Exchange Rate Pass-Through, Currency Invoicing and Market Share

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Abstract

In this paper, we develop a model of monopolistic competition and international trade that makes three predictions about the relationship between exchange rate pass-through and firm/product characteristics. We first show that there is a U-shaped relationship between exporter market share and pass-through to import prices. Next, the model predicts a negative relationship between importer market share and pass-through. Finally, we show that exchange rate pass-through to import prices will be higher for goods priced in U.S. dollars (for importing countries other than the U.S.), and low for goods priced in the domestic currency. We then test these hypotheses using a unique data set that covers the universe of Canadian imports over a six-year time span. Our findings, that focus on a subset of nine product types, show strong support for both the pass-through and market share hypotheses as well as the pass-through and currency hypotheses.

JEL Classification: F3, F4

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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’ (at both the aggregate and individual firm levels), 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 (see Knetter, 1989, Campa and Goldberg, 2005, and Burstein and Gopinath, 2013).

It is an almost universally recognized fact that at all levels of aggregation, pass-through of exchange rate changes to prices 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 (Devereux, Engel and Storgaard, 2003) may be responsible for partial pass-through both at the import price level and the level of retail prices. These two explanations are not at all exhaustive, however. Other theories of low exchange rate pass-through stress the role of distribution costs, or composition effects (Burstein, Neves and Rebelo, 2003, Nakamura and Zerom, 2010). Nor are the theories mutually exclusive—Engel (2006) and Gopinath et al. (2010) argue that the decision to engage in local currency pricing, which implies low short run pass-through, may coincide with the motivation for pricing to market, which, in turn, implies less than complete long run pass-through.

Progress in this literature has always been constrained by data availability. Recently, many studies of exchange rate pass-through have availed of more detailed micro data sets of goods prices (see Gopianath et al., 2011, for example). But it has been difficult to obtain comprehensive matched data on currency of invoicing and goods prices. The papers by Gopinath and Rigobon (2008) and Gopinath et al. (2010) focus on U.S. export and import price data. But it is widely accepted that the U.S. 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).¹

This paper adds to the literature on exchange rate pass-through by first developing a model of monopolistic competition that has three testable implications relating the relationship between pass-through, the currency of import price invoicing and the market share of exporters and importers. More specifically, we present a flexible price model to explore the determinants of exchange rate pass-through into import prices, then add sticky prices to emphasize the critical role of currency of pricing.

The model predicts a U-shaped relationship between pass-through and exporter market share (a prediction similar to the models presented in Auer and Schoenle, 2013, and Garetto, 2014). Firms with a small market share are usually small firms that charge a small markup. As a result, they have little room to adjust their markup, and hence their price, in the face of exchange rate movements. For this reason, they must pass all movements in the exchange rate on to the importing firm, and as a result, pass-through will be high. As market share increase, so does firm size and markups. This gives the exporting firm more room to adjust their markup and price to market, to maintain market share, which implies lower pass-through. However, once firms have sufficient market share, they no longer need to adjust their foreign currency price to maintain market share, and therefore pass-through increases. This all results in a U-shaped relationship between pass-through and exporter market share.

¹There is a growing literature using data for other countries. See, for example, Fitzgerald and Haller, 2013 (Ireland), Amiti et al., 2012 (Belgium), and Cravino, 2014 (Chile).
In addition, the model also predicts a negative relationship between pass-through and importer market share. Assuming importers differ in their demand elasticity so that importers with lower costs (or larger importers) have a higher elasticity of demand, the pass-through is lower for sales to importers with a higher elasticity of demand. The higher the elasticity of demand is, the more an exporter’s market share will decrease when it passes through exchange rate shocks. When the exporter is small, its concern for a reduced market share will limit the degree of exchange rate pass-through.

Finally, this model predicts that firms that prefer lower pass-through to import prices will choose to invoice in the currency of the importing country. Those that prefer higher pass-through will choose their own currency or the U.S. dollar. The model shows that in the context of a small open economy, pass-through will be highest for goods priced in U.S. dollars and lowest for the domestic currency.

Our next step is to take these three predictions to the data. We use a new and extremely large data set on Canadian import prices at a highly disaggregated level. The data includes the universe of Canadian imports over a six-year period from 2002-2008. The rich nature of the data allows us to investigate how exchange rate pass-through differs for different categories of imports, for different currencies of invoice, by country of origin and currency of export, and a series of other features of import prices. In this paper, we focus on nine products or sectors, which make up roughly thirty percent of all Canadian imports (by value) in any given month. The data set tracks every single import into Canada, and we use unit values (shipment value divided by the number of units) as a proxy for price. We start by measure overall pass-through in each product category and find that there is significant variation. For example, pass-through to import prices in Industrial Machinery is at 0.66 (that is, a one percent increase in the exchange rate is associated with a 0.66 percent increase in Canadian-dollar import prices), but it is only 0.30 for Vegetable Products. Pass-through estimates for all other industries fall within this range.

We then use these data to test the three predictions of the model. We look into the relationship between pass-through and market share and find strong evidence of a U-shaped relationship between pass-through and exporter market share and a downward sloping relationship between pass-through and importer market share. In addition, we look at the interactions between importers and exporters of the same and different size and find that relationships identified on pass-through versus exporter and importer market shares still hold when we maintain the size of the trading partner constant.

We also find strong evidence that pass-through is higher for U.S. dollar-priced goods than for Canadian-dollar priced goods (a finding that is similar to what is found in Gopinath et al., 2010), as this holds for all nine products/sectors. We also find that pass-through to Euro-priced goods is general higher than Canada-dollar priced goods.

The paper proceeds as follows. Section 2 presents the theoretical discussion. Section 3 describes the data and provides summary statistics. In section 4, we present the empirical model and test the predictions of the model. Finally, Section 5 concludes.
2. Theoretical Discussion

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

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

Assume that in each sector there are $N$ products each of which is sold by a unique exporter, and $M$ importing firms. Thus, there are $N$ firms on the supply side of the market, $M$ firms on the demand side, and $N$ products sold within each market. Each exporter $i \in N$ sells product $i$ to all $M$ importers. We assume that $N$ may be relatively small, so that exporters set prices strategically. In addition, exporters are assumed to be able to 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:

$$x_{ij} = p_{ij}^{-\rho_j} p_j^{\rho_j - \eta} X_j$$  \hspace{1cm} (2.1)

where $p_{ij}$ is exporter $i$’s price for importer $j$, evaluated in importers currency, and $p_j$ is the sectoral or market price index for importer $j$ (also in importer currency)$^2$. As we noted, it is assumed that $N$ is small enough that firm $i$ takes into account the impact of its pricing decision on the sectoral price

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$^2$Here maintain the assumption of constant demand elasticity $\rho_j$. 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.
index. In addition, as discussed above, we allow for the inner demand elasticity $\rho_j$ to be specific to the importer, while assuming that the elasticity of demand across markets $\eta$ is the same for all importers. As is usual, we assume that $\rho_j > \eta$, so that the elasticity of demand for individual goods is greater than the elasticity of demand for the sectoral composite good. In addition we assume that $\rho_j > 1$ and $\eta > 1$. Finally, we allow for importers to be different in total size or market share, as reflected in the scale factor $X_j$. As shown in the appendix, the distribution of importer market shares will be determined by the distribution of productivity among importing firms in the production of goods for retail sale using the basket of products that they purchase from exporters. The sectoral price index for importer $j$ is defined as:

$$ p_j = \left[ \sum_{i=1}^{N} \frac{1}{p_{ij}^{1-\rho}} \right]^{\frac{1}{1-\rho}} $$  \hspace{1cm} (2.2)

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

$$ c(y_{ij}, w_i, a_i) $$  \hspace{1cm} (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

$$ c(y_{ij}, w_i, a_i) = y_{ij} \phi(w_i, a_i) $$  \hspace{1cm} (2.4)

and we assume that $\phi(w_i, a_i)$ is increasing in all elements of $w_i$, and $\phi_2(w_i, a_i) \leq 0$.

2.1. Pass-through and Market Shares

If prices are fully flexible, the currency in which the firm sets its price is irrelevant. Thus, without loss of generality, say the firm sets its price in home currency (local currency).

Evaluated in home currency, the exporter’s profit is then defined as:

$$ \sum_{j}^{M} p_{ij} x_{ij} - \sum_{j}^{M} y_{ij} s_i \phi(w_i, a_i) $$  \hspace{1cm} (2.5)

where $s_i$ is the exchange rate for product $i$ (the importer currency price of a unit of exporter currency).

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

$$ p_{ij} = \frac{\epsilon_{ij}}{\epsilon_{ij} - 1} s_i \phi(w_i, a_i) $$  \hspace{1cm} (2.6)

where $\epsilon_{ij}$ is defined as the firms demand elasticity, given by:

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

\[
\left[ \frac{p_{ij}}{p_j} \right]^{1-\rho} = \frac{p_{ij}x_{ij}}{\sum_{i=1}^{N} p_{ij}x_{ij}} \equiv \theta_{ij}(w_i, a_i).
\] (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, \( \theta_{ij} \) is negatively related to the firms input cost \( w_i \) and positively related to the firm’s productivity \( a_i \). Given this notation, we can define the elasticity of demand for sales to importer \( j \) as

\[
\epsilon(\theta_{ij}) = \rho_j - (\rho_j - \eta)\theta_{ij},
\]
and this elasticity is decreasing in the firm’s market share, given that \( \rho_j > \eta \).

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

\[
\frac{d\log p_{ij}}{d\log s_i} = \frac{1}{1 + \omega} + \frac{\omega}{(1 + \omega)(1 - \theta_{ij})} \sum_{k \neq i} \theta_{kj} \frac{d\log p_{kj}}{d\log s_i} + \frac{1}{1 + \omega} \hat{\phi}_i \frac{d\log w_i}{d\log s_i}
\] (2.9)

where \( \hat{\phi}_1 \equiv \frac{\phi_1 w_i}{\delta} \), and \( \omega = -\frac{d\log(\mu)}{d\log(p_{ik})} \) is the elasticity of the markup to the firm’s price. We can calculate this elasticity as follows:

\[
\omega = \frac{(\rho - \eta)(\rho - 1)\theta_{ij}(1 - \theta_{ij})}{\epsilon(\theta_{ij})(\epsilon(\theta_{ij}) - 1)}.
\] (2.10)

The predictions for exchange rate pass-through from (2.9) depend on the elasticity of the markup, the extent to which the firm’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 \( \hat{\phi}_i \frac{d\log w_i}{d\log s_i} \) in (2.9) in the following way. We assume that changes in the exchange rate does not directly affect either the exporter currency prices of inputs in the exporters country, the prices of local inputs into the good in the importers currency, or the price of importers intermediate goods that the exporter may use from third countries. Assume also that the share of local (importing country) inputs in the good is \( \gamma_1 \), the share of third country intermediate imported inputs is \( \gamma_2 \), and the sensitivity of the exchange rate of the country where intermediate inputs are purchased relative the importing country’s exchange rate is \( \varphi \). Then it follows that

\[
\hat{\phi}_i \frac{d\log w_i}{d\log s_i} = -(\gamma_1 + \gamma_2 \varphi)
\] (2.11)

Then from (2.9), we have that:

\[
\frac{d\log p_{ij}}{d\log s_i} = \frac{1 - \gamma_1 - \gamma_2 \varphi}{1 + \omega}.
\] (2.12)

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

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

\[
\frac{d\omega}{d\theta_{ij}} = \frac{\eta(\eta - 1)\theta_{ij}^2 - \rho(\rho - 1)(1 - \theta_{ij})^2}{\epsilon(\epsilon - 1)(\theta_{ij}^3 - 1)^2}.
\]

(2.13)

Given the assumption \( \theta_{ij} \) close to zero, this is negative, while for \( \theta_{ij} \) close to unity, it is positive. Hence, the relationship between pass-through and exporter market share is non-monotonic. Intuitively, for \( \theta_{ij} \) 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 \( \theta_{ij} \). Exchange rate pass-through depends not on the markup itself, but on the elasticity of the markup \( \omega \), which is itself a function of the ‘elasticity of the elasticity’ of demand for the firm’s good in sector \( j \). For very low \( \theta_{ij} \), the elasticity of the markup with respect to price is increasing in \( \theta_{ij} \). 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 \( \theta_{ij} \). But as \( \theta_{ij} \) 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 \( \theta_{ij} \), and so exchange rate pass-through is declining in \( \theta_{ij} \). 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.\(^3\) But pass-through will in general depend on the own elasticity of demand \( \rho_j \). In the above discussion, we described the reason that larger importers would have a higher elasticity of demand. How does this affect the degree of exchange rate pass-through? Again using the definition of (2.10) we may establish that:

\[
\frac{d\log \omega}{d\log \rho_j} = \Gamma \left[ \frac{(\rho_j - 1)^2}{(\rho_j - \eta)^2} - \theta(1 - \frac{1}{\eta}) + \frac{1}{\eta} \right].
\]

(2.14)

where \( \Gamma > 0 \).\(^4\)

Since we have assumed that \( \rho > \eta > 1 \), and \( 0 \leq \theta \leq 1 \), the expression in square brackets on the right hand side of (2.14) is positive. Hence, \( \omega \) is increasing in \( \rho_j \) for all values of \( \theta \) between 0 and 1, and therefore exchange rate pass-through is decreasing in \( \rho_j \). Thus, exchange rate pass-through is systematically lower for sales to importers with a higher elasticity of demand. The intuition for this is

\(^3\)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 also.

\(^4\)\( \Gamma = \frac{\eta(\rho_j - \eta)^2}{(\rho_j - 1)^2} \).
clear. When the firm raises its price in response to an exchange rate shock, its concern for a reduced market share will limit the degree of pass-through. But the firm’s market share will fall more, the higher is the elasticity of demand. Hence, while a high elasticity of demand does not in itself lead to lower pass-through, the combination of a high elasticity and strategic price adjustment with variable market share implies a lower exchange rate pass-through.

If, as we have discussed above, importing firms that have a larger share of the market have higher elasticity of demand, then (2.14) implies that exchange rate pass-through should be lower, the larger the importing firms 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 given, 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 this prediction is supported.

Figure 1 illustrates the relationship between the exchange rate pass-through term $\frac{1}{1+\omega}$ and the firm’s share of market $j$, $\theta_{ij}$, assuming $\rho_j = 5$ and $\eta = 2$. As described above, exchange rate pass-through begins at unity when $\theta_{ij} = 0$, but falls to around 0.7 for intermediate values of $\theta_{ij}$. As $\theta_{ij} \to 1$, pass-through becomes complete again. Figure 1 also illustrates the relationship between pass-through and $\theta_{ij}$ for a higher elasticity $\rho_j = 8$. Again, for $\theta = 0$ or 1, pass-through is unaffected. But in intermediate ranges of $\theta_{ij}$, 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 0.5 when $\rho_j = 8$.

In the examples so far, 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 $i$. 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 $j$ 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:

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

We see that because there is no direct effects 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 $\theta_{ij}$ 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,

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5For this figure and those that follow, we assume that $\gamma_1 = \gamma_2 = 0$. To be consistent with the empirical findings however, it is important to allow for these factors, since in the data we find that even firms with very low market share have exchange rate pass-through that is below unity.
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. $\omega_{kj}$ 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 $\theta_{ij}$ between zero and unity, but is zero at the boundaries.

Figure 2 illustrates this result for $N = 2$, so there are only 2 firms in the industry. The first point to note from the Figure is that the essence of the results from Figure 1 still obtain. 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 rival firms response. This is shown by the comparison in Figure 2 of the case with and without price adjustment on the part of firms $k$. The second point of the Figure is to see that all other firms will have an inverse U shaped relationship between pass-through and $\theta_{ij}$. Their pass-through is highest for intermediate values of $\theta_{ij}$. We note also that the relationship between firm $i$’s pass-through and firm $k$’s pass-through takes quite distinctly separate phases. For low levels of $\theta_{ij}$, pass-through across the firm’s $i$ and $k$ move in opposite directions in response to a rise in $i$’s market share - thus, we can think of price responses being strategic substitutes. For intermediate levels of $\theta_{ij}$, both firm $i$ and firm $k$’s pass-through is declining in $\theta_{ij}$, so there is a situation of strategic complementarity. Finally, for $\theta_{ij}$ close to unity, firm $i$’s pass-through has passed its minimum in $\theta_{ij}$ and is rising, while firm $k$’s pass-through continues to decline in $\theta_{ij}$, so that again pass-through are strategic substitutes.

Figure 3 illustrates 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 firm 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 \( \theta_{ij} \) is essentially the same as in Figure 1, where we ignored the response of other firms in the market.

Finally, Figure 4 returns to the \( N = 2 \) case, but as in Figure 1, illustrates the pass-through response for the baseline case and the high elasticity case. Again, we see that firm \( i \)'s pass-through will be reduced in the case of a large (high-elasticity) importing firm. But interestingly the results for pass-through of other firms go in the opposite direction. That is, in selling to a large importer, there should be a higher price adjustment for firms not directly affected by the exchange rate shock than in the case of a smaller importer. While this implication may seem surprising, it is quite intuitive. With a higher demand elasticity, firms in an industry will have prices which are closer to one another. So a cost shock which leads to an increase in one firms 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.

How does 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 measure 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
Figure 3: Exchange Rate Pass-Though and Market Share with Four Firms ($N = 4$)

Figure 4: Exchange Rate Pass-Though and Market Share
of (2.9) with
\[
\frac{\text{cov}(\Delta \log p_{ij} \Delta \log s_i)}{\text{var}(\Delta \log s_i)}
\]

2.1.1. Country Shares versus firms shares

Up to now, we have implicitly assumed that all exporting firms produce in the same country, so the exchange rate relevant for affecting the import price is the same for all firms. But our data includes the full set of countries that export to Canada within any given sector. Hence the exchange rate affecting marginal costs will be country specific. Even if all firms within a given country are equally responsive to an exchange rate change, pass-through for a given sector may be limited because a price increase will affect the price of exported goods from that country relative to the rest of the world’s exports, within each sector. Because of this, we define the sectoral market share of a country as opposed to a firm within each sector, as follows. Let the market share of all goods to importer \( j \) from country \( z \) be:

\[
\theta_{jz} = \sum_{i, i \in z} \theta_{ijz}
\]

To see how this affects pass-through, assume that all firms within a country have identical market costs and therefore are affected equally by an exchange rate change between the home country and country \( z \) (where we denote this as \( s_z \)). Then exchange rate pass-through in response to a change in \( s_z \) (again ignoring local and intermediate imported inputs in the market share expression) is

\[
\frac{d \log p_{ijz}}{d \log s_z} = \frac{a(1 - \theta_{ijz})}{(1 - \theta_{ijz}) + \omega(1 - \theta_{iz})}
\]

(2.16)

This expression indicates that pass-through will depend sensitively on the relationship between the market share of an individual firm and the market share of a country. Take for instance the case of just one firm \( i \) in a country, which has market share \( \theta_{jz} = \theta_{ijz} \) of the overall market for sale to importer \( i \). Then pass-through expression is as before. But imagine instead that the country \( z \) has the full market share of sales to importer \( i \), so that \( \theta_{jz} = 1 \). Then exchange rate pass-through for firm \( j \) will be unity, whatever is the market share of the individual firm \( j \). This follows because the competitive position of all firms in the market are affected in exactly the same way by the exchange rate change when \( \theta_{jj} = 1 \). So in an equilibrium response, the concern for market share of any one firm \( j \) will not impact on its rate of pass-through. Equivalently, when it is adjusts its price to the exchange rate change, all other firms in the market will do likewise, so there is no change in its relative price.

This discussion indicates that it is important to control not just for the firm’s market share in exchange rate pass-through, but also the country market share. Conditional on the firm’s market share, exchange rate pass-through for any given firm should be higher, the higher is the country market share.
2.2. Sticky Prices and the Choice of Invoicing Currency

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

As we make more clear below, our measure of exchange rate pass-through is 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 (2007) shows an intimate 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 et al. (2010) extend Engel’s result to a model of Calvo staggered pricing. They show that the critical determinant of the currency of pricing is what they define as ‘medium run pass-through’, which measures the pass-through of exchange rate changes to a firm’s price after it has an opportunity to adjust its price.

The implication of these theories is that the causal relationship 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 transitions in its domestic currency (PCP), while a firm with low pass-through is more likely to invoice in Canadian dollars. Gopinath et al. (2010) show that if firms 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 our notation, we should anticipate that a given firm will invoice in its own currency (Canadian dollars) rather than in its own currency when

$$\frac{\text{cov}(\Delta \log p_t, s^*_t)}{\text{Var}(\Delta \log s^*_t)} > (<) \frac{1}{2}$$

(2.17)

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 be have transactions invoiced in the currency of the exporting country. In general we will find this prediction supported in our data. From a broader perspective, condition (2.17) implies that there should be a significant difference in pass-through measures between Canadian dollar invoiced goods and non-Canadian dollar invoiced goods. This prediction is strongly supported by our estimates.
3. Data

3.1. Customs Data

We use data from the Canadian Border Services Agency (CBSA) that contains information on every single commercial import/shipment into Canada from July 2002 to August 2008.\(^6\) The data is collected by the CBSA and housed at Statistics Canada. It contains 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 which finally exported the good directly to Canada, and several other pieces of information that are important for the analysis of exchange rate pass-through.

As a proxy for prices, we use unit values defined as total shipment value divided by the number of units.\(^7\) 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 not provided with an exact date a given shipment crossed the border and are only provided 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 Canada dollars, we have a monthly bilateral exchange rate. In the next sub-section, we explain how we convert this 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 (the number is scrambled for confidentiality reasons) that allows us to track a single Canadian buyer over time. Other than this, we have limited information about the buyer other than the province in which it is located. On the exporter side, we have a vendor identifier, which allows us to track a single exporter over time. What we do not know is whether this vendor is a producer or an intermediary—the identifier is built from the company name provided on the customs sheet, which refers to the company ultimately responsible for shipping the good to the border.

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

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\(^6\)This data set is similar to the Argentine import customs data used in Gopinath and Neiman (2013).

\(^7\)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 raised in Berman, Martin and Mayer (2012) and Amiti, Itskhoki and Konings (2012) who use similar data. In Section 3.2, we provide a very specific definition of a product that can be tracked over time that address these issues, to some extent, but the empirical results that we present must be interpreted with the understanding of these possible data limitations.
Finally, the data set provides a value for duty code, which, among other things, lets us know whether a reported import represents a transaction among affiliated companies (intra-firm trade). For our analysis, we drop all of these imports as we want to focus on inter-firm trade, and the model presented above reflects this fact.  

3.2. Panel Design: Defining Monthly Prices

In order 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 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. In order 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 importing firm ($f$), exporting firm ($v$), HS10 product ($p$), country of origin ($o$), country of export ($e$), currency ($c$), unit of measurement ($u$) and time ($t$) specific. For clarity of exposition, let $s = \{f, v, p, o, e, c, u\}$. We define the price of good $s$ in month $t$ as:

$$P_{st} = \sum_{i=1}^{n}(\alpha_{ist} \cdot P_{ist})$$  \hspace{1cm} (3.1)

where $i$ is an individual transaction (or import) and $\alpha_{ist}$ is a weight, defined as the relative shipment size to total shipments of the good $s$. That is:

$$\alpha_{ist} = \frac{\text{Shipment}_{ist}}{\sum_{i=1}^{n}\text{Shipment}_{ist}}$$  \hspace{1cm} (3.2)

where $\text{Shipment}_{ist}$ 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 Canada 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 a “collapsed” or “condensed” data set 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.

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8See Neiman (2010) for an analysis of pass-through and intra-firm trade.
3.3. Summary Statistics

In any given month, we observe approximately five million shipments (we have data for 72 months and the total data set has just under 400 millions 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 eighty 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). As for the currency of invoice, overall, 88 percent of weighted imports and 86 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 that has information on the currency of invoice (see citations). Across the nine products categories, we see that there is some variation in the currency of invoice. For example, in terms of the total value of imports, at one extreme only 64.6 percent of food and beverage imports are priced in U.S. dollars (with a significant portion, 33.3 percent, priced in Euros), while at the other end, 93.3 percent of vegetable product imports are priced in U.S. dollars.

<table>
<thead>
<tr>
<th>Table 1: Summary Statistics — Currency of Invoice</th>
</tr>
</thead>
<tbody>
<tr>
<td>HS Code</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Overall</td>
</tr>
<tr>
<td>Vegetable Products 07-14</td>
</tr>
<tr>
<td>Food and Beverage 16-22</td>
</tr>
<tr>
<td>Chemical Products 28-35</td>
</tr>
<tr>
<td>Textiles 50-60</td>
</tr>
<tr>
<td>Apparel 61-62</td>
</tr>
<tr>
<td>Footwear 64</td>
</tr>
<tr>
<td>Metal Products 72-81</td>
</tr>
<tr>
<td>Industrial Machinery 84</td>
</tr>
<tr>
<td>Consumer Electronics 85</td>
</tr>
</tbody>
</table>

Note: Within the HS2 ranges provided, some HS2 and HS4 products are dropped due to a lack of units of measurement, and hence an inability to calculate unit values.

Given that we have both importing and exporting firm identifiers in our data, we can calculate market shares for both groups. In order to do this, we must decide the level of aggregation at which we want to define market share. After experimenting with a number of definitions, we decided that defining

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9In 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.
market share at the HS6 was the suitable level of aggregation. That is, either for exporters or importers, we define market share as a given firm’s market share, 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 classification). With this, it is informative to examine the intersection of market share and the currency of invoice.

In Table 2, we present the share of overall imports accounted for by firms in the market shares quintiles. For both importers and exporters, and in terms of value and at the product level, importers and exporters in the first quintile of the market share distribution account for the majority of imports. However, in terms of import value, the other quintiles account for a non-negligible portion of imports. For exporters, the share of imports in U.S. dollars is fairly constant across the market share quintiles—falling within 87 and 91 percent. The share of Canadian-dollar- and Euro-priced goods varies very little across the exporter quintiles.

### Table 2: Currency of Invoice by Market Share

<table>
<thead>
<tr>
<th>Import Market Share Quintile</th>
<th>Weighted by Value</th>
<th>Unweighted – Product Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Share of Imports (%)</td>
<td>USD</td>
</tr>
<tr>
<td><strong>Importers</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>66.8</td>
<td>89.6</td>
</tr>
<tr>
<td>2</td>
<td>13.6</td>
<td>89.3</td>
</tr>
<tr>
<td>3</td>
<td>7.7</td>
<td>71.7</td>
</tr>
<tr>
<td>4</td>
<td>4.7</td>
<td>78.5</td>
</tr>
<tr>
<td>5</td>
<td>7.3</td>
<td>93.3</td>
</tr>
<tr>
<td><strong>Exporters</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>76.2</td>
<td>87.2</td>
</tr>
<tr>
<td>2</td>
<td>12.2</td>
<td>91.4</td>
</tr>
<tr>
<td>3</td>
<td>4.5</td>
<td>87.9</td>
</tr>
<tr>
<td>4</td>
<td>2.6</td>
<td>90.2</td>
</tr>
<tr>
<td>5</td>
<td>4.6</td>
<td>90.4</td>
</tr>
</tbody>
</table>

Note: An importer (exporter) is identified as being in a given quintile of the import market share based on the value of all their imports (exports) at the HS6 level within a given year. With definition, it is possible that a firm is in different quintiles in different years.

What is striking 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 the first quintile of the importer market share are priced in Canadian dollars. However, 21 percent of the value of imports by the third quintile are priced in Canadian dollars, and roughly 20 percent for the fourth quintile. This number drops to 4 percent for the fifth quintile. There is a similar pattern for the product-level measures of imports. In the next section, we take these stylized facts into account when testing the implications of the model.
4. Empirical Analysis

4.1. Exchange Rate Pass-Through

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

\[
\Delta \tau p_{st} = c + \beta_e \Delta \tau e_{st} + Z_{st}' \gamma + \epsilon_{st}
\]  

(4.1)

where \(\Delta \tau p_{st} = \ln(P_{st}) - \ln(P_{st})\) is expressed in Canadian dollars and \(\tau\) 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. \(\Delta \tau e_{st}\) 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. Note that this is a similar set of control variables to that used in Gopinath, Itskhoki and Rigobon (2010), and given that we are looking at cumulative changes in variables over time, this setup is equivalent to the medium-run pass-through regressions in that paper.

Table 3 presents the results for overall pass-through for each of the nine products/sectors with and without weights.\(^{10}\) The overall estimate of exchange rate pass-through (pooling all products together) is approximately 48 percent without weights, and 59 percent using value weights. We also see that there is a significant amount of variation across the products/sectors. At one extreme, in terms of value weighted results, the pass-through coefficient for apparel is 0.826 and significant at the 1% level. At the other end, the pass-through coefficient for vegetable products is 0.214, and it, too, is significant at the 1% level. The other pass-through point-estimates fall within this range, with pass-through for footwear and industrial machinery exhibiting high pass-through at 0.744 and 0.752, respectively, and metal products at the lower end with a point estimate of 0.422. Most of these findings are in line with the findings for many other countries that pass-through is incomplete. The amount of variation is surprising.

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

Now we move on to test some of the implications of the model. We start with pass-through and the currency of invoice. As documented in Table 1, there is some variation within products/sectors when it comes to the currency of invoice. The model predicts that pass-through rates will be associated with different currency types: exporters that price to market will be more likely to price their goods in Canadian dollars (CAD) and will therefore have lower pass-through to the Canadian-dollar import price; those that price in a foreign currency are less likely to price to market, and therefore pass-through

\(^{10}\) Table B.7 in Appendix B presents the pass-through estimates for all the products pooled together, along with the coefficients on the other variables.
Table 3: Exchange Rate Pass-Through Estimates

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

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 product and time fixed effects. We restrict the sample to price changes within the -100% to +100% range.

The coefficient \(\beta_1\) will pick up the degree of pass-through for goods priced in currencies other CAD, USD and EUR (this is understood to be a very small set of goods). Pass-through to CAD-priced goods will be \(\beta_C = \beta_1 + \beta_2\), to USD-priced goods it will be \(\beta_U = \beta_1 + \beta_3\), and to EUR-priced goods \(\beta_E = \beta_1 + \beta_4\).

Table 4 presents the results of the estimation. Note that these results are from unweighted regressions, to better reflect the assumptions and mechanisms presented in the model. Columns 2-6 show the estimates and the standard errors, while columns 7-9 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 USD-priced goods than for CAD-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 pass-through for USD-priced goods is 0.702 and it is 0.078 (and not significant) for CAD-priced goods. For most products/sectors it is also the case that the rate of pass-through is higher for EUR-priced goods than for CAD-priced goods. For example, in food and beverage products, pass-through to EUR-priced goods is 0.684, which is larger and significantly different from the CAD-priced estimate.
### Table 4: Pass-Through and Currency Choice

<table>
<thead>
<tr>
<th>Product</th>
<th>CA Dollar $\beta_C$ (s.e.)</th>
<th>US Dollar $\beta_U$ (s.e.)</th>
<th>Euro $\beta_E$ (s.e.)</th>
<th>$\beta_C - \beta_U$</th>
<th>$\beta_C - \beta_E$</th>
<th>$\beta_U - \beta_E$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>0.137*** (0.01)</td>
<td>0.502*** (0.01)</td>
<td>0.497*** (0.01)</td>
<td>-0.37***</td>
<td>-0.36***</td>
<td>0.01</td>
</tr>
<tr>
<td>Vegetable Products</td>
<td>0.300*** (0.04)</td>
<td>0.325*** (0.01)</td>
<td>0.547*** (0.06)</td>
<td>-0.07</td>
<td>-0.25***</td>
<td>-0.22***</td>
</tr>
<tr>
<td>Food and Beverage</td>
<td>0.020</td>
<td>0.481*** (0.02)</td>
<td>0.684*** (0.03)</td>
<td>-0.46***</td>
<td>-0.66***</td>
<td>-0.20***</td>
</tr>
<tr>
<td>Chemical Products</td>
<td>0.128*** (0.04)</td>
<td>0.459*** (0.02)</td>
<td>0.521*** (0.06)</td>
<td>-0.32***</td>
<td>-0.39***</td>
<td>0.06</td>
</tr>
<tr>
<td>Textiles</td>
<td>0.096*** (0.05)</td>
<td>0.587*** (0.02)</td>
<td>0.484*** (0.04)</td>
<td>-0.49***</td>
<td>-0.30***</td>
<td>0.10***</td>
</tr>
<tr>
<td>Apparel</td>
<td>0.123*** (0.02)</td>
<td>0.623*** (0.01)</td>
<td>0.484*** (0.02)</td>
<td>-0.50***</td>
<td>-0.36***</td>
<td>0.14***</td>
</tr>
<tr>
<td>Footwear</td>
<td>0.078</td>
<td>0.702*** (0.02)</td>
<td>0.562*** (0.04)</td>
<td>-0.62***</td>
<td>-0.48***</td>
<td>0.14***</td>
</tr>
<tr>
<td>Metal Products</td>
<td>0.193*** (0.03)</td>
<td>0.451*** (0.01)</td>
<td>0.255*** (0.04)</td>
<td>-0.26***</td>
<td>-0.06</td>
<td>0.20**</td>
</tr>
<tr>
<td>Industrial Machinery</td>
<td>0.211*** (0.04)</td>
<td>0.597*** (0.01)</td>
<td>0.589*** (0.06)</td>
<td>-0.39***</td>
<td>-0.38***</td>
<td>0.01</td>
</tr>
<tr>
<td>Consumer Electronics</td>
<td>0.169*** (0.06)</td>
<td>0.620*** (0.02)</td>
<td>0.740*** (0.08)</td>
<td>-0.45***</td>
<td>-0.57***</td>
<td>-0.12</td>
</tr>
</tbody>
</table>

**Note:** Given that USD is the most common currency in Canadian imports, it is not surprising that the coefficient estimates are USD transactions are closest to the overall pass-through estimates presented in Table 3. Nevertheless, there is some variation in currency within products/sectors, and understanding the relationship between the currency of invoice and pass-through is important for understanding overall pass-through.

### 4.3. Exchange Rate Pass-Through and Market Share

We now move on to the other predictions of the model: there exists a U-shaped relationship between exporter market share and exchange rate pass-through, and a monotonically decreasing relationship for importers. That is, for exporters, starting from a very small market share, as market share increases, the degree of pass-through will decrease, as firms gain some market power, charge higher markups and are able to price to market, to some degree, to maintain market share. At a certain point, market share becomes large enough that a firm need not price to market, at which point the degree of pass-through will begin to increase as market share grows. For importers, the larger the firm (in terms of market share), the higher the elasticity of demand and the lower the pass-through. To test these hypothesis, we run the following regression:

$$\Delta \tau_{p_{st}} = c + \alpha MS_{ft} + \beta_0 \Delta \tau e_{st} + \beta_1 [\Delta \tau e_{st} * MS_{ft}] + \beta_2 [\Delta \tau e_{st} * MS_{ft}^2] + Z_{st}^{\prime} \gamma + \epsilon_{st} \tag{4.3}$$

where $MS_{ft}$ refers to the market share (at the IHS6 product level) of a good exported or imported by firm $f$ at time $t$. This term, along with squared and cubed terms, are interacted with the exchange rate to capture the degree of curvature in the pass-through–market share relationship.

The results are presented in Table 6. For each product/sector, the coefficient estimates for $\beta_0$, $\beta_1$ and $\beta_2$ can be used, along with varying market shares, to map out the pass-through–market share relationship. In this setup, the coefficient on the cumulative log change in the exchange rate, $\beta_0$, represents the degree of pass-through if market share is zero. Columns (I) and (II) present the results...
for exporter market share, and columns (III) and (IV) present the results for importer market share. For exporter market share, in column (I) the coefficient on the exchange rate-market share interaction term is negative (-0.099) and significant, suggesting a negative relationship between exporter market share and pass-through. In column (II), we include an interaction term between the exchange rate and market share squared. The coefficient on the linear interaction terms is negative and significant, while the coefficient on the non-linear interaction term is positive and significant. This is evidence of a U-shaped relationship.

Table 5: Market Share and Pass-Through

<table>
<thead>
<tr>
<th></th>
<th>(I)</th>
<th>(II)</th>
<th>(III)</th>
<th>(IV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market share</td>
<td>-0.007***</td>
<td>-0.007***</td>
<td>-0.005***</td>
<td>-0.005**</td>
</tr>
<tr>
<td></td>
<td>(0.003)</td>
<td>(0.003)</td>
<td>(0.002)</td>
<td>(0.002)</td>
</tr>
<tr>
<td>Exchange rate</td>
<td>0.486***</td>
<td>0.487***</td>
<td>0.488***</td>
<td>0.486***</td>
</tr>
<tr>
<td></td>
<td>(0.004)</td>
<td>(0.004)</td>
<td>(0.004)</td>
<td>(0.004)</td>
</tr>
<tr>
<td>ER*(Exporter market share)</td>
<td>-0.099*</td>
<td>-0.290***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.056)</td>
<td>(0.111)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ER*(Exporter market share)²</td>
<td>0.402**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.201)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ER*(Importer market share)</td>
<td></td>
<td>-0.122***</td>
<td>-0.078</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.034)</td>
<td>(0.078)</td>
<td></td>
</tr>
<tr>
<td>ER*(Importer market share)²</td>
<td></td>
<td>-0.397***</td>
<td></td>
<td>(0.140)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.003**</td>
<td>0.003**</td>
<td>0.003**</td>
<td>0.003**</td>
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<tr>
<td></td>
<td>(0.002)</td>
<td>(0.002)</td>
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<tr>
<td>Obs.</td>
<td>7,993,402</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>R²</td>
<td>0.003</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Each regression includes combined (importing firm–product–(country of origin)–(country of export)–currency fixed effects.

For importer market share, there is evidence of a monotonically decreasing relationship between pass-through and market share. In column (IV), the coefficient on the linear interaction term is not significant, whereas the non-linear term is negative and significant. This suggests a downward slopping relationship, and we see further evidence of this in column (III).

Using the coefficients from columns (II) and (III), Figure 5 plots market share against pass-through for importers and exporters. We see in this chart that there is a U-shaped relationship for exporters and a downward-slopping relationship for importers.

The model outlined above makes predictions about the pass-through-market share relationship for importers and exporters while holding the market share of the trading partner constant. So far in our empirical work, we have not controlled for the market share of the trading partner (of importers if we are looking at the market share of exporters, and vice versa for importers). In Table 6, we present results for when we hold the market share of the trading partner constant. More specifically, we look at pass-through across different exporter (importer) market shares while holding the market share of the importer (exporter) constant. We focus mainly on the case where the trading partner falls within the first quintile of the market share distribution.

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

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

In this section, we explore how changes in market shares over time may be influencing overall exchange rate pass-through. We begin by running rolling regressions to get an estimate of pass-through over time. More specifically, we run the regression (4.1) on twelve months windows, moving up one month at a time. The whole data set covers seventy months, therefore the rolling-window methodology allows us to derive 58 pass-through estimates. We present the weighted pass-through estimates in Figure 6, 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.

![Figure 6: Exchange Rate Pass-Though Over Time and Market Share](image)

5. Conclusions

We develop a model that provides three predictions about the relationship between exchange rate pass-through and certain firm and product characteristics. First, exchange rate pass-through varies by currency of invoice; second, there is a U-shaped relationship between exporter market share and pass-through; and lastly, the relationship between importer market share and pass-through is monotonically decreasing. This paper remains a work in progress and these empirical results are preliminary. Nevertheless, we find evidence in favour of the three predictions of the model.
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 her technology. In period 1, given the technology, and realized intermediate prices, the importer purchases intermediates, repackages them using her technology, and sells them to retail consumers.

Take 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 her input market, so she 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:

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

The elasticity of substitution across imported inputs is $\rho$. The parameter $A$ is a measure of the importers technology.

Given this, the importer’s cost function is:

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

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

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

where $\Delta > 0$.

For a given $\rho$, importers with higher productivity will have lower prices and higher retail sales, which implies 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 importers expected profit is written as:

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

Here we explicitly account for the fact that expected profits will depend on the importers elasticity of substitution across intermediate imports and on her productivity.
Assume that the cost that the importer incurs for choosing an elasticity of substitution $\rho$ is as follows:

$$C(\rho) = \xi \rho^2 + \kappa.$$  \hfill (A.5)

In period zero, the firm will then choose $\rho$ to maximize:

$$\max_\rho E_0 \Pi(\rho, A) - \xi \rho^2 - \kappa$$  \hfill (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 so as to do better than responding linearly, so the cost function is concave in the input prices, which implies 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 $\rho$. Since expected profits are also increasing in $A$ this leads to the result that the optimal $\rho$ is greater for firms with higher $A$. The implication is that more productive firms, or firms who 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, and also a more elastic technology for substitution across different intermediate import goods.

Figure A.7 gives a simple illustration of the determination of optimal $\rho$ for a high $A$ firm and a low $A$ firm. It is assumed that $p_1$ is certain, but $p_2$ is uncertain at period 0. Firms share a similar technology adoption cost given by (A.5). This is represented by the cost of adoption curve. Both firms have expected profit functions increasing in $\rho$, but the more productive (high $A$) firm’s expected profit always lies above that of the less productive firm. As a consequence, the optimal $\rho$ 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. Overall Pass-Through Estimates

Table B.7 presents the results from the unweighted overall pass-through regression. The coefficient estimates on the cumulative changes in Exporter CPI, Canadian CPI and GDP are positive and significant, which are as expected.
Figure A.7: Choice of Elasticity of Substitution

Table B.7: Overall Exchange Rate Pass-Through

<table>
<thead>
<tr>
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<th>Estimate</th>
<th>(s.e.)</th>
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<tbody>
<tr>
<td>Exchange rate ($\beta$)</td>
<td>0.484***</td>
<td>(0.004)</td>
</tr>
<tr>
<td>Exporter CPI</td>
<td>0.073***</td>
<td>(0.016)</td>
</tr>
<tr>
<td>Canadian CPI</td>
<td>0.311***</td>
<td>(0.041)</td>
</tr>
<tr>
<td>Canadian GDP</td>
<td>0.735***</td>
<td>(0.033)</td>
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<thead>
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<tbody>
<tr>
<td>Obs.</td>
<td>7,993,402</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.003</td>
</tr>
</tbody>
</table>

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 product and time fixed effects. We restrict the sample to price changes within the -100% to +100% range.
References


Hong, G. H., and Li, N., 2013. Market structure and cost pass-through in retail. mimeo, University of Toronto.


