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Domestic and Foreign Influences on Canadian Prices over Exchange Rate Cycles, 1974 to 1996

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Abstract

The paper examines the pricing behaviour of 81 Canadian manufacturing industries from 1974 to 1996. It explores the domestic and foreign factors that affect price formation in Canada and the circumstances in which Canadian prices respond to foreign (U.S.) influences (the law of one price), as opposed to domestic factors (i.e., labour, energy costs and productivity growth). It finds that (1) Canadian manufacturing prices are, on average, set using a mixture of a cost mark-up pricing rule and the law-of-one-price rule: both domestic factors (such as input prices and productivity) and foreign factors (such as competing U.S. prices) exert important influences on Canadian prices. (2) Canadian prices are more sensitive to U.S. prices if the industry faces higher import competition and if home and foreign products are less differentiated. Compared to prices of domestic products, prices of imported foreign products are more responsive to foreign prices. However, the price of imports also responds to Canadian prices—though this pricing-to-market phenomenon is reduced as imports increase in importance. (3) Industry differences exist. Domestic prices respond more to productivity changes in industries where competition is more intense and where products are more homogeneous. Imports respond more to domestic factors when they account for a smaller share of the domestic market. (4) As the pressure from foreign markets increases, in a period of an appreciating Canadian dollar, changes in prices are influenced more by fluctuations in foreign prices. In comparison, when the pressure from foreign markets decreases, in a period of a depreciating Canadian dollar, changes in Canadian prices are more responsive to input cost changes at home. Disequilibria that were generated by previous shocks are overcome more quickly during periods when the exchange rate appreciated.

Keywords: law of one price, pricing to market, pricing, Canada and the United States

JEL Code: D40, F14, F31, L11, L60

Executive summary

What factors affect Canadian price formation in the manufacturing sector? Economic theory offers a host of possible explanations. Some models assume closed economies and make use of a cost mark-up pricing rule. Here, industries are hypothesized to base their selling prices on unit costs and targeted rates of return (the mark-up). Others assume a perfectly competitive and integrated world, where prices are governed by the law of one price (LOP). Here, prices of a homogeneous product are set equal to world (United States in this case) prices after adjusting for transport costs, the tariff rate and the exchange rate.

This paper examines the pricing behaviour of 81 Canadian industries over the 1974-to-1996 period. It asks which rule explains the price formation process in Canada and under which circumstances Canadian prices are more affected by foreign (U.S.) prices as opposed to domestic factors such as labour and materials costs and productivity. In particular, it asks:

(1) How are prices formed in Canada? Which rule explains price movements?

Canadian manufacturing prices are, on average, neither exclusively governed by the mark-up pricing rule nor by the LOP rule. They are set in accordance with a mixture of both rules.

(2) When are Canadian prices more subject to foreign influences?

Prices for domestic products are more sensitive to U.S. prices if the Canadian industry faces higher import competition, and if home and foreign products are less differentiated.

Compared to prices of domestic products, prices of imported foreign products are more responsive to foreign prices. However, in pricing their imports, importers do not merely pass through all foreign price changes to Canadian import prices; they also adjust to the local market conditions (i.e., the Canadian costs of labour, materials and energy). Import prices reflect domestic prices more (the pricing-to-market phenomenon) when import market share is lower.

Industry differences in price responses exist and are large.

By tying the short-run behaviour of prices to their long-run values, the paper also estimates the speed of price adjustment and evaluates how it varies with exchange-rate movements. It asks:

(1) What are the factors that drive short-run price fluctuations? What is the speed of price adjustment?

The short-run fluctuations in the prices of domestic and imported foreign products reflect current changes in foreign prices and domestic economic conditions. They also move to correct disequilibria that were generated by previous shocks.

It takes around 3.6 years for 50% of the discrepancy between the actual and the long-run equilibrium value of domestic output prices to be eliminated. It takes 6.6 years for import prices to do the same.

(2) Under what circumstances do Canadian prices react more to disturbances in foreign prices? And how does the speed of adjustment vary across the exchange-rate cycle (periods of appreciation as opposed to depreciation)?

As Canada's international competitiveness deteriorates in a period of an appreciating Canadian dollar, changes in Canadian prices are more responsive to fluctuations in foreign prices. When the Canadian dollar appreciates, products from Canada become relatively more expensive. In competing with foreign products, home producers have to price their products closer to their foreign counterparts when the dollar appreciates.

As Canada's international competitiveness improves in a period of a depreciating Canadian dollar, changes in Canadian prices are more responsive to cost changes at home and less to foreign prices. When the Canadian dollar depreciates, Canadian industries enjoy a relative cost advantage. This provides more room for domestic product prices to adjust to the cost conditions at home and to their long-run equilibrium.

The speed of adjustment toward equilibrium is faster when the pressure from foreign markets increases in a period of an appreciating Canadian dollar than in a period of a depreciating Canadian dollar.

1. Introduction

How are prices formed? Economic theory offers a host of different explanations. Some models assume closed economies and propose a mark-up pricing rule. Here, industries base their selling prices on their unit costs and targeted rates of return (the mark-up). Others assume a perfectly competitive and integrated world, where prices are governed by the law of one price (LOP). Here, prices of a homogeneous product are set equal to world prices after adjusting for transport costs, the tariff rate and the exchange rate.

These models offer different policy guidance for inflation control and have different implications for analysts. If, for example, the LOP is a valid hypothesis, analysts would be justified in using the exchange rate to convert and compare inter-country real output, or to use foreign (U.S.) prices adjusted for the exchange rate to deflate imports to obtain the growth in real imports. To the extent that the LOP does not hold, such practices lead to incorrect price estimates and cross-country comparisons of real gross domestic product (GDP).

This paper examines the pricing behaviour of 81 Canadian industries over the 1974-to-1996 period. We ask which rule explains the price-formation process in Canada. We also examine the circumstances under which Canadian prices are more responsive to foreign as opposed to domestic influences.

Several studies (Kardasz and Stollery, 1998; Karikari, 1988) have examined the pricing behaviour of Canadian producers under conditions of imperfect competition and product differentiation.[1] Based on a Cournot competition model and 33 Canadian manufacturing industries from 1972 to 1989, Kardasz and Stollery (1998) find that costs of both domestic and imported foreign goods are the main determinants of their prices. Karikari (1988) uses a Stackelberg pricing model and studies the changes of prices in 57 industries over three years (1970, 1975 and 1980). He finds that from 1970 to 1975, when the Canadian dollar appreciated, changes in Canadian prices reflected changes in both the domestic cost of production and foreign prices. However, from 1975 to 1980, when Canada's international competitiveness improved due to a depreciating Canadian dollar, Canadian prices solely reflected domestic costs of production.

This paper extends these studies in several aspects. Instead of using the Cournot and Stackelberg models, we base our study on the Bertrand oligopoly pricing competition model with differentiated products. The model allows us to incorporate explicitly the influence of industry characteristics, such as product differentiation, domestic market competition and import competition, on the sensitivity of Canadian prices to domestic and foreign (U.S.) influences. Newly available data allow us to measure additional industry characteristics and investigate industry-level differences in pricing behaviour. With longer time-series data (22 years) covering more matched Canada and United States industries (81), we also estimate the speed of price adjustment and evaluate how it varies with exchange-rate movements.

1. Other country studies include Feinberg (1989) for the U.S.; Feinberg (1986) for Germany; and Bloch (1992), and Bloch and Olive (1999) for Australia.

Our empirical finding on the elasticity of Canadian prices to foreign (U.S.) prices and how the elasticity differs with respect to market and product characteristics contributes to the purchasing power parity (PPP) or the LOP literature. Most studies of PPP or the extent to which exchange-rate effects are passed through to local markets focus on the prices of commodities[2] and then primarily on the pass-through of exchange-rate changes on import or export prices.[3] In this paper, we move from examining individual commodity prices to investigating industry prices, since we are inherently interested in whether there are industry characteristics that may affect the influence of foreign prices on domestic prices. It is less common to find research that examines how the deviation from the LOP at the industry level is related to industry characteristics, such as the nature of domestic market competition, the extent of product differentiation, the degree of trade orientation, and the difference in productivity growth. The LOP hypothesis is implicitly based on the assumption that domestic and foreign goods are perfect substitutes and are traded in a perfectly competitive and integrated world market. If industries differ with respect to whether their goods are perfect substitutes for goods produced in other countries, or in their intensity of competition, we might expect industry prices to vary in terms of their adherence to the LOP.

As part of the investigation, we also examine the pricing-to-market (PTM) hypothesis. In the PTM framework (Dornbusch, 1987; Krugman, 1987), oligopolistic suppliers are able to charge different prices for the same good sold in different markets, such as domestic and export markets. Empirical evidence indicates that local currency prices of foreign products do not respond fully to changes in the exchange rate (Knetter, 1989; Marston, 1990; and Gagnon and Knetter, 1995). An investigation of the applicability of the PTM model to Canada helps us to understand the mechanism and magnitude of international price transmissions.

Studies of the PTM phenomenon are limited in terms of country coverage, data and methodology. Menon (1995) finds that more than 50% of the 43 surveyed studies are for larger economies, in particular, that of the United States. The experience of small and more trade-dependent economies has received less attention. Twelve out of nineteen pass-through estimates for small countries are provided in one study by Khosla and Teranishi (1989). For Canada, there is only one study, by Schembri (1989), who finds that Canadian exporters only pass through a small percentage of exchange-rate depreciations to their export prices. Menon (1995) also points out that most researchers have relied on price proxies, such as the unit value of imports or on aggregate prices. The measurement errors inherent in the price proxies and possible aggregation bias raise concerns about the accuracy of these estimates. This paper contributes to the literature by providing additional evidence from a relatively small trade-dependent economy (Canada) and by using more disaggregated data.

The layout of the paper is as follows. Section 2 outlines the analytical framework—the Bertrand oligopoly pricing competition model with differentiated products. Section 3 describes the data. Section 4 discusses empirical specifications. Section 5 presents empirical results. Section 6 concludes.

2. See survey articles by Froot and Rogoff (1995) and Rogoff (1996).
3. See Menon (1995), and Goldberg and Knetter (1997) for a summary of articles on exchange-rate pass-through.

2. *Analytical framework*

The model is based on Bertrand oligopoly price competition with differentiated products (Kamien and Schwartz, 1983; Varian, 1992). Consider an industry composed of two groups of firms competing in the home market: H identical home producers and F identical importers of foreign products.[4] Each firm supplies some variant of a product that is a close but not perfect substitute.

The demand for firm i's variety is given by $Q_i = Q\,(P_i, P_h, P_f, P, Y)$, where P_i is the output price set by firm i, P_h is a vector of prices of rival home varieties in the same industry, P_f is a vector of prices of rival foreign varieties in the same industry, P is the average price for all other products outside firm i's own industry and Y is the nominal national income level. We use the GDP deflator to approximate P.

Let C_i be firm i's variable cost function. If firm i is a domestic producer, then $C_h = C_h\,(W_h, A_h, Q_h)$, where W_h and A_h stand for a vector of variable input prices and productivity respectively for h=1…H. If firm i is an importer of foreign products, its cost function is $C_f = C_f\,(W_f, Q_f)$, for f=1…F, and W_f is import costs that depend on the exchange rate (e), the foreign output price (P_u) and the tariff rate (τ). One may write $W_f = eP_u(1+\tau)$.

Given its rivals' prices, each firm selects its price P_i to maximize profit: $\Pi_i = P_i\,Q_i - C_i$. Since the demand function Q_i is homogeneous of degree zero and the cost function C_i is homogeneous of degree one in W_h or W_f, we can express all prices and income in real terms so that $p_i = P_i/P$, $p_h = P_h/P$, $p_f = P_f/P$, $y = Y_i/P$, $w_h = W_h/P$, $w_f = W_f/P$, $p_u = P_u/P$ and $\pi_i = \Pi_i/P$. That is: $q_i = q_i\,(p_i, p_h, p_f, y)$, $c_h = c_h\,(w_h, A_h, q_i\,(p_i, p_h, p_f, y))$ for the home producer, and $c_f = c_f\,(w_f, q_i\,(p_i, p_h, p_f, y))$ for the importer with $w_f = ep_u(1+\tau)$. The maximization problem is rewritten as: $\pi_i = p_i\,q_i - c_i$.

Let $\varepsilon_{ii} = d\ln q_i/d\ln p_i$, $\varepsilon_{ih} = d\ln q_i/d\ln p_h$, $\varepsilon_{if} = d\ln q_i/d\ln p_f$, $\theta_{hi} = d\ln p_h/d\ln p_i$, $\theta_{fi} = d\ln p_f/d\ln p_i$ and c_i' be the marginal cost ($c_i' = dc_i/dq_i$). The first-order condition of profit maximization yields

$$p_i = [(\varepsilon_{ii} + \Sigma_h\,\varepsilon_{ih}\,\theta_{hi} + \Sigma_f\,\varepsilon_{if}\,\theta_{fi})/(1+ \varepsilon_{ii} + \Sigma_h\,\varepsilon_{ih}\theta_{hi} + \Sigma_f\,\varepsilon_{if}\,\theta_{fi})]\,c_i' \qquad (1)$$

where ε_{ii}, ε_{ih} and ε_{if} denote respectively firm i's own price elasticity of demand, cross-price elasticity of demand with rival home products, and cross-price elasticity of demand with rival foreign products, and θ_{hi} and θ_{fi} measure firm i's conjectural price elasticity, the responsiveness of rival home producers and rival importers to firm i's price changes.

Since firms within each group are identical, in equilibrium they must have the same product prices, factor prices and demand functions, so that $p_h = p_d$, $c_h' = c_d'$, $\theta_h = \theta_d$, $q_h = q_d$ for all h=1…H, and $p_f = p_m$, $c_f' = c_m'$, $\theta_f = \theta_m$, and $q_f = q_m$ for all f=1…F. The price Equation (1) for home producers and importers in an industry can be rewritten as

$$p_d = \{[\varepsilon_{dd} + \varepsilon_{dm}\theta_{md}(F/H)]/[1/H + \varepsilon_{dd} + \varepsilon_{dm}\theta_{md}(F/H)]\}\,c_d' \qquad (2d)$$
$$p_m = \{[\varepsilon_{mm}(F/H) + \varepsilon_{md}\theta_{dm}]/[1/H + \varepsilon_{mm}(F/H) + \varepsilon_{md}\theta_{dm}]\}\,c_m' \qquad (2m)$$

4. The analytical results wouldn't change if we relax the identical assumption.

Note that the demand elasticities, ε_{dd}, $\varepsilon_{mm,}$ ε_{md}, *and* ε_{dm}, depend on the demand functions, which in turn, depend on (p_d, p_m, y). The marginal cost for domestic producer c_d' and for importer c_m' is a function of (c_d, A, $q_d(p_d, p_m, y)$) and (c_m, $q_m(p_d, p_m, y)$) respectively. Thus, the implicit forms for Equations (2d) and (2m) are

$$p_d = p\,(p_m\,, y, A, c_d;\, s(H, F/H, \theta)) \qquad (3d)$$
$$p_m = p\,(p_d\,, y, c_m;\, s(H, F/H, \theta)) \qquad (3m)$$

where p_d and p_m are the prices charged by home producers and importers respectively. Equations (3d) and (3m) are two price reaction functions of home producers and importers. Each chooses its optimal price to maximize its profit, given information on the rival firm's price, its own cost of production, the level of technology, the overall strength of the economy and the characteristics of the market ($s(H, F/H, \theta)$).

The term, $s(H, F/H, \theta)$, captures the effect of the competitiveness of the markets, the substitutability of foreign and home products, and the degree of import penetration. The total number of domestic firms (H) and the relative number of importers to domestic firms (F/H) reflect the degree of domestic market competition and import competition respectively. The conjectural elasticity, $\theta_{ij}=\partial \ln p_i / \partial \ln p_j$, is firm j's belief about the effect that a change in its price strategy has on the pricing behaviour of other firms. Values of the conjectural variation reflect the degree of product differentiation and market competition. When products are completely differentiated, there is little reason to expect a seller to react to a rival's price changes. There is no competition between the two groups of firms i and j. Each firm is a monopolist in its own brand. Hence the conjectural elasticity equals zero. On the other extreme, if the products of firms i and j are perfect substitutes, the conjecture elasticity θ_{ij} is equal to unity. If, however, the two products are imperfect substitutes, the conjectural elasticity, θ_{ij}, will fall between zero and one.[5]

The strategic interaction of home producers and importers yields equilibrium prices of (p_d, p_m), which can be written in a reduced form as

$$p_d = p_d\,(c_m\,, c_d\,, A, y;\, s(H, F/H, \theta)) \qquad (4d)$$
$$p_m = p_m\,(c_m\,, c_d\,, A, y;\, s(H, F/H, \theta)) \qquad (4m)$$

The equilibrium prices, p_d and p_m, are therefore determined by the cost of imports ($c_m = ep_u(1+\tau)$), the vector of variable input prices for domestic production (c_d), the level of production efficiency (A), and the overall strength of the economy (y). Their magnitude and relative importance, however, depend on the underlying demand and production functions, and on the degree of domestic market competition, foreign competition and product differentiation as captured in the term $s(H, F/H, \theta)$.

5. It is also possible for θ_{ij} to be zero even when products are close substitutes. This may happen if firm j behaves as a price follower and firm i as a price leader, in which case, firm j's expected response of firm i to firm j's price change is zero. Similarly, if firm j behaves as a price leader and firm i as a price follower, then the conjectural elasticity θ_{ij} is equal to unity. If there is no price leadership in the market, the conjectural elasticity, θ_{ij}, should fall between zero and one.

Equation (4d) nests two extreme cases of price determination: the fixed mark-up rule and the law of one price (LOP). The fixed mark-up rule implies that the price of domestic output is determined by the marginal cost of production and the mark-up. If only the fixed mark-up model is correct, we expect the elasticity of domestic output price with respect to input cost ($\frac{d \ln p_d}{d \ln c_d}$) to equal one and the elasticity with respect to foreign prices ($\frac{d \ln p_d}{d \ln c_m}$) to equal zero. The LOP, on the other hand, hypothesizes that domestic prices are entirely determined by the world prices (adjusted by the exchange rate, tariffs and transportation costs). If only the LOP holds, then the elasticity of domestic output price with respect to input cost ($\frac{d \ln p_d}{d \ln c_d}$) equals zero and the elasticity with respect to foreign prices ($\frac{d \ln p_d}{d \ln c_m}$) equals one.

These two hypotheses represent two separate extremes. The mark-up rule is based on the assumption of a closed economy and thus neglects foreign influences on domestic prices. The LOP rule is based on the assumption that domestic and foreign goods are perfect substitutes (homogeneous) and are traded in a perfectly competitive and integrated world market. It ignores product differentiation and market separation arising from border effects and barriers of trade. To the extent that neither of the assumptions underlying the two extremes hold exactly, it becomes possible for both forces, domestic and foreign, to play a role in affecting domestic prices, with their relative importance depending on the environment, which itself may be changeable. Between these two extreme cases, one may therefore expect that ($\frac{d \ln p_d}{d \ln c_d}$) and ($\frac{d \ln p_d}{d \ln c_m}$) lie between zero and one.

Equations (4d) and (4m) allow us to test the pricing-to-market (PTM) hypothesis. The PTM hypothesis refers to the phenomenon of less-than-proportional response of import prices to changes in foreign prices, exchange rate and tariffs. The PTM hypothesis implies that the elasticity of import price with respect to foreign prices ($\frac{d \ln p_m}{d \ln c_m}$) is less than one.

3. *Data sources and measurements of industry characteristics*

All data are from Statistics Canada, except the U.S. producer price index (P_u), which is from the National Bureau of Economic Research and Center for Economic Studies (NBER-CES) Manufacturing Industry Database. The NBER-CES Database covers 459 U.S. manufacturing industries from 1958 to 1996. They are matched to the Canadian P-level of aggregation (at the 3- and 4-digit Standard Industrial Classification [SIC] level), using the SIC created by Statistics Canada and the U.S. Census Bureau. The final dataset covers 81 comparable manufacturing industries from 1974 to 1996. The construction of the variables and the data sources are summarized in Table 1. There are a few points that require further elaboration.

Table 1 Data sources and measurements

Variables	Definition and measurement (1974 to 1996)	Source[1]
Variables on prices, costs, total factor productivity and income[2]		
P_d	Implicit chained Fisher price index of gross output, 1974=1	KLEMS[3] productivity database, MEAD[4]
P_m	Implicit price index of imports, 1974=1	IOD[5]
C_d	Implicit price index of variable inputs, 1974=1 C_d is constructed as a weighted average of Fisher variable input price indices with weights being the variable cost shares for labour, energy, material and services.	Derived from KLEMS, MEAD
A	Fisher gross multifactor productivity index, 1974=1	KLEMS
Y	GDP[6] for Canada in current dollar, normalized to 1974=1	CANSIM[7]
P_u	Producer price index for matching U.S. industries, 1974=1	NBER-CES Manufacturing Industry Database[8]
E	Nominal exchange rate (Canada dollar/U.S. dollar)	CANSIM
τ	Effective tariff rate = (total import duty)/(total imports−total import duty). All in current dollar.	MEAD
P	GDP deflator for Canada 1974=1	CANSIM
Variables on industry characteristics		
*CON*4	Top four-firm market share: $CON4 = \sum_i S_i$, where i=4 and S_i is the firm's output share.	ASM,[9] MEAD
HERF	Firm Herfindahl index: $\sum_i S_i^2$ for all firms classified to the industry.	ASM
ENTROPY	Firm entropy measure: $-\sum S_i \ln S_i$	ASM
NE_ENTR	Numbers equivalent to the entropy measure: the antilog of *ENTROPY*.	ASM
TURNE	Turnover rate due to entry and exit: percentage of total employment accounted for by the entry and exit of firms.	ASM
TURNC	Turnover rate due to decliner and grower in the continuing firms: percentage of total employment accounted for the decliner and grower firms.	ASM
MSH	Import share (proportion of imports to total domestic consumption): *MSH* = (imports)/(output−export+import)	IOD
GRB	Grubel-Lloyd intra-industry trade index *ITRGRB*=1−|export−import|/(export+import)	IOD
ADV	Advertising intensity: advertising expenditure/gross output	IOD
*PRN*1	A composite measure of the intensity of competition among home producers.	The first principle component from Table 2

1. All data are from Statistics Canada, except P_u which is from the NBER-CES Manufacturing Industry Database.
2. Variables (P_d, P_m, P_u, C_d, Y) are all deflated by the GDP deflator P before estimation, so that $p_d=P_d/P$, $p_m=P_m/P$, $p_u=P_u/P$, $c_d = C_d/P$, $y=Y/P$.
3. Capital, labour, energy, materials and services.
4. Micro-economic Analysis Division.
5. Input-output Division.
6. Gross domestic product.
7. Canadian Socio-economic Information Management System.
8. National Bureau of Economic Research and (U.S. Census Bureau's) Center for Economic Studies Manufacturing Industry Database. The NBER-CES Database covers 459 four-digit U.S. manufacturing industries from 1958 to 1996. They are matched to the Canadian P-level of aggregation (at the 3- and 4-digit Standard Industrial Classification [SIC] level), using the SIC created by Statistics Canada and the U.S. Census Bureau.
9. Annual Survey of Manufactures.

Sources: Statistics Canada, Micro-economic Analysis Division, Input-output Division, CANSIM, Annual Survey of Manufactures, KLEMS productivity database; National Bureau of Economic Research and Center for Economic Studies (U.S. Census Bureau), NBER-CES Manufacturing Industry Database; and Statistics Canada and U.S. Census Bureau, Standard Industrial Classification.

3.1 Prices, costs, total factor productivity and income

Domestic output prices (P_d) are the implicit chained Fisher price index from the Canadian capital, labour, energy, materials and services (KLEMS) productivity database, and import prices (P_m) are the implicit import prices derived from the input-output tables.[6] Productivity (A) is the Fisher gross output multifactor productivity index from the KLEMS database. As to the vector of variable input prices (C_d), we construct an implicit price index of variable inputs—a weighted average of Fisher variable price indices, with the weights being determined by the variable-cost shares.

We take U.S. industrial output prices as proxy for the world producer prices P_u. This assumes that the U.S. economy can be taken as the world from the Canadian perspective. The assumption is reasonable given that the Canadian economy is only one-tenth the size of the U.S. one, and around 60% to 70% of Canada's imports are from the United States during the period of study.

Data on prices, costs and income (P_d, P_m, P_u, C_d, Y) are all deflated by the GDP deflator P before estimation, so that $p_d=P_d/P$, $p_m=P_m/P$, $p_u=P_u/P$, $c_d=C_d/P$, $y=Y/P$. They, along with the productivity variable (A), are all measured as indices with a base value of one for the year 1974.

3.2 Industry characteristics

Import competition
Import competition is measured by the import proportion of domestic consumption (*MSH*).

Market structure
Traditionally, the measurement of market structure has focused on the size distribution of firms in an industry. The most widely used summary statistic is the concentration ratio—the percentage of output accounted for by a number of the largest firms (four, eight). Another variant considers the size distribution of all firms in an industry, using the Herfindahl index, the entropy index and the numbers equivalent to entropy measure (Baldwin, 1998).

These size-related statistics, however, typically exhibit considerable stability over time. They may not reflect the substantial change or firm mobility that is taking place within industries, as firms enter, exit, grow and decline. Baldwin (1998) examines the extent and the patterns of intra-industry turnover, their relationship to the intensity of the competitive process, and their importance to market performance, and demonstrates that concentration ratios are related to mobility statistics, but only imperfectly. The two measures often provide different pictures of the intensity of the competitive process at the industry level. It is, therefore, better to use both measures to depict the intensity of competition within each industry.

To summarize the intensity of competition, principal-component analysis is used here. Principal-component analysis is useful when there are a number of related yet different measures of a given phenomenon. The first principal component of a set of variables is a weighted average of

6. Data on imports by industry are derived by using a commodity mapping from import commodities to the make matrix of the input-output tables. The make matrix provides a picture of commodities produced by industry.

the original variables in which the weights (eigenvectors) are chosen to make a new composite index (principal component). It reflects the maximum possible proportion of the total variation in the set. Each succeeding component, uncorrelated to previous ones, can be similarly calculated to maximize the proportion of the remaining variation in the original variables. One simple criterion for selecting the number of principal components is to retain components with associated eigenvalues greater than the average eigenvalue (Kaiser, 1958).

For the principal component analysis, three concentration measures and two mobility measures are used here. The three concentration measures include the four-firm concentration ratio (*CON*4), the Herfindahl index (*HERF*) and the entropy index (*ENTROPY*). The two mobility measures include the turnover rate arising from entry and exit, measured as the employment share of entrants and exits (*TURNE*), and the turnover rate arising from continuing-firm growth and decline, measured as the share of employment gain and loss from growers and decliners (*TURNC*).

The results are presented in Table 2. The first principal component (*PRN*1) explains about 63% of the total variance. It is a composite index of overall intensity of domestic market competition since the first eigenvector has similar loadings on all variables, with higher loadings on concentration variables. The second principal component has higher positive weights on the two mobility measures. We use the first principal component in our regression, since its eigenvalue is greater than the average eigenvalue and it accounts for 64% of the total variation of the set of the original variables.[7]

Table 2 Principal-component analysis for market competition, 1974 to 1996

Competition variable	Eigenvector				
	*PRN*1	*PRN*2	*PRN*3	*PRN*4	*PRN*5
*CON*4	-0.54	0.23	0.04	-0.16	0.79
HERF	-0.50	0.32	0.03	0.75	-0.29
ENTROPY	0.53	-0.16	-0.02	0.63	0.54
TURNE	0.30	0.61	0.73	-0.08	0.01
TURNC	0.28	0.66	-0.69	-0.07	-0.02
Proportion of total sample variability accounted for	0.64	0.20	0.12	0.03	0.03
Eigenvalue	3.18	1.02	0.62	0.15	0.04

Note: Author's calculations based on data from the source below.
Source: Statistics Canada, Annual Survey of Manufactures.

Product differentiation

We consider two alternative measures of product differentiation: the Grubel-Lloyd intra-industry trade index (*GRB*) and the advertising–sales ratio (*ADV*). Intra-industry trade occurs when commodities are simultaneously both imported and exported. It is closely related to the notion of product differentiation (Grubel and Lloyd, 1975). Product differentiation is also related to the

7. We also experimented with the second principal component included in the regression. The coefficients on the interaction terms with this component are insignificant.

intensity of advertising. We postulate that the proportion of expenses on advertising is positively correlated with the extent of product differentiation at the industry level.

However, we are unable to use principal-component analysis to aggregate the different measures into one or two composite indexes, since they have almost zero correlation with each other. They may therefore capture different aspects of production differentiation, and we will enter both directly into the regression.

4. *Empirical specifications*

The exact form of Equations (4d) and (4m) depends on the functional form of demand and production functions, but is likely to be highly non-linear. We employ a log-linear approximation.

$$\ln p_d = a_0 + a_1 \ln[ep_u(1+\tau)] + a_2 \ln(c_d) + a_3 \ln A + a_4 \ln y + u_d \qquad (5d)$$
$$\ln p_m = b_0 + b_1 \ln[ep_u(1+\tau)] + b_2 \ln(c_d) + b_3 \ln A + b_4 \ln y + u_m \qquad (5m)$$

where u_d and u_m are the error terms. The coefficients measure the price elasticity with respect to U.S. prices, local production costs, productivity and the level of GDP.

The magnitude of each coefficient is expected to vary with industry characteristics: domestic market competition as measured by *PRN*1, foreign competition as measured by *MSH*, and the two measures of product differentiation—*GRB* and *ADV*. Suppose they are linearly related so that

$$a_1 = a_{10} + a_{11}\, PRN1 + a_{12}\, MSH + a_{13}\, GRB + a_{14}\, ADV \qquad (6a_1)$$
$$a_2 = a_{20} + a_{21}\, PRN1 + a_{22}\, MSH + a_{23}\, GRB + a_{24}\, ADV \qquad (6a_2)$$
$$a_3 = a_{30} + a_{31}\, PRN1 + a_{32}\, MSH + a_{33}\, GRB + a_{34}\, ADV \qquad (6a_3)$$
$$a_4 = a_{40} + a_{41}\, PRN1 + a_{42}\, MSH + a_{43}\, GRB + a_{44}\, ADV \qquad (6a_4)$$

$$b_1 = b_{10} + b_{11}\, PRN1 + b_{12}\, MSH + b_{13}\, GRB + b_{14}\, ADV \qquad (6b_1)$$
$$b_2 = b_{20} + b_{21}\, PRN1 + b_{22}\, MSH + b_{23}\, GRB + b_{24}\, ADV \qquad (6b_2)$$
$$b_3 = b_{30} + b_{31}\, PRN1 + b_{32}\, MSH + b_{33}\, GRB + b_{34}\, ADV \qquad (6b_3)$$
$$b_4 = b_{40} + b_{41}\, PRN1 + b_{42}\, MSH + b_{43}\, GRB + b_{44}\, ADV \qquad (6b_4)$$

Substituting Equations ($6a_1$) to ($6a_4$) and ($6b_1$) to ($6b_4$) into Equations (5d) and (5m), we obtain Equations (7d) and (7m), which are used to estimate industry impacts.

$$\begin{aligned}\ln p_d = a_0 &+ [a_{10} + a_{11}PRN1 + a_{12}MSH + a_{13}GRB + a_{14}ADV] \ln[ep_u(1+\tau)]\\ &+ [a_{20} + a_{21}PRN1 + a_{22}MSH + a_{23}GRB + a_{24}ADV] \ln(c_d)\\ &+ [a_{30} + a_{31}PRN1 + a_{32}MSH + a_{33}GRB + a_{34}ADV] \ln A\\ &+ [a_{40} + a_{41}PRN1 + a_{42}MSH + a_{43}GRB + a_{44}ADV] \ln y + u_d \qquad (7d)\end{aligned}$$

and

$$\ln p_m = b_0 + [b_{10} + b_{11}PRN1 + b_{12}MSH + b_{13}GRB + b_{14}ADV] \ln[ep_u(1+\tau)]$$
$$+ [b_{20} + b_{21}PRN1 + b_{22}MSH + b_{23}GRB + b_{24}ADV] \ln(c_d)$$
$$+ [b_{30} + b_{31}PRN1 + b_{32}MSH + b_{33}GRB + b_{34}ADV] \ln A$$
$$+ [b_{40} + b_{41}PRN1 + b_{42}MSH + b_{43}GRB + b_{44}ADV] \ln y + u_m \qquad (7m)$$

Equations (5d) and (5m) describe long-run equilibrium relationships between the dependent and independent variables. There may be, of course, disequilibrium in the short run. One may, therefore, treat the error term from the long-run regression as an 'error correction term,' and use it to tie the short-run behaviour of the dependent variables to their long-run value (Engle and Granger 1987). The error correction mechanism allows us to write the following model:

$$\Delta \ln p_d = \theta_0 + \theta_1 \Delta \ln[ep_u(1+\tau)] + \theta_2 \Delta \ln(c_d) + \theta_3 \Delta \ln A + \theta_4 \Delta \ln y + \theta_5 \hat{u}_{d,t-1} + \varepsilon_{d,t} \qquad (8d)$$
$$\Delta \ln p_m = \lambda_0 + \lambda_1 \Delta \ln[ep_u(1+\tau)] + \lambda_2 \Delta \ln(c_d) + \lambda_3 \Delta \ln A + \lambda_4 \Delta \ln y + \lambda_5 \hat{u}_{m,t-1} + \varepsilon_{m,t} \qquad (8m)$$

where Δ denotes the first difference; $\hat{u}_{d,\,t-1}$ and $\hat{u}_{m,\,t-1}$ are one-period lagged values of the residuals from regressions (5d) and (5m), which are the empirical estimates of the equilibrium error terms. The error correction term $\hat{u}_{d,\,t-1}$ and $\hat{u}_{m,\,t-1}$ capture the adjustment toward the long-run equilibrium. Values of θ_5 and λ_5, that are negative and less than one, indicate a stable process of adjustment to the long-run relationship. They tell us what proportion of the disequilibrium in one period is corrected in the next period, and thus the speed of adjustment.

5. *Results*

All equations are estimated as pooled cross-sectional time series with fixed industry effects, covering 81 manufacturing industries from 1974 to 1996. Two points are worth mentioning before examining results.

First, pooling cross-sectional data over time may introduce non-constant variance to the error terms. The error terms may differ across time due to non-stationarity of the data, or may differ across industries due to different characteristics of industries. Prior to estimation, we therefore check for stationarity of the regression residuals, using the panel unit root test method proposed by Im, Pesaran and Shin (2003). The method involves estimating a Dickey-Fuller (DF) regression for each industry, obtaining an average DF t-statistic across industries and then testing for a system-wide unit root by comparing the average t-statistics with the critical values that are tabulated in Im, Pesaran and Shin (2003). We find that the null of a unit root is rejected for the residuals from Equations (5d) and (5m).[8] This implies that the regressions are co-integrated and the standard statistical inference applies.

Second, Durbin-Wu-Hausman tests suggested that some or all of the independent variables were endogenous in Equations (5d) and (5m). We experimented with different assumptions on the endogeneity of the independent variables by using their lagged values as instrumental variables.

8. The calculated average t-statistics are -2.18 and -1.82 for Equations (5d) and (5m) respectively. This compares to the critical t-statistics of -1.67 at 5% significance level (Im, Pesaran and Shin, 2003).

Regression results from the different assumptions are qualitatively similar. Here, we only report two sets of results: results under specification (1) where we assume all independent variables are exogenous, and results under specification (2) where we assume all independent variables are endogenous. The former is our base case, and will be the focus of our presentation of the results. The latter demonstrates the sensitivity of results to the assumption of exogeneity.

Table 3 Long-run regression results based on 81 Canadian manufacturing industries, 1974 to 1996: Industry fixed effect model

Explanatory variables	$\ln(p_d)$ Equation (5d)		$\ln(p_m)$ Equation (5m)	
	Specification (1)	Specification (2)	Specification (1)	Specification (2)
$\ln[ep_u(1+\tau)]$	0.383 *	0.424 *	0.856 *	0.876 *
	(16.79)	(19.07)	(18.87)	(16.40)
$\ln(c_d)$	0.564 *	0.546 *	0.585 *	0.691 *
	(16.81)	(13.48)	(5.35)	(4.99)
$\ln(A)$	-0.569 *	-0.573 *	-0.251 *	-0.217 *
	(-19.74)	(-19.07)	(-3.93)	(-2.87)
$\ln(y)$	0.049 *	0.06 *	-0.006	-0.016
	(4.18)	(4.81)	(-0.2)	(-0.49)
Constant	-0.043 *	-0.037 *	0.124 *	0.168 *
	(-4.04)	(-3.05)	(2.74)	(3.09)
Observations	1,782	1,782	1,782	1,782
R-squared	0.96	0.96	0.83	0.83

* significant at the 5% level or better.

Notes: Robust t-statistics are in parentheses. All specifications include industry dummies. Specification (1) reports results without correcting for the possible endogeneity of explanatory variables, while specification (2) allows for endogeneity and uses lagged values of all explanatory variables as instrumental variables. Observations for the first year of a period are deleted due to the lagged variables.

Sources: Statistics Canada; and National Bureau of Economic Research and Center for Economic Studies (U.S. Census Bureau), (NBER-CES) Manufacturing Industry Database.

5.1 Pass-through elasticities

The elasticities reported in Table 3 are estimated based on Equations (5d) and (5m). They measure the percentage change of prices for a given percentage change in home and foreign factors. For example, if the fixed mark-up pricing rule is a valid hypothesis, the elasticity of domestic output prices, with respect to cost of production, should be one, i.e., a 1% increase in the cost of production would raise domestic output prices by 1% on average.

Under specification (1), the estimated elasticities of domestic output price with respect to U.S. prices, domestic cost of production, productivity and income are 0.38, 0.56, -0.57 and 0.05 respectively, all of which are significantly different from zero and from one. Both the pure mark-up pricing rule and the pure law of one price are rejected for Canadian manufacturing industries. The prices of domestic outputs are jointly determined by foreign prices and domestic conditions such as cost of production, productivity and GDP.

Compared to output pricing, import prices respond more to foreign factors, with an elasticity of 0.86 with respect to U.S. prices, 0.59 to domestic cost of production and -0.25 to productivity growth. All are greater than zero but less than one, and statistically significant at the 5% level.

Table 4 Industry impact

Explanatory variables	$\ln(p_d)$ (Equation [7d])		$\ln(p_m)$ (Equation [7m])	
	Specification (1)	Specification (2)	Specification (1)	Specification (2)
$\ln[ep_u(1+\tau)]$	0.281 *	0.44 *	0.686 *	0.728 *
	(6.50)	(6.23)	(4.78)	(3.03)
$PRN1 * \ln[ep_u(1+\tau)]$	0.011	0.015	-0.053 *	-0.084 *
	(1.55)	(1.40)	(-2.04)	(-2.03)
$MSH * \ln[ep_u(1+\tau)]$	0.36 *	0.286 *	0.717 *	0.918 *
	(8.44)	(4.85)	(5.01)	(4.23)
$GRB * \ln[ep_u(1+\tau)]$	-0.130 *	-0.240 *	-0.104	-0.199
	(-2.48)	(-2.93)	(-0.58)	(-0.71)
$ADV * \ln[ep_u(1+\tau)]$	-3.816 *	-3.980 *	-6.753 *	-5.497
	(-6.14)	(-5.13)	(-3.31)	(-1.95)
$\ln(c_d)$	0.46 *	-0.017	-0.523 *	-1.255 *
	(6.23)	(-0.09)	(-2.06)	(-2.20)
$PRN1 * \ln(c_d)$	-0.073 *	-0.094 *	-0.373 *	-0.449 *
	(-5.22)	(-4.37)	(-6.92)	(-6.10)
$MSH * \ln(c_d)$	-0.24 *	-0.086	-0.474	-0.610
	(-3.00)	(-0.71)	(-1.56)	(-1.25)
$GRB * \ln(c_d)$	0.198 *	0.714 *	0.470	1.332 *
	(2.20)	(3.18)	(1.50)	(1.96)
$ADV * \ln(c_d)$	0.630	0.935	37.65 *	36.591 *
	(0.51)	(0.56)	(7.29)	(6.09)
$\ln(A)$	-0.385 *	-0.456 *	-0.488 *	-0.743 *
	(-5.61)	(-4.82)	(-2.78)	(-2.84)
$PRN1 * \ln(A)$	-0.041 *	-0.041 *	-0.107 *	-0.097
	(-3.58)	(-2.43)	(-2.40)	(-1.40)
$MSH * \ln(A)$	-0.128	-0.093	0.665 *	1.114 *
	(-1.71)	(-0.94)	(2.68)	(3.13)
$GRB * \ln(A)$	-0.037	0.027	-0.384	-0.311
	(-0.45)	(0.25)	(-1.78)	(-1.06)
$ADV * \ln(A)$	3.195 *	3.485 *	24.359 *	29.881 *
	(2.97)	(2.38)	(5.38)	(5.01)
$\ln(y)$	0.047	0.112 *	-0.055	0.039
	(1.43)	(2.12)	(-0.58)	(0.26)
$PRN1 * \ln(y)$	0.005	0.01	0.048 *	0.049 *
	(0.95)	(1.33)	(2.91)	(2.07)
$MSH * \ln(y)$	-0.088 *	-0.09 *	0.387 *	0.380 *
	(-2.53)	(-2.00)	(3.40)	(2.46)
$GRB * \ln(y)$	-0.018	-0.098	-0.212	-0.345 *
	(-0.52)	(-1.69)	(-1.86)	(-1.98)
$ADV * \ln(y)$	0.367	0.404	-5.713 *	-5.443 *
	(0.88)	(0.82)	(-3.69)	(-2.96)
Constant	-0.109 *	-0.105 *	-0.112 *	-0.144 *
	(8.03)	(6.69)	(2.58)	(2.62)
Observations	1,782	1,782	1,782	1,782
R-squared	0.97	0.97	0.87	0.87

* significant at the 5% level or better.

Notes: Robust t-statistics are in parentheses. All specifications include industry dummies. Specification (1) reports results without correcting for the possible endogeneity of explanatory variables, while specification (2) allows for endogeneity and uses lagged values of all explanatory variables as instrumental variables. Observations for the first year of a period are deleted due to the lagged variables.

Sources: Statistics Canada; and National Bureau of Economic Research and Center for Economic Studies (U.S. Census Bureau), (NBER-CES) Manufacturing Industry Database.

Thus, the pricing-to-market hypothesis cannot be rejected. Changes in the cost of imports, caused by fluctuations in the exchange rate, are not completely passed through to import prices. Instead, importers absorb part of these fluctuations and take into account local market conditions when pricing their products.

5.2 Industry impact

Impacts of industry characteristics on pass-through elasticities are estimated using Equations (7d) and (7m). For the domestic price Equation (7d), we find that domestic market competition, *PRN*1, has significant negative signs (a_{21}=-0.07, a_{31}=-0.04) on its interaction terms with $\ln(c_d)$ and $\ln(A)$. A more competitive domestic market induces less pass-through of cost increases to consumers through rises in output prices, and more pass-through of productivity gains to consumers through a reduction in output prices.

Import share, *MSH*, has a positive sign (a_{12}=0.36) on its interaction term with $\ln[ep_u(1+\tau)]$, and negative (a_{42}=-0.09) on its interaction term with $\ln(y)$, both of which are statistically significant at the 5% level. As imports account for an increasing share of the domestic market, the influence of U.S. prices on Canadian prices increases, while the inflationary pressure from GDP growth on domestic prices decreases.

Product differentiation, measured by *GRB* and *ADV*, has negative signs (a_{13}=-0.13, a_{14}=-3.82) on their interaction terms with $\ln[ep_u(1+\tau)]$, and is statistically significant. The more differentiated are the products, the less likely will Canadian output prices follow the law of one price. In addition, higher product differentiation induces more pass-through of domestic costs and less pass-through of productivity growth to prices. This is evidenced by the positive coefficients (a_{23}=0.20, a_{34}=3.20) on the interaction terms $GRB*\ln c_d$ and $ADV*\ln A$ respectively. In an industry with highly differentiated products, firms behave as monopolists in their own brands, and pass on a greater proportion of their cost increases to higher prices, and a smaller portion of productivity gain to lower prices.

Next, we briefly examine the import price equation. The transmission of U.S. prices to import prices is significantly increased if the domestic market is less competitive (b_{11}=-0.05) or if there is a higher share of imports in the domestic market (b_{12}=0.72). The results also show that higher product differentiation gives importers more price-setting power by adjusting import prices upward more to reflect increases in the local cost of production (b_{24}=37.65), but less to changes in productivity and GDP in the local economy (b_{34}=24.36, b_{44}=-5.71). In addition, import prices are less affected by the local cost of production if the local market is more competitive (b_{21}=-0.37), and by productivity growth if the local market has a higher proportion of imports (b_{32}=0.67).

To see whether differences in industries' price responses are large, we calculate the price elasticity for different industry groups (Table 5). First, we classify industries into groups according to the degree of domestic market competition, import competition, product differentiation as measured by the Grubel intra-industry trade index and as measured by the advertising–sales ratio. For example, the top 25% and the bottom 25% of industries in terms of domestic market competition are classified as industries with high and low competition respectively. Next, the elasticity for each industry group is obtained by estimating Equations (5d) and (5m). In general, Table 5 shows that the impact of industries' characteristics on the price responses is not only statistically significant, but also large. For example, industries with high import competition (top 25% industries in terms of import shares) induce higher pass-through of U.S. prices to domestic output prices, that is almost six times as large as industries with less import competition (the bottom 25% in terms of import shares). Higher product differentiation gives importers more price-setting power and allows them to adjust import prices upward more to reflect increases in the local costs of production. Industries that are in the top 25%, in terms of advertising–sales ratios, have an elasticity that is more than 10 times as large as those in the bottom 25%.

Table 5 Price elasticity by industry group

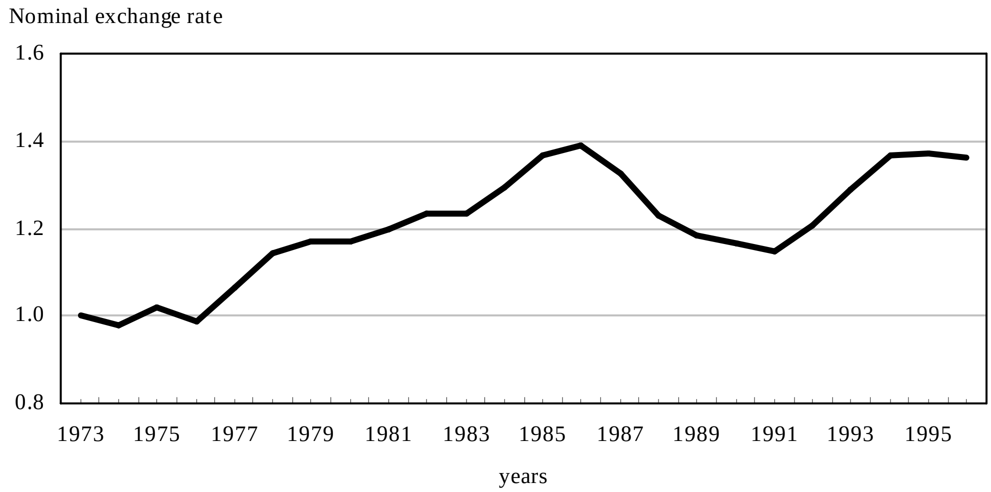
Specification	Industry characteristics	Industry group	Elasticity with respect to: U.S. prices [$\ln ep_u(1+\tau)$]	Input cost [$\ln c_d$]	Productivity [$\ln A$]	Income [$\ln y$]
Prices for domestic produced goods (Equation [5d])						
Specification (1)	Domestic market competition	Low	0.21*	0.72*	-0.39*	-0.002
		High	0.22*	0.41*	-0.45*	0.05*
	Import competition	Low	0.08*	0.82*	-0.32*	0.03
		High	0.51*	0.43*	-0.57*	0.03
	Product differentiation (Grubel intra-industry trade index)	Low	0.46*	0.28*	-0.42*	0.01
		High	0.22*	0.65*	-0.41*	0.01
	Product differentiation (advertising–sales ratio)	Low	0.35*	0.69*	-0.41*	-0.06*
		High	0.20*	0.68*	-0.37*	0.02
Specification (2)	Domestic market competition	Low	0.22*	0.78*	-0.45*	0.01
		High	0.30*	0.31*	-0.45*	0.07*
	Import competition	Low	0.13*	0.85*	-0.33*	0.04
		High	0.52*	0.40*	-0.58*	0.05*
	Product differentiation (Grubel intra-industry trade index)	Low	0.55*	0.02	-0.43*	0.06*
		High	0.28*	0.67*	-0.41*	0.02
	Product differentiation (advertising–sales ratio)	Low	0.43*	0.64*	-0.41*	-0.05*
		High	0.23*	0.72*	-0.41*	0.03
Prices for imported goods (Equation [5m])						
Specification (1)	Domestic market competition	Low	0.97*	1.02*	0.11	0.13
		High	0.63*	0.18	0.18	-0.08
	Import competition	Low	1.01*	0.67*	-0.34	0.29*
		High	1.03*	-0.03	-0.36*	-0.01
	Product differentiation (Grubel intra-industry trade index)	Low	0.75*	0.35	-0.04	-0.02
		High	0.36*	0.50*	-0.68*	-0.001
	Product differentiation (advertising–sales ratio)	Low	0.56*	0.28*	-0.40*	-0.09*
		High	0.74*	2.22*	0.56*	-0.13
Specification (2)	Domestic market competition	Low	0.92*	1.33*	0.24	0.05
		High	0.69*	0.09	0.14	-0.06
	Import competition	Low	1.17*	0.63*	-0.37	0.35*
		High	1.06*	-0.06	-0.33*	-0.01
	Product differentiation (Grubel intra-industry trade index)	Low	0.82*	0.39	-0.05	0.01
		High	0.26*	0.68*	-0.71*	-0.05
	Product differentiation (advertising–sales ratio)	Low	0.57*	0.39*	-0.37*	-0.11*
		High	0.84*	2.43*	0.61*	-0.15

* significant at the 5% level or better.

Notes: The top 25% and the bottom 25% of industries in terms of domestic market competition, import competition, product differentiation are classified as high and low industries respectively. Robust t-statistics are in parentheses. All specifications include industry dummies. Specification (1) reports results without correcting for the possible endogeneity of explanatory variables, while specification (2) allows for endogeneity and uses lagged values of all explanatory variables as instrumental variables. Observations for the first year of a period are deleted due to the lagged variables.

Sources: Statistics Canada; and National Bureau of Economic Research and Center for Economic Studies (U.S. Census Bureau), (NBER-CES) Manufacturing Industry Database.

Figure 1 Nominal exchange rate (Canadian dollar relative to U.S. dollar)



Sources: Statistics Canada; and National Bureau of Economic Research and Center for Economic Studies (U.S. Census Bureau), (NBER-CES) Manufacturing Industry Database.

5.3 Short-run adjustment

Equations (8d) and (8m), depicting the short-run adjustment process for prices, are estimated using residuals from Equations (5d) and (5m).

First, we examine results for the entire period from 1974 to 1996. Table 6 shows that the short-run movements in output prices and import prices reflect not only changes in foreign prices and domestic economic conditions, but also adjustments towards their long-run equilibrium. The speed of adjustment is -0.18 and -0.10 for domestic output prices and import prices respectively. The negative sign indicates a stable process of adjustment towards the long-run equilibrium. About 0.18 of the discrepancy between the actual and the long-run value of domestic output price is eliminated each year. This yields a half-life of decay of 3.6 years: the expected number of years for the price deviation to decay by 50% is 3.6 years for output prices. Similarly, the adjustment elasticity of -0.10 implies a half-life of 6.6 years for import prices. These estimates are very close to the half-life of 3 to 5 years found in the purchasing power parity convergence literature (Froot and Rogoff, 1995; Rogoff, 1996).

The exchange rate between Canada and the United States has undergone several long-term movements during the last 30 years (Figure 1). The Canadian dollar depreciated in relation to the U.S. dollar from the mid-1970s to the mid-1980s, followed by an appreciation from 1986 to 1991. Since 1991, the Canadian dollar declined steadily from 87 U.S. cents in 1991 to only 64 U.S. cents in 2002. To understand how the different exchange-rate regimes impact on the adjustment process of domestic output prices and import prices, we re-estimate Equations (8d) and (8m) for two sub-periods: 1974 to 1986 and 1991 to 1996 when the Canadian dollar depreciated, and 1986 to 1991 when the Canadian dollar appreciated.

Table 6 Short-run regression results based on 81 Canadian manufacturing industries, 1974 to 1996: Industry fixed effect model

Explanatory variables	$\Delta\ln(p_d)$ (Equation [8d])		$\Delta\ln(p_m)$ (Equation [8m])	
	Specification (1)	Specification (2)	Specification (1)	Specification (2)
The entire period: 1974 to 1996				
$\Delta\ln[ep_u(1+\tau)]$	0.231 *	0.235 *	0.496 *	0.497 *
	(11.19)	(11.29)	(14.04)	(14.05)
$\Delta\ln(c_d)$	0.525 *	0.523 *	0.3 *	0.306 *
	(17.35)	(17.29)	(5.07)	(5.14)
$\Delta\ln(A)$	-0.26 *	-0.26 *	-0.142 *	-0.141 *
	(-11.52)	(-11.62)	(-2.03)	(-2.02)
$\Delta\ln(y)$	0.355 *	0.348 *	0.288 *	0.285 *
	(10.02)	(9.86)	(3.85)	(3.81)
$\hat{u}_{t-1}$	-0.176 *	-0.18 *	-0.1 *	-0.101 *
	(-9.61)	(-10.15)	(-2.96)	(-2.98)
Constant	-0.013 *	-0.013 *	-0.02	-0.02
	(-2.62)	(-2.59)	(-1.05)	(-1.05)
Observations	1,782	1,782	1,782	1,782
R-squared	0.61	0.62	0.26	0.26
Half-life	3.6	3.5	6.6	6.5
The periods when Canadian dollar depreciated: 1974 to 1986 and 1991 to 1996				
$\Delta\ln[ep_u(1+\tau)]$	0.252 *	0.259 *	0.462 *	0.463 *
	(9.72)	(9.81)	(10.94)	(10.99)
$\Delta\ln(c_d)$	0.524 *	0.521 *	0.359 *	0.364 *
	(16.61)	(16.50)	(4.85)	(4.90)
$\Delta\ln(A)$	-0.268 *	-0.268 *	-0.206 *	-0.205 *
	(-10.35)	(-10.46)	(-2.51)	(-2.51)
$\Delta\ln(y)$	0.255 *	0.255 *	0.344 *	0.344 *
	(6.34)	(6.35)	(4.04)	(4.04)
$\hat{u}_{t-1}$	-0.197 *	-0.202 *	-0.081 *	-0.081 *
	(-8.70)	(-9.22)	(-2.50)	(-2.52)
Constant	-0.011 *	-0.011 *	-0.024	-0.024
	(-2.00)	(-2.02)	(-1.02)	(-1.04)
Observations	1,377	1,377	1,377	1,377
R-squared	0.63	0.63	0.27	0.27
Half-life	3.2	3.1	8.2	8.2
The period when Canadian dollar appreciated: 1986 to 1991				
$\Delta\ln[ep_u(1+\tau)]$	0.558 *	0.565 *	0.701 *	0.711 *
	(6.00)	(6.03)	(3.33)	(3.30)
$\Delta\ln(c_d)$	0.412 *	0.41 *	0.142	0.164
	(5.58)	(5.54)	(0.8)	(0.9)
$\Delta\ln(A)$	-0.09 *	-0.089 *	-0.132	-0.122
	(-2.17)	(-2.13)	(-1.15)	(-1.1)
$\Delta\ln(y)$	0.83 *	0.803 *	-0.023	-0.056
	(7.63)	(7.36)	(-0.17)	(-0.4)
$\hat{u}_{t-1}$	-0.332 *	-0.323 *	-0.443	-0.44
	(-6.57)	(-6.47)	(-1.64)	(-1.64)
Constant	-0.004	-0.002	0.038	0.043
	(-0.35)	(-0.25)	(0.86)	(0.93)
Observations	405	405	405	405
R-squared	0.73	0.73	0.4	0.4
Half-life	1.7	1.8	1.2	1.2

* significant at the 5% level or better.

Notes: Robust t-statistics are in parentheses. All specifications include industry dummies. Specification (1) reports results using residuals estimated from specification (1) of Table 3 where all independent variables are assumed to be exogenous. Specification (2) uses residuals estimated from specification (2) of Table 3 where all independent variables are assumed to be endogenous and where lagged values are used as instruments. Observations for the first year of a period are deleted due to the lagged variables.

Sources: Statistics Canada; and National Bureau of Economic Research and Center for Economic Studies (U.S. Census Bureau), (NBER-CES) Manufacturing Industry Database.

Results for the two sub-periods show that prices behave quite differently in the short-run under different exchange-rate regimes. When the Canadian dollar depreciates (1974 to 1986, 1991 to 1996), the elasticity of domestic output prices to U.S. prices is 0.25 and that to production costs is 0.52. When the Canadian dollar appreciates (1986 to 1991), the response of domestic output prices to U.S. prices rises to 0.56, and the response to the cost of production drops to 0.41. The same happens to changes in import prices. The elasticity of import prices with respect to U.S. prices increased from 0.46 during a depreciating Canadian dollar to 0.70 during an appreciating Canadian dollar, while the elasticity of import prices to production costs dropped from 0.36 to 0.14.

This may be explained by the fact that a depreciating Canadian dollar gives Canadian industries a relative cost advantage, which provides room for home producers to adjust their prices to cost conditions at home. However, an appreciating Canadian dollar makes the products from Canada relatively more expensive than foreign products. In competing with foreign products, home producers will have to price their products closer to the foreign counterparts. Therefore, domestic output prices and import prices will fluctuate more with cost changes at home in a period of a depreciating Canadian dollar, but more with foreign price changes in a period of an appreciating Canadian dollar. This complements the findings from Karikari (1988).

The different exchange-rate regimes also affect the speed of adjustment. In an appreciating period when the pressure from foreign markets increases, the rate of adjustment towards long-run equilibrium also increases, rising to -0.33 for domestic output prices and -0.44 for import prices. This yields a decay half-life of 1.7 and 1.2 years, respectively. When the Canadian dollar depreciates, the speed at which domestic output prices and import prices adjusts to their long-run equilibrium slows down, dropping to -0.20 and -0.08 respectively, and their half-life is increased to 3.2 and 8.2 years respectively.

6. Conclusion

Our results indicate that Canadian manufacturing prices are, on average, neither exclusively governed by the mark-up pricing rule nor by the law-of-one-price (LOP) rule. They are governed by a mixture of both rules. This is not unexpected, since Canada is neither a closed economy, as is required in the pure mark-up pricing rule, nor a country that is perfectly integrated with the U.S. market, as is required in the LOP rule. Our finding is consistent with Kardasz and Stollery (1998), who find a less than full pass-through of costs to prices.

The results do not mean that the simple price rules are invalid. On the contrary, the industry-level analysis indicates that these rules apply under certain conditions. Prices for domestic products are more sensitive to their U.S. counterpart if the industry faces higher import competition, and if home and foreign products are less differentiated. Likewise, if an industry faces lower competition, either lower competition from importers of foreign products or lower competition from rival firms in the domestic market, output prices are more likely to reflect domestic factors. An industry with higher market power passes on more of the cost increases and less of the productivity gain to output prices. These industry differences are both statistically significant and large.

Compared to domestic output prices, import prices are more responsive to foreign prices, though the amount of pass-through is less than proportionate to the change in the exchange rate. Therefore, we cannot reject the pricing-to-market hypothesis. In pricing their imports, importers do not merely pass-through all changes in import costs resulting from fluctuations in the exchange rate; they also adjust to local market conditions. The pricing-to-domestic market phenomenon is reduced if imports constitute a large share of consumption in the local market.

In the short-run, movements in output prices and import prices reflect changes in foreign prices and domestic economic conditions. As Canada gains international competitiveness in a period of a depreciating Canadian dollar, prices of domestic output prices and import prices are more influenced by cost changes at home. When the Canadian dollar depreciates, Canadian industries enjoy a relative cost advantage, which provides more room for domestic product prices to adjust to the cost conditions at home. As Canada's international competitiveness deteriorates in a period of an appreciating Canadian dollar, prices of domestic products and imported foreign products are more influenced by fluctuations in foreign prices. When the Canadian dollar appreciates, products from Canada become relatively more expensive. In competing with foreign products, home producers have to price their products close to their foreign counterparts.

Short-run movements in prices also incorporate adjustments that move prices towards their long-run equilibrium values. It takes around 3.6 years for 50% of the discrepancy between the actual and the long-run equilibrium value of domestic output prices to be eliminated. The half-life is 6.6 years for import prices. The speed of adjustment varies with the direction of the exchange-rate movement. As the pressure from foreign markets increases in a period of an appreciating Canadian dollar, the speed of price adjustment increases.

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