Revisiting the Case for Flexible Exchange Rates in North America

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1. Introduction

Canada has had a flexible exchange rate for all but eight of the last fifty years. Mexico adopted a flexible rate in 1995, in the wake of the 1994 peso crisis. The authorities in both of these countries argue that the flexible exchange rates in conjunction with explicit inflation targets have served their economies well.[1] Nonetheless, important commentators maintain that some form of fixed exchange rate with the U.S. dollar would be a better alternative. In Canada, the proposed alternatives range from an adjustable peg to a new North American currency, while in Mexico the main alternative appears to be unilateral dollarization.[2] There seems to be a variety of reasons behind these proposals to replace the flexible exchange rate regimes: chiefly, the so-far successful introduction of the euro and the dissatisfaction with sharp exchange rate depreciations caused by financial crises in other parts of the world.

The purpose of this paper is to argue that flexible exchange rate regimes play a critical role in stabilizing the Canadian and Mexican economies in the face of asymmetric shocks, nominal rigidities and limited international labour mobility. We do not consider the important issue of transaction costs nor do we assess the other criteria that have been developed in the optimum currency literature. Instead, we focus on the macro-stability benefits of a flexible rate and we make our case by providing evidence that supports the following propositions:

Proposition I: Canada, Mexico, and the United States' economies often experience large asymmetric shocks and the correlation between their business cycles is relatively small;

Proposition II: Flexible exchange rates in Canada and Mexico are primarily driven by macroeconomic fundamentals and adjust appropriately to the large asymmetric shocks; and

Proposition III: By responding to shocks in the underlying fundamentals, flexible exchange rates facilitate economic adjustment.

The paper is organized as follows: one section is devoted to each of the three hypotheses, with each section containing a brief theoretical discussion, a summary of recent empirical work, and the new empirical evidence that we have uncovered. The concluding section briefly addresses the trade-off between the macro-stability benefits provided by a flexible exchange rate and the associated transaction costs.

1. Canada began formal inflation targeting in February 1991, when the government and the Bank of Canada announced a target path for reducing inflation to the 1 to 3 per cent range by the end of 1995. This target range has been extended twice since then, most recently until the end of 2001. In 1998, the Banco de Mexico adopted an informal target of 12 per cent (actual inflation in 1998 was 18 per cent) and the target for 1999 was 13 per cent. By 2003, the inflation target will be a band similar to those of its major trading partners, roughly 0 to 3 per cent.
2. For Canada, recent contributions to the debate include: Courchene and Harris (1999) and Grubel (1999) in favour of fixed rates; and Crow (1999), McCallum (1999) and Murray (1999) in favour of flexible rates. For opposing views on Mexico, see Edwards and Savastano (1999) and Schuler (1999), and for dollarization in Argentina see Pou (1999).

2. Asymmetric Shocks: Fact, Folly or Simply Not Worth the Bother?

***Proposition I:* Canada, Mexico, and the United States' economies often experience large asymmetric shocks and the correlation between their business cycles is small.**

If the three North American economies were all subject to the same shocks, there would be no need for flexible bilateral exchange rates, even if nominal rigidities were present. Therefore, to justify the adoption of flexible exchange rates, the shocks have to be asymmetric (i.e., have a negative or a small positive correlation) and be economically significant. Under such circumstances, real exchange rate adjustment would be warranted and a flexible exchange rate would facilitate this process.

In this section, we consider the existence, magnitude and sources of asymmetric shocks among the three countries. A priori there are strong reasons to believe that asymmetric shocks exist and are probably economically important. The three countries have different output (and, to a lesser extent, consumption) bundles because of dissimilar factor endowments (including stocks of knowledge), tastes and economic institutions, which have been influenced by differences in geography, climate, and the evolution of economic and political forces. Thus, it is likely that exogenous shocks, such as commodity price shocks, will have a varied impact across countries. Independent national fiscal policies are another potential source of asymmetric shocks which may require real exchange rate adjustments.

In addition to looking at the symmetry of the shocks affecting the three countries, we examine the symmetry of their business cycles. It is useful to consider the latter since output fluctuations reflect not only the shock, but also the dynamic response of the economy. The business cycle can be seen as the sum of these two elements. However, a drawback of looking at business cycles is that the responses to the shocks may depend on the exchange rate regime. For instance, the business cycles of two countries may be more symmetric than the shocks affecting them because a flexible exchange rate smooths the impact of asymmetric shocks.[3]

A problem common to both shocks and business cycle measures is that they are subject to measurement errors and there is no consensus on what the preferred approach should be. In an attempt to overcome this problem, we consider various methodologies.

Finding less symmetry among the shocks and business cycles of the three countries than among U.S. regions would suggest that it would be more costly to impose a common monetary policy on the three countries than it is for regions of the United States to be in a monetary union.

In the rest of this section, we present evidence that the trade sectors of Canada, the United States and Mexico are different and that these countries are affected by asymmetric terms of trade shocks. Then we use a simple structural VAR approach to identify various types of shocks and present the correlations between these shocks for the three countries and various regions of the United States. We also use this SVAR approach together with other methodologies to examine and compare correlations between the business cycles of the three economies.

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3. See Mélitz and Weber (1996) and Dupasquier, Lalonde and St-Amant (1997) for additional discussion of the advantages and disadvantages of looking at shocks and business cycles.

2.1 Differences in economic structures and terms of trade shocks

Table 1 shows the share of various types of exports as a percentage of total exports and GDP in Canada, Mexico, and the United States. Canada and, to a lesser extent, Mexico, are more dependent on commodity exports than the United States. While total commodities (oil plus non-oil) account for more than a third of Canada's goods exports, they account for 19 percent of Mexico's goods exports and 17 percent of U.S. goods exports. The counterpart of this is that manufacturing and machinery exports represent a larger portion of total exports in Mexico and the United States than in Canada.

Table 1: Types of goods exports as a percentage of total goods exports and of nominal GDP (inside brackets) in 1997[a]

	Canada	United States	Mexico
Non-oil commodities[b]	31 (10)	16 (1)	9 (3)
Oil[c]	5 (2)	1 (0)	10 (3)
Chemicals	6 (2)	11 (1)	4 (1)
Manufacturing	16 (5)	19 (2)	23 (6)
Machinery	39 (5)	50 (4)	54 (15)
Others	3 (1)	4 (0)	0 (0)

a. OECD data.
b. Includes food and live animals, beverages and tobacco, non-fuel crude materials, animal and vegetable oils, coal, natural gas, electric current, leather and dressed fur skins, and wood and paper manufactures.
c. Petroleum, petroleum products, and related materials.

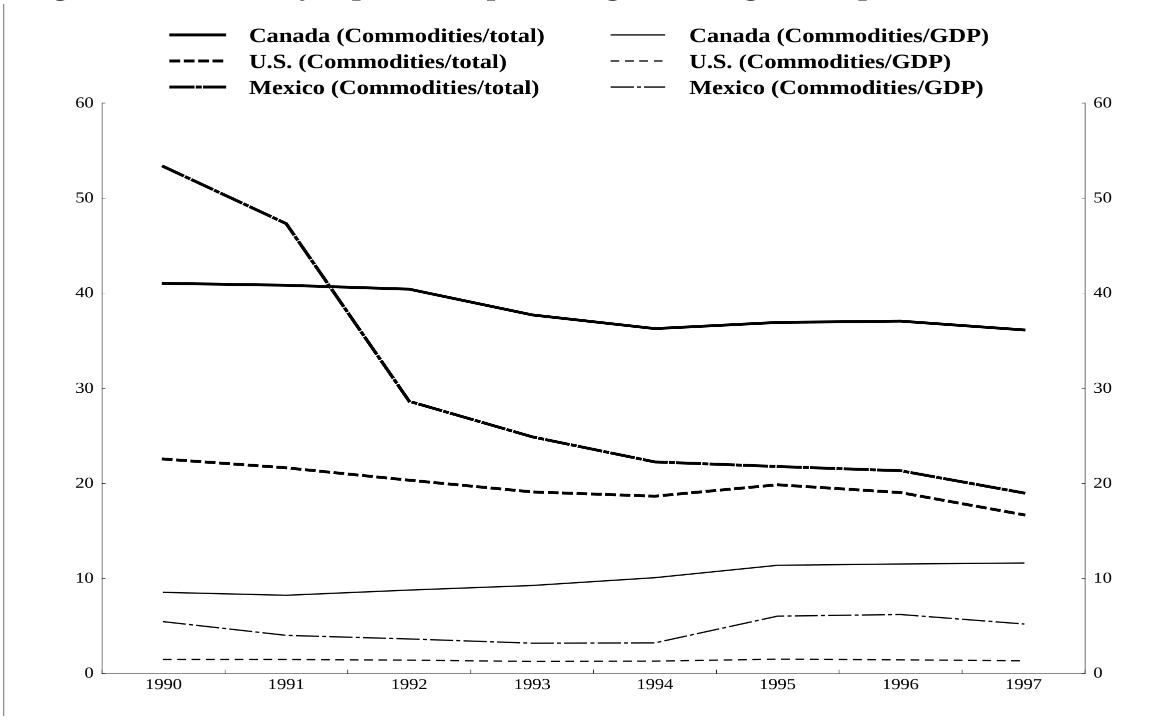
While non-oil commodity exports account for most of the commodity exports in Canada and the United States, in Mexico oil exports accounts for more than half of commodity exports. Differences in the role played by commodity exports become even more striking when exports are expressed as a percentage of nominal GDP. While total commodity exports account for 12 percent of Canada's GDP, in Mexico and the United States they represent 6 percent and 1 percent, respectively. These large differences reflect, to some extent, the fact that the Canadian economy is more open than the Mexican economy, which is itself more open than the economy of the United States. Indeed, total exports of goods and services accounted for 40 percent of Canada's GDP in 1997, compared with 30 percent for Mexico and 12 percent for the United States.

Figure 1 shows that, although total commodity exports have declined as a percentage of total exports in all three countries (particularly in Mexico[4]), they have been more stable as a share of

4. The relative importance of commodities has declined over the 1990s in Mexico because of a relative decline in oil exports and the burgeoning manufacturing sector, which has been driven in part by the maquiladora program and other measures to liberalise and enhance international trade.

nominal GDP. In fact, in the case of Canada, exports of commodities have increased significantly in the 1990s as a share of nominal GDP. Again, the increased openness of the three economies accounts for this fact.

Figure 1: Commodity exports as a percentage of total goods exports and nominal GDP



Differences between the three countries' export sectors suggest that they will be affected differently by certain types of shocks. Another way to look at this is too consider their terms of trade.[5] Table 2, which presents correlations between the terms of trade for Canada, the United States and Mexico, shows that while the terms of trade of the United States and those of the other two countries are negatively correlated, the terms of trade of Mexico and Canada are positively correlated.

Table 3 indicates that the negative correlations presented in Table 2 reflect, to a large extent, differences in the impact of commodity prices movements on the terms of trade of the three countries. While the correlation between the terms of trade of both Canada and Mexico and commodity prices is both high and positive, the terms of trade of the United States are negatively correlated with commodity prices. There is also a distinction to be made between Canada and Mexico, in that the terms of trade of Canada are more correlated with non-oil commodity prices, but those of Mexico are much more correlated with the price of oil.

5. See Roger (1991) for a study of optimum currency areas based on an analysis of terms of trade movements similar to ours. Roger's study, however, does not take into account the non-stationarity of terms of trade series.

Table 2: Correlations between the terms of trade of Canada, the United States, and Mexico (1982 to 1998)[a]

	Correlation with:		
	Canada	**United States**	**Mexico**
Canada	1.00	-0.36 (-0.54)	0.37 (0.35)
United States		1.00	-0.77 (-0.73)
Mexico			1.00

a. Annual data in first differences and filtered with an Hodrick-Prescott filter (in brackets), obtained from Statistics Canada, the IMF's International Financial Statistics (IFS), and the Banco de Mexico. Unit root tests (available on request) indicate that these series are non stationary in levels.

Table 3: Correlations of terms of trade with oil and non-oil commodity prices (1982 to 1998)[a]

	Oil	**Non-oil**
Canada	0.39 (0.48)	0.67 (0.50)
United States	-0.75 (-0.83)	-0.13 (-0.21)
Mexico	0.83 (0.75)	0.15 (0.19)

a. Annual data in first differences or HP-filtered (in brackets). The data on oil and non-oil commodity prices is taken from the IFS.

2.2 Measuring the symmetry of shocks with structural VARs

To assess the symmetry of the exogenous shocks hitting Canada, Mexico and the United States, we use an extension of the methodology proposed by Bayoumi and Eichengreen (1993, 1994). Their analysis is based on a traditional aggregate supply-aggregate demand model. Following Blanchard and Quah (1989), they assume that aggregate supply shocks have a permanent impact on output, while aggregate demand shocks are transitory. The econometric approach developed by Blanchard and Quah is then applied to the price and output series of various regions and countries in order to identify and estimate demand and supply shocks, after which the correlations between the various demand and supply shocks are compared. They give greater emphasis to the correlation of the supply shocks, because demand shocks include monetary policy shocks, a source of asymmetry that would not be present in a monetary union.

We extend Bayoumi and Eichengreen's analyses by separately identifying monetary policy shocks, so that the correlations between both real demand and supply shocks can be considered. We use three-variable VARs which include the first differences of output, inflation, and interest rates to identify supply (ε^s), monetary (ε^m), and real demand (ε^d) shocks. Supply and real demand shocks are identified as in Bayoumi and Eichengreen (1993); they are assumed to have no long-term effect on inflation. In contrast, monetary policy shocks can alter the trend of inflation. This is consistent with the view that monetary policy shocks are neutral in the long run and the fact that only the monetary authorities can affect the trend of inflation.

Using Wold's theorem, the structural model can be written as follows:[6]

$$x_t = A_0\varepsilon_t + A_1\varepsilon_{t-1} + \dots = \sum_{i=0}^{\infty} A_i\varepsilon_{t-i} = A(L)\varepsilon_t, \tag{1}$$

where

$$\varepsilon_t = \begin{bmatrix} \varepsilon_t^s \\ \varepsilon_t^m \\ \varepsilon_t^d \end{bmatrix}, \; x_t = \begin{bmatrix} \Delta\pi \\ \Delta y \\ \Delta r \end{bmatrix} \text{ and} \tag{2}$$

the variance of the structural shocks is normalized so that $E(\varepsilon_t\varepsilon_t') = I$, the identity matrix.The variables are defined as: y the logarithm of industrial production, π the rate of inflation, and r a nominal interest rate.[7]

The data are quarterly, seasonally adjusted, and for the period 1975Q1 to 1999Q2. Note that consistent interest rate data for Mexico are not available prior to 1975. The interest rates series for Canada, the United States, and Mexico are, respectively, the overnight rate, the Federal Funds rate and the average cost of funds (the only interest rates series available over a reasonably long period for Mexico). Inflation is measured with country and regional consumer prices data. The interest rate used for the regions of the United States is the Federal Funds rate. Data availability on Mexico's interest rates limits the sample to the period 1975q1-1999q2. The regional data was obtained from Data Resources Incorporated (DRI) and the country data from the OECD and the IMF.

The series are first-differenced since augmented Dickey-Fuller tests were unable to reject the null hypothesis of a unit root for each variable.[8] The cointegration tests produced mixed results, so that we proceed on basis of the assumption that there is no cointegrating relationship.[9]

The U.S. regions we consider are: Eastern North Central (ENC), Eastern South Central (ESC), Middle Atlantic (MATL), New England (NENG), Pacific North West (PNW), Pacific South West (PSW), South Atlantic (SATL) West North Central (WNC), and West South Central (WSC). Appendix 1 identifies the states that are included in each of these regions.

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6. We make the usual assumption that (1) is invertible. For a discussion of the cases where (1) is not invertible, see Lippi and Reichlin (1993).
7. Industrial production data are used because they are more readily available on a quarterly basis than GDP data for Mexico and the regions of the United States.
8. The only exception is that the unit root in Mexican inflation could be rejected. However, for the sake of consistency across models, Mexican inflation is assumed to be nonstationary. The rejection of the unit root in Mexican inflation might be due to the bias in the test induced by the presence of a large negative moving-average component in the process (Schwert, 1987).
9.Unit root and cointegration tests are available upon request.

We estimate three-variable VARs for each of the three countries and the nine regions of the United States. The number of lags is determined on the basis of sequential likelihood ratio tests applied in a general-to-specific approach with a maximum of 8 lags.[10] The estimated VAR models have the following moving average representation:

$$x_t = e_t + C_1 e_{t-1} + \dots = \sum_{i=0}^{\infty} C_i e_{t-i} = C(L)e_t \tag{3}$$

In all cases, the reduced-form residuals are related to the structural residuals through the following equation:[11]

$$e_t = A_0 \varepsilon_t \tag{4}$$

$$A(1) = C(1)A_0 \tag{5}$$

To identify the model, we need to impose three a priori restrictions on $A(1)$. First, we assume that real demand shocks have no effect on inflation in the long run. Identification is completed with the assumption that both real demand shocks and monetary policy shocks have no affect on output in the long run.[12]

Figures A3.1 to A3.9 in Appendix 2 present the responses of output, prices and the real interest rate to the three types of shocks in Canada, Mexico, and the United States.[13] These figures indicate that the shocks we identify behave in a manner broadly consistent with standard macroeconomic theory. For instance, monetary shocks are associated with a short-run decline in real interest rates, and temporary increases in output and inflation. Supply shocks cause a short-run decline in inflation and a long-run increase in output. It is important to remember that only the long-run impact of the shocks on output and inflation is constrained ex ante.

Figures A3.1 to A3.9 also indicate that the shocks we consider have a sizable impact on the output series. This is important because asymmetry of shocks is only relevant to the extent that these shocks have a significant economic impact. Notice, however, that the demand shocks hitting the Mexican economy dissipate quickly. Indeed, Mexico is characterized by a very important dominance of supply shocks and a very quick adjustment to all types of shocks. This result, which is consistent with the one obtained by Lalonde and St-Amant (1993), suggests that Mexico has fewer nominal rigidities than Canada and the United States.

Tables 4 and 5 show the estimated correlations between the supply and real demand shocks of Canada, Mexico, and the nine regions of the United States. They indicate that the shocks hitting

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10. Simulations performed by DeSerres and Guay (1995) indicate that this approach is to be preferred to other approaches such as Akaike or Schwarz information criteria for the specification of structural VARs with long-run restrictions.
11. Faust and Leeper (1997) show that it is necessary to assume that the parameter space is finite. Accordingly, we assume that the moving average representation of the VAR is truncated at some finite horizon. Sensitivity analysis performed with various truncation points indicate that this is a reasonable assumption.
12. For more discussion on related methodologies see Dupasquier, Lalonde, and St-Amant (1997), Bayoumi and Eichengreen (1993), and Blanchard and Quah (1989).
13.We consider the response of aggregate data for the United States instead of regional data in order to economize on space. We verified that regional responses are similar to aggregate responses.

the nine regions of the United States are more highly correlated than those hitting Canada, Mexico, and the United States. Our findings also suggest that, from the point of view of the symmetry of shocks, the Mexican economy is the part of North America that is least suited for NAMU. These results are broadly consistent with those obtained by Bayoumi and Eichengreen (1993) and Lalonde and St-Amant (1993), who employed different sample periods and identification strategies.

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Table 4: Correlations between supply shocks (1976Q4 to 1999Q2)

	Canada	Mexico	ENC	ESC	MATL	NENG	PNW	PSW	SATL	WNC	WSC
Canada	1.000	0.173	0.234	0.104	0.288	0.201	0.240	0.119	0.262	0.269	0.328
Mexico		1.000	-0.148	-0.244	-0.053	0.026	-0.134	0.078	-0.138	0.106	0.248
ENC			1.000	0.661	0.615	0.266	0.552	0.476	0.613	0.095	0.365
ESC				1.000	0.642	0.327	0.739	0.541	0.734	0.047	0.204
MATL					1.000	0.658	0.629	0.578	0.669	0.426	0.561
NENG						1.000	0.400	0.403	0.467	0.494	0.560
PNW							1.000	0.533	0.659	0.203	0.291
PSW								1.000	0.611	0.344	0.483
SATL									1.000	0.203	0.364
WNC										1.000	0.750
WSC											1.000

Average correlation between regions of the United States: 0.48
Average correlation between Canada and the regions of the United States: 0.23
Average correlation between Mexico and the regions of the United States: -0.03

Table 5: Correlation between real demand shocks

	Canada	Mexico	ENC	ESC	MATL	NENG	PNW	PSW	SATL	WNC	WSC
Canada	1.000	0.134	0.297	0.340	0.319	0.200	0.190	0.119	0.237	0.109	0.171
Mexico		1.000	0.198	0.111	0.153	0.201	0.104	0.052	0.182	0.120	0.083
ENC			1.000	0.726	0.796	0.606	0.618	0.578	0.707	0.580	0.596
ESC				1.000	0.680	0.480	0.603	0.515	0.711	0.384	0.418
MATL					1.000	0.833	0.642	0.752	0.855	0.697	0.759
NENG						1.000	0.595	0.674	0.754	0.720	0.774
PNW							1.000	0.631	0.770	0.598	0.644
PSW								1.000	0.819	0.745	0.817
SATL									1.000	0.677	0.815
WNC										1.000	0.826
WSC											1.000

Average correlation between regions of the United States: 0.68
Average correlation between Canada and the regions of the United States: 0.22
Average correlation between Mexico and the regions of the United States: 0.13

In Section 2.1, we presented evidence that commodity prices fluctuations may affect Canada, the United States, and Mexico differently. In order to see whether the correlations presented in Tables 4 and 5 are mainly driven by the impact of commodity price shocks, we added commodity prices (in first differences of the logs) as an exogenous variable to the set of variables for Canada and Mexico's VARs. This is consistent with Granger-causality tests we performed which suggested that commodity prices are exogenous to both Canadian and Mexican variables.

The commodity prices series that we used for Canada was the Bank of Canada total commodity prices series. The weights assigned to the various commodities in the index reflect their importance to Canadian output.[14] In the case of Mexico, we used an oil price series that was taken from the IMF International Financial Statistics.

The inclusion of commodity prices in the Canadian and Mexican models had very little impact on the correlations of both real demand and supply shocks. This suggests that other types of shocks have also been a source of asymmetry. Fiscal policy shocks are a likely candidate. Indeed, asymmetric fiscal policy shocks would be consistent with our results showing small or negative correlation between the real demand shocks affecting the three economies. We intend to investigate this further in future research.

2.3 Symmetry of Business Cycles

Table 6 presents correlations between the growth rates of industrial production in Canada, Mexico, and the nine regions of the United States. These correlations are a measure of how similar the business cycles of the various regions and countries are. By this measure, we find higher correlation coefficients between Canada and the United States than when shocks are looked at. However, we also find higher correlations among regions of the United States and it is still the case that business cycle correlations among the various regions of the United States are higher than those between Canada and Mexico and the U.S. regions.[15]

A limitation of the correlations presented in Table 6 is that they do not distinguish between various types of shocks; in particular, they do not control for the influence of monetary policy shocks on output in Canada, the United States, and Mexico. This is important because in a monetary union, independent monetary policies could not be a source of asymmetric shocks. Regional output in the United States could for instance be more correlated than those of the three countries because monetary policy has been a source of symmetry across regions of the United States.

14. Excluding the price of oil from the Canadian commodity price index did not affect the results.
15. Results similar to those presented in Table 6 were obtained using data filtered with an Hodrick-Prescott (HP) filter (the smoothing parameter was set at 1600).

Table 6: Correlation between the growth rates of industrial production series of Canada, Mexico, and the regions of the United States (1975Q1 to 1999Q2)

	Canada	Mexico	ENC	ESC	MATL	NENG	PNW	PSW	SATL	WNC	WSC
Canada	1.00	0.24	0.64	0.58	0.61	0.53	0.46	0.59	0.52	0.61	0.62
Mexico		1.00	0.09	0.09	0.15	0.17	0.14	0.24	0.09	0.09	0.31
ENC			1.00	0.86	0.93	0.74	0.63	0.82	0.74	0.93	0.79
ESC				1.00	0.91	0.82	0.67	0.75	0.92	0.84	0.81
MATL					1.00	0.86	0.62	0.89	0.84	0.93	0.87
NENG						1.00	0.55	0.82	0.86	0.78	0.80
PNW							1.00	0.63	0.72	0.63	0.53
PSW								1.00	0.77	0.85	0.79
SATL									1.00	0.76	0.74
WNC										1.00	0.83
WSC											1.00
Average correlation between regions of the United States: 0.78 **Average correlation between Canada and the regions of the United States: 0.57** **Average correlation between Mexico and the regions of the United States: 0.15**											

In order to overcome this problem, the SVAR methodology described in Section 2.2, was used to generate the following historical decomposition of industrial production:

$$\Delta y_t = A_s(1)\varepsilon_t^s + A_s(L)\varepsilon_t^s + A_m(L)\varepsilon_t^m + A_d(L)\varepsilon_t^d, \tag{6}$$

where $A(1) = \Sigma_{i=0}^{\infty} A_i$ and $A(L) = A(L) - A(1)$.

The right-hand side of equation (6) corresponds to the moving-average components of the different types of structural shocks affecting industrial production. The expressions $A(L)$ and the $A(1)$ correspond to the transitory and permanent components of the shocks. The first two terms on the right-hand side of equation (6) represent the permanent and transitory components of aggregate supply. The other two terms correspond to the monetary and real demand components of output. The sum of these last two components can be viewed as a measure of the business cycle defined as the gap between actual output and the level of output consistent with aggregate supply.[16] The term $A_d(L)\varepsilon_t^d$ can then be seen as a measure of the contribution of real demand shocks to this gap.

Table 7 shows the correlations between the real demand components of industrial production in Canada, Mexico and the regions of the United States. They are not very different from those presented in Table 6, although correlations between Canada and the United States tend to be

16.Dupasquier, Guay, and St-Amant (1999) discuss this component as a measure of the business cycle and compare it with other measures.

lower. Business cycles would appear to be much more correlated among regions of the United States than between these regions and either Canada or Mexico.

Table 7: Correlation between the real demand components of industrial production of Canada, Mexico, and the regions of the United States (1976q4 to 1999q2)

	Canada	Mexico	ENC	ESC	MATL	NENG	PNW	PSW	SATL	WNC	WSC
Canada	1.000	0.149	0.241	0.140	0.382	0.318	0.172	0.395	0.321	0.387	0.458
Mexico		1.000	0.116	0.090	0.203	0.107	0.221	0.146	0.307	0.152	0.217
ENC			1.000	0.770	0.793	0.648	0.707	0.608	0.743	0.590	0.667
ESC				1.000	0.683	0.623	0.712	0.506	0.711	0.521	0.520
MATL					1.000	0.901	0.748	0.834	0.883	0.767	0.832
NENG						1.000	0.673	0.830	0.831	0.748	0.806
PNW							1.000	0.633	0.837	0.630	0.669
PSW								1.000	0.769	0.756	0.868
SATL									1.000	0.740	0.850
WNC										1.000	0.787
WSC											1.000

Average correlation among regions of the United States: 0.73
Average correlation between Canada and the regions of the United States: 0.31
Average correlation between Mexico and the regions of the United States: 0.17

2.4 Summary

To summarize briefly the results of this section. The economic structures of Canada, the United States, and Mexico are different; in particular, Canada and Mexico are more dependent on commodity production than the United States. This is reflected by fact that the terms of trade of the United States are negatively correlated with commodity prices, while those of Canada and Mexico have a positive correlation.

Both supply and real demand shocks affecting the various regions of the United States are more highly correlated than the supply and real demand shocks affecting, respectively, Canada, the United States, and Mexico. Mexican shocks indeed stand out as being particularly little correlated with those of the other two countries. We also find that, although commodity prices can account for part of the differences we find in shocks and business-cycle correlations, other factors also seem to be involved. The asymmetry that we observe between the real demand shocks affecting the three countries indicate that independant fiscal politicies might be an important factor.

The correlations between the business cycles of the various regions of the United States are higher than those between Canada, the United States, and Mexico. Again, Mexico's business cycle is notable because it is less correlated with that of the other two countries.

3. Flexible Exchange Rates: Is There Anything but Noise?

Proposition II: Mexican and Canadian flexible exchange rates are primarily driven by macroeconomic fundamentals and adjust appropriately to large asymmetric shocks.

Recent evidence for Canada and Mexico suggests that most of the broad movements in their real exchange rates are driven by macroeconomic fundamentals. Moreover, the exchange rates move in a manner consistent with dampening the asymmetric shocks that hit the two economies. Although flexible exchange rates are often seen as a source of macroeconomic instability rather than a potential solution, closer scrutiny of the data for Canada and Mexico indicates that trend movements in their exchange rates tend to mitigate the effects of external shocks on domestic prices and output.

In this section we show that the bilateral exchange rates for Canada and Mexico vis-a-vis the United States can be modelled with simple econometric specifications which include commodity prices as key explanatory variables. Large movements in these prices, which represent important asymmetric shocks for the Canadian and Mexican economies, are found to have a significant and predictable effect on the exchange rates. Although there is some evidence of overshooting and excess volatility in the short run, destabilizing speculation does not appear to be a major problem. Tests based on a regime-switching model indicate that fundamentalists rather than noise traders often dominate the exchange market during turbulent periods and help to keep exchange rates close their equilibrium values. As a consequence, efforts by central banks to resist these changes and to preserve “orderly markets” could frustrate the equilibration process and reduce market efficiency.

3.1 An equation for the Canadian dollar

The equation that the Bank of Canada uses to explain and predict movements in the Canadian dollar is based on a simple error-correction model that was first developed in 1991.[17] Although the equation has undergone a number of minor adjustments over the past 9 years, its basic structure has remained unchanged.[18] The dependent variable is the nominal Can-U.S. exchange rate deflated by the GDP price indices for Canada and the United States. Its long-run equilibrium value is determined by two commodity prices: the relative price of energy (proxied by oil); and the relative price of non-energy commodities (a weighted average of the world price for grain, livestock, forest products and metals). The interest rate spread on Canadian and U.S. commercial paper is also added to the equation, but is not allowed to affect the long-run value of the exchange rate. Unlike the two commodity price terms, the interest rate differential is not cointegrated with the real exchange rate, and is therefore placed outside the error-correction term, helping to explain

17. The original specification was developed by Amano and van Norden, and published in a Bank of Canada conference volume in 1993.

18. The specification described above differs from the original Amano-van Norden equation in three respects. First, the energy and non-energy terms of trade variables are deflated by the U.S. GDP price index rather than the price of manufactured goods. Second, oil prices are used as a proxy for all energy prices. Third, the interest rate differential is simply the spread between 90-day commercial paper rates in Canada and the United States rather than the difference between long-term and short-term interest rates in the two countries. These changes do not affect the performance of the equation in any significant way and were introduced mainly to simplify it and reduce the number of data series required to use it.

the short-run dynamics of the Canadian dollar.

The basic equation for the real Can-U.S. exchange rate can be written as follows:

$$\Delta \ln(rfx) = \alpha(\ln(rfx)_{t-1} - \beta_0 - \beta_c comtot_{t-1} - \beta_e enetot_{t-1}) + \Upsilon intdif_{t-1} + \varepsilon_t \quad (7)$$

where: *rfx* = real Can-US exchange rate
comtot = non-energy commodity terms of trade
enetot = energy terms of trade
intdif = Can-US interest rate differential

Representative results for equation (1) estimated over four different sample periods are shown in Table 8. As the reader can see, most of the parameters have their expected signs and are statistically significant. Since the dependent variable is defined in a way that equates increases in rfx with depreciations (and decreases with appreciations), the results suggest that increases in $comtot$ and $intdif$ cause the exchange rate to strengthen, while increases in $enetot$ cause it to weaken. Although the last result was not expected when the equation was first estimated, since Canada is a (modest) net exporter of energy products, it has proven to be remarkably robust. It was only by separating the commodity price variable into two components -- one for energy and the other for non-energy commodities -- that the equation was able to respond to their opposing effects and provide reliable predictions. The unanticipated effect of $enetot$ on the exchange rate has been explained in some more recent work by the fact that many of Canada's industries are very energy intensive. As a result, any benefits that Canada receives from of higher-priced energy exports are more than offset by the higher costs incurred by firms in other industries and the resulting decline in their international competitiveness.

Aside from this one anomaly, the performance of equation (1) is surprisingly good. It is able to explain roughly 20 per cent of the quarterly variation in rfx; its parameters are for the most part sensibly signed and significant; and the relationship is remarkably robust. Attempts to improve its performance through the addition of other variables, such as government debt, the trade balance and net foreign assets, have so far proved unsuccessful.

Two dynamic simulations are shown in Figure 2, using parameter estimates drawn from the periods 1973Q1 to 1996Q1 and 1973Q1 to 1998Q4. In order to facilitate comparisons between the actual and predicted values of the exchange rate, the series were converted into nominal values by adjusting them for changes in the Canadian and U.S. GDP price deflators. The correspondence between the two simulated series and the actual exchange rate is very close (relative to the predictions of most other exchange rate equations), and remains essentially unchanged when the estimation period is lengthened. It is important to remember that the equation was first estimated in 1991 and that the predicted values shown in Figure 2 are based on a true dynamic simulation which starts in 1973Q1 (i.e. they are not updated with lagged values of the actual exchange rate as the simulation moves towards 1998Q4).

Table 8: Results for the Canadian Exchange Rate Equation

Variable	1973Q1 - 1986Q1	1973Q1 - 91Q3	1973Q1 - 96Q1	1973Q1 - 98Q4
Speed of adjustment	-0.198	-0.167	-0.141	-0.125
	(-3.251)[1]	(-3.917)	(-4.149)	(-3.752)
Constant	2.419	1.807	2.728	3.040
	(4.585)	(5.306)	(7.566)	(7.672)
COMTOT	-0.454	-0.368	-0.524	-0.580
	(-4.794)	(-5.713)	(-6.558)	(-6.328)
ENETOT	0.059	0.119	0.070	0.057
	(1.442)	(2.916)	(1.769)	(1.298)
INTDIF	-0.540	-0.519	-0.604	-0.576
	(-2.442)	(-3.105)	(-3.682)	(-4.040)
$\overline{R}^2$	0.218	0.227	0.204	0.194
Durbin-Watson	1.197	1.159	1.265	1.311

Note: [1] t-statistic

Figure 2: Equation for the Canadian Dollar

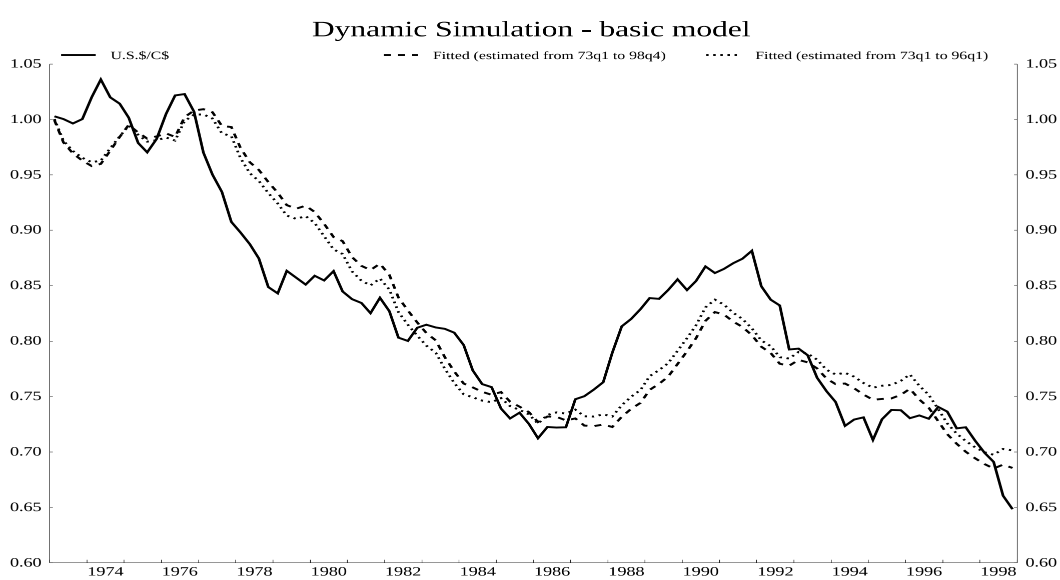

Table 9 provides a decomposition of one of the simulations shown in Figure 2 and indicates the relative contribution of each variable to changes in the actual Can-U.S. exchange rate.

Table 9
Relative Importance of the Explanatory Variables
1973Q1 - 1998Q4

Variable	Percentage share
COMTOT	56.20
ENETOT	1.85
INTDIFF	-6.52
Inflation	23.00
Lags	11.51
Other*	13.76
TOTAL	100.00

Note: * includes error term

Over the 1973Q1 to 1998Q4 period, the nominal Can-U.S. exchange rate depreciated by roughly 44 cents (Canadian). Of this, more than 56 per cent was the result of a trend decline in the relative price of non-energy commodities; 23 per cent was caused by higher inflation rates in Canada than the United States (purchasing power parity); 1.8 per cent came from higher energy prices; and 25 per cent was related to other unidentified factors (including the lagged adjustment term and the residual error). Short-term interest rate differentials provided some offset to the depreciation and raised the value of Canadian dollar by roughly 6.5 per cent.

3.2 An equation for the Mexican peso

As an aid to its internal monitoring and forecasting activities, the Bank of Canada has also developed an equation for the Mexican peso.[19] Although it has not been tested as extensively as the equation for the Canadian dollar, it shares many similarities with the latter (including the important role played by commodity prices) and its overall performance has been quite impressive.

The dependent variable in the equation is $rpeso$, which is simply the nominal bilateral rate deflated by the Mexican and U.S. consumer price indices. (Using GDP deflators or wholesale

19. The results presented here are an updated version of those reported in Kruger and van Norden (1995).

price indices does not change the results materially, but the CPI series are available over a longer time period and generally outperform the other measures.) Preliminary testing suggests that there are only two variables that seem to be co-integrated with *rpeso* and that offer significant explanatory power: the real price of oil, *rpoil*, the nominal U.S. dollar price deflated by the U.S. CPI index and the Mexican trade balance on goods and services, *gsbal*, expressed as a percentage of GDP. [20] Given the importance of oil to Mexico's exports over much of the sample period, it is not surprising that it is closely related to *rpeso* and highly correlated with the real trade balance. While colinearity could be a problem and in the empirical equation, the two explanatory variables seem to capture somewhat different effects.

The simple long-run relationship among these variables is estimated as:

(80Q1 to 99Q2): qrpeso = 3.2895 + 12.0259*gsbal - 0.0203*rpoil
(0.0769) (0.7911) (0.0028)

* standard errors are in brackets.

Figure 3 shows that the equation fits the Mexican real exchange rate reasonably well, although the fit deteriorates after 1996 as oil becomes less important in Mexican exports.

Representative results for the equation based on a series of rolling regressions over the 1980Q1 to 1999Q3 period, are shown in Table 10. As with *rfx*, increases in the dependent variable denote depreciations. Larger trade surpluses are therefore associated with a weaker exchange rate, while higher oil prices cause it to strengthen. The importance of the real trade balance also appears to grow towards the end of the sample period as the share of oil in Mexico's total exports begins to decline.

While the equation seems to fit the real Mexican exchange rate reasonably well, care should be used in interpreting the results. The world price of oil is clearly exogenous to *rpeso*, but real trade balance is, by definition, endogenous. Moreover, causality is likely to run from *rpeso* to *gsbal* rather than the reverse.

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20. Tables A5.1 and A5.2 in Appendix 4 present the results for the unit root and co-integration tests for these three variables. The evidence of a unit root is weakest for the real exchange rate: the Augmented-Dickey-Fuller (ADF) test rejects a unit root (barely at the 10% level), while the Phillips-Perron test does not and the Kwiatkowski et al. (KPS) test does not reject the null hypothesis of no unit root. Note that if the Kruger and van Norden sample period of 1980:1 to 1994:4 is used, all three tests find the Mexican exchange rate to be nonstationary. However, if a longer sample period is chosen, say from 1957 to 1999, all the tests reject nonstationarity. This difference in results between the short and longer sample is typical of the literature on testing exchange rates for purchasing power parity because the power of the test to reject the null of nonstationarity increases with the length of the sample. In addition, it is often the case that the real exchange rates for countries that have experienced relatively high rates of inflation are found to be stationary because PPP is most likely to hold when monetary rather than real shocks are predominant.

Figure 3

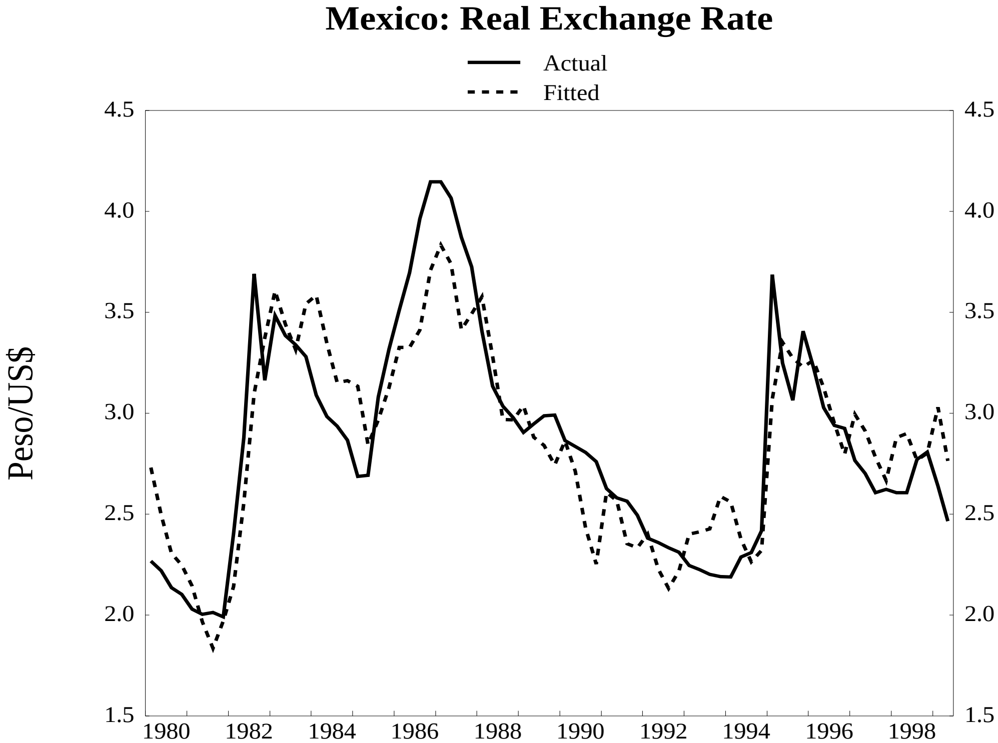


Table 10:

Estimation Period	gsbal	roil
80q1 - 92q4	11.3617 (0.8238)	-0.0283 (0.0033)
80q1 - 94q4	12.3001 (0.8103)	-0.0246 (0.0033)
80q1 - 99q2	12.0259 (0.7911)	-0.0203 (0.0029)

The dynamic simulations for the peso and the Canadian dollar are comparable, trend movements in the exchange rate are usually consistent with the underlying fundamentals and the large gaps that regularly appear between the actual and predicted values are all eventually closed. The fact that Mexico operated under a fixed exchange rate for most of the sample period does not prevent the equilibrium real exchange rate from asserting itself; it simply delays the process and makes the adjustment of output and employment in the real economy that much more difficult.

3.3 Speculative bubbles and excess volatility

The issue of exchange rate overshooting is of concern to policymakers, who often worry that excess volatility in exchange markets will spill over into domestic financial markets and prejudice their ability to control monetary conditions. Even when exchange rate movements are believed to be driven by fundamentals, there is a risk that sharp currency depreciations will become self-reinforcing, causing interest rates to jump and pushing monetary conditions much higher than macroeconomic circumstances would warrant. In turbulent periods such as this, chartists and noise traders are often cast as the villains and blamed for any sudden or unwanted exchange rate movement.

In an effort to see whether these concerns are justified, the Bank of Canada has developed a regime-switching model which it uses to gauge the effects that different agents might be exerting on the exchange rate at different points in time. According to the model, the exchange rate that is actually observed in the market at any time t is the result of a complex interaction between two types of agents -- fundamentalists, who try to keep the rate close to its equilibrium value; and chartists, who often cause it to deviate from its “fair” market value. The actions of the fundamentalists are assumed to be guided by the basic exchange rate equation outlined in Section 3.1. The fitted values that the equation provides represent the rates that one would observe if the market were dominated by these equilibrating agents. Noise traders or chartists, in contrast, are assumed to operate on the basis of a simple-rule of-thumb, modelled on real world trading strategies.

The joint exchange rate determination process is captured by the following equation, in which the expected change in the exchange rate is modelled as a weighted average of the expectations of fundamental and noise traders:

$$E\Delta s_{t+1} = \omega_t E\Delta s^f_{t+1} + (1-\omega_t)E\Delta s^c_{t+1} \quad (8)$$

where: $E\Delta s$ = expected change in s

s = log of the nominal Can.-US exchange rate

f, c = superscripts indicating fundamentalists and chartists

ω = weight assigned to fundamentalists

The individual equations describing the behaviour of fundamentalists and chartists can be written as:

$$\Delta s_t^f = \alpha^f + \phi(s_{t-1} - \tilde{s}_{t-1}) + \gamma intdif_{t-1} + \varepsilon_t^f \qquad (9)$$

where: $\tilde{s}$ = fundamentalists forecast of s

α^f = a constant

and

$$\Delta s_t^c = \alpha^c + \psi_{14} ma_{14} + \psi_{200} ma_{200} + \Gamma intdif_{t-1} + \varepsilon_t^c \qquad (10)$$

where: ma_{14} and ma_{200} = moving averages used by the chartists to forecast changes in s

α^c = *a constant*

The variables guiding the fundamentalists have already been discussed in detail in earlier sections of the paper. The only change that was introduced to the model was to convert quarterly data into a daily frequency using a cubic spline technique. The chartists' equation that was used in the estimations assumes the following simple (but not unrealistic) behavioural pattern. Whenever the 14-day (short-term) moving average of exchange rates exceeds the 200-day (long-term) moving average, chartists are assumed to buy the currency. If the 14-day moving average is lower than the 200-day moving average, the currency is sold.[21]

The transition equations in the Markov-switching process that link the two groups and assign a probability of being in regime f or c (i.e. fundamentalists or chartists) are:

$$\rho(R_t | R_{t-1}) = \Phi(\alpha_f) \qquad (11)$$

$$\rho(R_t | R_{t-1}) = \Phi(\alpha_c) \qquad (12)$$

where: $\rho(R_t)$ is the probability of being in regime R.

Portfolio managers try to determine which group will dominate the market at different points in time, and adjust their own investment activities accordingly. The log likelihood function that they are assumed to maximize is represented by the following equation:

$$LLF = \sum_{t=1}^{t} \sum_{t=1}^{t} \rho(R_t) d(s_t | R_t) \qquad (13)$$

A detailed discussion of the original results for this model can be found in Vigfusson (1996) and Murray et al. (1996). The main elements can be summarized as follows. First, all the variables in the chartists' and fundamentalists' equations have their expected signs and are statistically significant.[22] Second, chartists appeared to dominate the market during tranquil periods -- or

21. While this might seem overly simplistic, it is modelled after practices that are actually followed in the market.

about 70 per cent of the time. Third, periods of “excess” volatility in the exchange market are typically dominated by fundamentalists, who tried to push the exchange rate back to its equilibrium value. Chartists, it seems, lend a certain inertial force to the market, which generally causes the exchange rate to move in a stable but not necessarily appropriate manner. In time, once the exchange rate had deviated sufficiently from its equilibrium value, fundamentalists enter the market and (presumably) realize a profit by pushing the rate back to its appropriate level.

Re-running the model with data drawn from last three years should allow us to determine if the same qualitative results obtain. More importantly, it will also allow us to determine if chartists as opposed to fundamentalists were in control of the market during the turbulent episodes of 1997 and 1998, when the Bank of Canada moved short-term interest rates higher in an effort to keep monetary conditions on an even track.

Table 11
Parameter estimates for the Markov-switching model
Daily data

Jan. 1983 - Dec. 1992	f	θ	β	σ_f	α_f	
Fundamentalists	0.0001 (2.729)[a]	0.0119 (2.243)	0.0002 (0.381)	0.0018 (26.371)	1.2656 (10.076)	
	c	ψ_{14}	ψ_{200}	Γ	σ_c	α_c
Chartists	0.0002 (1.573)	0.0070 (2.381)	-0.0079 (-2.677)	-0.0007 (-4.000)	0.0007 (33.634)	1.6784 (17.704)
Jan. 1983 - Dec. 1998	f	θ	β	σ_f	α_f	
Fundamentalists	0.0001 (1.912)	0.0072 (3.098)	-0.0001 (-0.263)	0.0018 (58.448)	1.3778 (18.598)	
	c	ψ_{14}	ψ_{200}	Γ	σ_c	α_c
Chartists	0.0001 (1.341)	0.0062 (2.843)	-.00070 (-3.032)	-0.0006 (-5.062)	0.0008 (48.729)	1.6735 (24.386)

a. The t-statistic is shown in parentheses under the parameter estimate.

The results for both the original regression and the more recent time period are shown in Table 11. As the reader can see, parameter estimates for the two sample periods are virtually identical.

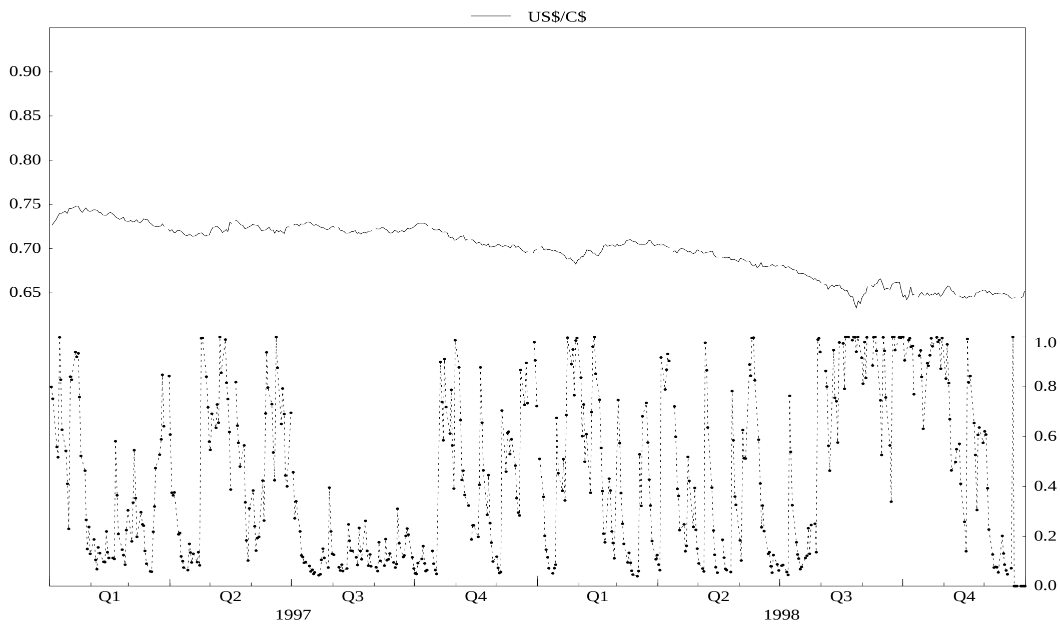
22. The variable *Enetot* had a positive (perverse) sign, but this was expected from our earlier regressions.

Moreover, they remain correctly signed and statistically significant. While chartists still dominate the foreign exchange market on most trading days, these also tend to be the more tranquil periods, in which the exchange rate is trending smoothly upward or downward. Fundamentalists are more prominent during turbulent periods, in which the exchange rate displays greater volatility and moves in a more exaggerated manner.

Figure 4 plots movements in the actual exchange rate against the probability that the market is dominated by either fundamentalists or chartists. A spike in the series shown in the bottom-half of the figure indicates a higher probability of being in a fundamentalist regime (or, conversely, a lower probability of being in a chartist regime). The two time periods in which the Bank of Canada entered the market to raise interest rates and help support the currency during the Asian and Russia crises (1997Q4 to 1998Q1 and again in August 1998) appear to have been dominated by fundamentalists. The major lesson that one can take from this experience that central banks should be wary of resisting any exchange rate movements. "Speculative bubbles" and "excess volatility" may, in reality, be necessary equilibrating adjustments.

Figure 4

Exchange Rate and Probability of Fundamentalist Regime



* Probability of Being in Fundamentalist Regime

4. Flexible Exchange Rates: Do They Help or Hinder Adjustment?

Proposition III: By responding to shocks to the underlying fundamentals, flexible exchange rates facilitate economic adjustment.

To this point we have shown that Canada and Mexico experience substantial assymetric shocks relative to the United States, driven, in part, by movements in world commodity prices, and that their flexible rates generally move in a direction consistent with these perturbations. The final leg in our argument is the proposition that these exchange rate movements significantly mitigate the macroeconomic impact of these shocks.

Most of the theoretical work to date implies that given some form of nominal rigidity in prices and or wages, a flexible exchange rate will adjust to help stabilize the domestic economy. For most shocks, a flexible rate will either facilitate the required movement in the real exchange rate or it shelters the domestic economy from price shocks, leaving the domestic real exchange rate unchanged. Generally speaking, an adverse real shock will cause domestic output and interest rates to decline, and cause the exchange rates (real and nominal) to depreciate. However, if the economy is hit by domestic monetary or foreign portfolio balance shocks then a flexible rate will not offer much protection. The evidence we have marshalled so far implies that most of the shocks that the Canadian and Mexican economies have faced were real. While monetary shocks have been more prevalent in Mexico, real shocks, especially oil price shocks and U.S. policy shocks have also been very important.[23]

4.1 Adjustment to Large Shocks: A Canada-Mexico Comparison

To illustrate the role of the exchange rate regime in the adjustment to exogenous shocks it is insightful to compare the economic histories of Mexico and Canada over the postwar period. The two countries on occasions faced similar large macroeconomic shocks, most of them either commodity shocks or shifts in U.S. macroeconomic policies, yet the two countries had very different exchange rate regimes in place over the period. While Canada has been on a flexible exchange rate regime for all but 8 of the past 50 years, almost exactly the opposite is true for Mexico, which has been on some form of fixed or controlled exchange rate regime for all but 5 years.[24] (Figures 5-7 display the nominal exchange rate for both countries over this period.)

23. A structural VAR analysis by Guay and St-Amant (1995) indicates that oil prices fluctuations can account for a large portion of output fluctuations in Mexico over the 1970s and the 1980s.
24. Canada was on a fixed rate from 1945-50 and again from 1962-70 while Mexico was on a flexible rate for brief periods immediately after crises in the 1970s and 1980s and also from 1995-99. Powell (1999) provides a useful overview of the history of the Canadian dollar.

Figure 5

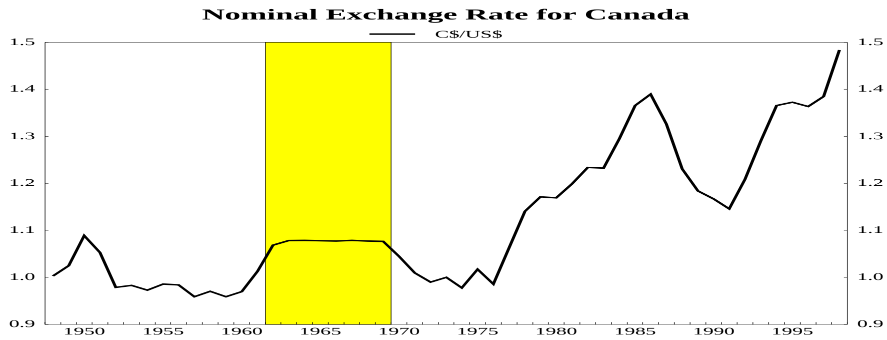
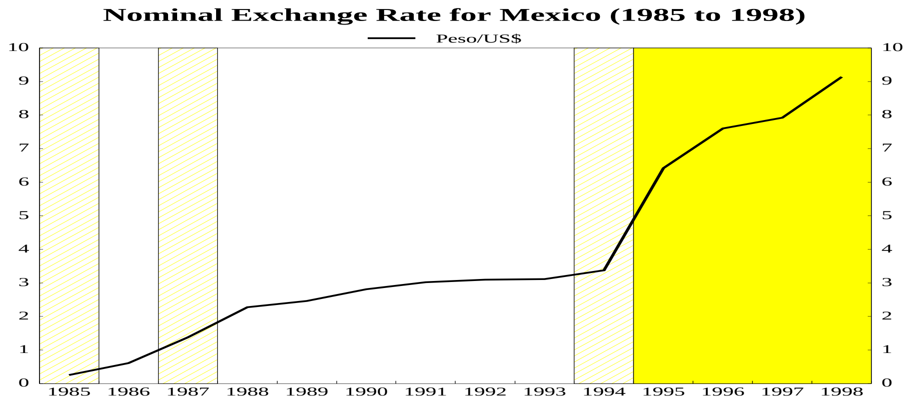


Figure 6

Note: Shaded areas represent the time periods of the large exogenous shocks examined in this section.

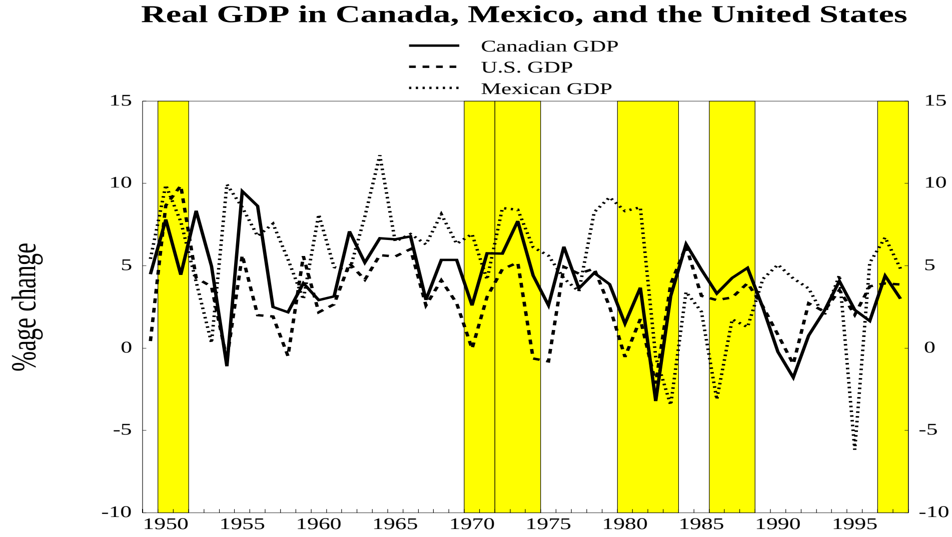
Figure 7



Note: For Mexico, crisis years are lightly shaded and the flexible rate period is more darkly shaded.

Figure 8 shows that output growth in Mexico has been significantly more volatile than Canadian output growth (by a ratio of almost two to one).[25] Although it would be misleading to attribute all of Mexico's higher output volatility and its troubled economic history to its managed exchange rates, it is, nevertheless, interesting to compare how the two economies have adjusted to similar large economic shocks.[26]

Figure 8



Note: Shaded areas represent the time periods of the large exogenous shocks examined in this section.

For the sake of brevity, we consider a small set of large exogenous shocks that both countries experienced, albeit to different degrees, over the postwar period. Analysing the adjustment of the Canadian and Mexican economies to these large shocks should provide additional insight into the macroeconomic implications of alternative exchange rate regimes and clearly demonstrates the advantages of a flexible exchange rate.

Consider first the two instances in which Canada left a fixed exchange rate to float: September 30, 1950 and May 31, 1970. These periods are highlighted in Figures 9 to 11. In both cases, the fixed exchange rate was under upward pressure because of inflationary expansions originating in the United States. In 1950, the inflationary pressures were fuelled by the Korean War, which started in June of 1950, and in 1970, by the Vietnam War, which had been ongoing for some time. Commodity prices were also moving upward in both periods, but more sharply in 1970, and spurred direct investment inflows. In both cases, the Canadian dollar appreciated after floating, thereby moderating demand pressures. Over 1950-51 and 1970-71, the inflation rates in Canada were

25. When trend movements in the output are removed with an HP filter, the relative volatility of Mexican output increases to 2.5 times that of Canadian output growth.
26. Osakwe and Schembri (1999) perform a counterfactual exercise indicating that, had Mexico been on a flexible exchange rate for the last 25 years, output volatility would have been reduced by half.

5.3% and 2.5%. Mexico, in contrast, remained on a fixed exchange rate over both periods and experienced much higher inflation (16.7% over 1950-51 and 4.9% 1970-71). Moreover, in 1953-54 when the shock reversed, the U.S. economy slowed, Mexico was left with an overvalued and uncompetitive real exchange rate and was forced to devalue by 44.5 per cent from 8.65 to 12.5 pesos per U.S. dollar.

Figure 9

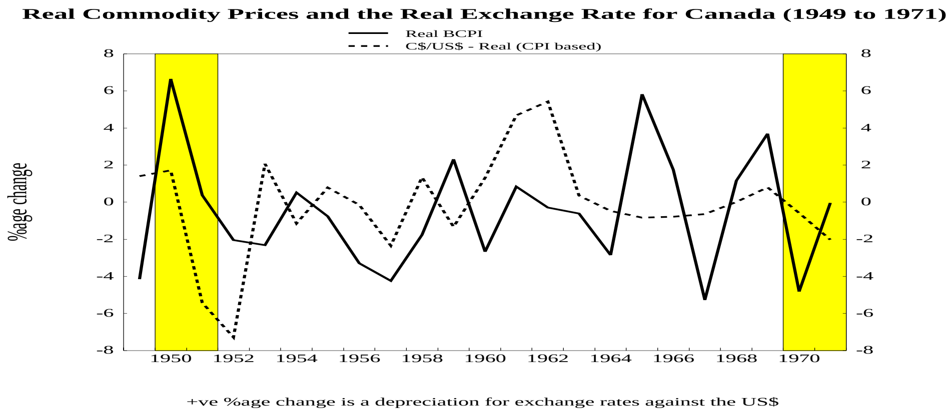


Figure 10

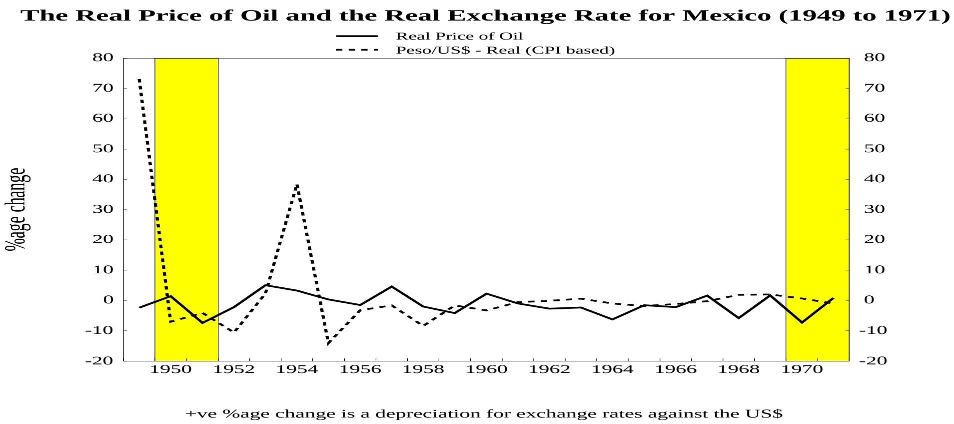
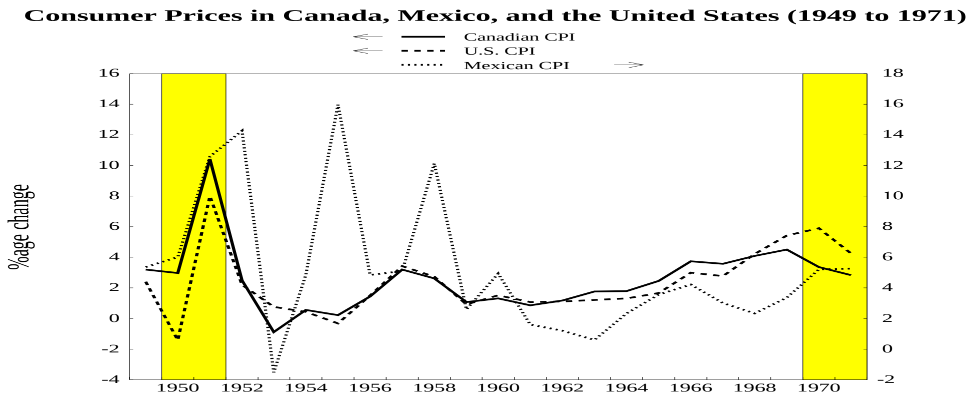


Figure 11



Note: Shaded areas represent the time periods of the large exogenous shocks examined in this section.

The next interesting episode is the commodity price boom of 1972-74, which included a tripling of the world price of oil. (See Figures 12-14). The Canadian dollar appreciated by more than 5 per cent over this period in response to the shock. The Mexican peso once again remained fixed and inflation rose sharply from 2.2 per cent in 1972 to 22.5 per cent in 1974. Eventually as commodity prices retreated from historic highs, Mexico found itself with a seriously overvalued pegged rate that collapsed in 1976 (from 12.5 to 20.0 pesos per U.S. dollar) and output growth fell to 3.4% in 1977, its lowest level in almost 20 years. The Canadian dollar, in contrast, depreciated in orderly fashion as commodity prices declined and output growth was maintained.

In the 1980s, Canada and Mexico experienced two major shocks: the first, which occurred in the first half of the 1980s, was the Reagan fiscal expansion in conjunction with the Volcker tightening of U.S. monetary policy; the second was the sharp fall in the price of oil in 1986, followed by a strong recovery in commodity prices in 1988-89. The Reagan-Volcker shock had the effect of sharply raising real and nominal interest rates in the United States. In Canada, domestic interest rates also increased as a similar monetary policy was adopted. Nevertheless, the exchange rate depreciated from Cdn$1.15 at the beginning of 1980 to a low of Cdn$1.45 in 1985. While Canada experienced a recession in 1981-82 due to the higher interest rates and reduced U.S. demand, it eventually recovered with a healthy expansion, fuelled in part by the depreciated real exchange rate. Once again, the Mexican economy fared much worse. In 1982, the adjustable pegged rate regime collapsed and the official peso depreciated by almost 300 per cent, which caused the domestic financial sector to implode. As a result, output in Mexico fell by 2% on average over 1982-83 - its worst two-year performance in the entire postwar period. The proximate cause was the Mexican debt crisis. During the latter half of the 1970s, when the price of oil was high and rising, Mexico had borrowed heavily in U.S. dollars to finance the expansion of its domestic oil industry. However, as U.S. interest rates rose and the world economy slipped into recession, these debts could no longer be serviced or rolled-over. Although Mexico's adjustable peg was not the root source of the problem, it served to amplify rather than mitigate the impact of the shock. As Osakwe and Schembri (1999) show, the peso should have been allowed to appreciate in the late 1970s, rather than remaining almost unchanged. An appreciating exchange rate would have reduced the incentives to borrow in foreign currency. Also, it should have been devalued earlier as U.S. policies shifted in 1980-81 rather than waiting and eventually collapsing in a free fall in 1982.

After peaking in 1980 the prices of oil and other commodities declined until 1986; the Canadian commodity price index fell by 37% while the price of oil fell by 68% over this period. Non-energy commodity prices fell more sharply at the beginning of the period whereas the price of oil declined more dramatically towards the end. After 1986, non-energy commodity prices experienced a stronger recovery than oil prices. As noted earlier, the Canadian dollar has a close positive relationship with non-energy prices and this generally held over the 1980s as the dollar depreciated sharply to Cdn$1.44 per U.S. dollar in 1986 and then appreciated to Cdn$1.15 in 1989. By adjusting in this manner the Canadian dollar served to stabilise the economy over the 1980s, depreciating when the economy was weak early in the period and then appreciating as the economy strengthened towards the end of the decade.

Following the 1982 exchange rate crisis, there were two mini-collapses in Mexico in 1985 and in 1987. Although the peso was officially on a crawling peg over the period 1982-87, it was not depreciating fast enough to accommodate movements in the equilibrium real rate caused by the falling price of oil. As a result a series of exchange rate collapses occurred, which reduced economic activity in Mexico as banking operations and financial markets were disrupted.

Figure 12

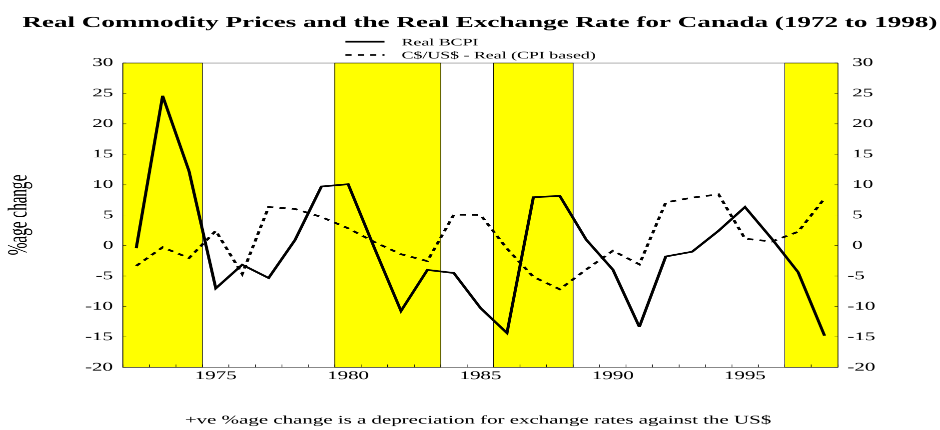


Figure 13

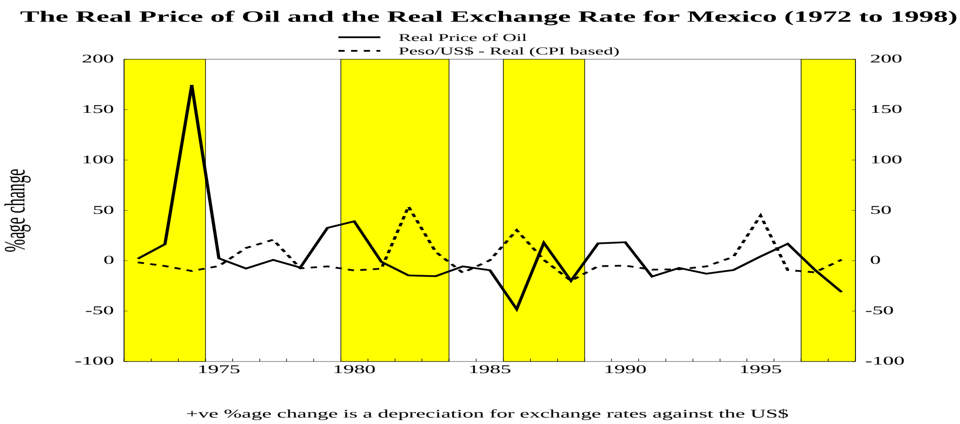
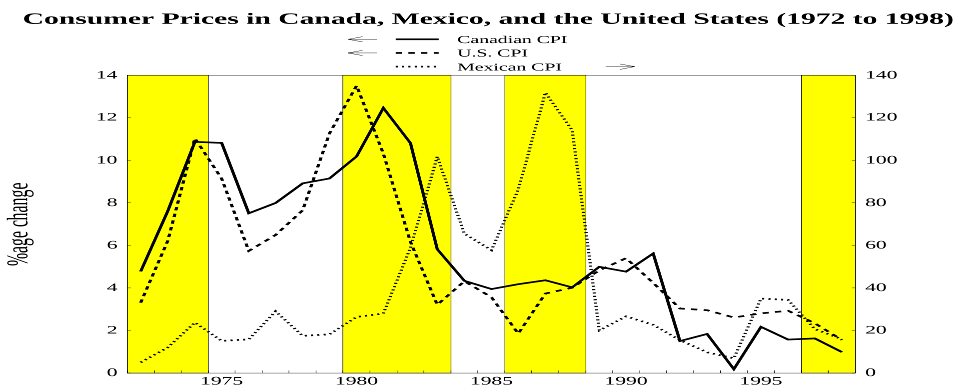


Figure 14



Note: Shaded areas represent the time periods of the large exogenous shocks examined in this section.

The final major exogenous shock that affected both Canada and Mexico was the fall in commodity prices due to the recent Asian crisis. From 1993 to 1996, commodity and oil prices increased moderately, but then plummeted by 25% until the end of 1998, due primarily to the fall in demand by the afflicted East Asian countries. Both Canada and Mexico were on a flexible exchange rate at the time of the crisis and both were able to continue to grow strongly despite the magnitude of the negative shock because their flexible exchange rates depreciated and thereby mitigated the impact of the shock on aggregate demand. In Canada, natural-resource dependent areas were hard hit by the commodity price decline; the damage, however, would have been far worse had the Canadian dollar not been allowed to adjust.

It is clear from this analysis that over the postwar period Canada has been well-served by its flexible exchange rate regime. In response to large exogenous shocks (both positive and negative), the flexible exchange rate has adjusted appropriately, thereby accommodating the necessary real exchange rate movement to stabilize the real economy. In contrast, the performance of Mexico's predominantly fixed exchange rate regime has been dismal. It has consistently retarded the necessary adjustment to exogenous real shocks, thereby sowing the seeds of its many collapses and crises. Rather than mitigating the impact of these shocks, Mexico's fixed exchange rate regime has greatly amplified and propagated their effect, primarily by hollowing out and decapitalizing the financial sector, thereby causing disintermediation and disrupting economic activity. Moreover, by hindering real exchange adjustment, the fixed exchange rate eventually transformed even positive shocks into negative outcomes (e.g. the oil price increases of the 1970s and the capital inflows resulting in part from the reform process of the early 1990s - both resulted in crises).

After the 1994 crisis, Mexico no longer had sufficient reserves to support a controlled exchange rate regime and was forced to float. Although it has been almost five years, the flexible rate has performed quite well and exceeded many observers initial expectations.[27]

4.2 A Simple Test: Provinces Versus States

The issue this section raises is whether comparing data on Canadian provinces and U.S. states can provide any insight into the stabilizing role of Canada's flexible exchange rate.[28] Unlike U.S. states, all Canadian provinces are heavily dependent on primary commodity-based products - lumber, pulp and paper, oil and natural gas, metals and minerals, agriculture, fishing, and electricity.[29] In addition, the prices of these products are highly correlated. Thus, it would stand to reason that if the Canadian exchange rate adjusted in a stabilizing manner to commodity price movements then the output of Canadian provinces should be less variable than comparable commodity-dependent U.S. states because these states lack the stabilizing benefit of a flexible exchange rate and are tied to other U.S. states via a common currency.

To test this hypothesis, we first compared the output and export profiles of seven Canadian provinces (we aggregated the Atlantic provinces into one province) and all the continental U.S. states plus Alaska, and for each province selected the four most similar U.S. states. We also took into account geographic similarities in our choices.[30] (The province-state concordance is given in Appendix 5). For each of the provinces and the states, as well as for the aggregate Canadian and U.S. economies, we then calculated the mean and the standard deviation of output growth over the sample period, 1982-97, as well as the coefficient of variation (i.e., the standard of deviation

27. In a recent *Wall Street Journal* article, Bank of Mexico Governor Ortiz (1999) praised the performance of Mexico's flexible exchange rate, stating ".. the flexible exchange rate allowed the Mexican economy to weather the real and financial shocks of 1998."
28. McCallum (1999) first raised this issue and performed an analysis with a limited number of Canadian provinces and U.S. states. He reaches the tentative conclusion that the Canadian flexible rate is a useful shock absorber for these provinces because they seem to perform better than comparable U.S. states.
29. Although Ontario is the Canadian province that is the least dependent on primary commodities, in 1997 approximately 22 percent of its exports were primary-commodity based. For the Canada, Mexico and the United States, comparable figures would be 37, 20 and 18 per cent.
30. The rationale for choosing four states per province is to obtain a sample of reasonable size and to insure that the matched provinces and states were not too dissimilar. Note that the results do not change significantly if five states are chosen instead of four.

divided by the mean). At the aggregate level the ratio of the Canadian and U.S. coefficients of variation is 1.33, implying that Canadian output has generally been more variable than U.S. output, which is not unexpected given Canada's dependence on commodity-based products and the relatively high volatility of commodity prices.

Our hypothesis is that if Canada's flexible rate adjusts appropriately in response to commodity price movements, and has a stabilizing macroeconomic effect, then the ratio of coefficients of variation for output of Canadian provinces to comparable U.S. states should be less than the national ratio of 1.33. Table 12 shows that for 23 out of 28 pairings, the ratio of the coefficients of variation of the seven Canadian provinces to comparable U.S. states is less than the national ratio. Thus for all provinces, except Manitoba, their output variability is generally much less than for comparable U.S. states.

We can test this outcome against the null hypothesis that the ratios of the province-state pairings are randomly distributed around the national ratio using a normal approximation to the binomial distribution. Under the null hypothesis of a random distribution, the p-value of the outcome that the output of 23 out of 28 provinces is less variable than the output of comparable U.S. states is 0.00046, less than one twentieth of one percent.[31] Thus, the null assumption is strongly rejected by the data.

Although this rejection is consistent with our hypothesis that Canada's flexible exchange rate mitigates the macroeconomic impact of commodity price shocks, two alternative explanations can be made. Federal government transfers and provincial government borrowing in Canada could also serve as stabilizing mechanisms. Because Canadian federal government transfers are sizable and often designed to mitigate regional inequities, the analysis was repeated by adjusting provincial output data for the effect of net transfers from the federal government. Our results did not change significantly. In future work, we also hope to consider the impact of provincial borrowing because U.S. states are often precluded from running deficits for current expenditures.

31. Although the current experiment does not exactly match the conditions necessary for application of the binomial distribution, (i.e., the Bernouilli trials are not identical nor completely independent) they are close enough, especially given the overwhelming strength of the rejection of the null hypothesis.

Table 12

Ratio's of Coefficient's of Variation (Provinces/States)

	Ontario	Alberta	BC	Manitoba	Atlantic	Quebec	SASK
Alabama	1.66	1.58	1.44	2.36	1.35	1.51	2.04
Alaska	**-0.04**	**-0.03**	**-0.03**	**-0.05**	**-0.03**	**-0.03**	**-0.04**
Arizona	1.60	1.53	1.39	2.28	**1.31**	1.46	1.97
Arkansas	1.53	1.46	**1.33**	2.18	**1.25**	1.46	1.89
California	**1.13**	**1.08**	**0.98**	1.61	**0.92**	**1.03**	1.40
Colorado	1.34	**1.28**	**1.16**	1.91	**1.09**	**1.23**	1.65
Connecticut	**1.05**	**1.00**	**0.91**	1.49	**0.86**	**0.96**	**1.29**
Delaware	1.44	1.38	**1.26**	2.06	**1.18**	**1.32**	1.78
District of Columbia	**0.46**	**0.44**	**0.40**	**0.66**	**0.38**	**0.42**	**0.57**
Florida	1.92	1.83	1.67	2.74	1.57	1.76	2.37
Georgia	1.93	1.85	1.68	2.76	1.58	1.77	2.39
Hawaii	**0.68**	**0.65**	**0.59**	**0.97**	**0.55**	**0.62**	**0.84**
Idaho	**1.31**	**1.25**	**1.14**	1.86	**1.07**	**1.20**	1.61
Illinois	1.34	**1.28**	**1.16**	1.91	**1.09**	**1.22**	1.65
Indiana	**1.30**	**1.24**	**1.13**	1.85	**1.06**	**1.19**	1.60
Iowa	**0.71**	**0.67**	**0.61**	**1.01**	**0.58**	**0.65**	**0.87**
Kansas	**1.14**	**1.08**	**0.99**	1.62	**0.93**	**1.04**	1.40
Kentucky	**1.26**	**1.20**	**1.09**	1.79	**1.03**	**1.15**	1.55
Louisiana	**0.29**	**0.27**	**0.25**	**0.41**	**0.23**	**0.26**	**0.35**
Maine	**0.81**	**0.78**	**0.71**	**1.16**	**0.66**	**0.74**	**1.00**
Maryland	**1.11**	**1.06**	**0.96**	1.58	**0.90**	**1.01**	1.37
Massachusetts	**0.88**	**0.84**	**0.76**	**1.25**	**0.72**	**0.80**	**1.08**
Michigan	**0.84**	**0.80**	**0.73**	**1.20**	**0.69**	**0.77**	**1.04**
Minnesota	**1.18**	**1.12**	**1.02**	1.68	**0.96**	**1.07**	1.45
Mississippi	**1.21**	**1.16**	**1.06**	1.73	**0.99**	**1.11**	1.50

*** Bold data represents coefficient's of variation that are less than the Aggregate (Can/US)**

Ratio's of Coefficient's of Variation (Provinces/States)

	Ontario	Alberta	BC	Manitoba	Atlantic	Quebec	SASK
Missouri	**0.98**	**0.94**	**0.85**	1.40	**0.80**	**0.90**	**1.21**
Montana	**0.61**	**0.58**	**0.53**	**0.87**	**0.50**	**0.56**	**0.75**
Nebraska	**0.85**	**0.81**	**0.74**	**1.21**	**0.69**	**0.78**	**1.05**
Nevada	2.53	2.42	2.20	3.61	2.07	2.32	3.13
New Hampshire	**1.10**	**1.04**	**0.95**	1.56	**0.89**	**1.00**	1.35
New Jersey	**1.23**	**1.17**	**1.07**	1.75	**1.00**	**1.12**	1.52
New Mexico	**0.81**	**0.78**	**0.71**	**1.16**	**0.66**	**0.74**	**1.00**
New York	**0.85**	**0.81**	**0.74**	**1.21**	**0.69**	**0.78**	**1.05**
North Carolina	1.57	1.50	1.37	2.24	**1.28**	1.44	1.94
North Dakota	**0.18**	**0.17**	**0.15**	**0.25**	**0.14**	**0.16**	**0.22**
Ohio	**1.15**	**1.09**	**1.00**	1.63	**0.94**	**1.05**	1.41
Oklahoma	**0.22**	**0.21**	**0.19**	**0.31**	**0.18**	**0.20**	**0.27**
Oregon	1.45	1.39	**1.26**	2.07	**1.19**	**1.33**	1.79
Pennsylvania	1.57	1.49	1.36	2.23	**1.28**	1.43	1.93
Rhode Island	**0.81**	**0.77**	**0.71**	**1.16**	**0.66**	**0.74**	**1.00**
South Carolina	1.66	1.58	1.44	2.36	1.35	1.51	2.04
South Dakota	**1.00**	**0.96**	**0.87**	1.43	**0.82**	**0.92**	1.24
Tennessee	1.60	1.53	1.39	2.28	**1.31**	1.46	1.98
Texas	**1.00**	**0.95**	**0.87**	1.42	**0.81**	**0.91**	**1.23**
Utah	1.33	**1.27**	**1.16**	1.90	**1.09**	**1.22**	1.64
Vermont	**1.07**	**1.02**	**0.93**	1.53	**0.88**	**0.98**	**1.32**
Virginia	1.57	1.49	1.36	2.23	**1.28**	1.43	1.93
Washington	2.16	2.06	1.88	3.08	1.76	1.97	2.66
West Virginia	**0.69**	**0.66**	**0.60**	**0.99**	**0.57**	**0.63**	**0.85**
Wisconsin	1.65	1.57	1.43	2.35	1.35	1.51	2.03
Wyoming	**0.35**	**0.33**	**0.30**	**0.50**	**0.28**	**0.32**	**0.43**

Aggregate ratio **1.33**

*** Bold data represents coefficient's of variation that are less than the Aggregate (Can/US)**

4.4 Response of the exchange rate to various types of shocks

The symmetry of shocks and business cycles criterion discussed in Section 2 gives us an idea of the potential cost to a country of entering into a currency union with another country or region. Yet this criterion does not allow us to determine whether the fact that a country is operating under a flexible exchange rate system has actually allowed it to alleviate the effect of shocks. To provide evidence on this, we study the response of the exchange rate and of domestic prices to relative shocks affecting Canada and the United States. This case is relevant since Canada and the United States have shared a flexible exchange rate since 1970.

We use a variant of the approach presented in Section 2. The latter has to be modified because the exchange rate is a relative price which should respond to relative shocks affecting Canada and the United States. Some of the shocks we identified in Section 2 were common to Canada and the United States. In this section, our VAR includes the differential between the following variables in Canada and in the United States: industrial production (in logarithms), inflation, and real interest rates (the nominal rate minus inflation), to which we add the exchange rate (in logarithms). We use monthly data (we used quarterly data in Section 2 because monthly data is not available at the U.S. regional level) covering the January 1970 to September 1999 period. Using monthly instead of quarterly data appears particularly appropriate here since we are primarily interested in the response of the exchange rate, a financial variable whose response to shocks is expected to be rapid so that it might be affected by time aggregation problems (this may still be a problem with monthly data).

Our unit root tests (available on request) indicated that the exchange rate and industrial production differentials are first-difference stationary, but that the inflation and real interest rates differentials are stationary in level. These variables are included in the VAR accordingly. The number of lags is selected on the basis of the method described in Section 2.

The procedure described in Section 2 to identify the various types of shocks is applied to this new set of variables. This means that a relative supply shock is now a permanent shock to the real output differential, a shock having no long-run impact on relative output but changing permanently relative <u>price levels</u> is a relative monetary policy shock, and a shock having no long-run impact on both relative output and the relative price levels is a relative real demand shock.[32] The restriction we use to identify monetary policy shocks may imply that we over-estimate the importance of monetary policy shocks since it is likely that the monetary authorities have accommodated other types of shocks that had an impact on relative price levels.[33]

Figures 15-18 present the responses of relative output, inflation, real interest rates, and of the nominal exchange to the various types of shocks. One-standard-deviation confidence bands calculated with Monte Carlo simulations (1000 replications) are also shown. The responses of the real output differential to the various shocks, shown in Figure 15, are broadly consistent with our expectations. While real demand and monetary policy shocks lead to a transitory increase in output, supply shocks have a positive long-run impact (remember that short-run responses and the

32.The fact that the VAR includes four variables implies that, in fact, we identify two relative real demand shocks. The sum of these two shocks is our series of real demand shocks.

33. The risk that such shocks are included in the monetary policy shocks presented in Section 2 is much reduced by the fact that an accommodation would then mean that central banks increased the trend growth rate of money supply (and not only the level of money supply) in response to shocks affecting the price level.

Figure 15: Responses of the output differential to one-standard-deviation shocks*

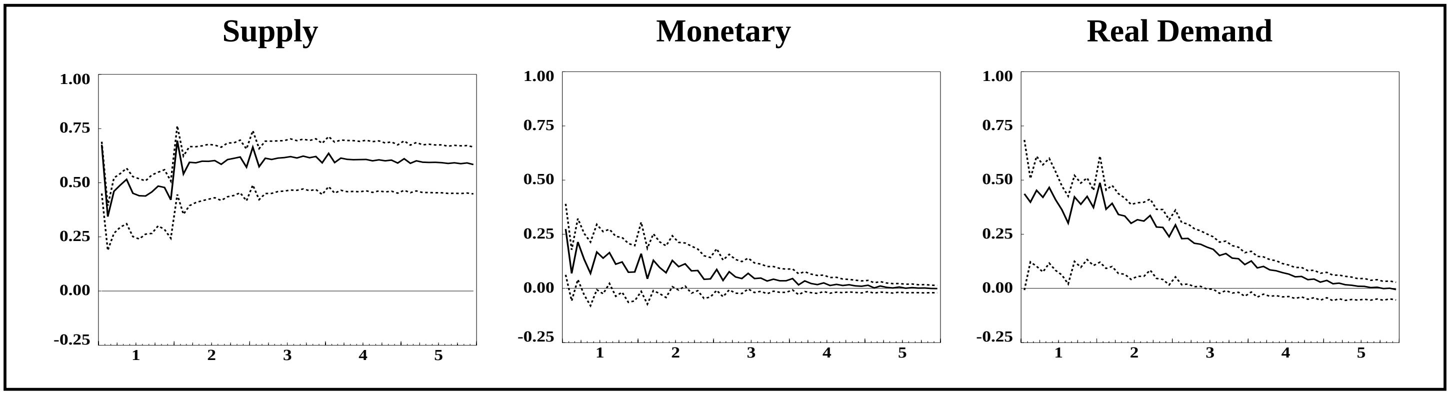


Figure 16: Responses of the price differential to one-standard-deviation shocks*

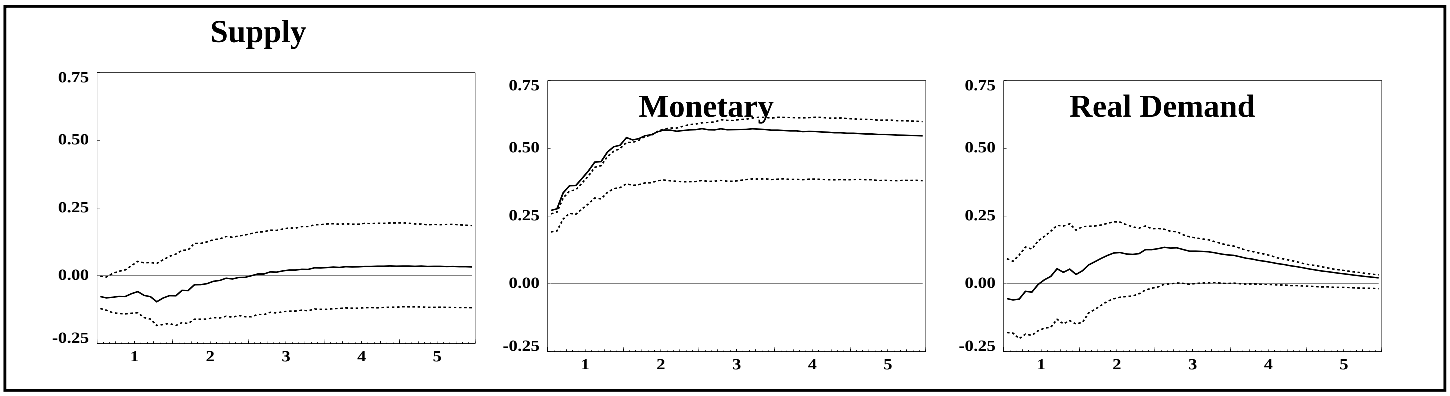
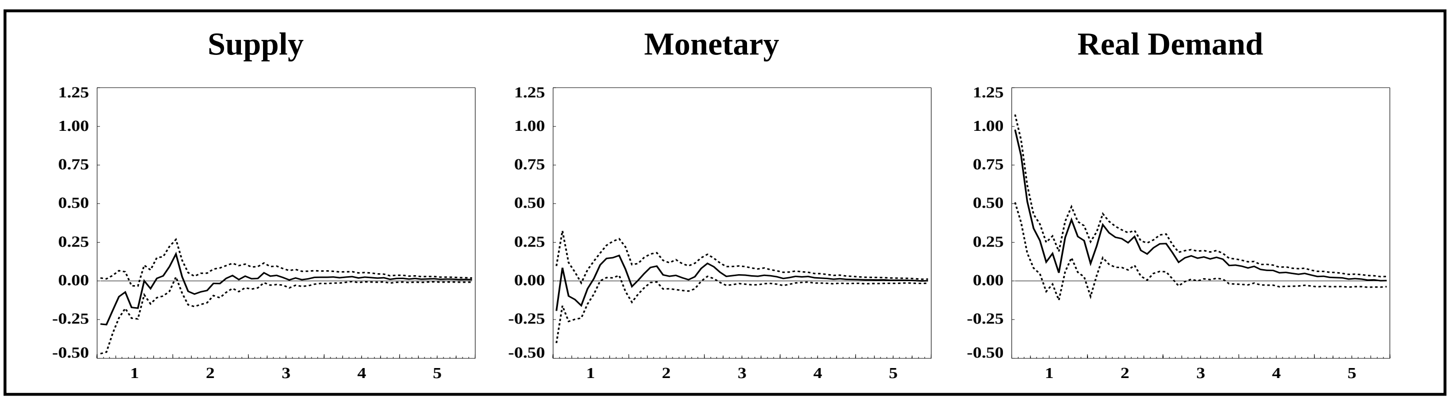
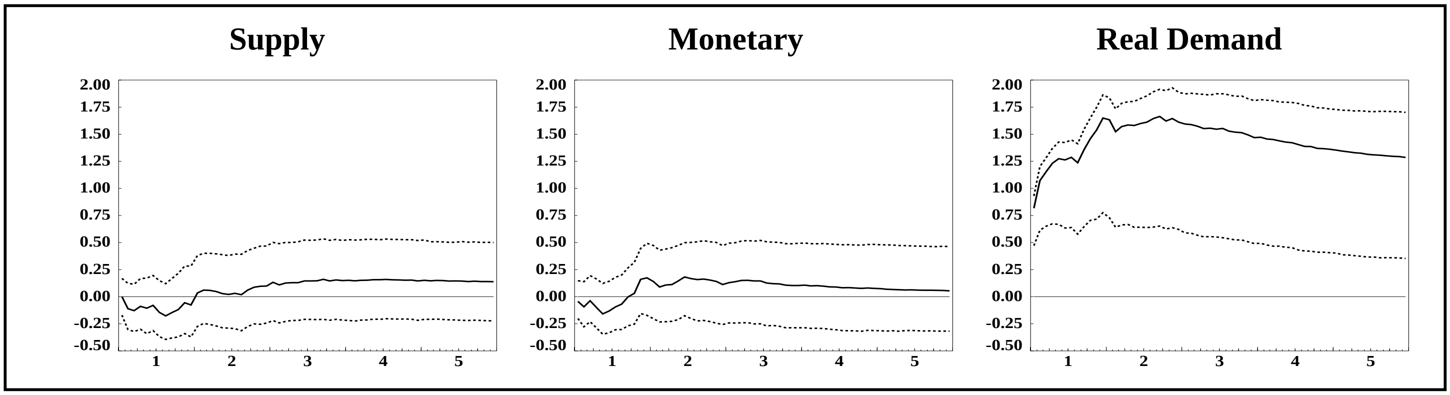


Figure 17: Responses of the real interest rates differential to one-standard-deviation shocks*



* Y-axis represents percentage change, except for Figure 17 where it represents basis points. Dashed lines enclose the one standard deviation confidence bands which have been calculated by monte carlo simulations with 1000 replications.

Figure 18: Responses of the nominal exchange rate to one-standard-deviation shocks*



sign and magnitude of the long-run responses are not constrained). Responses of the price differential, shown in Figure 16, are also consistent with our expectations in that the price differential goes up after a monetary policy shock, it goes down in the short run following a supply shock, and tends to go up in the short run following a real demand shock.

The responses of the real interest rates differential, shown in Figure 17, are also as expected. For instance, a relative monetary policy shock tends to be associated with lower relative interest rates. Also, a real demand shock pushes the real interest rate differential up, which is necessary if this shock is to have zero long-run impact on relative prices. Note that relative interest rates could not change in a monetary union in response to a country specific shock.

Figure 18 shows that the variance of nominal exchange rates is dominated by our real demand shocks. These shocks have a small impact on relative prices (Figure 16) but a large impact on the nominal exchange rate. This suggest that the adjustment of the real exchange rate to such shocks comes essentially through the response of the nominal exchange rate. This is consistent with the view that the flexible exchange rate has facilitated the adjustment of the Canadian economy to asymmetric real demand shocks. In a fixed exchange rate regime, the adjustment of the real exchange rate has to come through relative price levels. In the presence of nominal rigidities, this implies a greater volatility in variables such as production and employment.

Response of the nominal exchange rate to the other shocks are much smaller and not significantly different from zero. In the case of monetary policy shocks, this is surprising given that these shocks push relative prices up. This may indicate, as mentioned earlier, that our monetary policy shocks include other shocks, for instance fiscal shocks that have been accommodated by the monetary authorities, and not only pure exogenous monetary policy shocks.

It is of interest to compare the results presented in this section with the ones obtained by Clarida and Gali (1994) with a different specification and different identifying restrictions. These authors estimate three-variable VARs for a group of countries. The variables they include in their models are: real GDP differentials, real exchange rates, and inflation differentials. As in our case, relative aggregate supply shocks are assumed to be shocks having a long-run impact on relative output. Also like us, they define relative aggregate demand shocks (both nominal and real) as shocks having no long run impact on relative output. However, nominal and real demand shocks are distinguished by assuming that, while nominal shocks have no long-run impact on the real exchange rate, relative real demand shocks have such impact.

Despite the differences with our approach, Clarida and Gali obtain results similar to ours converning the response of the exchange rate. In particular, they find that relative real demand shocks favorable to the Canadian economy lead a large and sustained real appreciation of the Canadian dollar. They also find that most of this appreciation comes from the nominal exchange rate and that supply and nominal shocks account for a small part of the variance of the exchange rate. We updated these authors estimates using more recent data and obtained similar results.

We conclude that structural VAR analysis provides evidence that the flexible exchange rate has facilitated the adjustment to asymmetric real demand shocks between Canada and the United States. This evidence appears to be robust to changes in specifications and identification strategies. Of course, work remains to be done to better assess the robustness of the results. In particular, structural VARs designed to identify specific commodity prices shocks need to be explored. It would also be of interest to better assess what lies behind these real demand shocks which seem to account for a large portion of the variance of the Canada/United States exchange rate.

5. Concluding Remarks and Summary:

In making the case for flexible exchange rates for North America, we have argued that the Canadian, Mexican and U.S. economies normally experience significant and asymmetric economic shocks, which require real exchange rate adjustment. We then demonstrate that flexible exchange rates generally respond in the appropriate manner to such shocks, thereby facilitating the necessary real exchange rate adjustment. Finally, we provide evidence to indicate that by facilitating this adjustment, flexible exchange rates mitigate the effect of these shocks on the real economy by reducing output and employment volatility in Canada and Mexico.

The outstanding question, however, is whether this line of reasoning in favour of a flexible exchange rate is sufficient given the other arguments proffered by the huge literature on optimum currency areas spawned by Mundell's original paper? Clearly, the most obvious omissions from our analysis are the issues of monetary sovereignty/governance and transactions costs.

Both Mexico and Canada have relatively independent central banks that are responsible for implementing monetary policy. Both central banks have also adopted some form of inflation targeting as a nominal anchor in conjunction with their flexible exchange rates. This combination provides a coherent monetary order that is sustainable, transparent and publicly accountable. Thus, there are additional benefits from this monetary order that we have not considered.[34]

Broadly defined, the transaction costs associated with national currencies and flexible exchange rates can take many forms: currency translation, hedging, impediments to trade and investment, risk premia in Mexican and Canadian interest rates and inefficiencies due to lack of comparability of prices across borders. Moreover, these costs are probably not as small as many believe. Although estimates are normally in the range of 0.2 to 0.5 per cent of GDP per annum, recent

34. See Laidler (1999) for further details.

work by Helliwell (1996), McCallum (1995), Rose (1999) and others find unexpectedly large border/currency effects on trade flows. There is less tangible evidence for investment flows, yet many, including Courchene and Harris (1999), believe they are significant.

At this juncture, we believe that these transactions costs are not large enough to outweigh the substantial macroeconomic stability benefits of a flexible exchange rate. However, if the Canadian and Mexican economies became even more integrated into the U.S. economy and with each other, North American trade and investment flows may grow larger and the potential costs of having separate currencies could increase. Moreover, as the Canadian and Mexican economies evolve through the accumulation of human and physical capital, their economies may become more diversified and similar to that of the United States. Indeed, Mexico's dependence on oil has fallen substantially over the last 10 years. Hence, shocks may become less asymmetric and the benefits from having a floating rate could decline. Thus, the relevant questions may become under what circumstances would a switch to some form of fixed rate be economically beneficial and what form should it take? These are topics for ongoing and future research.

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Appendix 1

Table A2.1: Composition of the nine regions of the United States

Regions	Composition
New England	Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut
Middle Atlantic	New York, New Jersey, and Pennsylvania
East North Central	Ohio, Indiana, Illinois, Michigan, and Wisconsin
West North Central	Minnesota, Iowa, Missouri, South Dakota, North Dakota, Nebraska, and Kansas
Southern Atlantic	Delaware, Maryland and Colombia District, Virginia, West Virginia, North Carolina, South Carolina, Georgia, and Florida
East South Central	Kentucky, Tennessee, Alabama, and Mississippi
West South Central	Arkansas, Louisiana, Oklahoma, and Texas
Pacific North West	Alaska, Idaho, Montana, Oregon, Washington, and Wyoming
Pacific South West	Arizona, California, Colorado, Hawaii, New Mexico, Nevada, and Utah

Note: The groupings are by DRI.

Appendix 2: Impulse Responses - North American VAR Model

Figure A2.1: Response of output to the various types of shocks in Canada

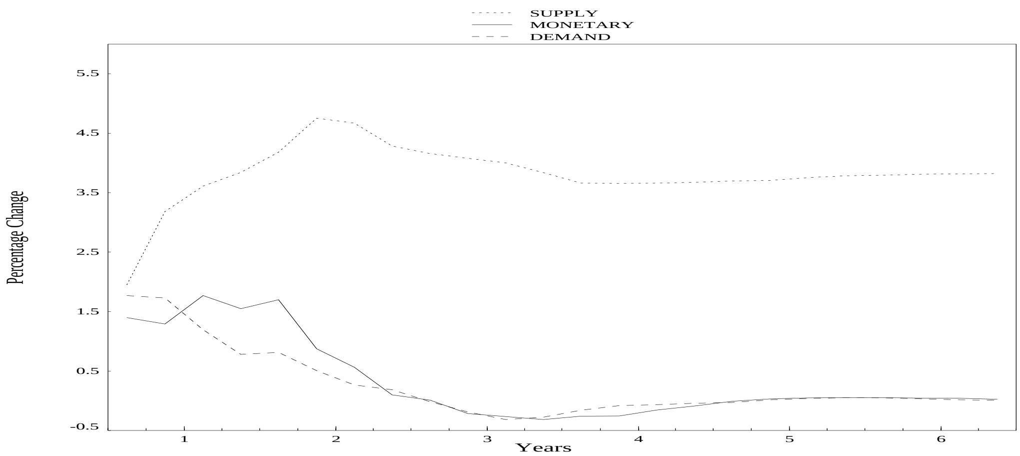


Figure A2.2: Response of output to the various types of shocks in the United States

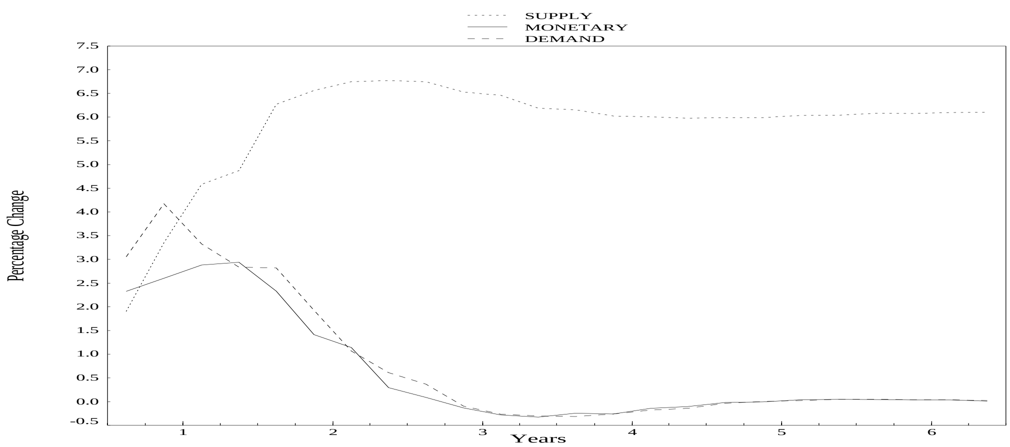


Figure A2.3: Response of output to the various types of shocks in Mexico

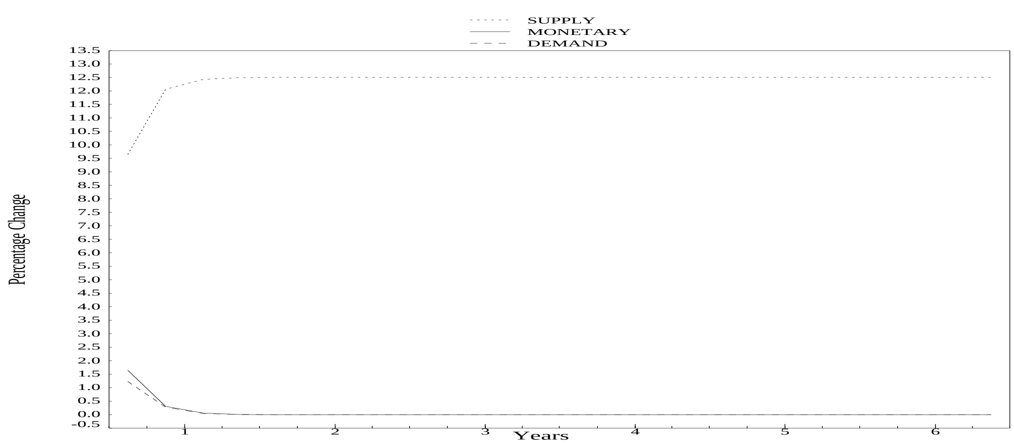


Figure A2.4: Response of inflation to the various types of shocks in Canada

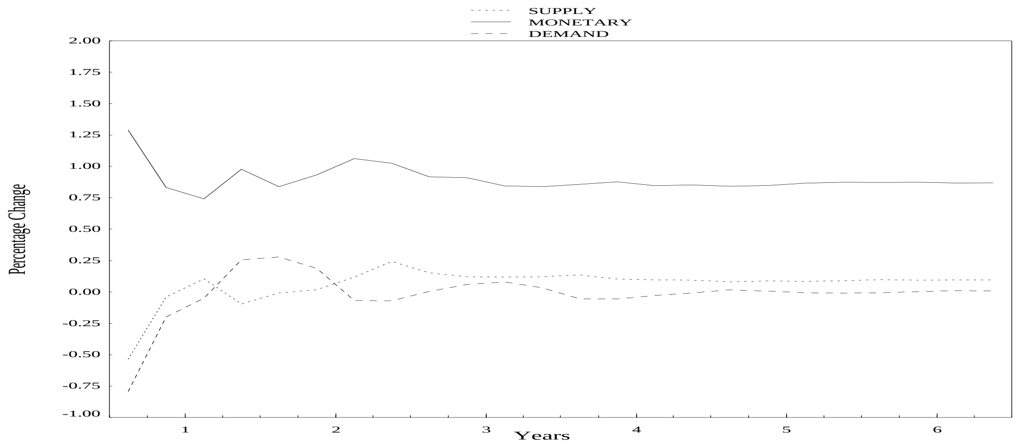


Figure A2.5: Response of inflation to the various types of shocks in the United States

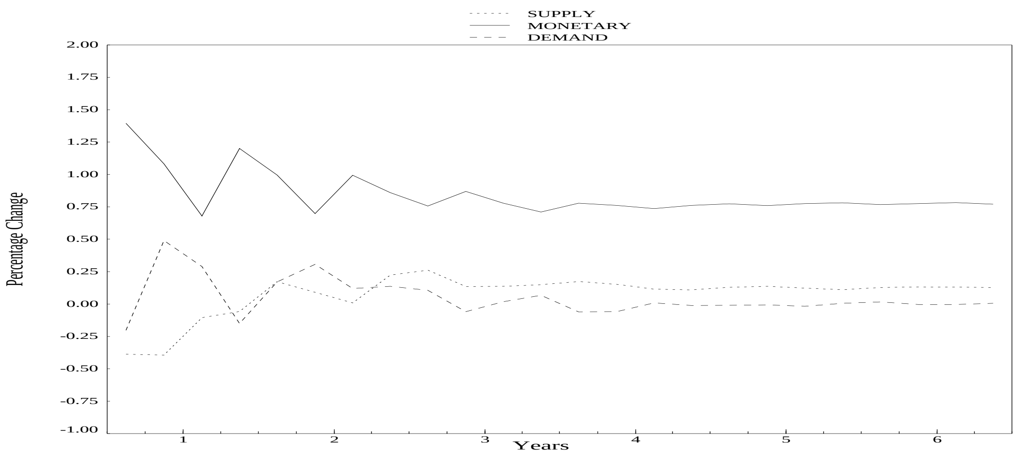


Figure A2.6: Response of inflation to various types of shocks in Mexico

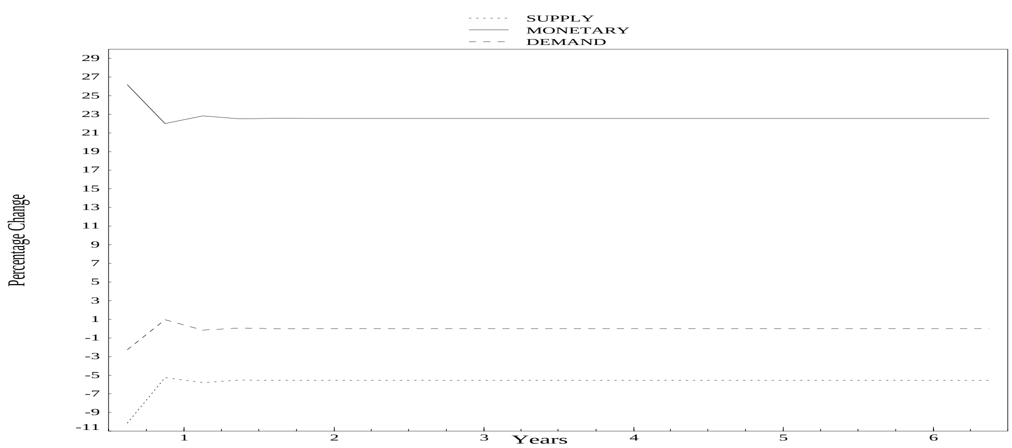


Figure A2.7: Response of real interest rates to the various types of shocks in Canada

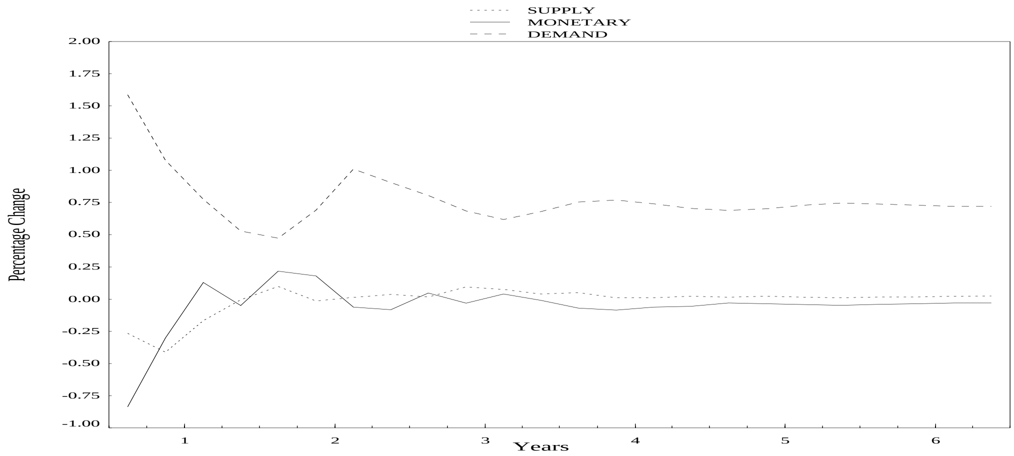


Figure A2.8: Response of real interest rates to the various types of shocks in the United States

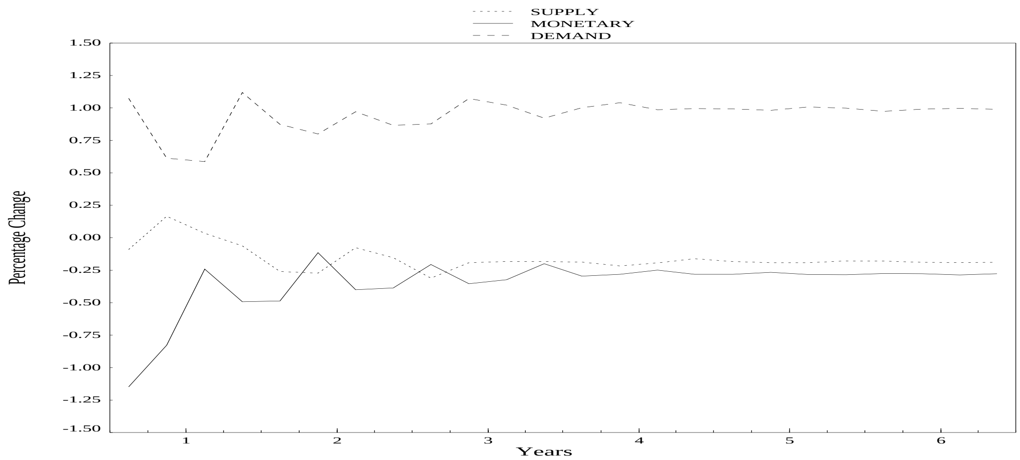
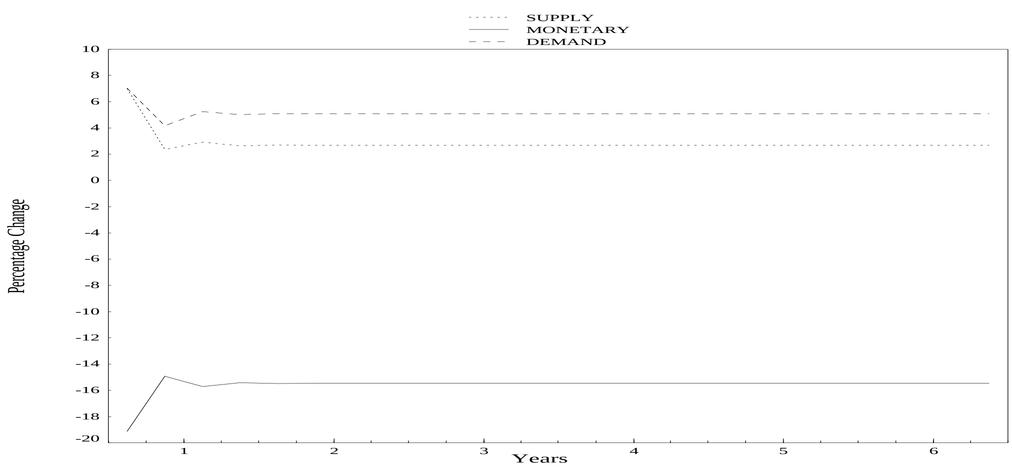


Figure A2.9: Response of real interest rates to the various types of shocks in Mexico



Appendix 3: Mexican Exchange Rate Equation

Table A3.1: Stationarity Test (80q1 to 99q2)

Variable	ADF	PP	KPS
rpesoq	-3.009** (3)	-2.389 (4)	0.194
gsbalq	-2.182 (3)	-2.015 (4)	0.453*
rwti	-1.164 (2)	-1.223 (4)	1.310**

a. The 5% critical Values for the ADF and PP tests are -2.890, while for the KPS test it is 0.463
The 10% critical values for the ADF and PP tests are -2.580, while for the KPS test it is 0.347

Null hypothesis for the ADF and PP is non-stationarity, while for the KPS it is stationarity
Lag lengths are in brackets

(**) indicates rejection of the null at the 5% level and (*) is at the 10% level

Table A3.2: Residual-Based Tests for Cointegration

ADF	PP	5% CV	10% CV
-3.379 (4)	-3.761** (4)	-3.74	-3.45

Null hypothesis for the ADF and PP is no cointegration

Lag lengths are in brackets

(**) indicates rejection of the null at the 5% level and (*) is at the 10% level

Appendix 4

Table X: Provincial - State Concordance

PROVINCE	MAIN EXPORTS	COMPARABLE U.S. STATES
Atlantic Provinces	Agricultural, forestry, energy	Maine, New Hampshire, New York, Massachusetts (Vermont)
Québec	Machinery and equipment, industrial, forestry	New York, Vermont, Maine, Massachusetts (New Hampshire)
Ontario	Automotive, machinery and equipment, industrial	New York, Ohio, Michigan, Pennsylvania (Kentucky)
Manitoba	Agricultural, machinery and equipment, industrial	Minnesota, Wisconsin, Iowa, Illinois (Kansas)
Saskatchewan	Agricultural, industrial	Montana, North Dakota, South Dakota, Wyoming (Minnesota)
Alberta	Energy, industrial and agricultural	Oklahoma, Texas, Alaska, Montana (Idaho)
British Columbia	Forestry, energy, industrial	Washington, Oregon, California, Alaska (Maine)