

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

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Abstract

This paper present empirical evidence suggesting that nominal exchange rate volatility has increased in Canada since the mid-1990s. The possible links between this increased volatility and reduced pass-through of exchange rate fluctuations are discussed. This leads to a consideration of the contributions of monetary policy and changing trade patterns to the observed reduction in exchange rate pass through. These results have several implications for the choice of an inflation target policy. First, inflation targets yield greater exchange rate volatility when pass through is low and so we may see continued increases in exchange rate volatility if pass-through continues to decline. The central bank may also need to reassess the optimality of the weight it places on exchange rate fluctuations if exchange rates no longer have an indirect impact on policy through their effect on inflation.

1. INTRODUCTION

There is a considerable amount of evidence to suggest that Canada's policy of announcing explicit targets for the inflation rate has been a success. Inflation itself 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 terms of other macroeconomic aggregates such as the growth rate of real GDP and the unemployment rate. Over the past decade, Canada's performance relative to the U.S. has been fairly favorable. The objective of 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, the paper presents evidence that the nominal exchange rate has become more volatile at relatively high frequencies.

Authors such as Devereux and Engel (2004) have studied the microeconomic 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 (2000) have also shown that a policy of inflation rate targeting can lead to increased exchange rate volatility if exchange rate has a relatively weak impact on the consumer price index. 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 some explicit weight on both 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 itself 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. Given this, it only seems prudent to ask if the change in the weight placed on the exchange rate remains optimal in the new low-pass-through environment.

The goal of this paper is to document a series of stylized facts and to link the patterns observed to the inflation rate targeting regime. The paper begins by documenting an apparent increase in the volatility of high-frequency changes in the Canada-U.S. nominal exchange rate. Next, an analysis of the impact of the Canada-U.S. border on variability in relative prices is conducted 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 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. This is done 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 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-U.S. 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 increased at the same time.

The remaining sections of the paper presents evidence that may bear upon 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 volatility of non-energy commodity prices over the same period. Next, changing patterns of international trade are explored as a determinant of reduced

exchange rate pass-through and disaggregated price index data are analyzed to determine whether their behavior is consistent with the role of monetary policy in producing low levels of pass-through to consumer prices. The findings of the paper are summarized in a concluding section.

2. EXCHANGE RATE VOLATILITY: EMPIRICAL EVIDENCE

Much of the literature on 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 FDI decisions. 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, then the impact of inflation targeting on exchange rate volatility is likely to be felt at a higher frequency. Essentially, the exchange rate will be impacted by shocks to the domestic inflation rate .

A fairly comprehensive study of exchange rate volatility was conducted by Murray, van Norden, and Vigfussen (1996). This paper 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 also compared volatility in currency markets to that in markets for other assets such as equities. In addition, the study attributed exchange rate volatility to traders looking to market fundamentals rather than to potentially de-stabilizing noise traders. The evidence presented in this paper is consistent with the Murray et al study because increased exchange rate volatility only begins to appear in the data after 1996.

Descriptive indicators of exchange rate volatility are provided by Figures One through Three. The two panels of Figure One show the daily change in a.) the level and b.) the log of the bilateral Canada-U.S. nominal exchange rate over the period 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 an discernible increase in these changes after the mid-90s and, in particular, since 1997. This visual impression is

quantified by the 67% increase of the standard deviation of the daily log changes (from 0.002527 to 0.004224) between the 1975-96 and 1997-2005 sub-samples. Under the (admittedly heroic) assumption of normality, the F-test for the hypothesis of equal variances in the two samples generate a value of 2.83. Under the null hypothesis this ratio has an $F(1992, 5348)$ distribution and the hypothesis is rejected at a very high confidence level. Figure Two shows histograms for changes in the exchange rate that confirms 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. Very similar patterns of increased volatility 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 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 Lafleche (1997) of the unexpectedly muted effect on consumer prices of the depreciation of the Canadian dollar between 1992 and 1994. The concluding section of the Lafleche 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.

3. 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-U.S. border was of similar magnitude as 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 actually 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 micro-economic 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 them 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-U.S. 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 are 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 U.S. prices by the price of a U.S. dollar in Canadian dollars (S_t):

$$R_t = \frac{P_t^{Can}}{S_t * P_t^{U.S.}}$$

While more recent work by Engel (2004) has used individual commodity price data to examine this ratio, the traditional Engel-Rogers approach uses consumer prices indices. The use of consumer prices indices means that levels of this relative price have no meaning and so 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 pair 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 prices 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-U.S. border on relative price variability between cities, the following cross-sectional regression equation can be used:

$$s_{i,j} = \mathbf{g} * \log(\text{dist}_{i,j}) + \mathbf{d} * \text{border}_{i,j}^1$$

In this equation, $s_{i,j}$ 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 U.S. city-level CPI data are only available in even or odd months and we only use even months in this analysis. The key parameters of interest in this regression are \mathbf{g} which captures the effect of distance on price dispersion and \mathbf{d} which measures the additional price dispersion caused by the border.

The focus of this paper is how the size of the border effect varies over time. In particular, we wish to determine how much the recent increase in variability of the nominal exchange rate has impacted border effects. We will follow the approach of Engel and Rogers (1998) who sought to identify changes in border effects due to 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 U.S. BLS has since dropped or modified the CPI series for several cities. This leaves seven U.S. cities in the analysis and they are matched with seven Canadian cities so that the sample for the regressions contains 91 pairs of cities². Like Engel and Rogers (1998), we use the all-items CPI but we do not include the 14 sub-indices that they also analyzed. This choice reflects the fact

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

² There are 21 [(7*6)/2] unique pairs of Canadian cities, 21 pairs of American cities, and 49 [7*7] pairs of cities which are on the opposite side of the border.

that sub-index data are only available for provinces rather than cities for recent periods. In any case, preliminary analysis using sub-indices showed results for very similar to those for the all-items results. The effect of time can be examined by varying the sample period used to calculate the standard deviation used as the dependent variable in the regressions.

Table One 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 sub-samples. The sample breaks were chosen to match the enactment of formal free trade agreements in 1989 and 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 date 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 Four 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 exchange rate variability variable 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 2000-2002, 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-U.S. exchange rate

during this period largely reflects a movement closer to purchasing power parity and so it seems perverse to view this as a widening of border effects. On the other hand, the appreciation of the Canadian dollar over the last few years coincides with a general realignment of the U.S. dollar relative to a wide range of currencies and it's unclear how this could be interpreted as a narrowing of Canada-U.S. border effects. It will be informative to watch over the next few years to see whether this recent adjustment prompts a lasting reduction in border effects. If cross-border relative prices have converged in levels and border effects have been reduced then there should be much closer movements of Canada-U.S. relative prices in the future.

4. EXCHANGE RATE VOLATILITY, PASS-THROUGH, AND INFLATION TARGETS: THEORY AND EMPIRICAL EVIDENCE

This paper has 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 (2000) 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 consumer-goods related expenditure switching if, for example, changes in relative labor costs induce 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, with low inflation pass-through declines 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, then the response of prices to changes in exchange rates is further muted.

To get some insight into the actual impact of low exchange rate pass-through on recent Canadian monetary policy, a Taylor rule is estimated. The specification used here 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 include 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 has an inflation-target policy.

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

$$r_t^* = \bar{r} + I_1(\mathbf{p}_t - \mathbf{p}_t^*) + I_2 \frac{y_t - y_t^*}{y_t^*} + I_3(e_t - e_{t-1})$$

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:

$$\Delta r_t = \mathbf{g}(r_t^* - r_{t-1}) + \mathbf{r}\Delta r_{t-1}$$

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

$$\Delta r_t = \mathbf{g}\bar{r} - \mathbf{g}r_{t-1} + \mathbf{g}l_1(\mathbf{p}_t - \mathbf{p}_t^*) + \mathbf{g}l_2 \frac{y_t - y_t^*}{y_t^*} + \mathbf{g}l_3(e_t - e_{t-1}) + \mathbf{r}\Delta r_{t-1}$$

When estimating this equation, we allow for changes in the three policy coefficients ($\mathbf{g}_1, \mathbf{g}_2, \mathbf{g}_3$) 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 Three while the table below shows the implied values for the parameter variables:

	1993-1996	1997-2004
Inflation Gap (\mathbf{g}_1)	-6.595	-6.4608
Output Gap (\mathbf{g}_2)	2.986	-0.869
Exchange Rate Change (\mathbf{g}_3)	223.832	-53.018

This table reveals some interesting results. First, the effect of the inflation gap is perverse in both sub-periods: the real overnight rate *falls* when inflation rises relative to the target, rather than rising. 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-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 both the output gap and the exchange rate change are as expected for 1993-1996 period. An increase in output relative to potential raises the real overnight rate while a depreciation (increase in the price of the U.S. 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 have 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 Five which shows the relative volatility of the two components of the Bank of Canada's Monetary Conditions Index. This index summarizes the effects of both interest rates and exchange rates on the stance of monetary policy and is defined as:

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

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 Five, monthly changes in the two components of the MCI were calculated and then trailing 12-month standard deviations were obtained. The ratio of the standard deviation for the exchange rate to that for the interest rate are shown in Figure Five. The graph seems to reveal a clear increase in the relative volatility of the exchange rate component of the MCI, once again in 1997.

5. 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-U.S. exchange rate through the terms of trade. Panel a.) of Figure Six 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 volatility of commodity prices.

The analysis of the MCI graph presented earlier 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 Figure Six b.). 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 alternative explanation for exchange rate volatility.

6. WHY HAS PASS-THROUGH DECLINED AND WHY DOES IT MATTER?

There is little disagreement regarding the empirical regularity that 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 emphasize increased international competition, perhaps due to 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 U.S. 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 intra-firm trade contribute to reduced pass-through and this trend might continue as intra-industry and intra-firm expands in importance.

While traditional theories of trade focus on specialization and comparative advantage, deepening of economic integration is increasingly linked to the expansion of intra-industry trade. An example is the automotive industry in which Canada and the U.S. both export and import large volumes of automotive products. As in the automotive industry, a large fraction of this within-industry trade is between different entities within the same firm. This 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 U.S. at a unit price P_{int} , adds value to them in Canada by employing labor inputs, and then ships the finished product back to the U.S. for sale at unit price P_{fin} . If E is the value of a U.S. dollar in Canadian dollars, then profits in Canadian dollars for this firm are:

$$p = EP_{fin}Q_{fin} - EP_{int}Q_{int} - W * L.$$

An exporting firm like this one that imports a significant fraction of its inputs is partially hedged against any change in the value of the U.S. dollar because the cost 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 U.S. dollars when if the U.S. 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

which showed that “over half of the rapid rise in the share of exports in GDP in the early 1990s reflected rising import content and not valued-added”. An important effect of intra-firm 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 intra-firm trade. The level of intra-industry trade is readily observable using detailed trade statistics, and the levels of intra-firm and intra-industry trade are likely to be correlated. This is true both at the theoretical and empirical levels. Models of intra-industry 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 intra-firm trade. Also, empirical analysis confirms that industries such as the automotive industry tend to have high degrees of both intra-firm and intra-industry trade.

Several means of measuring intra-industry 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 intra-firm trade as is the case in the automotive industry, for example.

Figure Seven shows the recent behavior of the Grubel-Lloyd index since 1980 based on 34 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 due to 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 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 both 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 somewhat 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 hands, a recent study by Frankel, Parsley, and Wei (2005) using data for higher-inflation rate developing countries finds that monetary policy can't 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.

7. 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 several implications for the growth rate of prices of individual commodities. It would seem 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 eight 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 consumer price index (the omitted component is alcohol and tobacco which is affected by changes in indirect taxes). The first panel 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. The second panel looks at the actual growth rate of prices for three of the eight major components of inflation (food, clothing & footwear, and reading, recreation, and education). The graph shows a rapid and synchronized drop in inflation in the early 1990s. In future work, it would be informative to determine whether price contract models can explain the speed with which this disinflation occurred. Also, the models’ implications for the persistence of dispersion of inflation rates should be derived and compared to the data.

8. CONCLUSIONS

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

One implication of the findings of this paper 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 question of 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.

The results presented in this paper point to a need for future research in several areas. First, while this paper has not provided any estimate of 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 mean that an optimal monetary policy rule may need to account for the micro-level 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 and Province Price Index Data

Canadian Cities	CANSIM Number	U.S. Cities	BLS Identifier
Edmonton	V737287	Chicago	CUURA207SA0
Halifax	V737227	Detroit	CUURA208SA0
Montreal	V737245	Houston	CUURA318SA0
Regina	V737275	L.A.	CUURA421SA0
Toronto	V737257	N.Y.	CUURA101SA0
Vancouver	V737299	Philadelphia	CUURA102SA0
Winnipeg	V737269	San Francisco	CUURA422SA0

2. Exchange Rate Data

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

3. 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 web site at: http://www.bankofcanada.ca/en/indinf/cpi_data_en.html
- The Bank of Canada's measure of the output gap measure from the Bank of Canada web site: http://www.bankofcanada.ca/en/indinf/product_data_en.html
- Monetary Conditions Index data from the Bank of Canada web site: <http://www.bankofcanada.ca/en/mci.htm>

4. Intra-Industry Trade Data

U.C. Davis Center for International Data, World Trade Database.

5. Commodity Price Data

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

6. CPI series by Commodity

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

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Table One: Regression Analysis of Border Width

	Full Sample 1978-04	Pre- FTA 1978-88	Post- FTA 1989-04	Post- FTA 1 1989-93	Post- FTA 2 1994-97	Post- FTA 3 1998-04
Border	1.359 (0.008)	1.127 (0.015)	1.537 (0.011)	1.223 (0.015)	1.037 (0.012)	1.924 (0.020)
LogDistance	2.960 (0.679)	3.211 (1.26)	2.344 (0.928)	-0.778 (1.262)	1.360 (1.016)	4.907 (1.634)

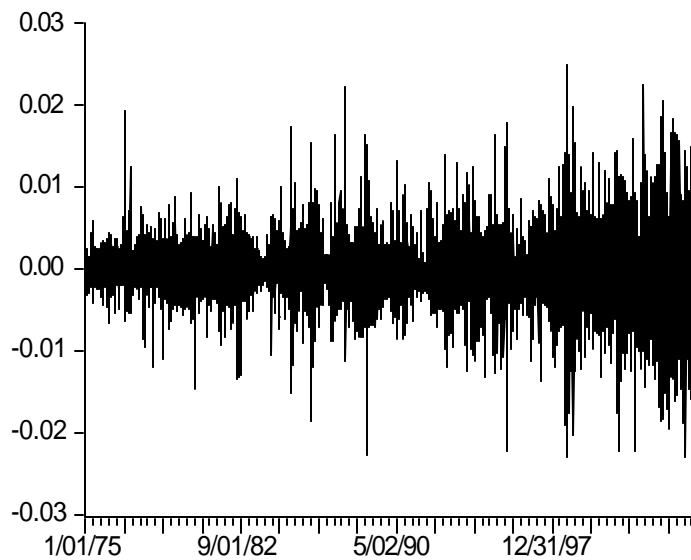
Note: Standard errors are in parentheses below the coefficient estimates.

Table Two: Taylor Rule Reaction Functions

Variable	Coefficient	Standard Error	t-Statistic	Prob.
Constant	0.0253	0.2036	0.12	0.902
$p - p^*$	-0.9393	0.48635	-1.931	0.062
$y - y^*$	0.4252	0.1827	2.33	0.026
Δ PFX	31.8781	9.9779	3.19	0.003
$(p - p^*) * \text{DUM97}$	0.01916	0.48869	0.04	0.969
$(y - y^*) * \text{DUM97}$	-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			

Figure One: Daily Change in the Canada-U.S. Exchange Rate

a.) Change in the Level



b.) Change in the Natural Logarithm

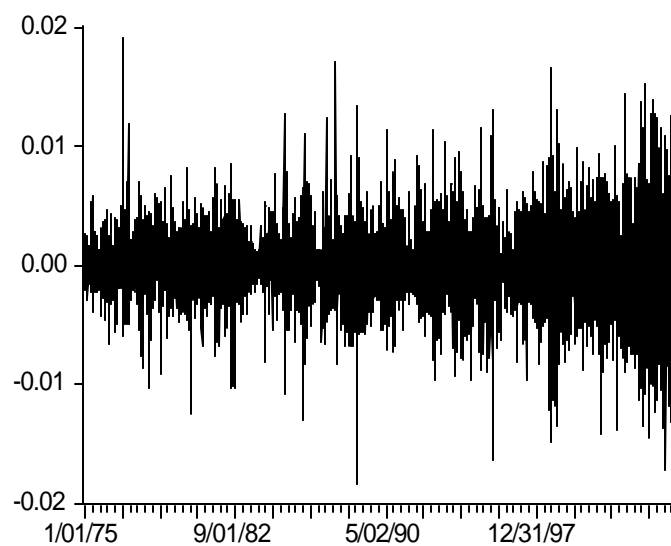
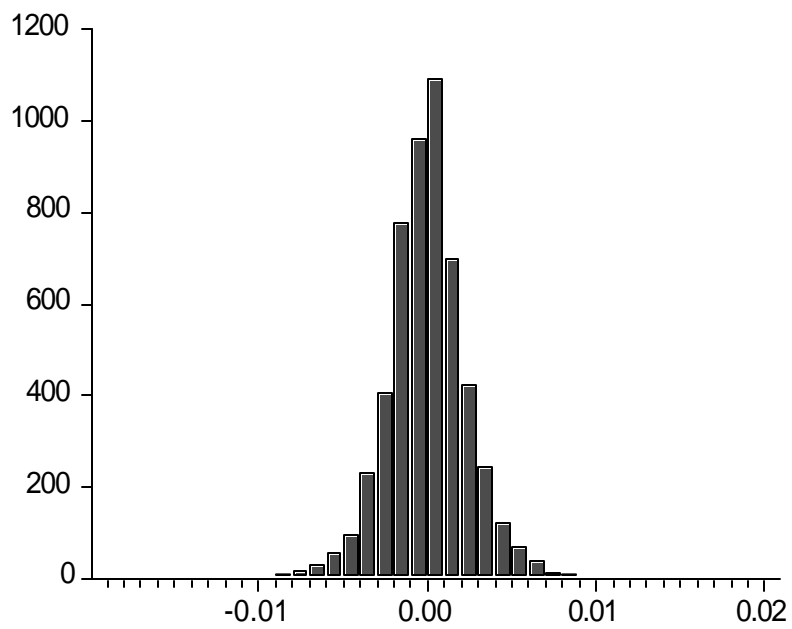
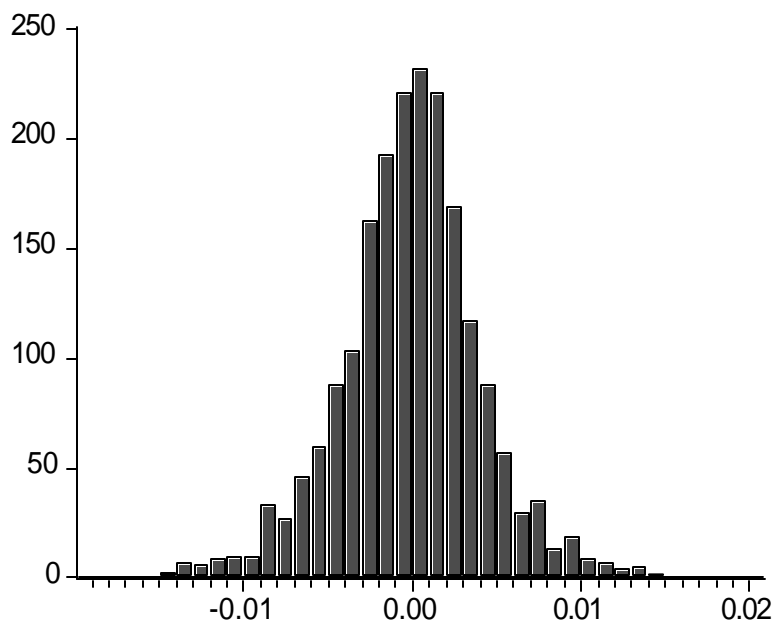


Figure Two: Properties of the Daily Change of the Log Exchange Rate



a.) 1975-1996



b.) 1997-2005

Figure Three: 30-day Moving Standard Deviation of Daily Changes
In the Canada-U.S. Nominal Exchange Rate

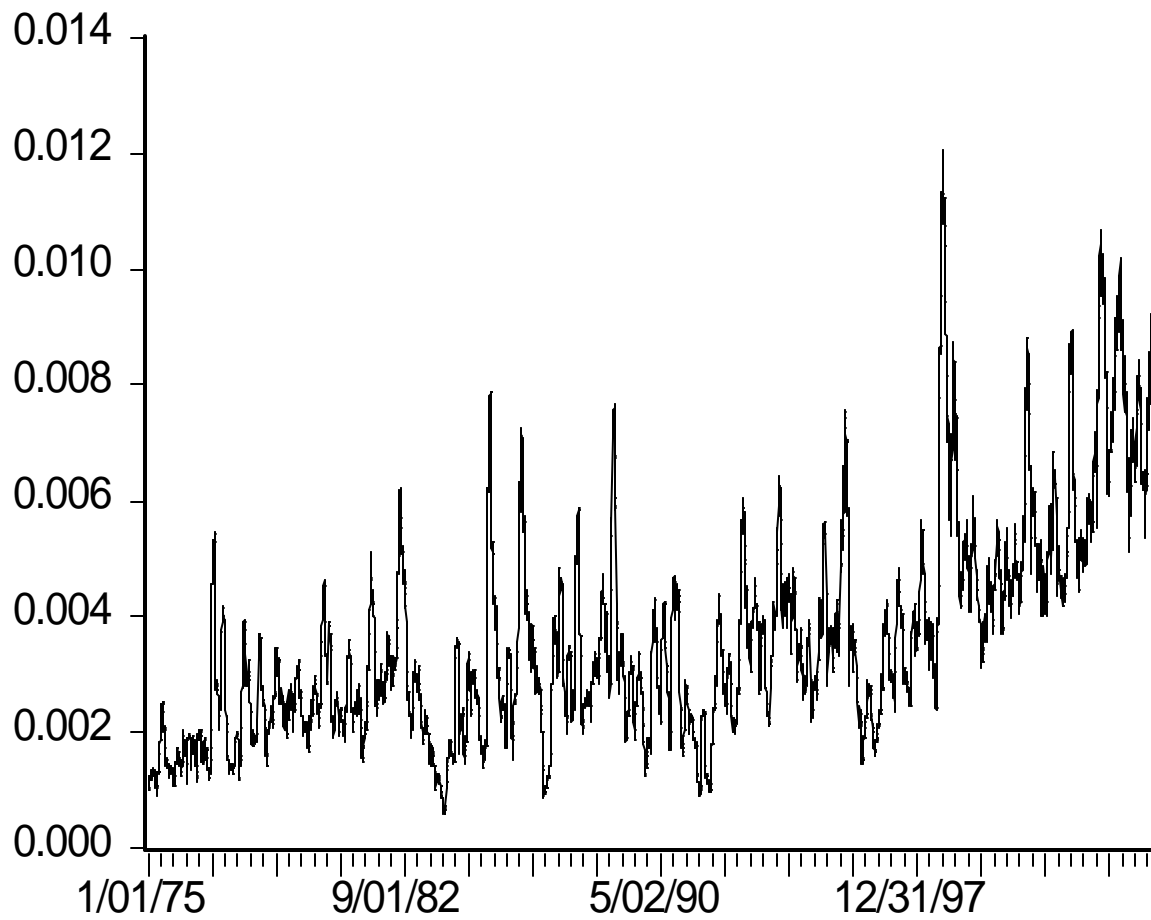


Figure Four: Evolution of Border Effects Over Time

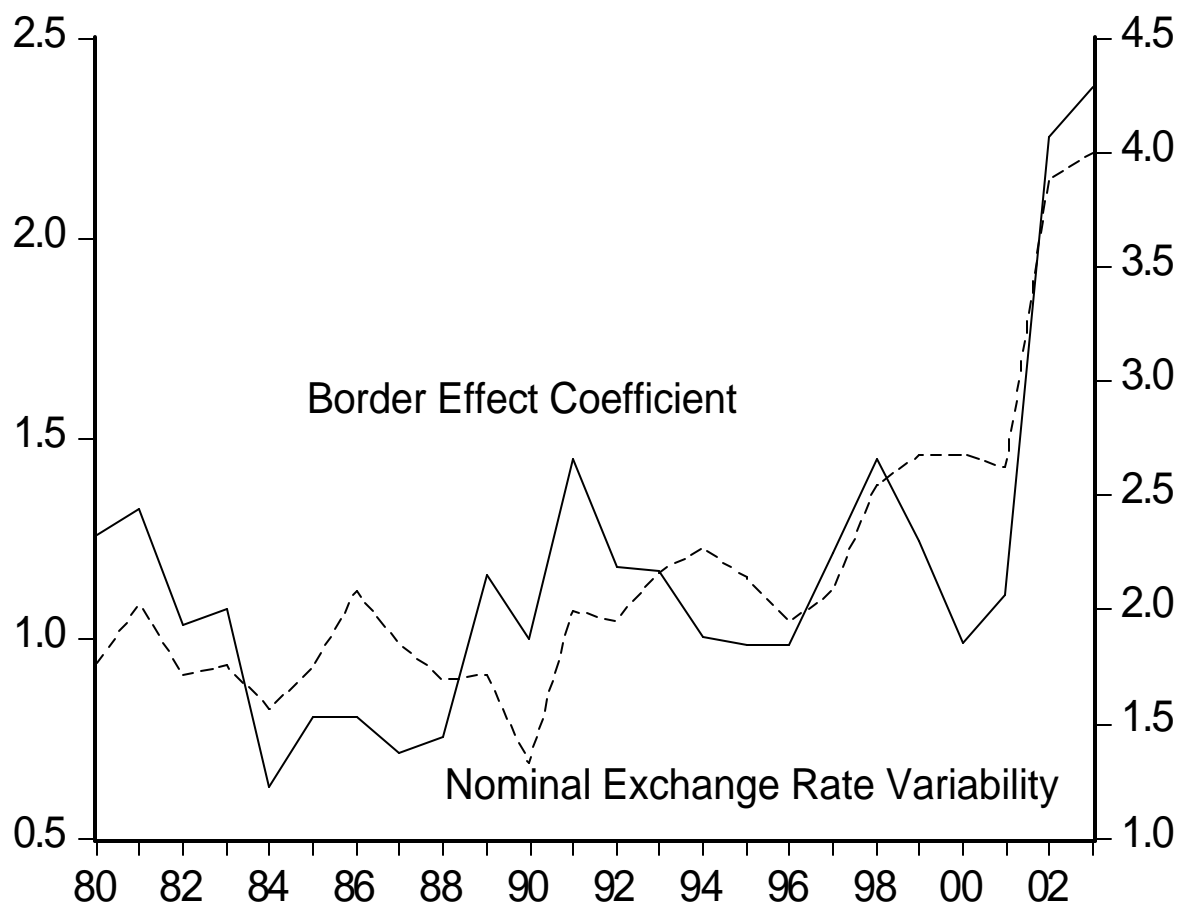


Figure Five: Relative Volatility of the Components of the Monetary Conditions Index

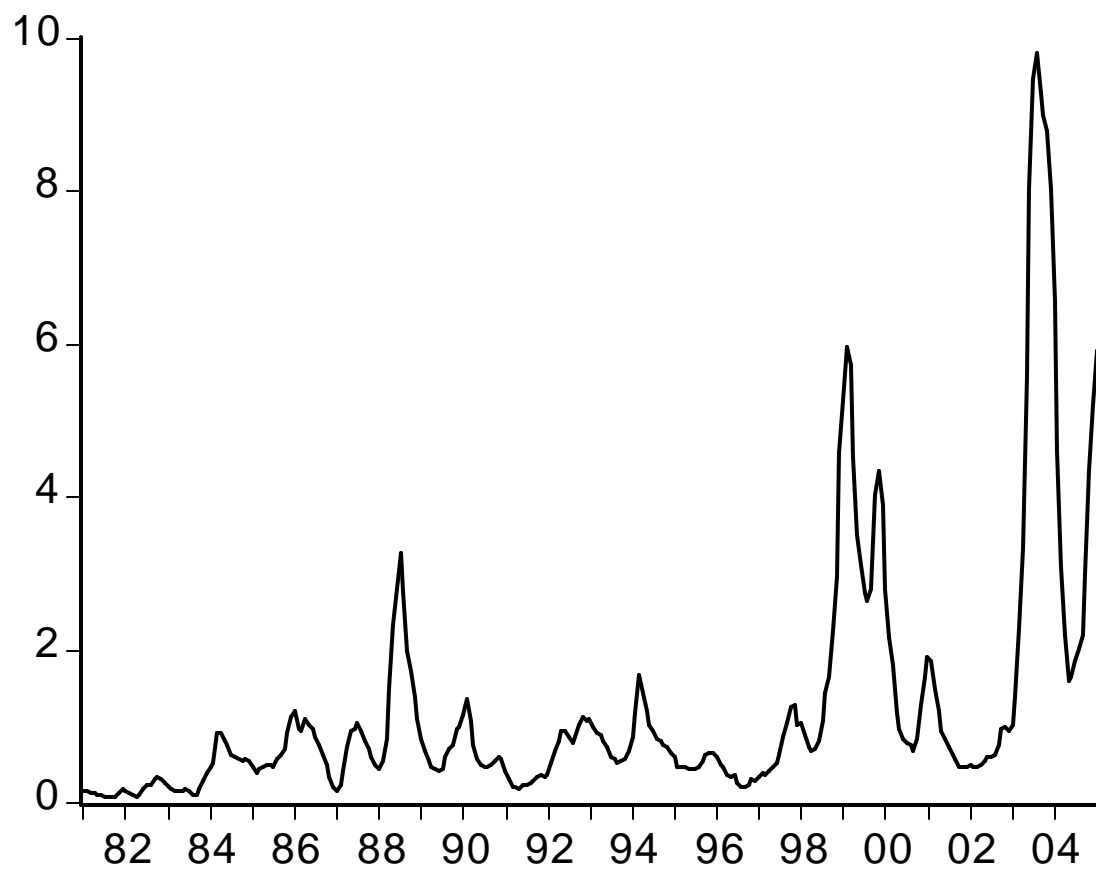


Figure Six a.): Volatility of Monthly Changes in
The Exchange Rate and Non-Energy Commodity Prices

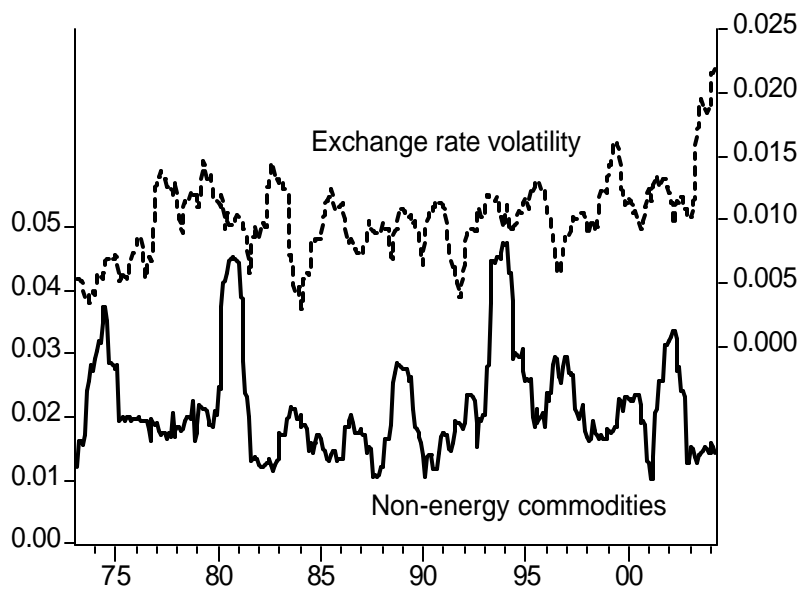


Figure Six b.): Volatility of All Commodities and Non-Energy
Commodities

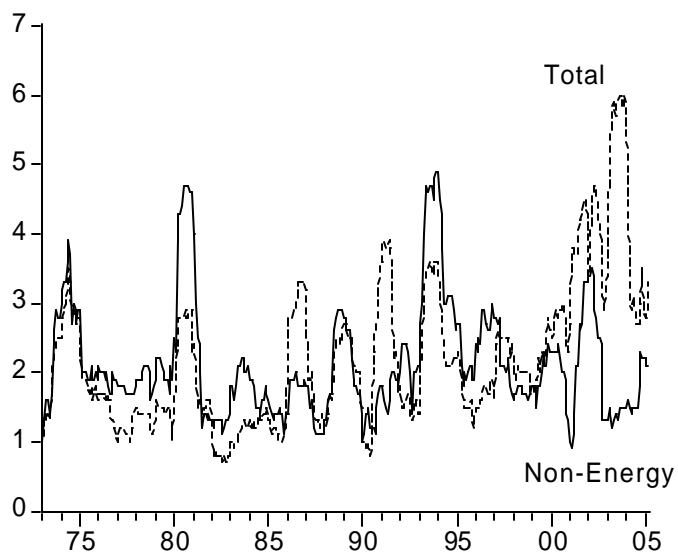


Figure Seven: Grubel-Lloyd Index of Intra-Industry Trade

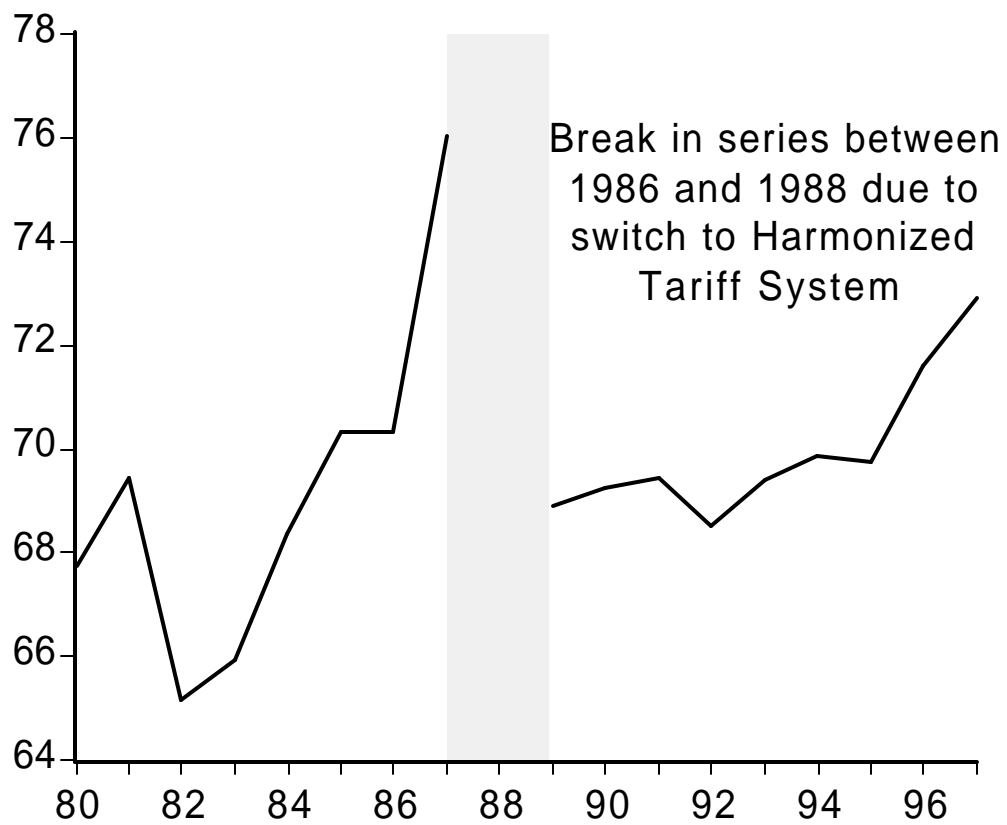


Figure Eight a.): Dispersion of Major Inflation Rate Categories

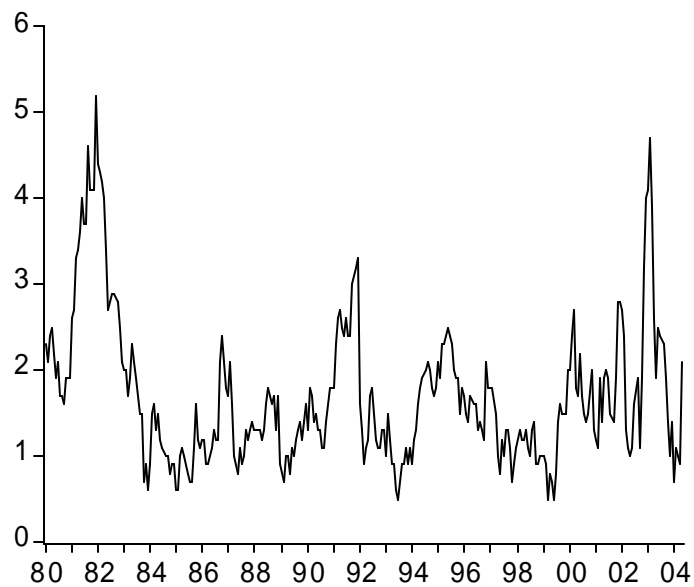


Figure Eight b.) Growth Rates of Three CPI Sub-Indices

