Market Share

We next explore the predictions of a U-shaped relationship between exporter market share and exchange rate pass-through, and a monotonically decreasing relationship for importer market share. To test these hypotheses, we run the following regression:

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

[21] 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.

Table 4: Pass-Through and Currency Choice

Product	CA Dollar β_C	(s.e.)	US Dollar β_U	(s.e.)	Euro β_E	(s.e.)	Difference β_C - β_U	β_C - β_E	β_U - β_E
Overall	0.137***	(0.02)	0.502***	(0.01)	0.497***	(0.02)	-0.37***	-0.36***	0.01
Vegetable products	0.300***	(0.08)	0.325***	(0.05)	0.547***	(0.08)	-0.07	-0.25***	-0.22**
Food and beverage	0.020	(0.03)	0.481***	(0.03)	0.684***	(0.04)	-0.46***	-0.66***	-0.20***
Chemical products	0.128**	(0.06)	0.459***	(0.02)	0.521***	(0.07)	-0.32***	-0.39***	0.06
Textiles	0.096*	(0.06)	0.587***	(0.02)	0.484***	(0.04)	-0.49***	-0.39***	0.10**
Apparel	0.123***	(0.03)	0.623***	(0.01)	0.484***	(0.03)	-0.50***	-0.36***	0.14***
Footwear	0.078	(0.09)	0.702***	(0.03)	0.562***	(0.07)	-0.62***	-0.48***	0.14*
Metal products	0.193***	(0.04)	0.451***	(0.02)	0.255***	(0.07)	-0.26***	-0.06	0.20***
Industrial machinery	0.211***	(0.05)	0.597***	(0.02)	0.589***	(0.07)	-0.39***	-0.38***	0.01
Consumer electronics	0.169**	(0.08)	0.620***	(0.03)	0.740***	(0.11)	-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 are clustered at the HS10 level.

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 but not statistically significant from zero. 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 5% level, while the coefficient on the non-linear interaction term is positive and significant at the 10% level. This provides initial evidence of a U-shaped relationship.

For importers, there is evidence of a negative relationship between pass-through and market share; however, this does not show up in the linear interaction term, but in the squared interaction term, suggesting some curvature in the relationship. In column (III), the coefficient on the linear interaction term is negative but not statistically different from zero. In column (IV), we include the non-linear interaction term for importers and find that while the linear term becomes positive, it remains insignificant. The non-linear term, on the other hand, is negative and significant at the 5% level. We take this as initial evidence that the relationship between importer market share and exchange rate pass-through is negative.

Table 5: Market Share and Pass-Through

	(I)	(II)	(III)	(IV)	(V)
Exchange rate	0.486***	0.487***	0.488***	0.486***	0.486***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Exporter market share	-0.007***	-0.007***			-0.005**
	(0.002)	(0.002)			(0.002)
ER·(Exporter market share)	-0.099	-0.290**			-0.341**
	(0.065)	(0.145)			(0.159)
ER·(Exporter market share)^2		0.402*			0.648***
		(0.216)			(0.223)
Importer market share			-0.005***	-0.005***	-0.003*
			(0.002)	(0.002)	(0.002)
ER·(Importer market share)			-0.122	0.078	0.164
			(0.082)	(0.142)	(0.151)
ER·(Importer market share)^2				-0.397**	-0.546***
				(0.197)	(0.210)
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 are clustered at the HS10 level.

Finally, in column (V) we include both exporter and importer market share in the same regression and find that the results largely hold. The linear exporter interaction term is negative and significant, while the non-linear interaction term is positive and significant, suggesting a U-shape relationship between exporter market share and pass-through. On the importer side, we see that again the linear interaction term is positive, but not significant, and the non-linear interaction term is negative and statistically significant. Depending on how we view the insignificant coefficient on the linear interaction term, either the relationship between importer market share and pass-through is flat to start with, but largely declining afterwards, or pass-through is monotonically decreasing in importer market share (if we were to assume that the linear interaction term is equal to zero).

To help clarify these issues and to get an idea of the magnitude of the relationships, in Figure 3, we use the coefficients from column (V) 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 0.8 range depending on exporter market share. We provide two lines for the importer market share and pass-through relationship. In the first, we assume that the linear interaction term is positive and equal to 0.164. In this case, there is a very slight hump shape, that can also be viewed as a flat spot in the relationship as pass-through

increases by less than 1 percent from a market share of zero to the peak of the hump at roughly twenty percent market share, after which it decreases from 0.5 to approximately 0.1 for importer market share equal to 1. Alternatively, we could assume that because the linear interaction term is not statistically different from zero, that it can be treated as being equal to zero. In this case, pass-through is monotonically decreasing in importer market share, decreasing from roughly 0.5 for very small market share firms to just below zero for very large importers.[22]

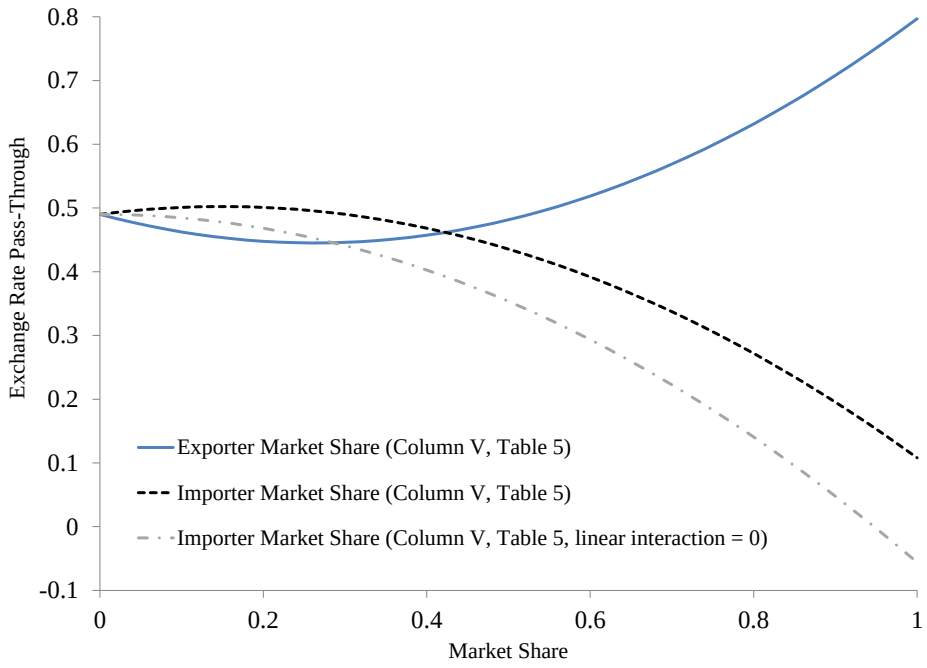

Figure 3: Exchange Rate Pass-Through and Market Share

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 from information on exporters (importers) 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

[22]Our use of quadratic interaction terms in linear regressions to pick up non-linearities in pass-through will not accurately capture the exact relationship between market share and pass-through at all points along the market-share distribution. Therefore, the focus should be on the overall shape of the curves rather the implied pass-through rates at exact market shares. This is particularly the case when pass-through drops below zero. Note also 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.

distribution.

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
		(0.010)	(0.038)	(0.056)	(0.087)	(0.247)
		[7,559,207]	[132,492]	[121,261]	[14,458]	[4,817]
	2	0.582***	0.514***			
		(0.061)	(0.077)			
		[60,047]	[35,954]			
	3	0.438***		0.649***		
		(0.107)		(0.155)		
		[16,082]		[10,130]		
	4	0.785***			0.131	
		(0.138)			(0.210)	
		[4,955]			[4,441]	
	5	1.232***				0.277
		(0.294)				(0.193)
		[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, and the standard errors are clustered at the HS10 level. The number of observations in the regression is provided in the square brackets.

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, this is generally 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 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, 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.[23] 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

[23]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.

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. [24]

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***	-9.506***
	(0.273)	(0.273)	(0.272)	(0.272)	(0.270)
Exporter market share	-1.668***	-4.543***			-5.135***
	(0.253)	(0.877)			(1.162)
(Exporter MS)^2		5.387***			7.051***
		(1.439)			(1.735)
Importer market share			-0.898***	-0.170	1.352
			(0.301)	(0.620)	(0.873)
(Importer MS)^2				-1.241*	-3.005***
				(0.663)	(0.911)
Constant	3.302***	3.345***	3.299***	3.281***	3.325***
	(0.162)	(0.163)	(0.161)	(0.162)	(0.163)
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. Standard errors are clustered at the hs10 level.

Finally, in column (V) we include the market share of both exporters and importers in the same regression. We find that the results hold on the exporter side: the coefficient on the linear market share term is negative and significant, and the coefficient on the non-linear term is positive and significant, suggesting a U-shaped relationship between exporter market share and the probability of pricing in U.S. dollars. On the importer side, the coefficient on the linear term becomes positive, but it is not statistically significant. The coefficient estimate on the non-linear

[24] It is possible that the very high market share importers are more likely to trade 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 share.

term is negative and statistically significant. Therefore, as in our analysis of the results in column (V) of Table 5, depending on how we treat the insignificant linear term, the relationship between importer market share and the probability of pricing in U.S. dollars is either very slightly hump shaped, but largely decreasing, or it is strictly decreasing (if we assume the coefficient on the linear term is equal to zero).

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.

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

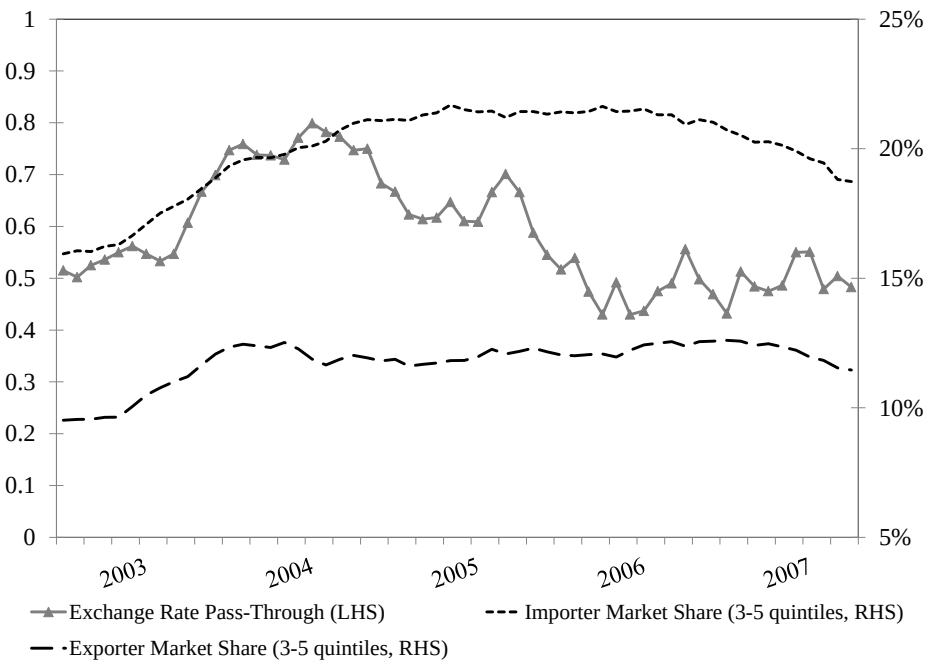

Figure 4: Exchange Rate Pass-Through and Market Share Over Time

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.

6. Conclusions

In this paper, we explore the relationship between market share, exchange rate pass-through and currency invoicing in international trade. Our detailed micro data allow us to measure the import market share, by value of shipment, of all exporters to, 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. To provide a framework for thinking about these issues, we develop 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 negatively related to importer market share.

Our empirical work finds evidence in support of the importance of exporters and importers in the joint determination of pass-through and currency invoicing. This finding is new and important to the literature. The implications of our 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

$$\left[vp_1^{1-\rho} + (1-v)p_2^{1-\rho}\right]^{\frac{1}{1-\rho}} \frac{y}{A}. \tag{A.2}$$

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

$$\Delta\left(\left[vp_1^{1-\rho}+(1-v)p_2^{1-\rho}\right]^{\frac{1}{1-\rho}}\frac{1}{A}\right)^{1-\lambda}, \tag{A.3}$$

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

$$E_0\Pi(\rho, A) = E_0\Delta\left(\left[vp_1^{1-\rho}+(1-v)p_2^{1-\rho}\right]^{\frac{1}{1-\rho}}\frac{1}{A}\right)^{1-\lambda}. \tag{A.4}$$

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

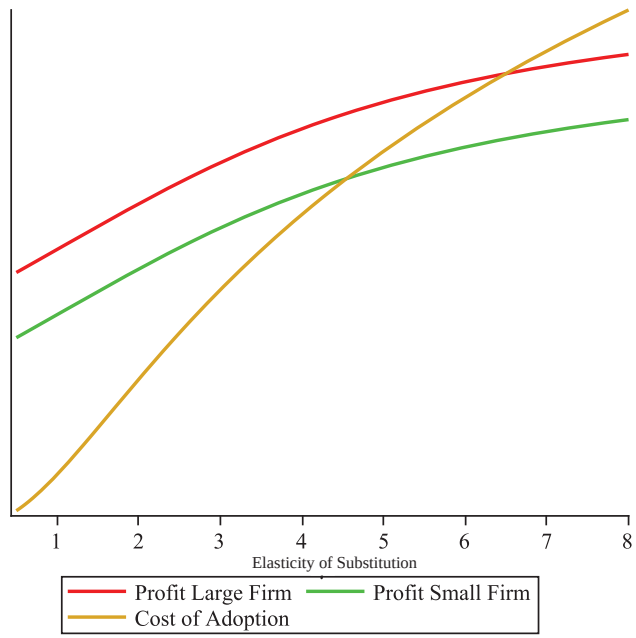

Figure A.1: Choice of Elasticity of Substitution

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:

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

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.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

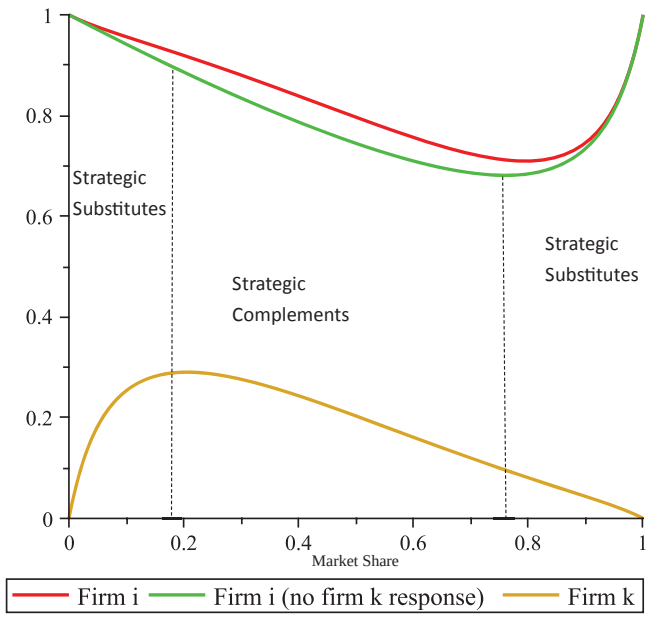

Figure B.1: Exchange Rate Pass-Through and Market Share with Two Firms ($N = 2$)

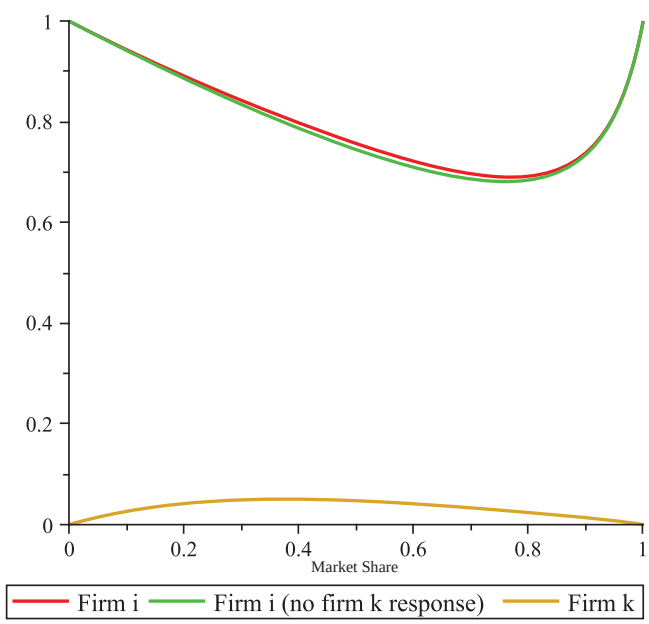

Figure B.2: Exchange Rate Pass-Through and Market Share with Four Firms ($N = 4$)

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. 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.

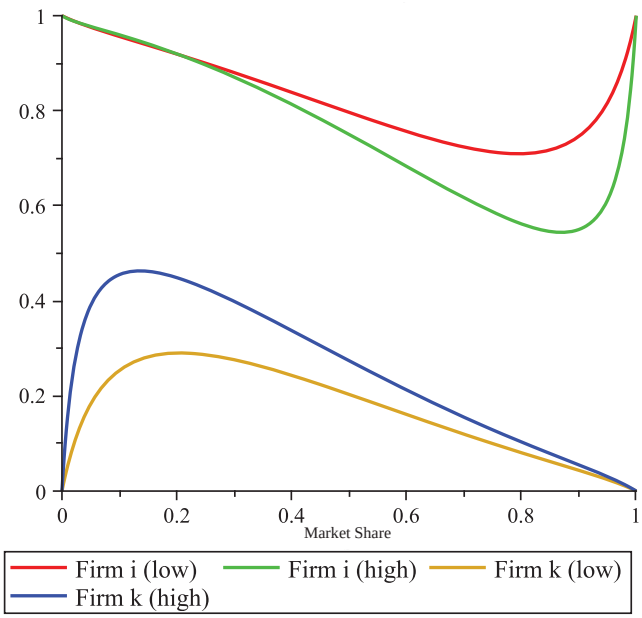

Figure B.3: Exchange Rate Pass-Through and Market Share

Appendix C. Data Details

The trade transaction data from the Canadian Border Services (CBSA) is confidential data housed at Statistics Canada. This means that the data can only be accessed at the Statistics Canada head offices in Ottawa, and all statistics and results derived from the data must be screened before release. The data is provided in monthly files that cover all commercial imports into Canada within that month. Each monthly file has over five million observations, and with 72 months of data we have just under 400 million observations.

As mentioned, the data set provides information on the number of units in a shipment of a given 10-digit HS code product (as well as the unit of measurement) and the total value of the shipment (in the currency of invoice, as well as in Canadian dollars, if this is not the currency of invoice), which allows us to back out a unit price. However, for many shipments the number of units (or to a lesser extent, the value of the shipment) are not reported, which precludes the calculation of a unit price. In some months, up to fifty percent of observations do not have the number of units reported.

In examining the data, we found that these missing values for the number of units were generally concentrated in certain products types rather than being spread evenly across products. We therefore wrote a program that keeps only those 4-digit HS products for which at least 85

percent of the observations had unit prices that could be calculated. For most products, the percentage of observations that had associated unit prices was close to 100 percent. It was primarily in the consumer electronics category where the percentage of reported number of units was a bit lower. We include the consumer electronics product category to ensure that we have a broad set of products that includes heavier manufacturing consumer goods.

Note that due to the size of the full data set, we were unable to simply stack the monthly observations to undertake analysis with the full data set. Therefore, we worked with the monthly data sets to identify candidate product classes, and then pulled these products from the monthly data sets and stacked the monthly observations. At that point we double checked to ensure that unit prices could be calculated for at least 85 percent of the product observations.

After cleaning the data set in this way, we were left with nine 2-digit HS product categories and just over 37 million observations. These nine product categories account for roughly forty percent of the total value of Canadian imports in any given year, and represent a wide range of product types—non-durables (i.e. vegetable products) and durables (i.e. consumer electronics), consumer goods (i.e. apparel and footwear) and intermediate goods (i.e. metal products), and light manufacturing (i.e. textiles) and heavy manufacturing (i.e. industrial machinery).

The next step was to convert these data into data that could be used for the analysis of exchange rate pass-through. Within a given month, shipments of the same product can enter into Canada multiple times. It is therefore difficult to track the price of a single good over time. Moreover, even though the 10-digit HS code identifies a fairly specific product, there can still be variation in product characteristics within these 10-digit codes (i.e. quality, color, size). For this reason, we decided to define a product based on a number of other criteria. That is, we define a product s as being specific to an exporting firm, importing firm, ten-digit HS code, country of origin, country of export, currency, and unit of measurement. With this definition of a product, we then combined all unit price observations of a product within a month into a single price. This provides us with monthly data that can be used to construct price changes for the estimation of exchange rate pass-through.

Appendix C.1. Importer and Exporter Identifiers

Importantly, the data set provides firm identifiers for the exporting firm and the importing firm. Importing firms are identified off of their importer identification numbers (we do not actually observe these numbers, but are provided with a scrambled identifier that can be used to track a single importer over time). For exporters, the companies names provided on the import documentation have been used by researchers at Statistics Canada to create firm identifiers. These identifiers refer to the firm responsible for the final shipment of the good to the Canadian border. Therefore these firms are not necessarily the producer of the good and may be interme-

diaries. For all exporters, a name-matching algorithm was used, and for U.S. based exporters, this was cross referenced with the state of export (a variable available in the data).

Appendix C.2. Country of Origin and Export

In the identification of a product s, we distinguish between the country of origin and the country of export of a good. The country of origin is determined based on the World Trade Organization rules of origin. The exact rules for determining the country of export are complicated, but can generally be understood as follows (this information is based on discussions with officials at the CBSA). If a good is shipped directly from the country of origin to Canada, the country of export will be the same as the country of origin. This will also be true if the good is shipped to Canada via a third country, but the good does not enter the economy of the third country in any way. More specifically, this means that the good does not clear customs in the intermediary country—i.e. it stays in bond as it passes through the intermediary. Even if a firm located in the intermediary is responsible for the transport of in-bond goods, the country of export will not be the intermediary country (nor will the transport company be the exporter). The country of export will be different from the country of origin if the good clears customs in the intermediary country and therefore enters the intermediary economy. The exporter will always be located in the country of export.

Appendix C.3. Data Availability for Replication

The CBSA data is confidential data and must be accessed at the Statistics Canada head office in Ottawa. For access to the data for replication purposes, proposals can be made to the Canadian Data and Economic Research (CDER) center at Statistics Canada (cder@statcan.gc.ca). Anyone working with the data will have to pass a reliability check to become a deemed employee of Statistics Canada.

Appendix D. Overall Pass-Through Estimates

Table D.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.

Table D.1: Overall Exchange Rate Pass-Through

	Value-Weighted		Product Level	
	Estimate	(s.e.)	Estimate	(s.e.)
Exchange rate (β)	0.592***	(0.030)	0.484***	(0.010)
Exporter CPI	0.038	(0.082)	0.073***	(0.022)
Canadian CPI	1.233***	(0.369)	0.311***	(0.062)
Canadian GDP	0.641**	(0.290)	0.735***	(0.061)
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.

References

Amiti, M., Itskhoki, O., and Konings, J., 2014. Importers, exporters, and exchange rate disconnect. American Economic Review, 104(7):1942-1978.

Amiti, M., Itskhoki, O., and Konings, J., 2015. International shocks and domestic prices: how large are strategic complementarities? Working paper.

Atkeson, A. and Burstein, A., 2008. Trade costs, pricing-to-market, and international relative prices. American Economic Review 98(5):1998-2031.

Auer, R., and Schoenle, R., 2015. Market structure and exchange rate pass-through. Working paper.

Bailliu, J., Dong, W., and Murray, J., 2010. Has exchange rate pass-through really declined? Some recent insights from the literature. Bank of Canada Review (Autumn):1-8.

Berman, N., Martin, P., and Mayer, T., 2012. How do different exporters react to exchange rate changes? Quarterly Journal of Economics 127(1):437-492.

Bouakez, H., Rebei, N., 2008. Has exchange rate pass-through really declined? Evidence from Canada. Journal of International Economics 75(2):249-267.

Burstein, A., and Gopinath, G., 2013. International prices and exchange rates. Handbook of International Economics, 4th Edition.

Campa, J., and Goldberg, L., 2005. Exchange rate pass-through into import prices. Review of Economics and Statistics, 87(4):679-690.

Cravino, J., 2014. Exchange rates, aggregate productivity and the currency of invoicing of international trade. Working paper.

Devereux, M. B., Engel, C., and Storgaard, P. E., 2004. Endogenous exchange rate pass-through when nominal prices are set in advance. Journal of International Economics, 63(2):263-291.

Dong, W., 2012. The role of expenditure switching in the global imbalance adjustment. Journal of International Economics, 86(2):237-251.

Dornbusch, R, 1987. Exchange rates and prices. American Economic Review, 77(1):93-106.

Engel, C., 2006. Equivalence results for optimal pass-through, optimal indexing to exchange rates, and optimal choice of currency for export pricing. Journal of European Economic Association, 4(6):1249-1260.

Feenstra, R., Gagnon, J., and Knetter, M., 1996. Market share and exchange rate pass-through

in world automobile trade. Journal of International Economics, 40(1-2):187-207.

Fitzgerald, D. and Haller, S., 2013. Pricing-to-market: evidence from plant-level prices. Review of Economic Studies, 81(2):761-786.

Friberg, R. and Wilander, F., 2008. The currency denomination of exports – A questionnaire study. Journal of International Economics, 75(1): 54-69.

Froot, K. A. and Klemperer, P. D., 1989. Exchange rate pass-through when market share matters. American Economic Review, 79(4):637-654.

Garetto, S., 2014. Firms' heterogeneity and incomplete pass-through. Working paper.

Goldberg, L. S. and Tille, C., 2008. Vehicle currency use in international trade. Journal of International Economics, 76(2):177-192.

Goldberg, L. S. and Tille, C., 2013. A bargaining theory of trade invoicing and pricing. Federal Reserve Bank of New York Staff Report No. 611.

Goldberg, L. S. and Tille, C., 2014. Micro, macro, and strategic forces in international trade invoicing. Updated version of Federal Reserve Bank of New York Staff Report No. 405 (2009).

Gopinath, G., 2015. The international price system. Paper presented at the Jackson Hole Symposium (August 28, 2015).

Gopinath, G., Itskhoki, O., and Rigobon, R., 2010. Currency choice and exchange rate pass-through. American Economic Review, 100(1):306-336.

Gopinath, G. and Neiman, B., 2014. Trade adjustment and productivity in large crises. American Economic Review, 104(3):793-831.

Gopinath, G. and Rigobon, R., 2008. Sticky borders. Quarterly Journal of Economics, 123(2):531-575.

Knetter, M., 1989. Price discrimination by U.S. and German exporters. American Economic Review, 79(1):198-210.

Krugman, P., 1987. Pricing to market when the exchange rate changes. In Arndt, S. and Richardson, J., editors, Real Financial Linkages among Open Economies, pages 49-70. MIT Press, Cambridge.

Marazzi, M. and Sheets, N., 2007. Declining exchange rate pass-through to U.S. import prices: the potential role of global factors. Journal of International Money and Finance, 26(6):924-947.

Neiman, B., 2010. Stickiness, synchronization, and pass-through in intrafirm trade prices. Journal of Monetary Economics, 57(3):295-308.