Exchange Rate Volatility, Pass-Through, Trade Patterns, and Inflation Targets

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Introduction

Considerable evidence suggests that Canada's policy of announcing explicit targets for the inflation rate has been a success. Inflation has been brought within the target bands and, at least since the early 1990s, this seems to have been achieved at very little cost in other macroeconomic aggregates such as the growth rate of real GDP and the unemployment rate. Over the past decade, Canada's performance relative to that of the United States has been fairly favourable. Our objective in this paper is to look beyond these traditional measures of macroeconomic performance to determine whether the current policy regime may impose other costs on the economy. In particular, we present evidence that the nominal exchange rate has become more volatile at relatively high frequencies.

Authors such as Devereux and Engel (2004) have studied the micro-economic costs that exchange rate volatility can impose on the economy if it impedes the equalization of relative prices across borders. Papers by Betts and Devereux (2000) and Devereux (2001) have also shown that a policy of inflation-rate targeting can lead to increased exchange rate volatility if the exchange rate has a relatively weak impact on the consumer price index (CPI). Combined, these two lines of research suggest that inflation targeting could impose microeconomic costs that need to be set against the macroeconomic benefits. One implication for policy is that welfare might be improved if the monetary policy rule puts explicit weight on inflation and the change in the exchange rate.

When there is significant pass-through of exchange rates to consumer prices, the central bank will put weight on the exchange rate even in an inflation-targeting regime. This is the "indirect" policy effect of the exchange rate described by Taylor (2001), which stems from the impact of the exchange rate on future inflation and the output gap (with the output gap providing potential information about future inflation). Hence, changes in the degree of perceived exchange rate pass-through change the implicit weight given to the exchange rate even if there has been no change in the microeconomic costs of fluctuations in relative prices across the border. It seems only prudent, therefore, to ask whether the change in the weight placed on the exchange rate remains optimal in the new low pass-through environment.

Our goal is to document a series of stylized facts and to link the patterns observed to the inflation-rate-targeting regime. We begin by outlining an apparent increase in the volatility of high-frequency changes in the Canada-US nominal exchange rate. Next, we analyze the impact of the Canada-US border on variability in relative prices, using the methodology devised by Engel and Rogers (1996). This analysis shows an increase in the size of the border effect at roughly the same time that the exchange rate became more volatile. The implication is that, to the extent that relative-price border effects impose costs on the economy, increased exchange rate volatility may be partly responsible for these costs.

To establish a link between exchange rate volatility and the monetary policy regime, it is useful to investigate the determinants of monetary policy decisions. We do this by estimating a simple monetary policy rule of the type first specified by Taylor (1993). The equation is modified along the lines suggested in Taylor (2001) to provide a direct measure of the effect of the exchange rate on monetary policy. This analysis shows a significant change in the weight placed on the exchange rate in Canadian monetary policy at roughly the same time that the Canada-US exchange rate became more volatile. A related stylized fact is that the relative volatility of the exchange rate component of the Bank of Canada's monetary conditions index (MCI) increased at the same time.

In the remaining sections of the paper, we present evidence that may have a bearing on two remaining questions: whether increased volatility of the nominal exchange rate is desirable and whether exchange rate pass-through is linked to factors other than the inflation-rate regime. Exchange rate variability would be desirable if it simply mirrored increased volatility of underlying determinants of the exchange rate. To examine this link, we look at the volatility of non-energy commodity prices over the same period. Next, we explore changing patterns of international trade as a determinant of reduced exchange rate pass-through, and we examine disaggregated price index data to determine whether their behaviour is consistent with the role of monetary policy in producing low levels of pass-through to consumer prices. We summarize our findings in the concluding section.

1 Exchange Rate Volatility: Empirical Evidence

Much of the literature on the economic effects of exchange rate volatility focuses on the long term, because the analysis is intended to study impacts of exchange rate volatility on longer-term decisions related to foreign direct investment. Measures of border-width effects based on changes of relative prices between cities are affected by the short-term change in the nominal exchange rate. If exchange rate pass-through is declining over time, the impact of inflation targeting on exchange rate volatility is likely to be felt at a higher frequency. Essentially, the exchange rate will be affected by shocks to the domestic inflation rate.

A comprehensive study of exchange rate volatility was conducted by Murray, van Norden, and Vigfusson (1996). They concluded that the popular perception of increased exchange rate volatility was not supported by the data. The authors looked at trends in exchange rate volatility over time and compared volatility in currency markets to that in markets for other assets such as equities. They attributed exchange rate volatility to traders looking to market fundamentals rather than to potentially destabilizing noise traders. The evidence presented in this paper is consistent with the Murray, van Norden, and Vigfusson study, because increased exchange rate volatility begins to appear in the data only after 1996.

Descriptive indicators of exchange rate volatility are set out in Figures 1 through 3. The two panels of Figure 1 show the daily change in (i) the level and (ii) the log of the bilateral Canada-US nominal exchange rate from January 1975 to March 2005. While the changes seem to remain within roughly the same band over the period through the mid-1990s, there is a discernible increase in these changes after the mid-1990s and, in particular, since 1997. This visual impression is quantified by the 67 per cent increase of the standard deviation of the daily log changes (from 0.002527 to 0.004224) between the 1975–96 and 1997–2005 subsamples. Under the (admittedly heroic) assumption of normality, the F-test for the hypothesis of equal variances in the two samples generates a value of 2.83. Under the null hypothesis, this ratio has an F-distribution with 1,992 and 5,348 degrees of freedom, and the hypothesis is rejected at a very high confidence level. Figure 2 shows histograms for changes in the exchange rate that confirm the shift in the distribution, while Figure 3 smooths some of the noise in the daily data by plotting a 30-day lagged moving standard deviation of these changes in the daily exchange rate. Similar patterns of increased volatility

Figure 1
Daily change in the Canada-US exchange rate

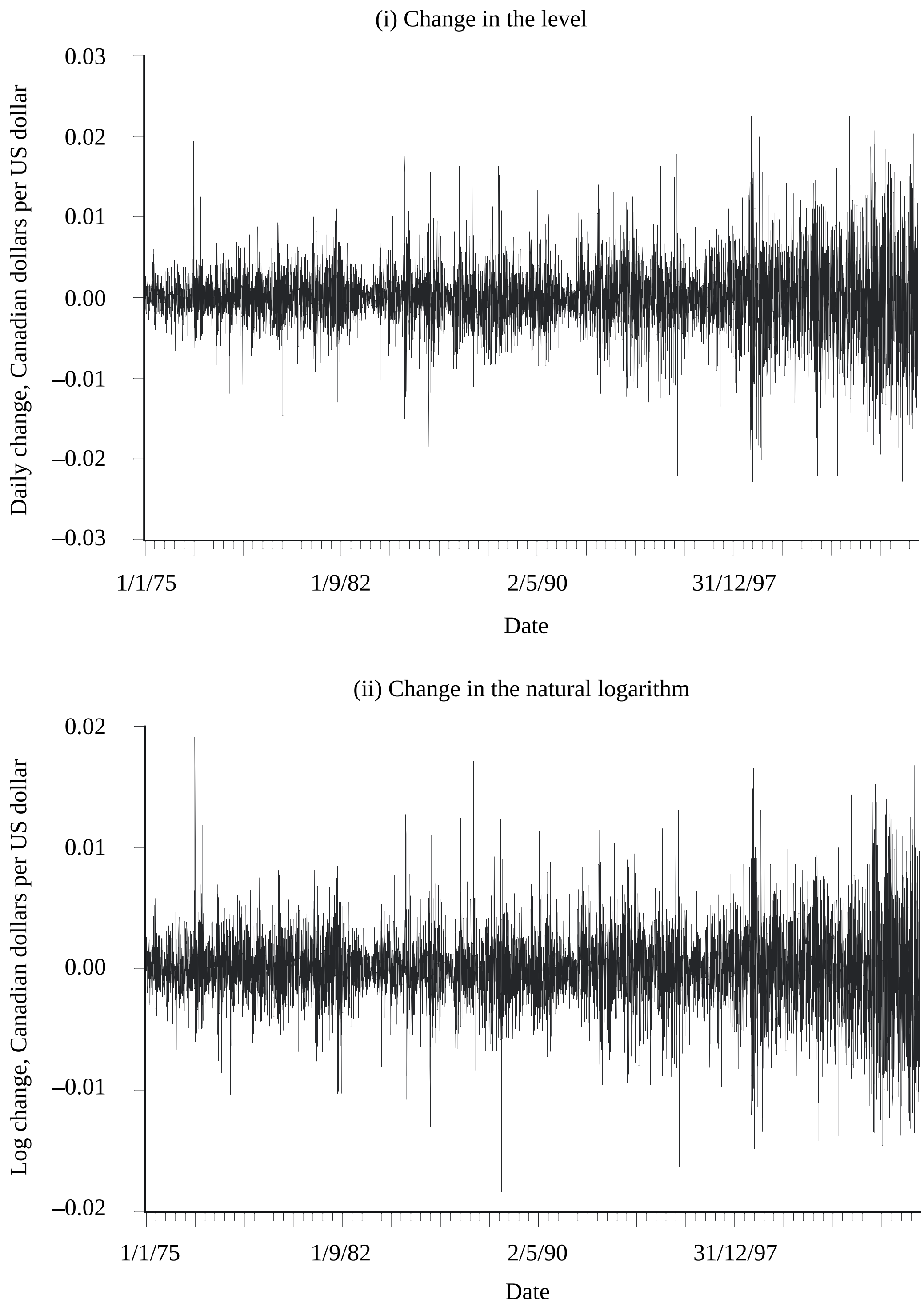


Figure 2
Properties of the daily change of the log exchange rate

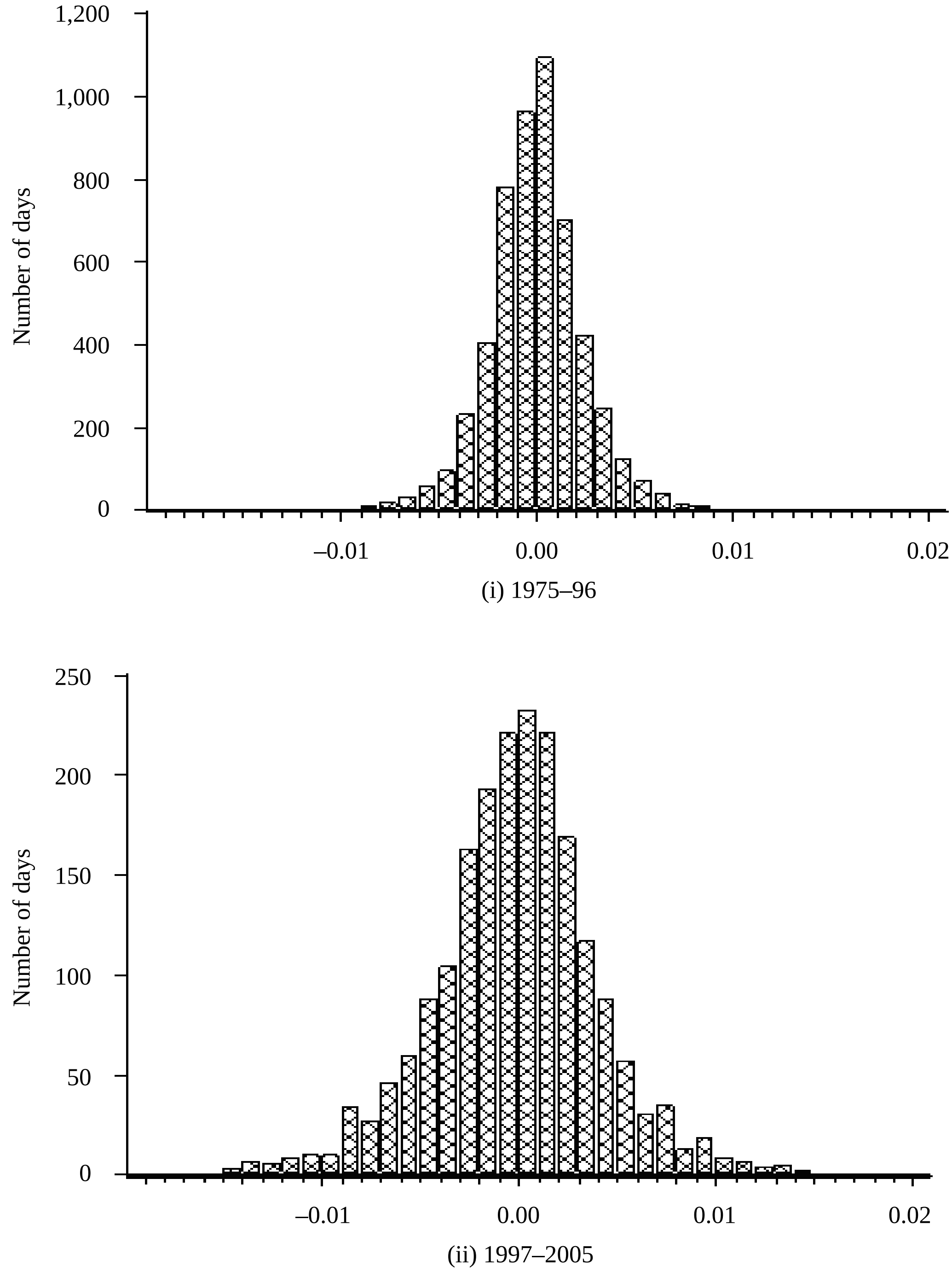
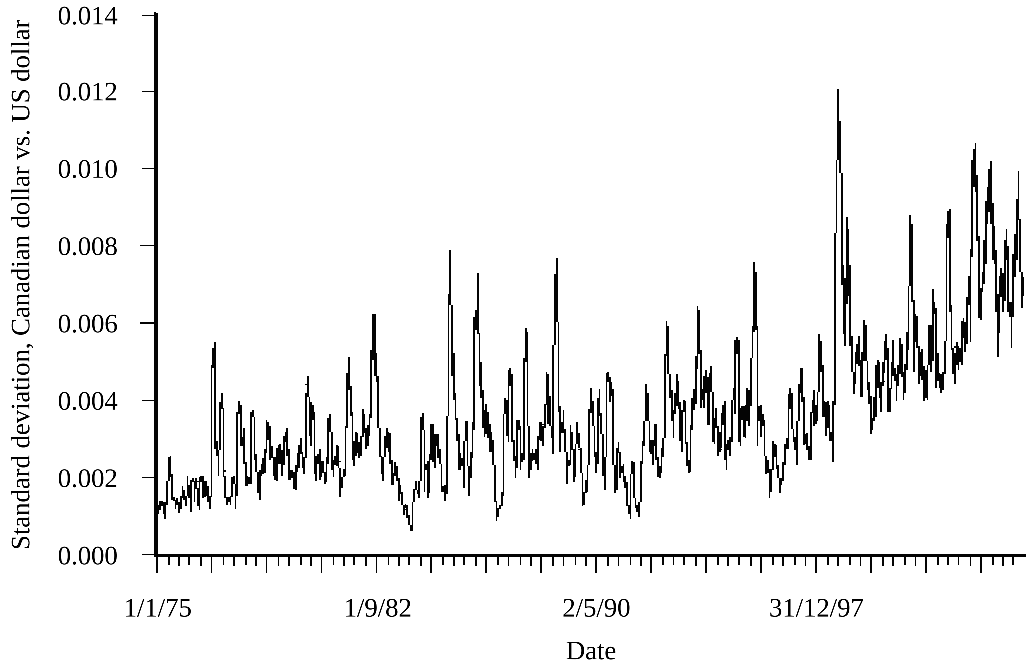


Figure 3
30-day moving standard deviation of daily changes in the Canada-US nominal exchange rate



are observed if 12-month standard deviations of monthly exchange rate changes are used instead of daily data.

The timing of this apparent shift in high-frequency exchange rate volatility is relevant to the debate on inflation targeting, in part because the change seems to have occurred a few years after Canada's adoption of formal inflation targets. The full impact of the inflation-targeting regime may not have been felt until somewhat later, however, when reduced exchange rate pass-through was recognized and came to be viewed as a lasting phenomenon rather than as the result of a series of temporary special events. Public discussion of reduced pass-through effects may have begun at the Bank of Canada with the analysis by Laflèche (1997) of the unexpectedly muted effect on consumer prices of the depreciation of the Canadian dollar between 1992 and 1994. The concluding section of her article gives equal attention to explanations for reduced pass-through that are based on increased competition or monetary policy. This may have indicated the growing acceptance that low pass-through had become a more permanent feature of the Canadian economy.

2 Border Effects and Welfare Implications

Nominal exchange rate volatility has been discussed as a source of border effects since the study of Engel and Rogers (1996), which found that the effect of the Canada-US border was of similar magnitude to a distance of roughly 75,000 miles within a country. This has implications for economic welfare if economic efficiency suffers as a result of wedges between prices. Of course, these wedges promote efficiency if they allow for needed adjustment of the terms of trade in the face of rigid nominal prices. The tension between these two roles for the exchange rate has been considered by Devereux and Engel (2004), who use a static, two-country model to show that considerations of microeconomic efficiencies related to relative price variability may imply that exchange rates should fluctuate significantly less than is implied by terms-of-trade considerations alone.

Given this possibility, it is useful to review the evidence regarding the size of border effects and link it to observed patterns of exchange rate variability. Essentially, we estimate border effects of the type discussed by Engel and Rogers (1996) and relate them to factors such as Canada-US trade liberalization and exchange rate fluctuations. The original Engel-Rogers analysis assumed that exchange-rate-adjusted prices in any two North American cities would be more likely to diverge if the cities are farther apart or in different countries. The basic unit of analysis is the ratio of relative prices for similar baskets of goods where all prices are expressed in common currency terms by multiplying US prices by the price of a US dollar in Canadian dollars (S_t):

$$R_t = \frac{P_t^{Cdn}}{S_t * P_t^{US}}. \tag{1}$$

While more recent work by Engel (2005) has used individual commodity price data to examine this ratio, the traditional Engel-Rogers approach uses consumer price indexes, which means that levels of this relative price have no meaning, and analysis focuses instead on the change in this ratio.

Given time-series data on changes in relative prices for a set of locations, it is possible to calculate the standard deviation of these changes for pairs of locations. If prices in two locations move closely together, these standard deviations should be small, while there could be significant variability in relative prices over time if the markets are not closely integrated. We expect to see that as the distance between two locations grows, the variability of relative price changes will increase. Similarly, the existence of a national border should also tend to increase relative price variability.

To measure the effects of distance and the Canada-US border on relative price variability between cities, the following cross-sectional regression equation can be used:[1]

$$\sigma_{i,\,j} = \gamma^{*}\log(dist_{i,\,j}) + \delta^{*}border_{i,\,j}. \quad (2)$$

In this equation, $\sigma_{i,\,j}$ is the standard deviation of the two-month change in the ratio of the CPI in location *i* to the CPI for location *j*. All CPI values are adjusted to Canadian dollar terms. Two-month changes are used because most US city-level CPI data are available only in even or odd months, and we use only even months in this analysis. The key parameters of interest in this regression are γ, which captures the effect of distance on price dispersion, and δ, which measures the additional price dispersion caused by the border.

In this paper, we focus on how the size of the border effect varies over time. In particular, we wish to determine the impact of the recent increase in variability of the nominal exchange rate on border effects. We will follow the approach of Engel and Rogers (1998), who sought to identify changes in border effects resulting from formal free trade agreements by using different sample periods to calculate the standard deviations used in the basic border-effect cross-sectional regression.

Updating this analysis to include recent data requires deviation from the list of cities used in the Engel and Rogers study, because the US Bureau of Labor Statistics (BLS) has since dropped or modified the CPI series for several cities. This leaves seven US cities in the analysis, and they are matched with seven Canadian cities so that the sample for the regressions contains 91 pairs of cities.[2] Like Engel and Rogers (1998), we use the all-items CPI, but we do not include the 14 subindexes that they also analyzed, since the subindex data are available only for provinces rather than cities for recent periods. In any case, preliminary analysis using subindexes showed results very similar to those for the all-items CPI. The effect of time can be examined by varying the sample period employed to calculate the standard deviation used as the dependent variable in the regressions.

Table 1 shows the results of estimating the cross-sectional border-width regressions using standard deviations calculated over the full 1978–2004 sample as well as over a series of subsamples. The sample breaks were chosen to match the enactment of formal free trade agreements in 1989 and

1. A series of dummy variables for each location is included to capture location-specific (as opposed to pair-specific) differences in the noisiness of the CPI series.

2. There are 42 [(7*6)/2)] unique pairs of Canadian cities, 42 pairs of American cities, and 49 [7*7] pairs of cities that are on the opposite side of the border.

Table 1
Regression analysis of border width

	Full sample 1978–2004	Pre-FTA 1978–88	Post-FTA 1989–2004	Post-FTA 1 1989–93	Post-FTA 2 1994–97	Post-FTA 3 1998–2004
Border	1.359	1.127	1.537	1.223	1.037	1.924
	(0.008)	(0.015)	(0.011)	(0.015)	(0.012)	(0.020)
LogDistance	2.960	3.211	2.344	–0.778	1.360	4.907
	(0.679)	(1.26)	(0.928)	(1.262)	(1.016)	(1.634)

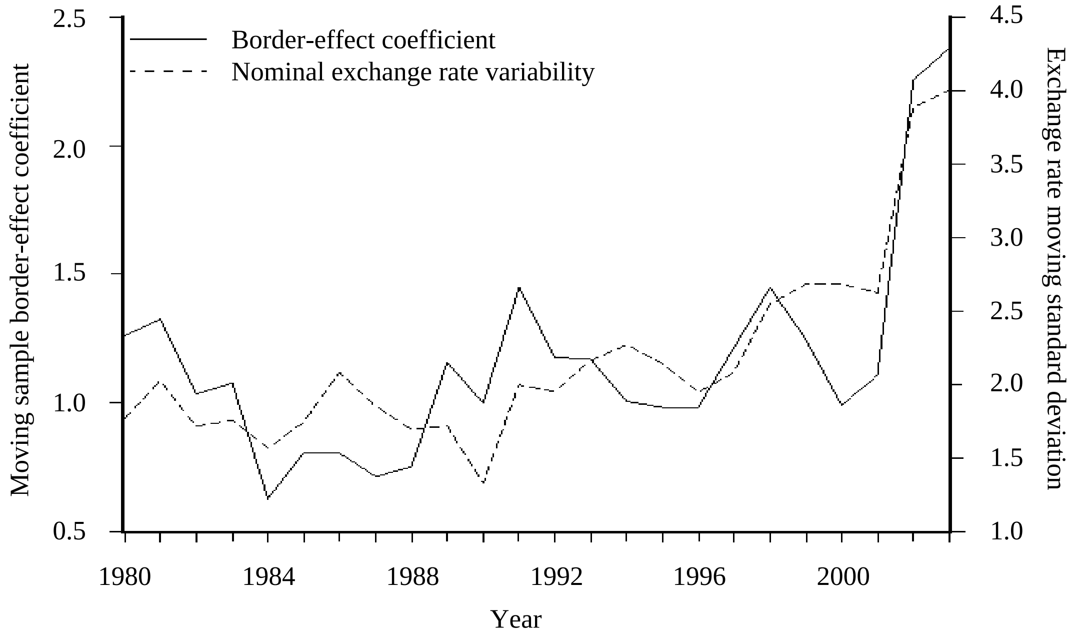
Note: Standard errors are in parentheses below the coefficient estimates.

1994. After 1994, the sample is broken in 1997, because the analysis of exchange rate volatility in the previous section pointed to 1997 as the year when exchange rates became more volatile. The results through 1997 basically replicate those already reported by Engel and Rogers (1998), who found that the border effect fell somewhat after the free trade agreements but that distance effects also declined. The more interesting and novel result in this analysis is the sharp increase in the size of border effects after 1997.

To obtain some feel for the timing and possible source of these results, we estimated a series of border-effect regressions using rolling three-year samples for the standard deviation of changes in relative prices. Figure 4 plots results of this rolling border-effect analysis along with a measure of the standard deviation of two-month changes in the nominal exchange rate. The graph suggests a strong link between these two series that is confirmed by regression analysis. Over the longest possible sample period, the adjusted R-squared from a regression of the border effect on the variable for exchange rate variability is 0.67, and the *t*-statistic for the coefficient on exchange rate variability is 6.91.

The significance of the relationship is largely attributable to changes observed in the final few years of the sample, however. If the latest three-year period of standard deviation used is 2000–02, the adjusted R-squared falls to 0.11 and the *t*-statistic is only 1.88. This is interesting, because the rapid movement of the Canada-US exchange rate during this period largely reflects a movement closer to purchasing-power parity, and consequently it seems counterintuitive to view this as a widening of border effects. On the other hand, the appreciation of the Canadian dollar over the past few years coincides with a general realignment of the US dollar relative to a wide range of currencies and it is unclear how this could be interpreted as a narrowing of Canada-US border effects. It will be informative to see whether this recent adjustment prompts a lasting reduction in border effects over the next few years. If cross-border relative prices have converged in

Figure 4
Evolution of border effects over time



levels and border effects have been reduced, there should be much closer movements of Canada-US relative prices in the future.

3 Exchange Rate Volatility, Pass-Through, and Inflation Targets: Theory and Empirical Evidence

We have shown that there is evidence of increased exchange rate volatility that may have translated into welfare-decreasing border effects. The relevance of these findings for research into inflation targeting comes from work by Devereux (2001) and Betts and Devereux (2000), who have used dynamic macroeconomic models to show that inflation-targeting policies tend to produce a higher level of exchange rate volatility in models with incomplete pass-through. This result holds when the effect of the exchange rate on consumer price inflation is sufficiently muted that a central bank following either an inflation target or a Taylor-type rule will see little or no cost to allowing the nominal exchange rate to fluctuate. If there is no perceived cost to allowing these exchange rate fluctuations and some possible benefit in terms of economic outcomes, then the central bank will tend to allow greater variability of the exchange rate. Such a benefit could exist without expenditure switching related to consumer goods if, for example, changes in relative labour costs result in between-country shifts of production.

This means that a policy with low inflation will tend to have a significant impact on exchange rate variation through two channels. First, pass-through declines with low inflation, and this exaggerates the volatility of the exchange rate. Also, the fact that inflation is targeted will force greater variability onto the exchange rate because it essentially becomes a "free variable" that can bear a greater burden of adjustment. There could be an additional feedback effect in models with price rigidities such as those described by Taylor (2000). In this framework, firms set their prices as a weighted average of expected future average prices and marginal costs. If increased exchange rate volatility also makes exchange rate changes less persistent, the response of prices to changes in exchange rates is further muted.

A Taylor rule is estimated to gain insight into the impact of low exchange rate pass-through on recent Canadian monetary policy. The specification used is a modified version of the equation estimated by Judd and Rudebusch (1998) for the United States. Unlike Taylor (2001), who added the real exchange rate to a basic Taylor rule, our specification includes the change in the exchange rate. This yields the "change rule" described in Armour, Fung, and Maclean (2002) and allows the central bank to care about exchange rate movements independently of changes in the current CPI (perhaps because the exchange rate may be a leading indicator of future inflation). A similar "leading-indicator" argument motivated the inclusion of the output gap even when the central bank follows an inflation-target policy.

With this modification, the equation for the desired real overnight rate becomes:

$$r_t^* = \bar{r} + \lambda_1(\pi_t - \pi_t^*) + \lambda_2\frac{y_t - y_t^*}{y_t^*} + \lambda_3(e_t - e_{t-1}). \tag{3}$$

The right-hand-side variables are the equilibrium real overnight rate $(\bar{r})$, the difference between the actual core inflation rate and the target value, the output gap, and the change in the nominal exchange rate. Given that the Bank of Canada announces explicit inflation targets, the inflation-target variable can change over time.

Like Judd and Rudebusch, we assume that the target for the overnight rate changes gradually according to a simple error-correction model:

$$\Delta r_t = \gamma(r_t^* - r_{t-1}) + \rho\Delta r_{t-1}. \tag{4}$$

This can be combined with the previous equation to obtain the following estimating equation:

$$\Delta r_t = \gamma\bar{r} - \gamma r_{t-1} + \gamma\lambda_1(\pi_t - \pi_t^*) + \gamma\lambda_2\frac{y_t - y_t^*}{y_t^*}$$
$$+ \gamma\lambda_3(e_t - e_{t-1}) + \rho\Delta r_{t-1}. \tag{5}$$

When estimating this equation, we allow for changes in the three policy coefficients $(\lambda_1, \lambda_2, \lambda_3)$ in 1997. This date was chosen because it corresponds with the observed increase in the volatility of nominal exchange rates and the increased recognition that exchange rate pass-through had declined. The results for the estimation of the equation are presented in Table 2, while Table 3 shows the implied values for the parameter variables.

This table reveals interesting results. First, the effect of the inflation gap is perverse in both subperiods: the real overnight rate *falls* when inflation rises relative to the target, rather than rises. The same result was obtained by Vanderhart (2003) in his study of a different specification of the Bank of Canada's reaction function over the period February 1987 to September 2002, and so it is not likely to be an artifact of the Taylor-rule framework. Vanderhart found the expected sign on the inflation rate only when the CPI inflation rate was replaced by a measure of inflation pressure such as the growth of wages or prices of raw and intermediate goods. In this specification, the output gap and exchange rate variables may play this same role.

The effects of the output gap and the exchange rate change are as expected for the 1993–96 period. An increase in output relative to potential raises the real overnight rate, while a depreciation (increase in the price of the US dollar) also elicits a tightening of monetary policy. After 1996, however, there is a significant decline in the effects of both of these variables to the point where neither has the correct sign. One interpretation of this result is that monetary policy began to put less weight on exchange rate fluctuations after 1996, just as theory suggests should be the case in an environment with little or no pass-through to the CPI.

Another potential measure of the changed weight of the nominal exchange rate is provided by Figure 5, which shows the relative volatility of the two components of the Bank of Canada's MCI. This index summarizes the effects of both interest rates and exchange rates on the stance of monetary policy and is defined as:

$$MCI = (RCP_{90} - 7.9) + \frac{100}{3}[\ln(CPFX_6) - \ln(91.33)], \tag{6}$$

Table 2
Taylor rule reaction functions

Variable	Coefficient	Standard error	*t*-statistic	Probability
Constant	0.0253	0.2036	0.12	0.902
$\pi - \pi^*$	–0.9393	0.48635	–1.93	0.062
$y - y^*$	0.4252	0.1827	2.33	0.026
Δ PFX	31.8781	9.9779	3.19	0.003
$(\pi - \pi^*)$ *DUM97	0.01916	0.48869	0.04	0.969
$(y - y^*)$ *DUM97	–0.54896	0.2288	–2.40	0.022
Δ PFX*DUM97	–39.42898	10.8860	–3.62	0.001
R(–1)	–0.14242	0.0721	–1.98	0.056
Δ R(–1)	–0.12023	0.1368	–0.88	0.386
Adjusted R^2	0.437			

Table 3
Implied values for the parameter variables

Parameter variables	1993–96	1997–2004
Inflation gap (λ_1)	–6.595	–6.4608
Output gap (λ_2)	2.986	–0.869
Exchange rate change (λ_3)	223.832	–53.018

where RCP_{90} is the rate on 90-day commercial paper, and $CPFX_6$ is the effective exchange rate of the Canadian dollar against the currencies of Canada's six main trading partners. To create Figure 5, monthly changes in the two components of the MCI were calculated, and trailing 12-month standard deviations were obtained. The ratio of the standard deviation for the exchange rate to that for the interest rate is shown in Figure 5. The graph appears to reveal a clear increase in the relative volatility of the exchange rate component of the MCI, once again in 1997.

4 Do Fundamentals Explain Increased Exchange Rate Volatility?

While the timing of changes in monetary policy and pass-through are consistent with the theoretical link from policy to volatility, it is also possible that other determinants of exchange rates underwent similar increases in volatility and that these other factors explain the patterns observed. In particular, there may have been an increase in the volatility of fundamental factors affecting the Canadian dollar. A number of studies have suggested that non-energy commodity prices have an important impact on the Canada-US exchange rate through the terms of trade. Panel (i) of

Figure 5
Relative volatility of the components of the monetary conditions index

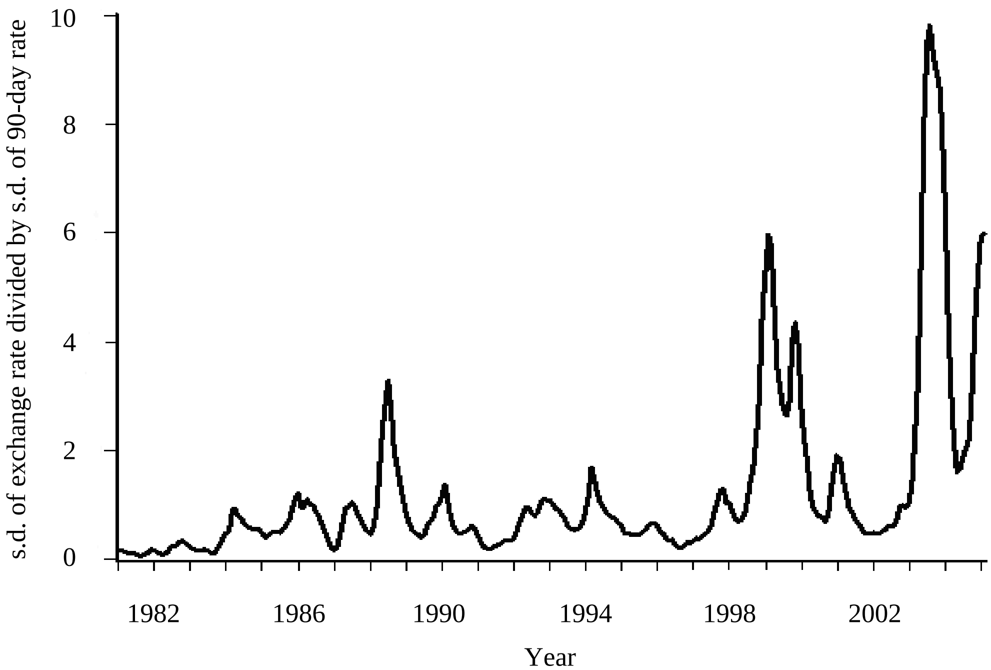


Figure 6 looks at the moving standard deviation of monthly changes in the exchange rate and non-energy commodity prices and, if anything, they are moving in opposite directions during the post-1997 period. This provides no evidence that exchange rate volatility is simply mirroring commodity price volatility.

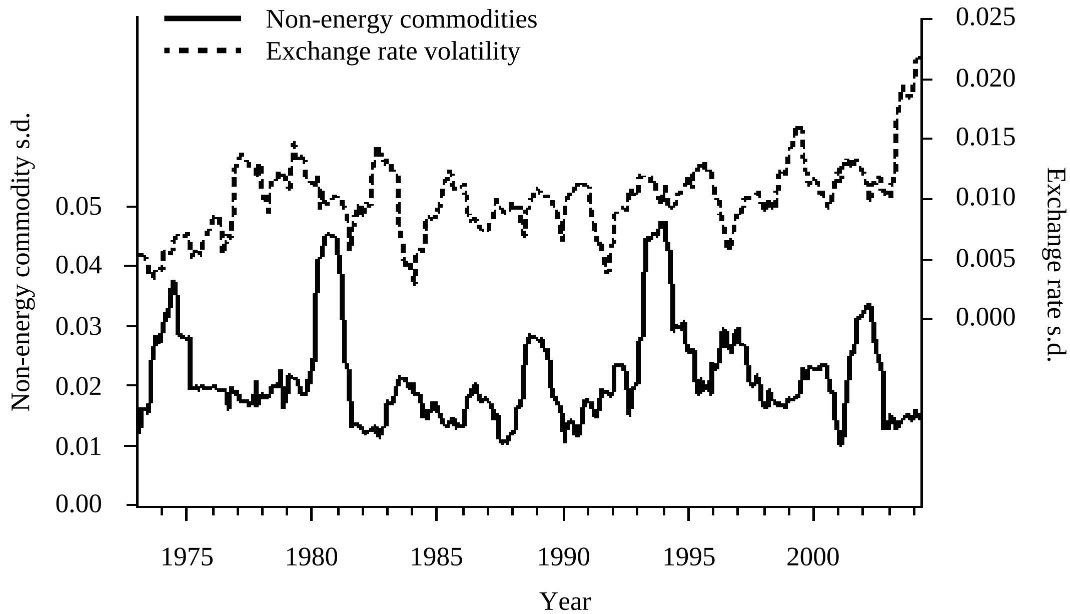
The analysis of the MCI graph from Figure 5 also shows no evidence that interest rates became more volatile along with the exchange rate. There is evidence of an increase in volatility of commodity prices as a whole (including energy prices), as shown in panel (ii) of Figure 6. Given that the link has historically been stronger between non-energy commodities and the Canadian dollar, it is not clear that this is an appealing explanation for exchange rate volatility.

5 Why Has Pass-Through Declined and Why Does It Matter?

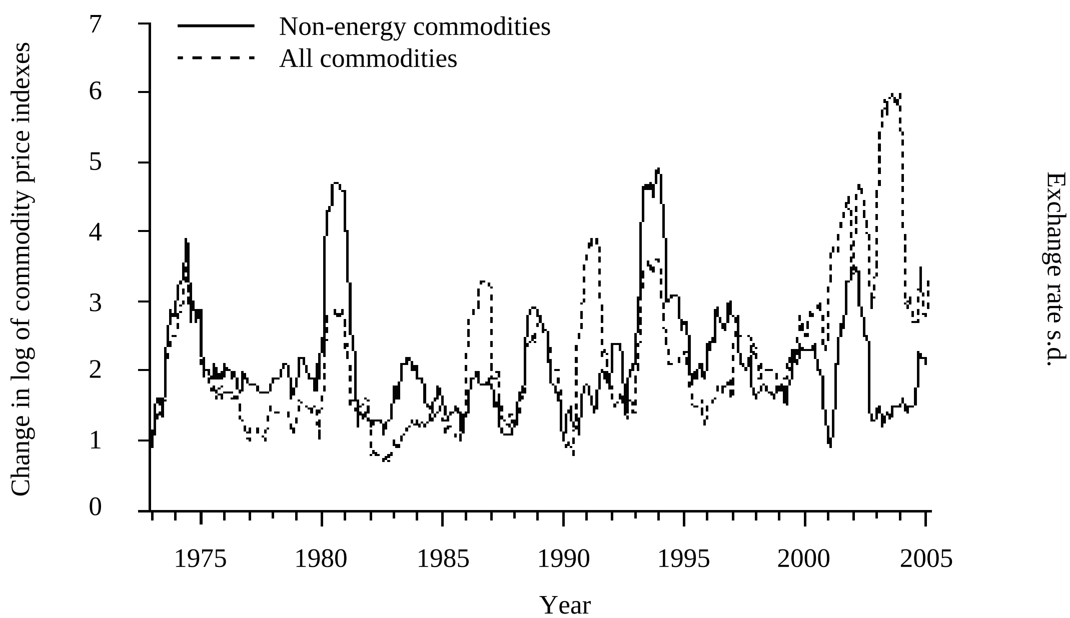
There is little disagreement regarding the empirical regularity with which average consumer prices have become less responsive to changes in exchange rates. As pointed out by Taylor (2000), however, there is a certain divergence between popular and academic explanations for the recent decline in exchange rate pass-through. Writers in the popular press seem to

Figure 6

(i) Volatility of monthly changes in the exchange rate and non-energy commodity prices



(ii) Volatility of all commodities and non-energy commodities



emphasize increased international competition, resulting perhaps from globalization. In the recent academic literature, however, the explanation largely turns on a decline in both the level and persistence of inflation. After the large depreciation of the US dollar in the mid-1980s, Krugman (1989) made an argument for reduced pass-through in which adjustment costs led firms to absorb revenue losses caused by depreciations in foreign markets rather than suffer a loss in market share. Furthermore, Krugman argued that this low pass-through would increase the variability of the nominal exchange rate and that this noisiness of the nominal exchange rate would further discourage firms from adjusting export market prices in the face of exchange rate movements.

It is important to determine the cause (or causes) of reduced pass-through, because pass-through effects may differ in the future depending on their origin. For example, the effects of lower inflation would likely be more complete than effects of the type described by Krugman that are related to entry and exit costs and international competition. It is also possible that increasing levels of intrafirm trade contribute to reduced pass-through, and this trend might continue as intraindustry and intrafirm trade increase in importance.

While traditional theories of trade focus on specialization and comparative advantage, deepening of economic integration is increasingly linked to the expansion of intraindustry trade. An example is the automotive industry in which Canada and the United States export and import large volumes of automotive products. A large fraction of this within-industry trade is between different entities within the same firm, which means that exchange rate fluctuations may have offsetting impacts on the revenues and costs of a firm. Consider the simple example of a Canadian firm that buys intermediate inputs from the United States at a unit price P_{int}, adds value to them in Canada by employing labour inputs, and then ships the finished product back to the United States for sale at unit price P_{fin}. If E is the value of a US dollar in Canadian dollars, then profits in Canadian dollars for this firm are:

$$\pi = EP_{fin}Q_{fin} - EP_{int}Q_{int} - W^*L . \qquad (7)$$

An exporting firm such as this one that imports a significant fraction of its inputs is partially hedged against any change in the value of the US dollar, because the costs of imported inputs vary along with the Canadian dollar value of export revenues. If domestic value added falls as a fraction of the revenues of the firm, it becomes increasingly possible to avoid changing the export price in US dollars when the US dollar depreciates. Indeed, there is evidence that this very phenomenon has been taking place recently in Canada. For example, Cross (2002) cites a 1997 Statistics Canada study that demonstrated that "over half of the rapid increase in the share of exports in GDP in the early 1990s reflected rising import content and not valued-added (p. 31)". An important effect of intrafirm trade on the decline in pass-through was also found for Japan by Otani, Shiratsuka, and Shirota (2003).

This analysis suggests that any trend towards increased trade in intermediate goods will raise the level of "natural hedging" available to exporters in North America and hence lower the degree of price pass-through. Accordingly, it is useful to seek empirical measures of intrafirm trade. The level of intraindustry trade is readily observable using detailed trade statistics, and the levels of intrafirm and intraindustry trade are likely to be correlated. This is true both at the theoretical and empirical levels. Models of intraindustry trade are typically set in an environment with differentiated products and increasing returns to scale. This is much the same environment that gives rise to multinational firms that engage in intrafirm trade. Also, empirical analysis confirms that industries such as the automotive industry tend to have high levels of intrafirm and intraindustry trade.

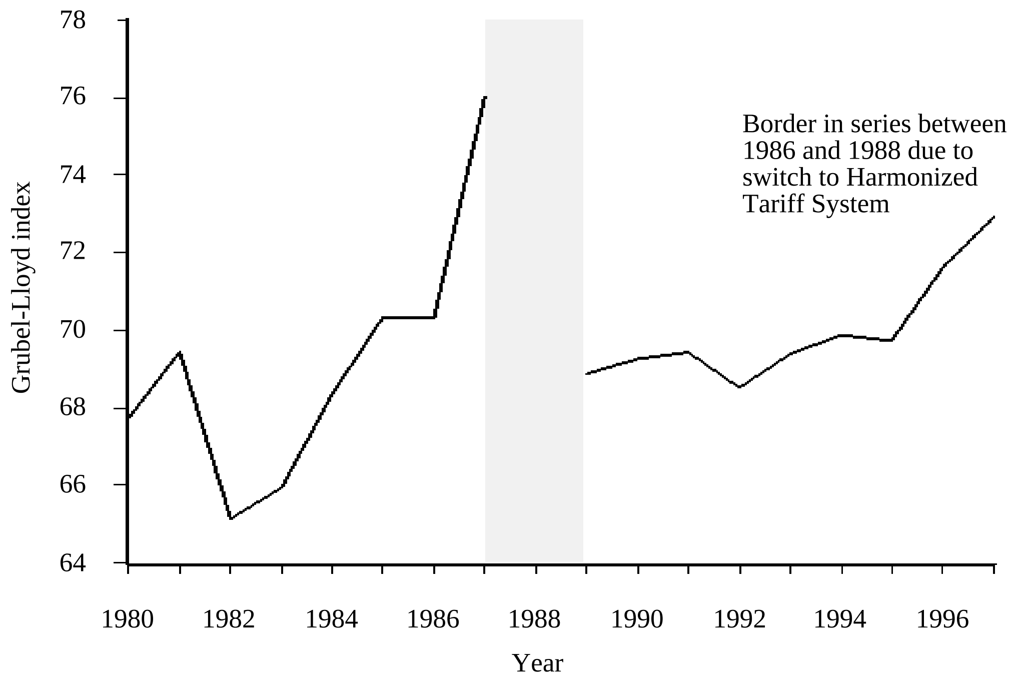
Several means of measuring intraindustry trade are typically used, but perhaps the most common is the Grubel-Lloyd measure, defined for industry *i* as:

$$100^{*}\left(1-\frac{|X_i - M_i|}{X_i + M_i}\right).$$

If trade is completely balanced within an industry, exports equal imports and the Grubel-Lloyd index equals one. At the other extreme, if trade is completely specialized so that either exports or imports equal zero, the Grubel-Lloyd index also equals zero. For the entire economy, the industry-level indexes are summed with weights equal to the industry's share of total trade. While this is not a direct measure of within-firm trade, changes in the Grubel-Lloyd index do tend to be associated within intrafirm trade, as in the case in the automotive industry, for example.

Figure 7 shows the recent behaviour of the Grubel-Lloyd index since 1980 based on 34 Bureau of Economic Analysis (BEA) manufacturing industry classifications from the World Trade Database CD-ROM distributed by the Center for International Data at UC Davis. The data break in the series between 1986 and 1988 reflects changes in the recording of categories resulting from the switch to the Harmonized Tariff System from the former national Canadian system. As documented by Kehoe and Ruhl (2003), this transition resulted in classification switches at the data recording level, and these changes create inconsistencies in the value of exports and imports by BEA industry category. Despite this re-basing effect, there was a clear

Figure 7
Grubel-Lloyd index of intraindustry trade



upward drift to the Grubel-Lloyd index both from 1980 through 1986 and 1988 through 1997. It is worth noting that the index seemed to rise at a steep rate in the early 1980s, a period associated with declining pass-through and a sharp deceleration of the inflation rate in most industrialized countries.

Finally, it is important to recognize that the empirical evidence giving monetary policy the credit for reduced exchange rate pass-through remains circumstantial. While there is convincing evidence that changes to lower inflation rate regimes coincide with reduced pass-through, there is not yet enough variation in the data to rule out other possible explanations. On the other hand, the study by Frankel, Parsley, and Wei (2005) using data for higher inflation rates in developing countries finds that monetary policy cannot explain all of the decline in pass-through. To further investigate the determinants of pass-through, a fuller set of potential determinants needs to be considered.

6 Exchange Rate Volatility, Low Inflation, and Relative Prices

A deeper understanding of pass-through in a low-inflation environment can be obtained by looking at the inflation process at a less aggregated level. For instance, if monetary policy reduces exchange rate pass-through, it should also reduce pass-through of costs more broadly. This may have implications for the growth rate of prices of individual commodities. It would appear that prices might grow at more similar rates pinned down by the inflation rate target. Examining changes in relative prices also sheds light on the degree of relative price adjustment that is possible when inflation does not provide "grease for the wheels" of the economy.

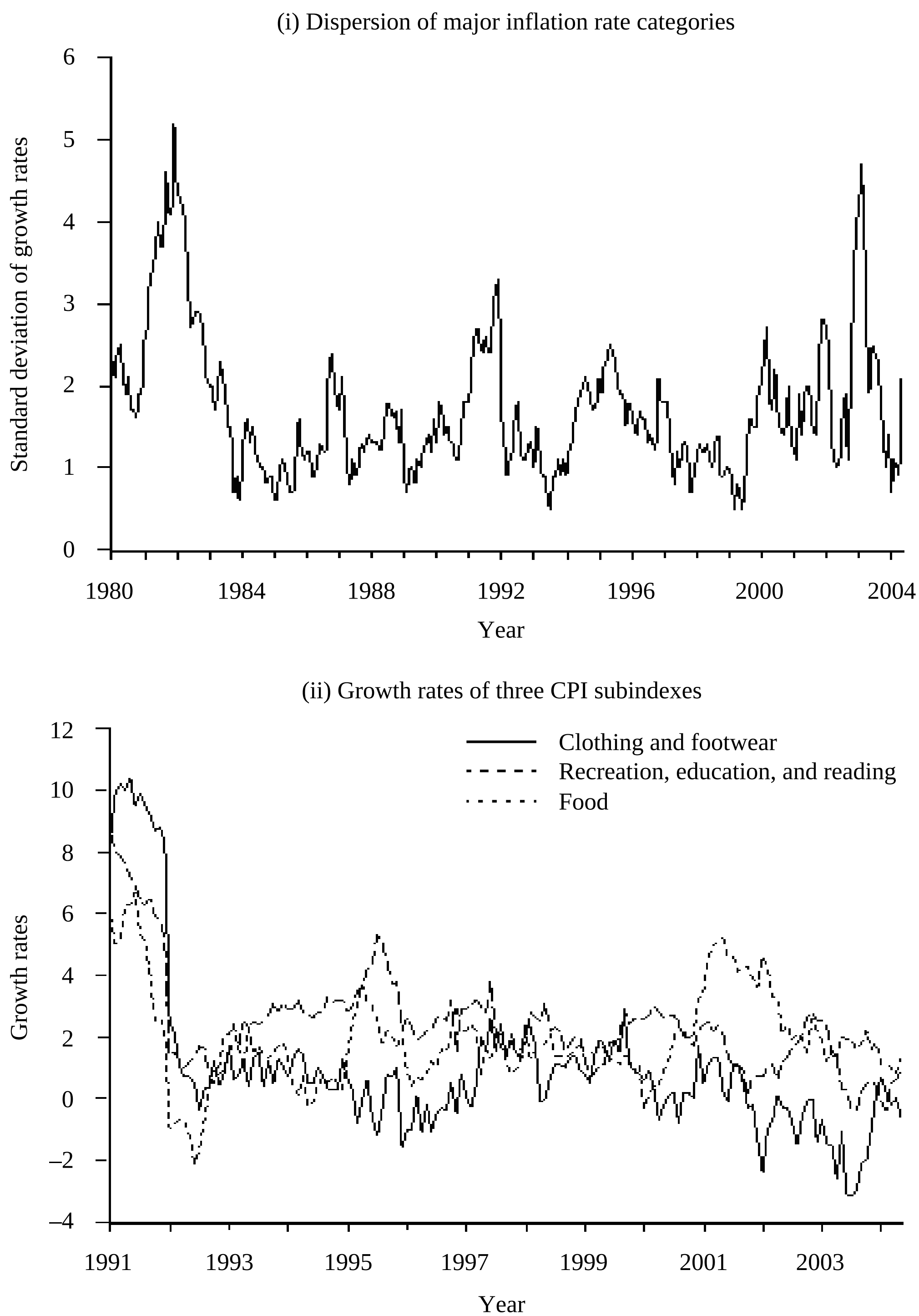
The two panels of Figure 8 provide a preliminary analysis of this issue by examining the standard deviations of the growth rates for seven of Statistics Canada's eight "major components" of the CPI (the omitted component is alcohol and tobacco, which is affected by changes in indirect taxes). Panel (i) shows significant variability in rates of price growth, which presumably reflect desirable changes in relative prices. There is no evidence that declining inflation targets have reduced the dispersion of price growth rates. In fact, the opposite pattern is observed. Panel (ii) looks at the actual growth rate of prices for three of the eight major components of inflation (food; clothing and footwear; and recreation, education, and reading). The graph shows a rapid and synchronized drop in inflation in the early 1990s. In future work, it would be useful to determine whether price-contract models can explain the speed with which this disinflation occurred. In addition, the models' implications for the persistence of dispersion of inflation rates should be derived and compared to the data.

Conclusion

This paper has documented increased high-frequency variability of the nominal Canada-US exchange rate, which may have significant impacts on the cross-border convergence of prices at the consumer level. There is also evidence that increased exchange rate volatility is consistent with the behaviour of a central bank that is targeting inflation in an environment with low exchange rate pass-through.

One implication of this paper's findings is that indirect effects of exchange rates on the monetary policy rule may have become attenuated in the current low pass-through regime. This is significant, because Taylor (2001) concluded that putting the exchange rate directly into the Taylor rule may not matter much if it is already there through the indirect channel. A corollary of Taylor's conclusion is that it might be necessary to revisit the role of the exchange rate in a Taylor rule if the indirect channel no longer functions. From a policy viewpoint, this might be justified by the Bank of Canada's legislative authorization to "control and protect the external value of the national monetary unit" and to mitigate fluctuations in macroeconomic variables. If the latter goal is best served through an inflation-target policy, it need not jeopardize the former.

Figure 8


(i) Dispersion of major inflation rate categories
Standard deviation of growth rates
6
5
4
3
2
1
0
1980
1984
1988
1992
1996
2000
2004
Year
(ii) Growth rates of three CPI subindexes
Growth rates
12
10
8
6
4
2
0
–2
–4
Clothing and footwear
Recreation, education, and reading
Food
1991
1993
1995
1997
1999
2001
2003
Year

The results presented in this paper point to a need for future research in several areas. First, while we have not estimated the size of variations in cross-border relative prices, the evidence provided here suggests that it would be useful to try to quantify these effects. The size of the apparent links between exchange rate volatility and the policy regime means that an optimal monetary policy rule may need to account for the microlevel welfare costs of relative price volatility. It is also important to conduct further analysis of possible fundamental determinants of increased exchange rate volatility, including an analysis of the experience of other countries that have experienced decreased exchange rate pass-through while pursuing formal inflation targets.

Data Appendix 1

City price index data

Canadian cities	CANSIM number	US cities	BLS identifier
Edmonton	V737287	Chicago	CUURA207SA0
Halifax	V737227	Detroit	CUURA208SA0
Montréal	V737245	Houston	CUURA318SA0
Regina	V737275	Los Angeles	CUURA421SA0
Toronto	V737257	New York	CUURA101SA0
Vancouver	V737299	Philadelphia	CUURA102SA0
Winnipeg	V737269	San Francisco	CUURA422SA0

BLS: Bureau of Labor Statistics.

Exchange rate data

- Daily noon spot exchange rate: CANSIM series V121716.
- For the border-effect regressions, the US CPI series were multiplied by the monthly average of the daily noon spot exchange rate.

Taylor rule equation and MCI data

- Overnight interest rate: CANSIM series V39079.
- Core inflation rate data: CPI less food, energy, and indirect taxes over 1992–2001 and the Bank of Canada's core inflation rate afterward. Data from the Bank of Canada website at: http://www.bankofcanada.ca/en/rates/indinf/cpi_data_en.html.
- The Bank of Canada's measure of the output gap from the Bank of Canada website: http://www.bankofcanada.ca/en/rates/indinf/product_data_en.html.
- Monetary conditions index data from the Bank of Canada website: http://www.bankofcanada.ca/en/rates/mci.html.

Intraindustry trade data

UC Davis Center for International Data, World Trade Database.

Commodity price data

Bank of Canada Commodity Price Index, in US dollars, excluding energy. CANSIM series V36383. Including energy: V36382.

CPI series by commodity

Food (V73520); Shelter (V73596); Household Operations and Furnishings (V735413); Clothing and Footwear (V735456); Transportation (V735493); Health and Personal Care (V735518); Recreation, Education, and Reading (V735536); Alcohol and Tobacco (V735573).

References

Armour, J., B. Fung, and D. Maclean. 2002. “Taylor Rules in the Quarterly Projection Model.” Bank of Canada Working Paper No. 2002–1.

Betts, C. and M.B. Devereux. 2000. “Exchange Rate Dynamics in a Model of Pricing-to-Market.” *Journal of International Economics* 50 (1): 215–44.

Cross, P. 2002. “Cyclical Implications of the Rising Import Content in Exports.” *Canadian Economic Observer* 15 (12): 3.1–3.9.

Devereux, M.B. 2001. “Monetary Policy, Exchange Rate Flexibility, and Exchange Rate Pass-Through.” In *Revisiting the Case for Flexible Exchange Rates*, 47–82. Proceedings of a conference held by the Bank of Canada, November 2000. Ottawa: Bank of Canada.

Devereux, M.B. and C. Engel. 2004. “Expenditure Switching vs. Real Exchange Rate Stabilization: Competing Objectives for Exchange Rate Policy.” Photocopy.

Engel, C. 2005. “Canada’s Exchange Rate: New Evidence, a Simple Model, and Policy Implications.” John Kuszczak Memorial Lecture. In *Canada in the Global Economy*, 341–67. Proceedings of a conference held by the Bank of Canada, November 2004. Ottawa: Bank of Canada.

Engel, C. and J.H. Rogers. 1996. “How Wide Is the Border?” *American Economic Review* 86 (5): 1112–25.

———. 1998. “Relative Price Volatility: What Role Does the Border Play?” Board of Governors of the Federal Reserve System, International Finance Discussion Paper No. 623.

Frankel, J.A., D.C. Parsley, and S.-J. Wei. 2005. “Slow Passthrough Around the World: A New Import for Developing Countries?” National Bureau of Economic Research Working Paper No. 11199.

Judd, J.P. and G.D. Rudebusch. 1998. “Taylor’s Rule and the Fed: 1970–1997.” *Federal Reserve Bank of San Francisco Economic Review* (3): 3–16.

Kehoe, T.J. and K.J. Ruhl. 2003. “How Important Is the New Goods Margin in International Trade?” Research Department Staff Report No. 324. Federal Reserve Bank of Minneapolis.

Krugman, P. 1989. *Exchange Rate Instability.* Cambridge, MA: MIT Press.

Laflèche, T. 1996–1997. “The Impact of Exchange Rate Movements on Consumer Prices.” *Bank of Canada Review* (Winter): 21–32.

Murray, J., S. van Norden, and R. Vigfusson. 1996. *Excess Volatility and Speculative Bubbles in the Canadian Dollar: Real or Imagined?* Bank of Canada Technical Report No. 76.

Otani, A., S. Shiratsuka, and T. Shirota. 2003. “The Decline in the Exchange Rate Pass-Through: Evidence from Japanese Import Prices.” Bank of Japan Institute for Monetary and Economic Studies (IMES) Discussion Paper No. 2003–E–1.

Taylor, J.B. 1993. “Discretion versus Policy Rules in Practice.” *Carnegie-Rochester Conference Series on Public Policy* 39 (0): 195–214.

———. 2000. “Low Inflation, Pass-Through, and the Pricing Power of Firms.” *European Economic Review* 44 (7): 1389–408.

———. 2001. “The Role of the Exchange Rate in Monetary-Policy Rules.” *American Economic Review* 91 (2): 263–67.

Vanderhart, P.G. 2003. “The Bank of Canada’s Reaction Function.” *American Review of Canadian Studies* 33 (3): 357–71.