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Abstract

This paper studies the sensitivity of Canadian producer prices to the Canada-U.S. exchange rate. Using a unique product-level price data set, we estimate and analyze the impact of movements in the exchange rate on both domestic and export producer prices. First, we find that both domestic and export prices are sensitive to movements in the exchange rate. A one percent depreciation in Canadian dollar is associated with a 0.18 (0.25 conditional on price changes in the currency of pricing) percent increase in domestic prices, and a 0.39 (0.60 conditional on price changes in the currency of pricing) percent increase in export prices (once prices are converted into a single currency). Next, we find that there is an important difference in export price sensitivity to the exchange rate depending on the currency of pricing. Those Canadian producers that invoice their exported products in Canadian dollars do not adjust prices to movements in the exchange rate. Meanwhile, those invoicing in U.S. dollars increase their Canadian dollar prices when the Canadian dollar depreciates. Finally, for the same good sold in both the domestic and U.S. markets, the currency of pricing appears to play an important role in determining mark-up adjustment and the degree of pricing to market. These findings shed light on understanding the sources of incomplete exchange rate pass-through into import prices, as well as the indirect effect of the exchange rates on domestic prices through import competition and the use of imported inputs.

JEL classification: F31, F41, E30, L11
Bank classification: Exchange rates; Inflation and prices; Market structure and pricing

Résumé

Les auteurs étudient la sensibilité des prix à la production canadiens au taux de change Canada–États-Unis. À l'aide d'un ensemble de données sur les prix ventilées par produit, ils estiment et analysent l'incidence des mouvements du taux de change sur les prix à la production des biens destinés au marché intérieur et des biens exportés. Ils constatent d'abord que les prix des deux catégories de biens réagissent aux variations de change. Une dépréciation de 1 % du dollar canadien s'accompagne d'une hausse de 0,18 % des prix intérieurs et de 0,39 % des prix à l'exportation (après conversion des prix en une même monnaie); les hausses atteignent 0,25 % et 0,60 % respectivement si le producteur modifie le prix qu'il facture. Les auteurs notent ensuite que la sensibilité du prix à l'exportation est nettement influencée par le choix de la monnaie de facturation. Les exportateurs canadiens facturant leurs produits en dollars canadiens ne révisent pas leurs prix en réaction à l'évolution du taux de change, alors que ceux qui facturent en dollars É.-U. majorent leurs prix en dollars canadiens lorsque le huard se déprécie. Enfin, quand un même bien se vend tant au Canada qu'aux États-Unis, la monnaie de facturation semble jouer un rôle important dans la variation du taux de marge et le degré de différenciation des prix selon le marché. Ces résultats aident à mieux comprendre les raisons pour lesquelles les mouvements de change ne se répercutent pas entièrement sur

les prix des importations, ainsi que l’effet indirect qu’exercent les taux de change sur les prix intérieurs du fait de la concurrence des importations et de l’utilisation d’intrants importés.

Classification JEL : F31, F41, E30, L11
Classification de la Banque : Taux de change; Inflation et prix; Structure de marché et fixation des prix

1 Introduction

The transmission of movements in a currency's foreign exchange value into domestic prices has long been a question of interest to both central banks and academics. Exchange rate pass-through, the degree to which exchange rate movements are transmitted to import prices and then onto consumer prices, is of clear importance to monetary policy as it measures how much of exchange rate movements are reflected in domestic prices, and hence, short-run inflation.[1] More generally, understanding the sensitivity of prices to movements in exchange rates has broad implications for macroeconomic stability and international transmission of shocks. In this paper, we contribute to this effort by examining the sensitivity of product-level producer prices to movements in exchange rates and consider the prices of both exported and non-exported goods in the analysis.[2]

The study of export price sensitivity to exchange rates is important for understanding producer price adjustment and export dynamics. It is also complimentary to the study of exchange rate pass-through (to import prices), but from the other side of the transaction: the exporter rather than the importer. Recent theoretical work has suggested a number of potentially important factors in causing incomplete pass-through of exchange rates to import prices, including mark-up adjustment, local costs and barriers to price adjustment. The existing micro studies show that non-traded local costs emerge as the primary cause of incomplete pass-through. Using product-level producer price data, which are absent of the local cost component, we are able to further explore the importance of other factors in accounting for incomplete pass-through.

Non-exported product prices may also adjust to movements in the exchange rate for strategic reasons, since they compete with imports for domestic market share. Moreover, producers may use imported machinery, equipment and commodities from foreign sellers, therefore connecting movements in exchange rates to marginal costs, and (possibly) output prices. Quantifying how much non-exported goods prices respond to exchange rate fluctuations is important for our understanding of the impact of exchange rates on the real economy beyond the export and import sectors.

[1] Much has been written on exchange rate pass-through in the literature. See, for example, Campa and Goldberg (2005), Marazzi and Sheets (2007), Frankel, Parsley, and Wei (2005), Bouakez and Rebei (2008), and Gopinath, Itskhoki, and Rigobon (2010). Taken together, the available empirical evidence suggests that exchange rate pass-through to import prices is incomplete, and there is only a small degree of consumer-price responsiveness to exchange rate fluctuations.

[2] In this paper, we use the term "price sensitivity" to distinguish our analysis from the traditional study of pass-through (to import and consumer prices). While our findings contribute to the understanding of pass-through, the analysis of exported and non-exported goods prices has broader implications.

With our detailed product-level data on Canadian producer prices from the manufacturing sector, we first document a number of important facts concerning price adjustment behaviour, and then examine the extent to which producer prices respond to changes in the exchange rate. We focus our attention on goods produced in Canada and sold to the Canadian and U.S. markets. We find that many firms do not change their prices from month to month—73.6 percent of observations are of zero price changes—and the mean and median implied price durations are 3.4 and 10.9 months, respectively.[3] In addition to reporting the price of individual products and their destination, our data set reports the currency in which prices are set. This allows us to separate exporters into two groups: those that price in Canadian dollars and those that price in U.S. dollars. In line with the findings in Gopinath and Rigobon (2008), we find that the prices of those exported goods set in Canadian dollars have a longer mean implied price duration (4 months) than those exported goods whose prices are set in U.S. dollars (2.5 months).[4]

Motivated by theoretical models of monopolistic competition, we run a number of price-sensitivity regressions to explore how domestic and exported goods prices co-move with the exchange rate. In our baseline specification, we convert all prices into Canadian dollar prices. Our regression analysis results in three main sets of findings. First, we find that a one percent increase in the Canada-U.S. exchange rate (a depreciation of the Canadian dollar) is associated with a 0.18 percent increase in domestic prices, and a 0.39 percent increase in export prices. We also find evidence of cross-industry heterogeneity in price sensitivity within the manufacturing sector, but little evidence of asymmetric responses to increases versus decreases in the value of the Canadian dollar.

Next, given that many of our observations are of zero price changes in their pricing currency, there will be a mechanical relationship between the exchange rate and those goods priced in U.S. dollars once they are converted into Canadian dollars. We therefore examine the relationship between Canadian dollar prices and the exchange rate, conditional on price adjustment in the currency of pricing. In this setup, we find that a one percent increase in the exchange rate is associated with a 0.25 percent increase in domestic prices, and 0.60 percent increase in export prices. Our results suggest that, without the role of local costs, firms choose to absorb some of the

[3]The mean and median implied price durations are calculated using the mean and median monthly frequency of price adjustment. The implied price duration is equal to $-1/ln(1-f)$, where f is either the mean or median price change frequency.

[4]Gopinath and Rigobon (2008) find that non-U.S. dollar priced goods imported into the U.S. have longer mean price durations than imports set in U.S. dollars.

fluctuations in the value of the currency rather than pass it all through to output prices.

Finally, we find that the currency of pricing in export markets is closely associated with different pricing behaviour. Specifically, the Canadian-dollar price of exported goods whose prices are set in U.S. dollars are highly sensitive to the exchange rate. A one percent increase in the exchange rate (a depreciation of the Canadian dollar) is associated with a 0.82 percent increase in the Canadian dollar price of these goods (and the result is similar if we condition on a price change in the currency of price setting). We also exploit the fact that we observe some firms that sell the same good in both the domestic and U.S. markets, which allows us to difference out the common marginal cost in each price. With this, we can look into whether the currency of pricing is related to firm mark-ups in different markets. We find that the price change difference of the same good sold in the two markets is highly sensitive to movements in the exchange rate when the domestic price is set in Canadian dollars and the export price set in U.S. dollars. The sensitivity of the price change differential is smaller when both prices are set in U.S. dollars, and smallest when both are set in Canadian dollars.

In general, our paper builds on, and contributes to the pricing-to-market literature (see Goldberg and Knetter, 1997, and Dong, 2012, among others), which studies the price adjustment of firms in international trade as a way of obtaining greater insight into the role of the exchange rate in influencing trade flows and current accounts. An important distinguishing feature of our work is that we examine the sensitivity of producer prices to the exchange rate using product-level data. As suggested by many recent studies, the stickiness observed in aggregate price indexes masks a substantial amount of dynamics in the behaviour of prices at a more disaggregate level (Nakamura and Steinsson, 2008, and Klenow and Kryvtsov, 2008). A better empirical understanding of individual price setting is therefore crucial to building macroeconomic models with adequate micro foundations that may help improve the design and conduct of monetary policy.[5] This paper also contributes to the growing theoretical and empirical literature on the currency choice of exporters.[6] The fact that we know the currency in which the prices are set allows us to explore the relationship between currency of pricing and price sensitivity to exchange rates, and we find that currency choice is associated with distinct pricing behaviour.

[5] Goldberg and Hellerstein (2009) document facts of producer prices for the U.S.

[6] See Bacchetta and van Wincoop (2005), Devereux and Engel (2003), Engel (2006), Goldberg and Tille (2009), and Gopinath, Itskhoki, and Rigobon (2010).

The paper proceeds as follows. Section 2 describes the product-level data and presents some stylized facts regarding producer price setting in Canada. In Section 3, we briefly outline a theoretical model of monopolistic competition to highlight the channels through which exchange rates affect producer prices, and present our empirical model. Section 4 presents the estimation results, focusing on overall price sensitivity, heterogeneity across industries and asymmetric responses to appreciations versus depreciations. In section 5, we extend our empirical model to examine the relationship between currency of pricing and price sensitivity to exchange rates. Finally, our conclusions are presented in section 6.

2 Micro Data: Producer Prices

We use unpublished monthly data from Statisitics Canada's Price Report Survey (PRS), which records product-level prices for major products sold by producers in Canada on both the domestic and international markets.[7] The prices collected are for goods sold at the factory gate and exclude all direct and indirect taxes (such as sales taxes and tariffs), as well as transportation and distribution costs. The data in the PRS are obtained at the establishment level and the sampling framework is based on the plant-level Annual Survey of Manufacturers. Important and large producers are normally included in the survey, and a random selection of smaller producers are included as well. The PRS is conducted on a monthly basis and our sample period is from January 2006 to March 2010. The data can be organized at the industry level—based on the North American Industry Classification System (NAICS)—or the product level—based on the Principal Commodity Group (PCG) number.[8] Of note, the units of quantity measure differ across products and producers which precludes the plotting the (unit) price distribution. We merge the product price data with weights data based on unpublished commodity weights provided by Statistics Canada (the weights are product specific). In what follows, all statistics and regression results will be derived using these weights. In our analysis, we will focus on the manufacturing sector as the price quotes of firms in this sector (NAICS 31-33) make up 99 percent of the observations in the PRS.

[7]The PRS data is used to construct the Industrial Product Price Index, which is used in the calculation of real GDP by industry.

[8]The PCG classification is created at Statistics Canada by consolidating various commodity classifications, such as the Standard Commodity Classification, the Industry Commodity Classification, and the Import and Export Commodity Classifications.

Some further screening of the data is needed in order to ensure that that our final data set is suitable for our analysis. A number of prices reported in the PRS are not survey responses, but imputed numbers provided by other government departments and statistical agencies, and therefore do not reflect the price of an individual product sold by a firm, but rather an average price for a product across foreign firms.[9] These price quotes makes up ten percent of the original data and we drop them from our sample. We also drop products with less than three months of data, that do not have an associated PCG number, and those where the unit or format of the price changes over time.[10]

In addition to reporting the price, the data set provides information on the location of the seller within Canada and the location of the buyer (inside and outside of Canada), which allows us to identify exported products. In our empirical work below, our aim is to study the relationship between producer prices and exchange rates, and so to clarify the analysis we will focus on a single bilateral exchange rate—the Canada-U.S. exchange rate defined as Canadian dollars per U.S. dollar.[11] And since shipments to the U.S. make up the majority of our observations, we retain only the prices of goods sold to either the Canadian or U.S. markets. Finally, we exclude manufacturers in the auto and auto parts manufacturing industries (NAICS 3361-3363). There is likely a substantial amount of cross-border intra-firm trade in these industries, and so many of the reported prices would be transfer prices, rather than prices reflecting actual sales. It is unclear what the relationship between transfer prices and the exchange rate would be, so we drop them from our sample. Once we make all of these adjustments to the data, we are left with approximately 60,000 observations per year, from 1,600 firms, in 21 3-digit NAICS industries.

In Table 1, we report the percentage of goods exported for the manufacturing sector as a whole, and each of its three 2-digit NAICS component industries.[12] Overall, nearly 24 percent of products are exported, and there is variation across the component industries from 9 percent for NAICS 31 to 38 percent for NAICS 32. A unique aspect of the PRS data is that it provides us with the currency

[9]Many of these prices are drawn from the U.S. Bureau of Labor Statisitics, the U.S. Department of Agriculture and other foreign statistical agencies.

[10]More detail on the cleaning of the data set can be found in the Appendix.

[11]Based on this definition of the Canada-U.S. exchange rate, an increase in the exchange rate will signify a depreciation of the Canadian dollar relative to the U.S. dollar.

[12]Broadly, firms in NAICS 31 produce food, textile and leather products. Firms in NAICS 32 produce wood, paper, printing, petroleum and coal, chemical, and plastic and rubber products. Finally, firms in NAICS 33 produce metal, machinery, computer and electronics, and transportation products.

in which the goods are priced. This not only allows us to separate out the mechanical relationship between prices and the exchange rate that would be a problem if all the prices were reported in a single currency, but it also allows us to study, directly, the connection between currency choice and price sensitivity to the exchange rate.[13] Therefore, Table 1 also reports the percentage of exports priced in Canadian and U.S. dollars.[14] We see that for the manufacturing sector as a whole, 48 percent of exported goods are priced in Canadian dollars and the rest are priced in U.S. dollars. At the extremes, the majority of exports (76 percent) in NAICS 31 are priced in Canadian dollars, and the majority of exports (77 percent) in NAICS 33 are set in U.S. dollars.

Table 1: Exports and Reported Currency

NAICS	Industry Description	Products Exported (%)	% of Exports CAD	USD
31-33	Manufacturing	23.5	48.0	52.0
31	Food, textiles, leather products	9.1	75.9	24.1
32	Wood, paper, chemicals, plastic, rubber products	37.5	53.7	46.3
33	Metal, machinery, electronics, transportation products	14.2	23.0	77.0

Note: The column entitled Products Exported % reports the percentage of products exported for each industry, whereas the last two columns report the proportion of exports to the U.S. set in Canadian and U.S. dollars. In 2010, NAICS 31 accounted for 18% and 21% of revenue and employment, respectively, in the manufacturing sector. NAICS 32 accounted for 39% and 29%, and NAICS 33 accounted for 43% and 50%.

Before moving on to our empirical work, it is worthwhile exploring some statistics related to producer price adjustment to get a better feel for the data. While the facts about producer price setting at the disaggregated level have been extensively documented for the U.S. (see Gopinath and Itskhoki, 2010), little work has been done on small open economies such as Canada. In addition to providing background on the data set for the empirical work that follows, these facts on price adjustment can be used for the calibration of macro models. Table 2 presents the frequency of price adjustment (in the currency of pricing) for the manufacturing sector and many sub-groups. We can see from the fact that the mean and median price change frequencies in the manufacturing sector are 25.2 and 8.8 percent, respectively, that the distribution of price change frequencies is positively skewed. This skewness is likely a result of the fact that many observations are of zero

[13] In the construction of aggregate data, prices are often converted into a single currency using the contemporaneous exchange rate and then incorporated into an aggregate price index. This creates a mechanical relationship between prices and exchange rates, which can confound the true study of price sensitivity to exchange rates.

[14] There is a very small percentage of exports priced in Euros. These are dropped from our sample.

price changes (26.4 percent of the weighted observations are non-zero price changes).[15] Moreover, this pattern holds across the three component industries. In light of this observed skewness, in addition to the standard price sensitivity regressions that include all observations (including zero price changes), we examine price sensitivity to movements in the exchange rate conditional on a price change, which, in essence, drops issues related to price stickiness from the analysis.

Table 2: Monthly Frequency of Price Changes, 2006-2010 (%)

NAICS		All products	Non-exported goods	Exported goods	CAD goods	USD goods
31-33	Mean	25.2	23.6	30.1	22.2	32.8
	Median	8.8	8.8	7.0	8.8	7.0
31	Mean	25.4	24.4	34.8	25.2	31.1
	Median	12.3	12.3	36.8	12.3	15.8
32	Mean	29.3	29.5	28.8	22.3	50.1
	Median	12.3	14.0	5.3	7.0	56.1
33	Mean	20.4	18.4	32.7	20.0	21.2
	Median	5.3	5.3	10.5	7.0	3.5

Table 2 also compares price change frequencies across non-exporters and exporters, as well as goods that are priced in Canadian and U.S. dollars. In NAICS 31 and 33, the frequency of price changes (both mean and median) are significantly higher for exported goods, and for the most part, the frequency of price change in every industry is higher for those goods that are priced in U.S. dollars. The numbers indicate that their are important differences in the price setting behaviour of firms that operate in different industries and different markets. We examine these issues further in our empirical work below.

3 Exchange Rates and Producer Price Adjustment

In this section, we begin by investigating the mechanisms through which the exchange rate affects producer prices. To do so, we outline a simple model of monopolistic competition with firms that sell their goods on either the domestic or export markets, or both. We then use this theoretical motivation to outline our empirical model.

[15] This finding is similar to what is found in Gopinath and Itskhoki (2010) using U.S. data.

3.1 Theoretical Motivation

Consider the example of a Canadian producer that can sell its goods to Canadian buyers and/or ships their goods to the U.S. On the domestic market, this producer competes with other domestic producers as well as imported goods, and the degree of competition is affected by movements in the bilateral exchange rate. When the Canadian dollar appreciates, the relative cost of importing (measured in Canadian dollars) decreases, which will either lead to an increase in the share of imports in the domestic market if local producers do not adjust their prices, or a decrease in the overall domestic price if domestic producers lower their prices to maintain market share. Moreover, domestic producers may use imported intermediate inputs in their own production process. An appreciation of the Canadian dollar thus leads to lower inputs prices that can be passed on to output prices.

To formalize these mechanisms, let P_{it} be the price that a domestic producer charges for good i at time t in the Canadian market, and $MC(P_t^d, P_t^m)$ be the marginal cost of production, where P_t^d is the price of domestic inputs and P_t^m is the price of imported inputs (expressed in Canadian dollars). Assuming monopolistic competition, the optimal price for producers to set is:

$$P_{it} = \mu_{it} MC(P_t^d, P_t^m) \tag{1}$$

where μ_{it} denotes the proportional mark-up over marginal cost. In a setup where the producer faces CES demand (i.e. $\mu_{it} = \mu$), movements in the exchange rate will have no impact on the proportional mark-up and any relationship between the exchange rate and prices will come through the use of imported intermediate inputs. The degree to which marginal costs, and hence prices, vary with the exchange rate will depend on the share of imported inputs and the extent that movements in the exchange rate are passed-through to import prices, among other things. However, in a more general setup, a firm's mark-up can depend on the price elasticity facing the firm:

$$\mu_{it} = \frac{\rho_{it}(P_{it}, \bar{P}_t, Z_t)}{\rho_{it}(P_{it}, \bar{P}_t, Z_t) - 1} \tag{2}$$

where ρ_{it} is the elasticity of substitution, $\bar{P}_t$ is the aggregate output price level in the domestic market, and Z_t is a set of exogenous variables. To the extent that the exchange rate affects $\bar{P}_t$, the

producer may choose to sacrifice margins in order to keep market share.

Next, consider a Cobb-Douglas specification for marginal cost:

$$MC_{it} = (P_t^d)^{\delta}(e_t P_t^{m*})^{1-\delta}, \tag{3}$$

where e_t is the exchange rate, P_t^{m*} is the foreign currency price of imported inputs, and δ and $1-\delta$ are the shares of domestic and imported inputs used in production. If there is full pass-through of exchange rate movements to import prices (i.e. $Var(P^{m*}|e) = 0$), an increase in e_t (a depreciation of the Canadian dollar) will lead to a proportional increase in marginal costs. Of course, a change in the relative price of inputs stemming from an increase in the exchange rate may cause a shift away from foreign inputs, lessening the effect of the exchange rate on marginal costs.

On the foreign market, the producer faces a similar maximization problem, and looks to set its Canadian dollar price as a mark-up over marginal cost:

$$e_t P_{it}^* = \gamma_{it} MC(P_t^d, P_t^m) \tag{4}$$

where P_{it}^* is the foreign market price of good i in U.S. dollars and γ_{it} is the mark-up set in the foreign market. Again, marginal cost is a function of the price of imported inputs, and so the export price (in Canadian dollars) may vary with the exchange rate. The mark-up may also vary with the exchange rate as the elasticity of substitution in the foreign market depends on the foreign price level ($\bar{P}_t^*$), as well as some other exogenous variables (Z_t^*):

$$\gamma_{it} = \frac{\nu_{it}(P_{it}^*, \bar{P}_t^*, Z_t^*)}{\nu_{it}(P_{it}^*, \bar{P}_t^*, Z_t^*) - 1}. \tag{5}$$

Closely related to the pricing decision of exporters is the choice of currency of invoicing. The firm can set its price in Canadian dollars, U.S. dollars, or a third (vehicle) currency. Since the U.S. dollar is the most common vehicle currency in international trade (Devereux and Shi, 2010), and our data suggests that the overwhelming majority of exports to the U.S. are set in either Canadian or U.S. dollars, we focus on these two currency choices. In the literature, a number of theories have been put forward as to how firms select the currency of invoicing. In a static model with sticky prices, Engel (2006) derives a sufficient statistic for currency choice such that firms opt for their own

currency exactly when their price would exhibit high pass-through if they were set flexibly, and the foreign currency if the opposite holds. In other words, they would choose Canadian dollars if the variance of their ideal (freely flexible) price is less than the variance in their foreign currency ideal price (in the foreign currency). Gopinath, Itskhoki, and Rigobon (2010) develop a similar sufficient statistic in a dynamic setting and provide conditions under which this sufficient statistic can be empirically tested. Finally, Goldberg and Tille (2009) develop a model where currency invoicing is set through a bargaining game between the exporter and the buyer. They offer this model as a possible explanation for the link between currency choice and the size of the transaction that they observe in their data.

3.2 Empirical Model

With this intuition in mind, we now develop our empirical model which will be used in the next section to analyze the relationship between producer prices and the exchange rate. As mentioned, we focus on goods that were sold to either the Canadian or U.S. markets, and therefore we use the nominal bilateral exchange rate for these two countries. We also convert all of the observed prices in U.S. dollars into Canadian dollars using the average monthly exchange rate so that all prices are in a single currency. Of course, this will create a mechanical relationship between these converted prices and the exchange rate, and we take this into account when analyzing the results in the next section. Our baseline linear model is specified as follows:

$$\begin{aligned}\Delta p_{ijt} &= \alpha + \sum_{\tau=0}^{n} \left(\beta_{1\tau} \Delta e_{t-\tau}\right) + \sum_{\tau=0}^{n} \left(\beta_{2\tau} \Delta e_{t-\tau} \cdot D_{it}\right) + \gamma_1 \Delta gdp_t^{US} + \gamma_2 \Delta gdp_t^{CA} \\ &\quad + \gamma_3 \Delta p_t^{CA} + \gamma_4 \Delta p_t^{US} + \gamma_5 \Delta p_{jt}^{input} + \gamma_6 \Delta w_t + \gamma_7 X_{it} + \epsilon_{ijt} \end{aligned} \tag{6}$$

where Δp_{ijt} is the log difference in the price of product i produced by a firm in industry j from time $t-1$ to t, Δe_t is the log difference of the Canada-U.S. nominal exchange rate, and D_{it} is a dummy variable that can take on a number of meanings. The interaction of D_{it} and Δe_t will enable us to explore the differences across non-exporters and exporters, across industries, and across currencies, among other things. As for the other variables, Δgdp_t^{US} and Δgdp_t^{CA} are the log difference of U.S. and Canadian GDP, respectively, and are included to control for fluctuations in demand, Δp_t^{CA} and Δp_t^{US} are the log difference of the consumer price indexes for Canada and the U.S., respectively,

and are included in the regression framework as proxies for the price levels in the two countries, which reflect the level of competition facing domestic producers.

The variable Δp_{jt}^{input} is the log difference in an input price index created using Statistics Canada's input/output tables, which is industry specific and is included to capture how movements in input prices affect output prices. This input price index is calculated as the average price of inputs used in one industry, weighted by the input cost structure. More specifically, for each 3-digit NAICS industry j, let the real input cost share of type h be c_{hj}, and let the input price of type h be p_{ht}^{input}.[16] The input price index for the NAICS industry i is computed as:

$$p_{jt}^{input} = \frac{\sum_{h=1}^{H}(c_{hj} \cdot p_{ht}^{input})}{\sum_{h=1}^{H} c_{hj}}.$$

Finally, Δw_t is the quarterly log difference of aggregate labour costs, and X_{it} is a vector of product-specific dummy variables.[17] Included in X_{it} is a dummy for whether the original price was set in U.S. dollars and dummies for the location of the producer.[18] ϵ_{ijt} is an i.i.d. error term, and in all of the regressions that follow, we cluster the errors at the firm level. Moreover, all the regressions include firm fixed effects and a time trend.

4 Estimation Results

4.1 Baseline Results

Table 3 presents the baseline results. We start with the exchange rate change being the only explanatory variable in column (1), then add an interaction term between the exchange rate and a dummy for whether the product was exported in column (2). This allows us to estimate separately

[16]Note that while the input price has a time subscript, the cost shares do not. We only have information on cost shares for two years (at annual frequency). We therefore take the average cost shares over these two years and use this in the calculation of the industry-specific input price index. For this paper, we use data on physical inputs including energy, raw materials and industrial products, giving us 60 input types. We obtain the monthly input price indices at the 3-digt NAICS level from three CANSIM data tables: the raw material input price index (table 330-0007), the industrial product price index (table 329-0056), and the electric power selling price index (table 329-0050). Table 381-0014 contains the cost shares of all inputs (raw material, industrial products, and energy) for each 3-digit NAICS industry.

[17]Labour cost data is only available on a quarterly basis and therefore Δw_t refers to the log difference in labour costs from the previous quarter to the current quarter.

[18]We have four location dummies: (1) maritime provinces; (2) Quebec; (3) Manitoba, Saskatchewan and Alberta; and (4) British Columbia. Ontario is the reference province. It should be noted that our data set has limited information on the producer's variables. We do not observe producer output (or revenue), or whether the product is a primary, intermediate or final good, which limits firm-specific or stage-of-production analysis.

the relationship between the exchange rate and products sold in the domestic and foreign markets. Columns (3) and (4) present the estimation results for the full model.[19]

Table 3: Producer Price Sensitivity (Baseline Results)

	(1)	(2)	(3)	(4)
Δe_t	0.221***	0.171**	0.223***	0.178***
	(0.071)	(0.078)	(0.062)	(0.067)
Δe_t*Export		0.233**		0.214*
		(0.113)		(0.111)
Δgdp_t^{CA}			0.259	0.261
			(0.177)	(0.177)
Δgdp_t^{US}			-0.062	-0.062
			(0.067)	(0.067)
Δp_t^{US}			0.009	0.014
			(0.168)	(0.170)
Δp_t^{CA}			-0.366	-0.359
			(0.272)	(0.274)
Δp_t^{input}			0.405***	0.401***
			(0.102)	(0.103)
Δw_{jt}			-0.068	-0.068
			(0.111)	(0.111)
Currency = USD			-0.001	-0.001
			(0.001)	(0.001)
Constant	0.003***	0.003***	0.003***	0.003***
	(0.001)	(0.001)	(0.001)	(0.001)
Observations	233,069	233,069	233,069	233,069
R-squared	0.016	0.017	0.031	0.032

Dependent variable: price change in Canadian dollars. Region and firm fixed effects included and standard errors are clustered at the firm level.
*** p<0.01, ** p<0.05, * p<0.1.

In column (1), with exchange rate changes as the only explanatory variable, the price elasticity with respect to the exchange rate is 22 percent. This suggests that when the Canadian dollar appreciates by one percent (a decrease in the exchange rate), Canadian producer prices (in Canadian dollars) drop by an average of 0.22 percent. However, as can be seen from the coefficient estimates in column (2), exported products and domestic products exhibit different responses to changes in the exchange rate. The price elasticity of domestic prices is 17 percent. For exported goods, this elasticity is 40 (0.171 + 0.233) percent and the estimate is significant at the 1% level.[20] It is not surprising that exported goods display a larger sensitivity of prices to exchange rate movements, as they generally compete with U.S. manufacturers for market share. In addition, since we converted

[19]The specifications in columns (1) and (3) can be thought of as being analogous to aggregate regressions—where the dependent variable is an aggregate price index—since we include all observations including zero price changes.

[20]We perform an F-test to establish the joint significance of the coefficients for exported products, and all other combined point estimates in the paper.

all U.S. dollar prices to Canadian dollars, this sensitivity of exporter prices comes, in part, from the currency conversion—a little more than fifty percent of exporters' prices are reported using the U.S. dollar. We explore the issue of currency choice further in the next section.

In columns (3) and (4), we add additional variables that likely affect producer price adjustment, including an input price index, wage costs and GDP and inflation in both markets.[21] Overall, the coefficient estimates for the price sensitivity to exchange rates are quite robust. U.S. and Canadian GDP growth and inflation rates, as well as wage costs, have impacts on producer prices, but the impacts are not statistically significant.[22] The coefficient on the input price is statistically significant and implies that when input prices increase by one percent, producer prices increase by 0.4 percent. However, comparing column (2) and (4), the estimates of price elasticities of both domestic and exported goods to exchange rate movements remain largely unchanged. This suggests that the correlation between these additional explanatory variables and the exchange rate is small. The U.S. dollar dummy is negative but insignificant.

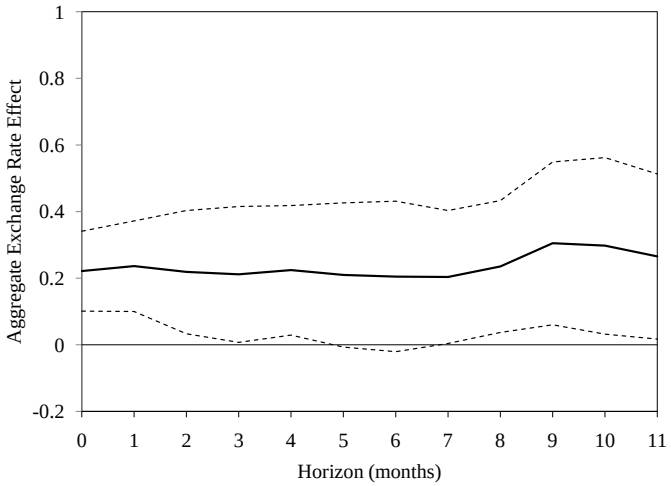
Next, we examine whether producer price adjustment responds to lagged changes in the exchange rate. Prices may respond to lags of the exchange rate for a number of reasons, including purchase agreements between a producer and buyer that prevent the producer from changing the price every period—such as infrequent contracting or costly price renegotiation. In Figure 1, we plot the aggregated exchange rate effect over different horizons. That is, we run the regression (6) with an increasing number of lags (we set $D_{it} = 0$) and plot the sum of the estimated $\beta_{1\tau}$ coefficients. We include up to eleven lags, which captures the effects of movements in the exchange rate over the previous year. The fact that the effect of the exchange rate does not change much as we include more lags suggest that producer prices are not sensitive to lagged values of the exchange rate. When we set $D_{it} = 1$, we find that lags value of the exchange rate also have little effect on

[21] Given that the value of the Canadian dollar is highly correlated with commodity prices, it is possible that our measure of input prices in negatively correlated with the exchange rate. However, the input price index also includes imported inputs whose prices are likely positively correlated with the exchange rate, since a strong Canadian dollar (a low exchange rate) will be associated with lower imported input prices. Therefore, the overall relationship between the exchange rate and our measure of input prices is ambiguous. Accounting for correlation between these input prices and the exchange rate is difficult given that the direction of causality in not always clear. In our baseline results, the addition of input prices as an explanatory variable has no effect on the exchange rate point estimates, and only increases the explanatory power of the model.

[22] Despite being statistically insignificant, the coefficient on the wage is negative, which at first glance seems odd. However, it is important to note that this is quarterly growth in wages (not monthly) and so a quarterly increase in wages may be associated with a shift from labour to capital (capital deepening), which reduces prices. This would create a negative relationship between wages and prices.

export prices.

Figure 1: Sensitivity of Producer Prices to Exchange Rates at Different Horizons



Note: The doted lines refer to the 95% confidence interval.

4.2 Cross-Industry Heterogeneity and Asymmetric Sensitivity

In this subsection, we study to what extent the responses of producer prices to exchange rate movements differ across industries within the manufacturing sector, and between appreciations and depreciations of the Canadian dollar. Differences in price sensitivity to exchange rates across industries may arise from differences in the share of exported products, in currency denomination, and in competition with imported products across sectors. The manufacturing sector is made up of three 2-digit NAICS component industries: 31 (food, textiles and clothing), 32 (wood and paper products, petroleum and coal, chemical, rubber and plastic, fertilizer, medicine, and mineral products), and 33 (metal, machinery, electronic products, electrical products, and non-wooden furniture).

In columns (1) and (2) of Table 4, we present the regression results when we include an interaction term between the exchange rate and dummies for 2-digit NAICS identifiers (NAICS 31 being the reference industry) in order to explore any cross-industry variation in the relationship between movements in the exchange rate and prices.[23]

Two observations stand out from the results in column (2). First, the differences across indus-

[23]Since the lagged changes in exchange rate have little affect on current period pricing, we omit them in this analysis.

Table 4: Industry and Asymmetric Effects

	Industry Effects		Asymmetric Effects	
	(1)	(2)	(3)	(4)
Δe_t	0.038	0.017	0.243***	0.189***
	(0.028)	(0.028)	(0.062)	(0.071)
Δe_t*NAICS32	0.178***	0.111***		
	(0.049)	(0.035)		
Δe_t*NAICS33	0.273**	0.279**		
	(0.135)	(0.137)		
Δe_t*Export		0.296**		0.253**
		(0.134)		(0.106)
Δe_t*Export*NAICS32		-0.031		
		(0.188)		
Δe_t*Export*NAICS33		-0.177		
		(0.232)		
Δe_t*Appreciation			-0.037	-0.022
			(0.050)	(0.056)
Δe_t*Export*Appreciation				-0.069
				(0.083)
Δgdp_t^{CA}	0.260	0.263	0.250	0.251
	(0.179)	(0.179)	(0.176)	(0.176)
Δgdp_t^{US}	-0.062	-0.062	-0.055	-0.055
	(0.067)	(0.067)	(0.066)	(0.066)
Δp_t^{US}	0.014	0.022	-0.007	-0.002
	(0.164)	(0.165)	(0.171)	(0.173)
Δp_t^{CA}	-0.360	-0.349	-0.410	-0.404
	(0.269)	(0.269)	(0.280)	(0.281)
Δp_t^{input}	0.402***	0.396***	0.405***	0.402***
	(0.101)	(0.102)	(0.102)	(0.103)
Δw_{jt}	-0.068	-0.068	-0.064	-0.064
	(0.111)	(0.111)	(0.112)	(0.112)
Currency = USD	-0.001	-0.001	-0.001	-0.000
	(0.001)	(0.001)	(0.001)	(0.001)
Constant	0.003***	0.003***	0.003***	0.003**
	(0.001)	(0.001)	(0.001)	(0.001)
Observations	233,069	233,069	233,069	233,069
R-squared	0.033	0.034	0.031	0.032

Dependent variable: price change in Canadian dollars. Region and firm fixed effects included and standard errors are clustered at the firm level.
*** p<0.01, ** p<0.05, * p<0.1.

tries in the response of prices of domestically-sold products are generally large. Producer prices in NAICS 31 are the least sensitive to movements in the exchange rate with a point estimate of 0.02 that is not statistically significant. For NAICS 32, the combined point estimate of 0.13 is statistically significant at the 1% level, as is the combined estimate for NAICS 33, 0.30. The fact that the domestic prices of goods sold by firms in NAICS 33 are most sensitive to the exchange rate is likely a reflection of the fact that these firms face intense import competition in the domestic

market, as compared to firms in the other two industries. A detailed look at the 3-digit NAICS industries within NAICS 33 reveals that there are many sub-industries that have a large import share. For example, 86 percent of electronic and electrical equipment sold in Canada is imported. On the other hand, many sub-industries within NAICS 31 do not face import competition (the key exceptions being textile products and food). Second, there are no additional cross-industry effects for exported good. There are differences across exporters in the three industries—the combined point estimates for exported goods in NAICS 31-33 are 0.31, 0.39 and 0.42, respectively—but they are rooted in differences at the industry level rather than the exporter level.

Finally, in column (3) and (4) of Table 4, we explore asymmetry in the response of producer prices to the exchange rate. That is, do prices react differently depending on whether the exchange rate appreciated or depreciated? To do this, we add an interaction term to the baseline model between the exchange rate and a dummy variable indicating an increase in the exchange rate (as opposed to a decrease). The estimate on the interaction term is not statistically significant and therefore there is no evidence that prices respond asymmetrically to appreciations and depreciations.

4.3 Conditioning on Price Changes in the Currency of Pricing

Producer price adjustment is infrequent. In a typical month, only about 27 percent of prices adjust (in their currency of pricing). For prices set in U.S. dollars that do not change from month to month, there will be a mechanical relationship between their Canadian dollar price and the exchange rate. Moreover, the inclusion of those goods priced in Canadian dollars that do not adjust from period to period will lead to lower estimates of price sensitivity. In order to address these issues, we examine the relationship between producer prices and the exchange rate, conditional on a price adjustment in the original currency of pricing. The analysis of price sensitivity to exchange rates can be decomposed into price adjustment on the intensive and extensive margins. The extensive margin relates to the examination of whether prices change in the face of exchange rate movements and is related to the observed frequency of price changes. The intensive margin, on the other hand, pertains to the analysis of the magnitude of price adjustment, given that prices changed in the first place. By conditioning on a price change in the currency of pricing, we can examine adjustment on the intensive margin.

Once we restrict the sample to non-zero price changes, we would expect the point estimate on

products sold in the domestic market to increase, since these goods are priced in Canadian dollars and we are dropping the prices that did not respond to movements in the exchange. For exported products, it is not clear what the results will be once we restrict the sample. Exported products are priced in Canadian and U.S. dollars, and dropping zero price changes in the currency of pricing will have opposing effects for these goods.

Table 5 presents the estimates when we restrict the analysis to the sub-sample which only includes non-zero price adjustments. As expected, the point estimate on the exchange rate for domestically-sold goods in column (4) becomes larger after having removed the observations with zero price adjustment—0.25 versus the 0.18 estimate for the whole sample (Table 3 column (4)). For exported goods, the estimate is larger as well. The combined point estimate of 0.60 (significant at the 1% level) is approximately fifty percent larger than the analogous estimate of 0.39 in Table 3 column (4).

Table 5: Sensitivity Conditional on a Price Change

	(1)	(2)	(3)	(4)
Δe_t	0.115	0.019	0.340***	0.252**
	(0.098)	(0.086)	(0.106)	(0.110)
Δe_t*Export		0.383*		0.348*
		(0.224)		(0.206)
Δgdp_t^{CA}			0.391	0.406
			(0.610)	(0.612)
Δgdp_t^{US}			0.009	0.009
			(0.235)	(0.235)
Δp_t^{US}			1.415***	1.415***
			(0.409)	(0.410)
Δp_t^{CA}			-0.251	-0.255
			(0.882)	(0.884)
Δp_t^{input}			0.875***	0.871***
			(0.198)	(0.199)
Δw_{jt}			-0.515	-0.511
			(0.393)	(0.394)
Currency = USD			0.002	0.002
			(0.002)	(0.002)
Constant	0.006**	0.006**	-0.001	-0.001
	(0.002)	(0.002)	(0.005)	(0.005)
Observations	45,493	45,493	45,493	45,493
R-squared	0.074	0.076	0.110	0.111

Dependent variable: price change in Canadian dollars. Region and firm fixed effects included and standard errors are clustered at the firm level.
*** p<0.01, ** p<0.05, * p<0.1.

In the sub-sample conditional on a price change, adding GDP, the consumer price indexes and

the 3-digit NAICS input price index has two important consequences. First, the explanatory power of the model increases, as seen in the larger R-squared value in column (4). Second, in this setup we find that the point estimate on the exchange rate term changes substantially when other control variables are included in the regression. For example, in comparing columns (2) and (4) we see that the coefficient on the exchange rate increases from 0.02 (insignificant) to 0.25 (significant at the 1% level). This suggests that, for the sample with non-zero price changes, changes in the exchange rate are to some degree correlated with the other explanatory variables.

5 Currency Choice and Mark-ups

In this section, we expand on the results presented in the previous section and examine the relationship between producer price sensitivity and the choice of currency. We then use theory to develop an empirical model that allows us to study how mark-ups in different markets adjust to movements in the exchange rate.

5.1 Producer versus Local Currency Pricing

In the sticky price literature, the term producer currency pricing (PCP) is used to denote the case where prices are set in the producer's currency and the term local currency pricing (LCP) is used to denote the case where prices are set in the currency of the export destination. The currency in which exporters set the price of their goods has long been recognized as an important issue in international economics. Specifically, it determines who among the exporter or the customer is exposed to exchange rate risk. In this subsection, we explore whether there is a connection between currency choice and the degree of price sensitivity.

In Table 4, we saw that both domestic and export prices are most sensitive to movements in the exchange rate in NAICS 33, an industry facing intense import competition and where export prices are primarily set in U.S. dollars, and least sensitive in NAICS 31, where goods are primarily priced in Canadian dollars. We would expect that the Canadian dollar price of those goods that are set in U.S. dollars will be more sensitive to movements in the exchange rate than those priced in Canadian dollars. In order to explore this possibility, we add another interaction term to the baseline model (6). We take the interaction term between the exchange and the export dummy,

Table 6: Currency Choice and Price Sensitivity

	Full sample		Conditional on price change	
	(1)	(2)	(3)	(4)
Δe_t	0.171**	0.178***	0.019	0.254**
	(0.078)	(0.067)	(0.086)	(0.110)
Δe_t*Export	-0.197**	-0.211***	-0.298	-0.338
	(0.087)	(0.079)	(0.342)	(0.280)
Δe_t*Export*USD	0.843***	0.836***	0.837***	0.841***
	(0.077)	(0.067)	(0.303)	(0.241)
Δgdp_t^{CA}		0.261		0.399
		(0.177)		(0.611)
Δgdp_t^{US}		-0.062		0.006
		(0.067)		(0.235)
Δp_t^{US}		0.017		1.432***
		(0.169)		(0.408)
Δp_t^{CA}		-0.354		-0.221
		(0.274)		(0.887)
Δp_t^{input}		0.399***		0.870***
		(0.103)		(0.198)
Δw_{jt}		-0.068		-0.521
		(0.111)		(0.393)
Constant	0.003***	0.002**	0.006**	-0.001
	(0.001)	(0.001)	(0.002)	(0.005)
Observations	233,069	233,069	45,493	45,493
R-squared	0.024	0.039	0.077	0.112

Dependent variable: price change in Canadian dollars. Region and firm fixed effects included and standard errors are clustered at the firm level. *** p<0.01, ** p<0.05, * p<0.1.

and interact this with the dummy for whether the good is priced in U.S. dollars. Again, all prices are converted into Canadian dollars using the monthly exchange rate. We present the results for this regression in Table 6, where the errors are clustered at the firm level.

As before, because this regression includes zero price changes, estimates on variables including the exchange rate will capture, in part, a mechanical relationship between prices in U.S. dollars (converted to Canadian dollars) and the exchange rate. In column (1), we present the results without the set of control variables. The point estimate on Δe_t is 0.171 (significant at the 5% level) and suggests that a one percent increase in the exchange rate is associated with 0.17 percent increase in the prices of goods sold in the domestic market. For those goods that are exported and priced in Canadian dollars, the combined point estimate of -0.026 (0.171 - 0.197) is not statistically significant and therefore suggests that export prices of goods set in Canadian dollars are not sensitive to movements in the exchange rate. Finally, for those goods that are exported and their prices set

in U.S. dollars, the combined point estimate of 0.817 (0.171 - 0.197 + 0.843) is significant at the 1% level. These results suggest that those who are practising producer currency pricing are not pricing to market, while those using local currency pricing are adjusting their Canadian dollar price to stabilize their U.S. dollar price in the face of exchange rate fluctuations.

In column (2), we introduce the set of control variables and find that the point estimates of interest change very little. The coefficient on goods sold to the domestic market is 0.178 (significant at the 1% level), -0.033 (insignificant) on exported goods priced in Canadian dollars, and the coefficient on exported goods set in U.S. dollars is 0.803 (significant at the 1% level). These findings are important in that they reveal the connection between currency choice and the degree of price sensitivity to movements in the exchange rate.

Next, in columns (3) and (4), we condition on non-zero price adjustment in the currency of pricing. As mentioned before, 73.6 percent of weighted observations are of zero price change in the pricing currency. In the full model in column (4), the point estimate on Δe_t increases to 0.254, which is not surprising given that the sample no longer includes zero price changes of goods sold in the domestic market (which are priced predominantly in Canadian dollars). The estimate is significant at the 5% level, and implies that a one percent increase in the exchange rate (a depreciation of the Canadian dollar) is associated with a 0.25 percent increase in domestic prices. For goods that are exported, but priced in Canadian dollars, there is no exchange rate effect—the combined point estimate of -0.084 is not statistically significant. Finally, for those exported goods priced in U.S. dollars, their Canadian dollar prices increase by 0.76 percent when the exchange rate increases by one percent. Therefore, even when we remove zero price changes, we still find a large difference in the price sensitivity of goods priced in Canadian versus U.S. dollars that suggests unique pricing strategies associated with each currency choice.

5.2 Currency of Pricing and Mark-ups in Different Markets

In order to look further into the relationship between currency of pricing and price sensitivity to exchange rates, we exploit the fact that in our data we observe firms that sell the same product to both the domestic and U.S. markets, and provide us with a different price for each product. For these firm-product pairs, if we assume that the marginal cost of production is the same for both the non-exported and exported goods (a similar assumption is made in Fitzgerald and Haller,

2010), then the ratio of the price of the non-exported good to the price of the exported good (both in Canadian dollars) will provide a variable that is devoid of marginal cost, and a function of the relative mark-ups only:

$$\hat{P}_{it} \equiv \frac{P_{it}}{e_t P^*_{it}} = \frac{\mu_{it}}{\gamma_{it}}. \tag{7}$$

Variations in $\hat{P}_{it}$ will be driven by changes in the proportional mark-up set across markets over time, and will not be affected by changes in marginal costs (let i identify a product pair—sold to the domestic and export markets—rather than an individual product, as before).[24] To explore the relationship between relative mark-ups, the currency of pricing and the exchange rate, we regress the price ratio on the exchange rate and a number of other relevant variables:

$$\Delta\hat{p}_{it} = \alpha + \beta_1 \Delta e_t + \beta_2 \Delta e_t \cdot USD_{it} + \beta_3 \Delta e_t \cdot MIX_{it} + Z'_{it}\gamma + \epsilon_{it} \tag{8}$$

where $\Delta\hat{p}_{it}$ is the log difference of the price ratio (both the domestic and export prices in Canadian dollars) and Z_{it} is the vector of control variables in equation (3). We know from the previous section that currency choice is strongly associated with different pricing behaviour. Therefore, the log difference of the exchange rate appears on its own and interacted with two dummy variables: USD_{it} is a dummy variable for whether the product is priced in U.S. dollars in both Canadian and U.S. markets and MIX_{it} is a dummy for whether the domestic price is set in Canadian dollars and the export price is set in U.S. dollars. The base case is a product whose price is set in Canadian dollars in both the domestic and U.S. markets.[25]

We would expect that if firms are pricing their exports to market, the mark-up they set on their exported product would vary more with the exchange rate than the domestic price. In this case, an increase in the exchange rate would be associated with a drop in the price ratio as the export price (in the denominator) is likely to increase more than the domestic price. If, on the other hand, firms are using the same pricing rule across markets, there should be no relationship between the exchange rate and the price ratio. Given that currency choice has already been found

[24] Since the price quotes in our data are meant to be prices at the factory gate, they should not include shipping costs. Also, the marginal cost of producing a product for the domestic market may differ from the marginal cost of an exported good because of different regulations, such as labeling requirements. However, it is unlikely that these costs are correlated with the exchange rate.

[25] There are no products whose domestic price is set in U.S. dollars and export price set in Canadian dollars, and there are only a few products that are set in U.S. dollars in both the Canadian and U.S. markets.

Table 7: Mark-ups and Price Sensitivity

	(1)	(2)
Δe_t	-0.140	-0.223*
	(0.123)	(0.118)
Δe_t*USD	-0.392	-0.371*
	(0.251)	(0.215)
Δe_t*Mix	-0.511***	-0.506***
	(0.175)	(0.178)
Δgdp_t^{CA}		-0.917**
		(0.384)
Δgdp_t^{US}		0.083
		(0.259)
Δp_t^{US}		-0.978***
		(0.234)
Δp_t^{CA}		2.430
		(2.328)
Δp_t^{input}		0.162**
		(0.066)
Δw_{it}		-0.369
		(0.444)
Observations	2,510	2,510
R-squared	0.046	0.064

Dependent variable: change in price ratio (domestic price/export price) in Canadian dollars. Region and firm fixed effects included and standard errors clustered at the firm level.
*** p<0.01, ** p<0.05, * p<0.1

to be associated with different pricing strategies, if there is evidence of distinct mark-up setting behaviour across markets, it is likely to be found by separating producers by currency choice.

In order to estimate equation (8), we must first identify those firms that ship the same product to the domestic and U.S. markets. We say a firm is selling the same product to both markets when we observe a firm shipping products with the same product class code to both the domestic and U.S. markets. Product class codes are detailed product classifications (provided in the data set) that identify a very specific product type. With this, we present the estimation results in Table 7. In column (1), we find that without control variables, there is no evidence of differential mark-up setting for goods that are priced in Canadian dollars in both markets or for those priced in U.S. dollars in both markets. There is however, strong evidence of differential mark-up setting for goods priced in different currencies. The combined point estimate on the exchange rate for goods priced in different currencies is -0.65 and it is significant at the 1% level, which indicates that firms are adjusting the mark-up on their exported good more than on their domestically sold

good in response to a movements in the exchange rate. In column (2), we introduce the full set on control variables and find that all of the coefficients on the exchange rate variables are significant at at least the 10% level. For goods priced in Canadian dollars, the point estimate is -0.22, for goods priced in U.S. dollars the combined point estimate is -0.59 (significant at the 1% level), and for mixed currencies the estimate in -0.73 (significant at the 1% level). This all suggests that even within a firm, different pricing strategies are used across markets, and the extent that prices vary across market is associated with the choice of currency.

6 Concluding remarks

We find that Canadian producer prices (once converted into a single currency) are sensitive to movements in the bilateral Canada-U.S. nominal exchange rate. We also find that that there are important differences across industries in how prices react to movements in the exchange, and that the currency of pricing in export markets is closely associated with different pricing behaviour. Canadian producers who are practicing producer currency pricing for their exports are not pricing to market, as their export prices do not respond to movements in the exchange rate, even when they are adjusting their prices. Those producers using local currency pricing are adjusting their Canadian dollar price to stabilize their U.S. dollar price in the face of exchange rate fluctuations, as the Canadian dollar prices of exports set in U.S. dollars are highly sensitive to movements in the exchange rate, and this result holds even if we condition on a price change in the currency of pricing. For the same good sold by a single firm to both the domestic and U.S. markets, the price ratio is sensitive to exchange rate movements, especially when the domestic price is set in Canadian dollars and the exported good is set in U.S. dollars. This suggests that firms use different pricing strategies across markets, and adjust their mark-ups accordingly.

The empirical findings of this paper provide useful parameters for understanding the impact of exchange rate fluctuations on price dynamics in a small open economy. The results are also helpful for developing structural monetary models that are consistent with micro facts. Moreover, our findings are important for understanding firm dynamics and competition in industries that are open to trade. Our findings contribute to understanding the structural determinants of exchange-rate pass-through to domestic prices. Finally, the finding that the currency of pricing is strongly

associated with different pricing bevahiour of firms lays the ground work for future research in better understanding the dynamics of real exchange rates.

Appendix

A Micro Data: Details

The PRS data set provides information on whether a price was reported even if there was no sale, the reason for changing the price of a good, whether the price change is temporary, as well as the number of prices reported by each firm.

No sale

In some cases, firms report a product price even though no sale of the product occurred. These no-sale prices account for about two percent of the total sample size. No information is given as to the reason for no sale (e.g. no stock or zero demand). In about thirteen percent of the no-sale price observations, there is a change in the price in the current period. In ten percent of the no-sale observations, there was a price change in the previous two months, and in twelve percent of the observations, there is a price change in the next two months. We keep these no-sale observations in our final sample.

Reason for Price Change

The survey asks producers to choose from a list of seven reasons for having changed their prices (conditional on the producer having changed the price). Only fifty percent of observed price changes have a reported reason for the change. Nevertheless, Table A1 reports the main reasons for price change.

Table A1: Main Reported Reasons for Price Changes, 2006 - 2010

Reason	Fraction of price changes (%)
Purchase Prices of Materials	44.3
Competitive Factors	36.8
Not Elsewhere Specified	7.6
Physical Characteristics	5.3
Terms of Sale	4.6

Temporary price change

Unlike consumer retail prices, there is rarely a sale on producer prices, or even a temporary price change within a certain period of time. Nevertheless, we identify a temporary price as a price change that is reversed within four months. The four month interval is chosen because an interval longer than four month may pick up seasonal price changes. These temporary price changes account for only four percent of all the observed price changes, and about half of the temporary prices changes involve a price decrease.

Multiple products

Many firms report prices for multiple products. Figure A1 shows the fraction of firms reporting a given number of unique product prices. About fifteen percent of firms report one product price, 38 percent of firms report two, and 24 percent report three. Four percent of firms report ten or more product prices. Some industries have more firms that report multiple product price than others, such as the metal, machinery and chemicals industry.

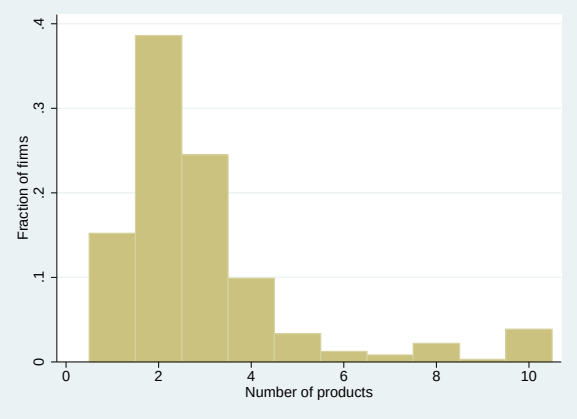


Figure A1: Multiple products

Frequency of price adjustment

Mean and median price adjustment frequencies exhibit substantial heterogeneity within each 2-digit NAICS industry. Price adjustment frequency is skewed to the left for the manufacturing sector as a whole, as well as for its component industries. The skewed distribution of price adjustment is clearly seen in Figures A2 to A9, which plot the histograms of the frequency of price adjustment in both the original reported currency and in Canadian dollars. We exclude price quotes from the

auto and auto parts manufacturing industries (NAICS 3361-3363).

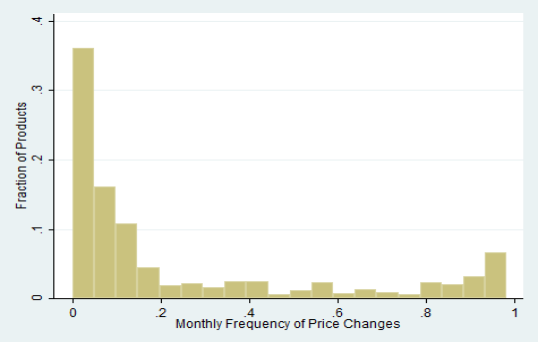


Figure A2: Frequency of Price Change, manufacturing (reported currency)

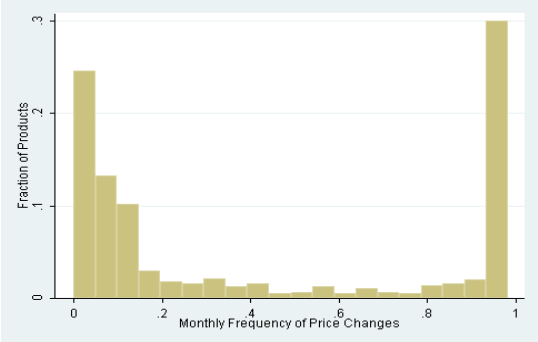


Figure A3: Frequency of Price Change, manufacturing (CAD)

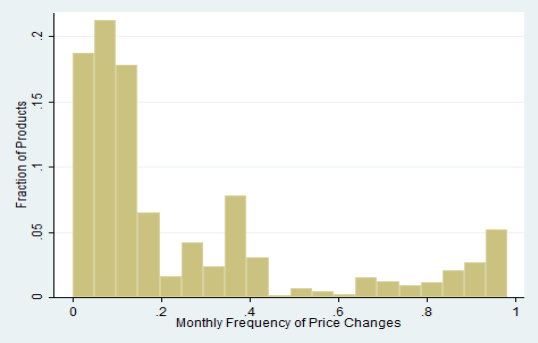


Figure A4: Frequency of Price Change, NAICS 31 (reported currency)

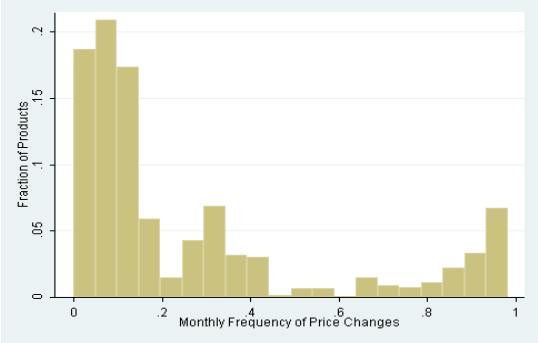


Figure A5: Frequency of Price Change, NAICS 31 (CAD)

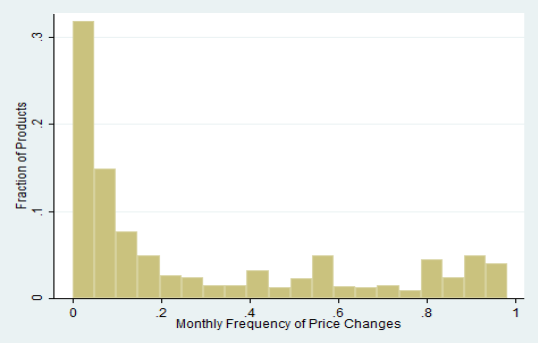


Figure A6: Frequency of Price Change, NAICS 32 (reported currency)

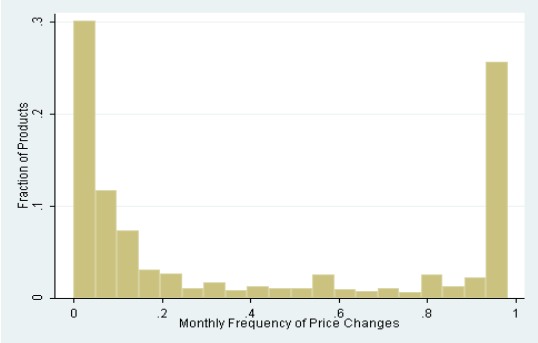


Figure A7: Frequency of Price Change, NAICS 32 (CAD)

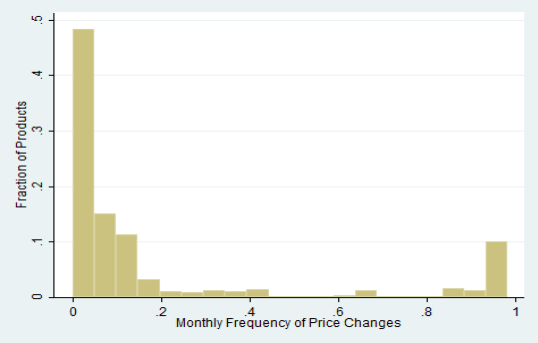


Figure A8: Frequency of Price Change, NAICS 33 (reported currency)

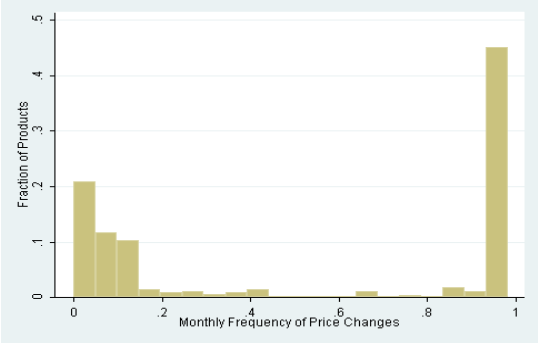


Figure A9: Frequency of Price Change, NAICS 33 (CAD)

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