International financial crises and flexible exchange rates: some policy lessons from Canada

John Murray, Mark Zelmer and Zahir Antia[1]

"In other words, for cyclical as well as for more fundamental reasons, the prospects are good for a stronger Canadian currency." [2]

1. Introduction

The near-term prospects for the Canadian economy and the Canadian dollar looked very promising in early 1997. Canada's current account balance had swung into surplus for the first time in 11 years; the federal government deficit had finally been eliminated; public sector debt was now on a clear downward track; world commodity prices had recovered from their 1992–93 lows; and inflation had remained steady at 1 to 2% for more than five years.

While the Governor's exchange rate forecast may seem optimistic in retrospect, this positive outlook was shared by many other observers. Canadian interest rates had fallen below comparable US rates across the yield curve, suggesting that most investors believed the Canadian dollar would soon appreciate and continue to strengthen for several years to come. The only question was how high it would go. Some market analysts were concerned that the dollar might strengthen too much, undermining Canada's new-found competitiveness and throwing the economy back into recession.

> *"Can Canada compete with a higher currency?... C$ bulls may soon be pointing to 80 cents US as a fair evaluation of C$ fundamentals... [However] without an extraordinary response from Canadian consumers growth in our borderline economy could easily come to a standstill or worse."*[3]

While there was widespread agreement among analysts and most forecasting groups that the Canadian dollar would soon appreciate, few of them shared Buchanan's and Rubin's concerns about the "borderline" growth prospects in Canada (or the world economy more generally). Both the IMF and the OECD predicted that growth in Canada would be higher than in any other G7 country, reaching 3.5% in 1997 and 3.3% in 1998. World output was expected to grow by more than 4% a year, and world trade was expected to increase by more than 9% – continuing a trend that had started in 1994.

In the event, none of these optimistic predictions came true. Although the Canadian economy did post respectable growth rates in 1997 and 1998, they were not the highest in the G7.[4] (That honor belonged to the United States, which grew by 3.9% in both years.) The performance of the Canadian dollar was even more disappointing. It fell from an average level of US 74 cents in the first quarter of 1997 to a

---

[1] The views expressed in this paper are those of the authors. No responsibility for them should be attributed to the Bank of Canada. John Murray works in the International Department of the Bank of Canada, while Mark Zelmer and Zahir Antia work in the Financial Markets Department. The authors would like to thank Robert Amano, David Laidler, James Powell and Lawrence Schembri for their helpful comments. They are also grateful for the invaluable technical assistance provided by Jason Daw and Francine Rioux.

[2] Excerpted from "Flexible Exchange Rates in a World of Low Inflation". Remarks by Gordon Thiessen, Governor of the Bank of Canada, to the FOREX '97 Conference in Toronto, 30 May 1997.

[3] See Rubin and Buchanan (1996).

[4] Real economic growth in Canada was 3.3% in 1997 and 2.8% in 1998.

record low of US 63.1 cents in the third quarter of 1998 – roughly 15% below its starting point (see Graph 1).[5]

Although the reasons for the weakness of the Canadian dollar are easy to identify ex post, few observers were able to anticipate them ex ante. Indeed, a brief review of the reports and newsletters that were published immediately before the Asian crisis failed to uncover any analyst who correctly forecast the traumatic events that were about to unfold. The IMF, the OECD and the Bank of Canada can perhaps be forgiven, therefore, for not being more perspicacious than the rest of the economics profession.

Graph 1: Canadian dollar against the US dollar

Weekly (average of Wednesdays)

Canada, of course, was not the only industrial country to be affected by the Asian crisis and the resulting collapse in world commodity prices. Other countries, such as Australia and New Zealand, which had more extensive trade links with Asia and were more dependent on commodity exports, saw their currencies fall much further. These dramatic depreciations did not provide much comfort to analysts and investors who had counted on a stronger Canadian dollar, however; nor to the Canadian public, who awoke each day to find their currency at a new historical low. Had it not been for the positive forecasts that had preceded this sudden downturn, and the proximity of the surging US economy, the disappointment might not have been so great. There was a widespread sense during much of this period that the Canadian dollar had fallen much further than fundamentals alone could justify. Although some of this angst disappeared with the subsequent recovery of the dollar, the experience of the last three years has raised new concerns about the destabilizing effects of exchange market speculation and the practicality of a flexible exchange rate. Critics of the existing system have called for a new, more rigid currency arrangement with the United States, including perhaps the introduction of a common currency.

The purpose of the present paper is to examine the behavior of the Canadian dollar over the last three years and to determine the extent to which it has been oversold or pushed below its "fair" market

5 Of course, were it not for the "disappointing" performance of the dollar, Canada's real growth in 1997 and 1998 would have been much lower.

value. The principal tool for our analysis is a simple exchange rate equation that was first developed at the Bank of Canada in the early 1990s. Extensive testing with the equation during the past nine years has shown that it is able to explain most of the broad movements in the dollar over the post-Bretton Woods period.

Three major conclusions can be drawn from the evidence that is presented below. First, any difference between the actual and predicted values of the Canadian dollar over the past three years has been small and generally short-lived. Overshooting has not been a major problem. Second, the dollar's current value is very close to the fitted values predicted by our simple exchange rate equation and is not significantly undervalued. Most of its recent weakness can be explained by two or three critical variables. Third, periods of market turbulence and increased exchange rate volatility, like the ones associated with the Asian and Russian crises, are typically dominated by fundamentalists rather than destabilizing speculators. Efforts by the Bank of Canada to resist these movements through exchange market intervention or higher interest rates are therefore likely to reduce market efficiency. Tactical manoeuvres to support the exchange rate and calm market expectations should be used sparingly, where there is clear evidence of market failure and the remedial interest rate increases can be quickly reversed.

The rest of the paper is organized as follows. Section 2 describes the basic exchange rate equation that is used in our analysis and presents the results of a number of simulations designed to measure the extent to which the dollar has been undervalued. Section 3 extends the analysis by adding two new variables to the exchange rate equation – differences in Canadian-US productivity and the level of public debt – to see if they improve its explanatory power. The role of speculative bubbles and destabilizing currency traders is investigated in Section 4 with the aid of a regime-switching model. The final section of the paper provides a summary of the main results and some suggestions for future work.

2. The basic exchange rate equation

The Bank of Canada's exchange rate equation is based on a simple error-correction model that was first developed by Robert Amano and Simon van Norden in 1991. The dependent variable is the real Canadian-US exchange rate, and its equilibrium value is determined by two independent variables: the energy terms of trade, and the commodity terms of trade (ex-energy). Short-run dynamics are captured by changes in the Canadian-US interest rate differential.

The equation can be written as follows:

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

where *rfx* = real Canadian-US exchange rate, *comtot* = non-energy commodity terms of trade, *enetot* = energy terms of trade and *intdif* = Canadian-US interest rate differential.

The dependent variable, *rfx*, is simply the nominal Canadian-US exchange rate deflated by either the CPI or the GDP price index. The choice of deflator makes little difference to the resulting time series since the CPI and GDP price indices move in a very similar manner over the sample periods relevant for our study. The two independent variables, *enetot* and *comtot*, are obtained by dividing the US dollar price of energy and non-energy commodities by the US GDP deflator. The effects of Canadian and US monetary policies on the real exchange rate are proxied by *intdif*, which is simply the difference between Canadian and US short-term interest rates.[6]

---

[6] The specification described above differs from the original Amano-van Norden equation in three respects. First, the energy and commodity terms of trade are deflated by the GDP price index rather than the price of US manufactured goods. Second, oil prices are used as a proxy for all energy prices. Third, the interest rate differential is just the spread between Canadian and US short-term interest rates rather than the difference between long-term and short-term interest rates in the two countries. These changes have no significant effect on the performance of the equation and were introduced simply to reduce the number of data series that were required to use it.

$$intdif = (i_{st}^{ca} - i_{st}^{us})$$

While equation (1) contains many of the variables that one would expect to find in a Canadian-US exchange rate relationship, and has performed surprisingly well over the past nine years, it is important to note that Amano and van Norden only arrived at this simple specification after testing over a much larger set of explanatory variables. The fact that the relationship has remained stable through time and has retained much of its explanatory power is remarkable, particularly for an exchange rate equation, and is testament to the important influence that *comtot*, *enetot* and *entdif* exert on the Canadian dollar.[7]

2.1 Regression results

Representative results for the basic exchange rate equation estimated over four different sample periods are shown in Table 1. As the reader can see, most of the parameters are statistically significant and have their expected signs. Since the dependent variable is defined in a way that associates downward movements in the exchange rate with appreciations (and upward movements with depreciations), 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 latter may seem counter-intuitive, and was not expected when Amano and van Norden first ran their regressions, it has proven to be a remarkably robust result. Indeed, it was only when energy and non-energy commodity prices were separated into two variables, and allowed to affect *rfx* in different ways, that the equation was able to work. Earlier results, based on a single commodity price variable which combined the two effects, proved disappointing.

The unexpected result on the energy price term can be explained by noting that Canada is only a marginal net exporter of energy products, but has other industries which are very energy-intensive. As a consequence, the benefits realized from larger energy exports when the price of energy increases are more than offset by the additional costs borne by other Canadian industries.[8] Higher energy prices, therefore, cause the real exchange rate to depreciate.

Table 1
Standard exchange rate equation

Variable	1973Q1–1986Q1	1973Q1–1991Q3	1973Q1–1996Q1	1973Q1–1998Q4
Speed of adjustment	–0.198	–0.167	–0.141	–0.125
	(–3.251)	(–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)
R2	0.218	0.227	0.204	0.194
Durbin-Watson	1.197	1.159	1.265	1.311

Note: t-statistics in parentheses.

7 The unit root and cointegration tests that were used to check the original specification are described in Appendix 1.

8 Macklem (1993) has constructed a three-sector general equilibrium model of the Canadian economy which generates results very similar to those described above.

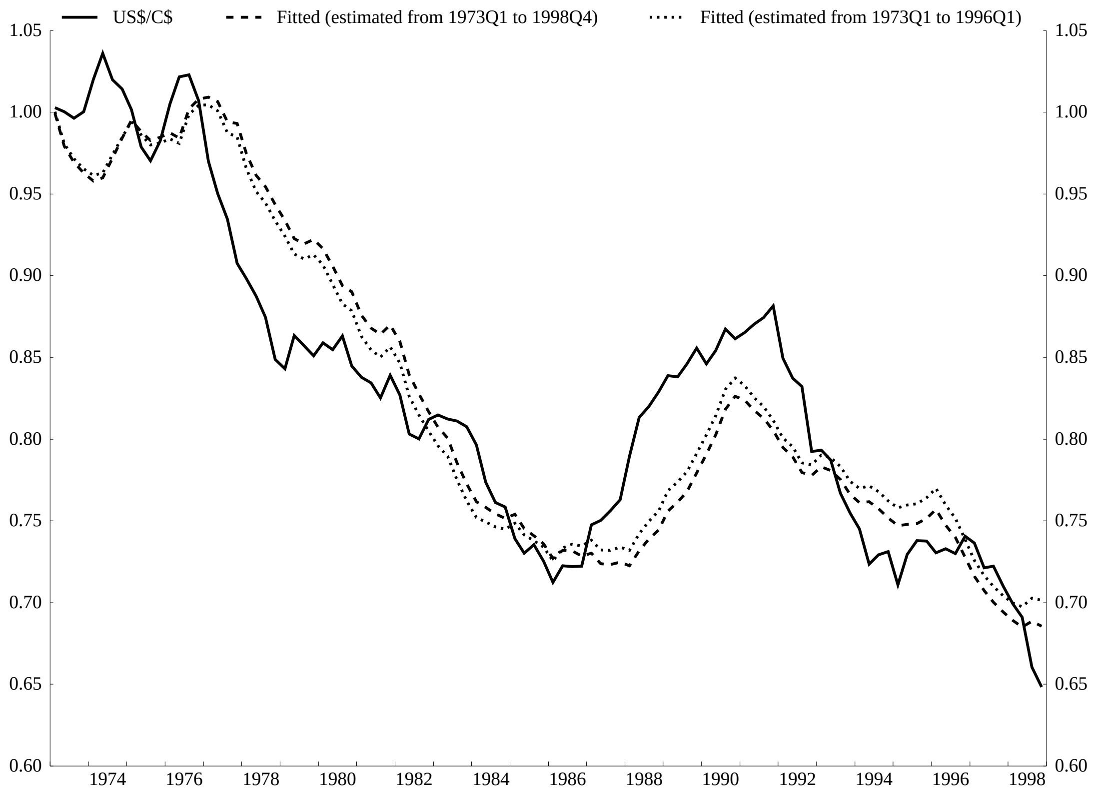
The only other feature of the regression results that might seem surprising is the long implied adjustment lag associated with changes in commodity prices. While long lags are not unusual in simple reduced-form models of this kind, the mean adjustment lag in equation (1) is approximately four quarters. One might have expected the response time to be much shorter for an asset price variable such as *rfx*. The more gradual reaction that is observed in equation (1) suggests that agents wait to see if commodity price changes are permanent before factoring them into the exchange rate completely.

Aside from these two anomalies, the performance of the basic equation is quite impressive. It is able to explain roughly 20% of the quarterly variation in the real exchange rate; the relationship is remarkably robust; and its parameters are (for the most part) sensibly signed and significant.[9] Tests of the model's ex ante predictive power also indicate that it is able to beat a random walk (see the original Amano and van Norden (1993) paper). While the latter may seem like a rather modest benchmark, few exchange rate equations are able to make this claim.

2.2 Simulations

Two dynamic simulations are shown in Graph 2, using parameter estimates drawn from the periods 1973Q1–1996Q1 and 1973Q1–1998Q4. In order to facilitate comparisons between the actual and predicted values of the exchange rate, *rfx* was first converted into a nominal exchange rate by adjusting the real series for changes in the Canadian and US GDP price deflators.

Graph 2: Dynamic simulation - basic model



9 Some variability in the parameter estimates is observed over the 1973–91 sample compared to other periods. This may be due to the sizable overshooting of the exchange rate towards the end of the 1980s. In any event, none of the differences is statically significant. Parameter stability tests that were conducted as part of an earlier exercise indicated that the estimates never exceeded their 5% confidence bands.

The correspondence between the simulated values of the nominal exchange rate and its actual value is very close. Most of the broad movements in the exchange rate are captured by the three explanatory variables. Sizeable deviations do occur on occasion, but they typically disappear after a short period of time. The 1987–90 episode is an example of this. While 1998 may provide another example of speculative overshooting, the deviations that were recorded over this "crisis" period appear to be relatively modest compared to earlier episodes. Moreover, the actual exchange rate has now returned to a level that is very close to what the equation would predict. In other words, very little of an exceptional or potentially troubling nature was observed during this period of international turbulence.

Table 2 provides a decomposition of one of the simulations shown in Graph 2, and indicates the relative contribution of each variable to changes in the actual Canadian-US exchange rate.

Table 2
Relative importance of the explanatory variables 1973Q1–1998Q4

Variable	Percentage share
comtot	56.20
enetot	1.85
intdif	–6.52
Inflation	23.00
Lags	11.51
Other*	13.76
Total	100.00

* Includes error term.

Over the 1973Q1–1998Q4 period, the nominal bilateral exchange rate depreciated by roughly 44 cents (Canadian). Of this, more than 56% was the result of a trend decline in the relative price of non-energy commodities; 23% was caused by higher inflation in Canada than in the United States (purchasing power parity); 2% came from higher energy prices; and 25% 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 the dollar by roughly 7%.

3. An extended equation

The results reported in the previous section suggest that most of the movements in the exchange rate have been driven by two or three fundamental variables, and that it would be possible to predict the general direction of the exchange rate, if not its exact level, provided one had prior knowledge of these forcing variables. Nevertheless, independent of which sample period is used to estimate the equation, it tends to overpredict the actual value of the exchange rate over most of the 1990s. Is this evidence of overshooting or is there a chance that other explanatory variables might be uncovered that could help explain these discrepancies?

Amano and van Norden (1993) ended their estimations in 1992Q2. While the regressions reported above in Table 1 extend their results to 1998Q4, no new variables have been added to the original equation. The same specification has simply been applied to more data. Although the new results are essentially unchanged vis-à-vis those of Amano and van Norden, the longer sample that is now available might allow us to uncover additional variables that could help explain the "undervalued" dollar over the 1992–98 period.

3.1 Canadian-US differences in productivity and government debt

Several new variables have been examined as part of an effort to find a new and improved exchange rate equation for the Canadian dollar. A complete list of the variables that have been tested is contained in a recent paper written by two colleagues, David Tessier and Ramdane Djoudad, who have conducted a more exhaustive study of this issue.[10]

Rather than reproduce all of the results of Tessier and Djoudad, we have decided to focus our attention on two variables: the difference in Canadian and US labor force productivity, and the difference in Canadian and US general government debt. These variables are of particular interest owing to the public attention that they have attracted in recent months. Moreover, the results that we obtain are broadly similar to those reported by Tessier and Djoudad using a number of other specifications.

(i) Productivity

Sagging productivity has been the focus of a lively public debate in Canada since late last year, when the OECD published a report suggesting that the level of labor productivity in Canada's manufacturing sector was well below that in the United States, and was also growing at a much slower rate. Although the data on which these results were based have now been revised, and the productivity growth puzzle seems to have largely disappeared, the debate continues. As a result, there is considerable interest in seeing if any evidence of a productivity slowdown can be detected in the exchange rate equation. Since Canada is not a large enough producer to materially affect the world price of most commodities, and is unlikely to suffer from "immiserizing growth", one would expect lower productivity growth to cause the Canadian dollar to depreciate. (It is important to note, however, that the exchange rate effects of a (relative) decline in productivity are in theory ambiguous.)

(ii) Government debt

The high level of government debt in Canada relative to that in the United States has also been a source of concern in recent years. As with slow productivity growth, one would also expect it to lead to an exchange rate depreciation, since countries must eventually pay for any excess absorption with higher net exports. (This assumes that the counterpart of higher domestic debt is higher foreign indebtedness.) In the short run, however, the net effect of higher government debt on the exchange rate could be ambiguous. The positive demand shock generated by higher government spending and reduced taxes might be expected to put upward pressure on the exchange rate, in part through higher interest rates.[11] On the other hand, if the outstanding debt were to approach levels that raised concerns about the government's ability to service it, the positive Keynesian effect described above could easily be outweighed by risk considerations, causing domestic interest rates to rise and the exchange rate to depreciate. Whether the statistical techniques employed below will be able to disentangle these conflicting effects, and the sudden changes in market sentiment that might occur once certain debt thresholds are breached, is unclear.

3.2 Regression results

Preliminary tests which were run on the new variables prior to estimating the extended model suggest that any results one might obtain should be treated with caution, since it was impossible to identify a stable cointegrating relationship between the new variables and the exchange rate.[12] Nevertheless, it is interesting to see how the results compare with those of the original specification reported in Table 1.

---

10 See Tessier and Djoudad (1999). Some of the variables that Tessier and Djoudad considered were (1) differences in Canadian-US unemployment rates, (2) differences in Canadian-US productivity, (3) differences in Canadian-US government spending, (4) differences in Canadian-US foreign indebtedness, and (5) differences in the levels of Canadian and US government debt.

11 Although Canadian-US interest rate differentials are entered as a separate variable, the stimulative short-run effects of increased government spending and lower taxes could still lead to an appreciation of the exchange rate through other channels.

12 Unit root and cointegration tests for the extended model are reported in Appendix 2.

The three new equations that were estimated can be written as follows:

(2) $\Delta\ln(rfx) = \alpha(\ln(rfx)_{t-1} - \beta_0 - \beta_c\, comtot_{t-1} - \beta_e\, enetot_{t-1} - \beta_d\, debtdif_{t-1}) + \gamma\, intdif_{t-1} + \varepsilon_t$

where *debtdif* = Canadian government debt to GDP ratio less US government debt to GDP ratio;

(3) $\Delta\ln(rfx) = \alpha(\ln(rfx)_{t-1} - \beta_0 - \beta_c\, comtot_{t-1} - \beta_e\, enetot_{t-1} - \beta_p\, proddif_{t-1}) + \gamma\, intdif_{t-1} + \varepsilon_t$

where *proddif* = Canadian-US labor productivity differential; and

(4) $\Delta\ln(rfx) = \alpha(\ln(rfx)_{t-1} - \beta_0 - \beta_c\, comtot_{t-1} - \beta_e\, enetot_{t-1} - \beta_d\, debtdif_{t-1}) - \beta_p\, proddif_{t-1} + \gamma\, intdif_{t-1} + \varepsilon_t$

Table 3
Standard exchange rate equation with government debt

Variable	1973Q1–1986Q1	1973Q1–1991Q3	1973Q–1996Q1	1973Q1–1997Q4
Speed of adjustment	–0.300	–0147	–0.162	–0.156
	(–3.278)	(–3.295)	(–4.156)	(–4.173)
Constant	1.781	2.541	2.089	2.235
	(3.983)	(3.719)	(3.472)	(3.631)
comtot	–0.297	–0.515	–0.402	–0.430
	(–3.251)	(–3.710)	(–3.448)	(–3.588)
enetot	0.032	0.1033	0.090	0.083
	(1.031)	(2.182)	(2.145)	(1.987)
intdif	–0.465	–0.476	–0.627	–0.566
	(–2.035)	(–2.771)	(–3.735)	(–3.981)
debtdif	0.804	–0.587	0.302	0.180
	(2.014)	(–1.290)	(1.159)	(0.706)
R2	0.238	0.243	0.205	0.207
Durbin-Watson	1.148	1.230	1.238	1.311

Note: t-statistics in parentheses.

Table 4
Exchange rate equation with productivity

Variable	1973Q1–1986Q1	1973Q1–1991Q3	1973Q1–1996Q1	1973Q1–1997Q4
Speed of adjustment	–0.281	–2.07	–0.144	–0.147
	(–5.017)	(–5.347)	(–4.258)	(–4.468)
Constant	2.400	2.740	3.478	3.307
	(7.258)	(8.521)	(5.859)	(6.306)
comtot	–0.477	–0.529	–0.653	–0.622
	(–7.787)	(–8.367)	(–5.535)	(5.905)
enetot	0.106	0.080	0.037	0.043
	(3.559)	(2.932)	(0.936)	(1.146)
intdif	–0.622	–0.411	–0.565	–0.645
	(–3.234)	(–2.715)	(–3.392)	(–4.474)
proddif	1.059	1.015	0.618	0.414
	(3.994)	(4.044)	(1.812)	(1.790)
R2	0.429	0.415	0.230	0.234
Durbin-Watson	1.637	1.563	1.326	1.369

Note: t-statistics in parentheses.

The first thing to note from the results reported in Table 3 for the government debt variable is that, while *debtdif* often enters equation (2) with the expected positive sign (i.e. higher debt leads to a weaker exchange rate), it is seldom significant. Indeed, the only period in which it has a t-statistic greater than 2.0 is 1973Q1 to 1986Q1, when Canada's debt-to-GDP ratio was growing but still much lower than that of the United States. The productivity variable, in contrast, is significant at the 10% level in all four sample periods (see Table 4), but always has the wrong sign (i.e. higher relative productivity leads to a weaker exchange rate). When both variables are entered into the equation simultaneously, they become highly significant over the last two sample periods, but *proddif* still has the wrong sign. Interestingly, none of the other variables in the original equation is affected by the addition of the new variables, though their t-statistics are sometimes slightly higher (see Table 5).

Table 5
Exchange rate equation with government debt and productivity

Variable	1973Q1–1986Q1	1973Q1–1991Q3	1973Q1–1996Q1	1973Q1–1997Q4
Speed of adjustment	–0.262	–0.216	–0.211	–0.199
	(–3.25)1	(–5.100)	(–5.374)	(–5.178)
Constant	2.568	2.580	2.162	2.206
	(3.879)	(6.222)	(4.917)	(4.801)
comtot	–0.520	–0.491	–0.401	–0.412
	(–3.277)	(–6.075)	(–4.781)	(–4.666)
enetot	0.118	0.084	0.081	0.801
	(2.365)	(3.055)	(2.701)	(2.552)
intdif	–0.844	–0.417	–0.557	–0.685
	(–3.141)	(–2.732)	(–3.484)	(–4.847)
debtdif	–0.205	0.137	0.782	0.637
	(–0.309)	(0.560)	(3.640)	(2.932)
proddif	1.183	1.031	0.898	0.605
	(2.363)	(4.217)	(3.564)	(3.205)
R2	0.418	0.409	0.296	0.273
Durbin-Watson	1.672	1.559	1.366	1.367

Note: t-statistics in parentheses.

3.3 Simulations

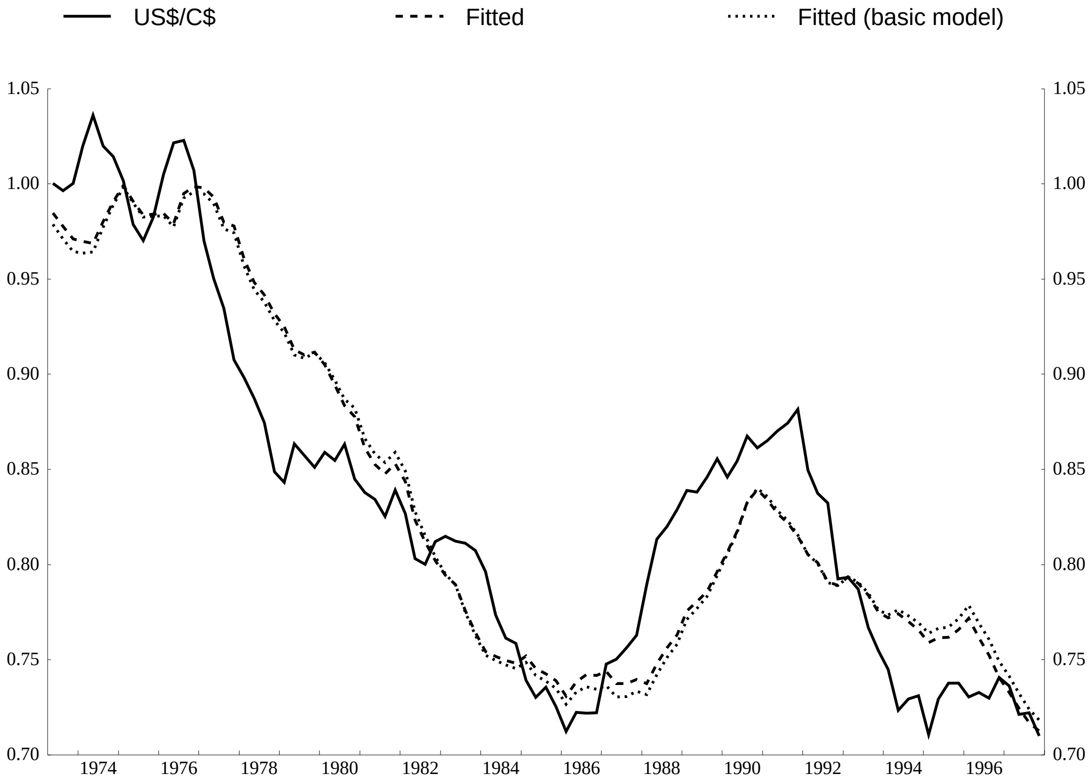
Graphs 3, 4 and 5 compare the actual value of the nominal Canadian-US exchange rate with the simulated value from the original equation and those of equations (2), (3) and (4). Unfortunately, the simulations have to end in 1997Q4 since the debt and productivity variables that we use are not available for 1998 or 1999. While the extra variables seem to improve the explanatory power of the equation, the overshooting that was noted in earlier simulations over much of the 1990s is still evident.

Differences in national debt and labor productivity do not seem to provide the missing link that we were looking for. Neither do they represent a very reliable addition to the basic model that we first examined. Perhaps the overshooting that we have observed has been driven by other forces, such as the destabilizing behavior of noise traders and speculators who, popular wisdom suggests, regularly cause exchange rates to become disconnected from market fundamentals.

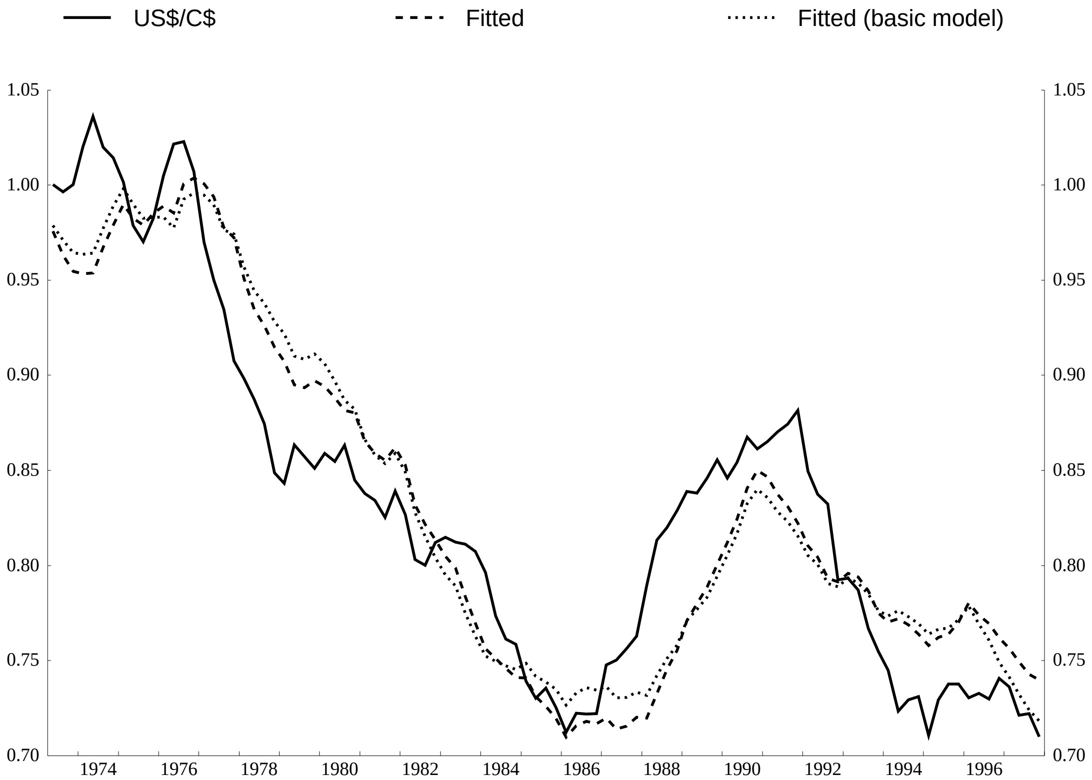
4. Excess volatility and speculative bubbles

Chartists and noise traders are often cast as the villains in any discussion of sudden or unwanted exchange rate movements. This is not to suggest that the stories are untrue, or that speculative activity does not occasionally cause the exchange rate to move in an excessive or misguided manner; simply that there are few credible tests of this proposition. Absent a reliable exchange rate equation that can

Graph 3: Dynamic simulation - with debt

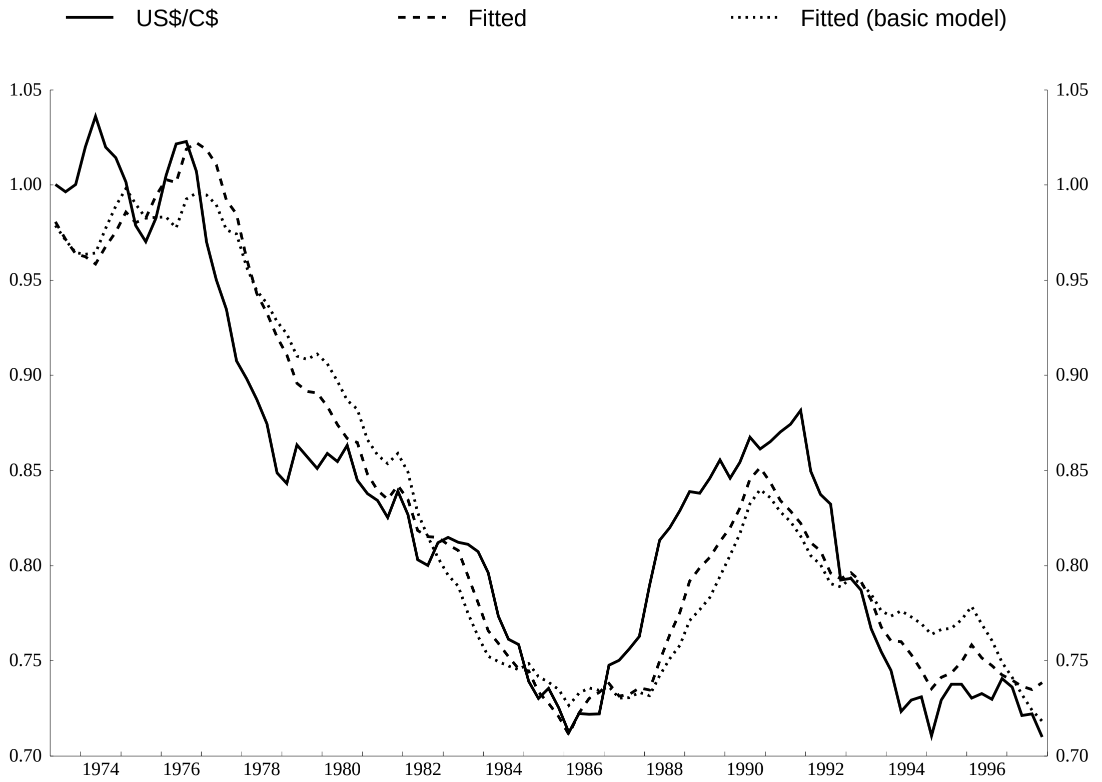


Graph 4: Dynamic simulation - with productivity



tell the authorities exactly where the currency should be at every point in time, it is impossible to make anything other than informed guesses about whether or not the exchange rate has deviated from its fair market value and what might have caused it.

Graph 5: Dynamic simulation - with productivity and debt



The issue of exchange rate overshooting is of critical concern to policymakers, who often worry that excessive volatility in exchange markets will spill over into domestic interest rates and prejudice the central bank's 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 might become self-reinforcing, causing interest rates to jump and pushing monetary conditions much higher at a time when easier conditions would clearly be called for.[13, 14]

In periods such as this, it may be necessary for central banks to raise official short-term interest rates in a pre-emptive manner, in order to calm exchange markets and dampen extrapolative expectations. A tactical manoeuvre like this is undertaken, not because tighter monetary conditions are desired, but to avoid the more dramatic tightening that might otherwise occur if market expectations were to become destabilizing.

[13] Given Canada's past record of exchange rate depreciation and uncertainty associated with financial market volatility, the Bank of Canada has been concerned for many years that there is little firm conviction in financial markets about the appropriate level for the Canadian dollar exchange rate. Consequently, when the Canadian dollar depreciated rapidly, the Bank often raised its Bank Rate in order to provide "comfort" to exchange market participants and contain the potential feedback effects on domestic interest rates. See Zelmer (1996) and Clinton and Zelmer (1997) for a more complete discussion of the tactical challenges confronting Canadian monetary policy.

[14] In the past the Bank also feared that a marked exchange rate depreciation would spark an increase in inflation expectations, thereby putting upward pressure on nominal interest rates – see the 1985 Bank of Canada Annual Report. However, the introduction of inflation targets, and more importantly their achievement, appears to be providing a firmer footing for inflation expectations. The significant depreciation of the Canadian dollar in 1998 was accompanied by a narrowing of the spread between nominal and real return bond yields in Canada and longer-term private sector forecasts of inflation remained firmly rooted around the mid-part of the inflation central target range.

The Bank of Canada engaged in such an exercise in late August 1998, shortly after the collapse of the Russian rouble. The depreciation of the Canadian dollar had started to accelerate, domestic interest rates across the yield curve had moved sharply higher, and there was a growing sense of unease among market analysts and traders. During this episode, the overnight rate was raised by a full percentage point, after which financial markets appeared to calm and the overnight rate was gradually reduced.[15]

The key to any successful operation of this type is to know when destabilizing expectations are beginning to take hold and to apply just enough contractionary medicine to reverse the process. Once conditions have improved, interest rates can be lowered and authorities can guide the economy back to the desired monetary policy track. Ideally, central banks would like to have a model that could tell them exactly when these destabilizing episodes were about to occur. The model would be able to capture the joint effects of fundamentalists and speculative noise traders in the exchange market, and allow the central bank to gauge which group was exerting a stronger influence on the exchange rate at different points in time.

Robert Vigfusson, an economist at the Bank of Canada, developed such a model in 1996, based on a Markov-switching procedure. According to the model, the exchange rate that is actually observed in the market at any time is the result of a complex interaction between two types of agents – fundamentalists, who try to keep the exchange rate close to its true equilibrium value, and noise traders (or chartists), who often cause it to deviate from its fair market value. The actions of fundamentalists are assumed to be guided by the basic exchange rate equation described in Section 2. The fitted values that the equation provides represent the exchange 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, designed to detect shifts in market sentiment and the emergence of new support levels or trends in the exchange rate.

This joint exchange rate determination process is captured by the following equation, in which the expected change in the exchange rate is modeled as a weighted average of the expectations of these two groups:

(5) $$E\Delta s_{t+1} = \omega_t E\Delta s_{t+1}^{f} + (1-\omega_t) E\Delta s_{t+1}^{c}$$

where $E\Delta s$ = expected change in s, s = log of the nominal Canadian-US exchange rate, f,c = superscripts indicating fundamentalists and chartists, and ω = weight assigned to fundamentalists.

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

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

where $\tilde{s}$ = fundamentalists' forecast of s, α^f = a constant, and

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

where ma_{14} and ma_{200} = moving averages used by the chartists to forecast changes in s, and 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 by Vigfusson was to convert quarterly data into a daily frequency using a cubic spline technique. The chartists' equation that he used assumes the following simple (but not unrealistic) behavioral 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

[15] It must be conceded that on the day the Bank acted there were no immediate salutary effects on markets. The exchange rate remained weak that day and interest rate spreads across the yield curve widened out even further (see the empirical results contained in Muller and Zelmer (1999)). However, the situation improved shortly thereafter as expectations of a monetary easing by the Federal Reserve began to emerge and as commodity prices showed signs of stabilizing.

currency. If the 14-day moving average is lower than the 200-day moving average, the currency is sold.[16]

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:

$$\rho(R_t / R_{t-1}) = \Phi(\alpha_f) \tag{8}$$

$$\rho(R_t / R_{t-1}) = \Phi(\alpha_c) \tag{9}$$

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:

$$LLF = \sum_{t=1}^{t} \sum_{t=1}^{t} \rho(R_t) d(s_t | R_t) \tag{10}$$

where $d(s_t|R_t)$ = the normal density function of the regime's residual.

A detailed discussion of the original results 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 had their expected signs and were statistically significant.[17] Second, chartists appeared to dominate the market during tranquil periods – or about 70% of the time. Third, periods of "excess" volatility in the exchange market were typically dominated by fundamentalists, who tried to push the exchange rate back to its equilibrium value. Chartists, it seems, lent a certain inertial force to the market, which generally caused 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 would enter the market and (presumably) realize a profit by pushing the rate back to its appropriate level.

Table 6
Parameter estimates for the Markov-switching model (daily data)

January 1983–December 1992	f	θ	β	σ_f	α_f	
Fundamentalists	0.0001 (2.729)	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)
January 1983–December 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)	–0.00070 (–3.032)	–0.0006 (–5.062)	0.0008 (48.729)	1.6735 (24.386)

Note: t-statistics in parentheses.

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

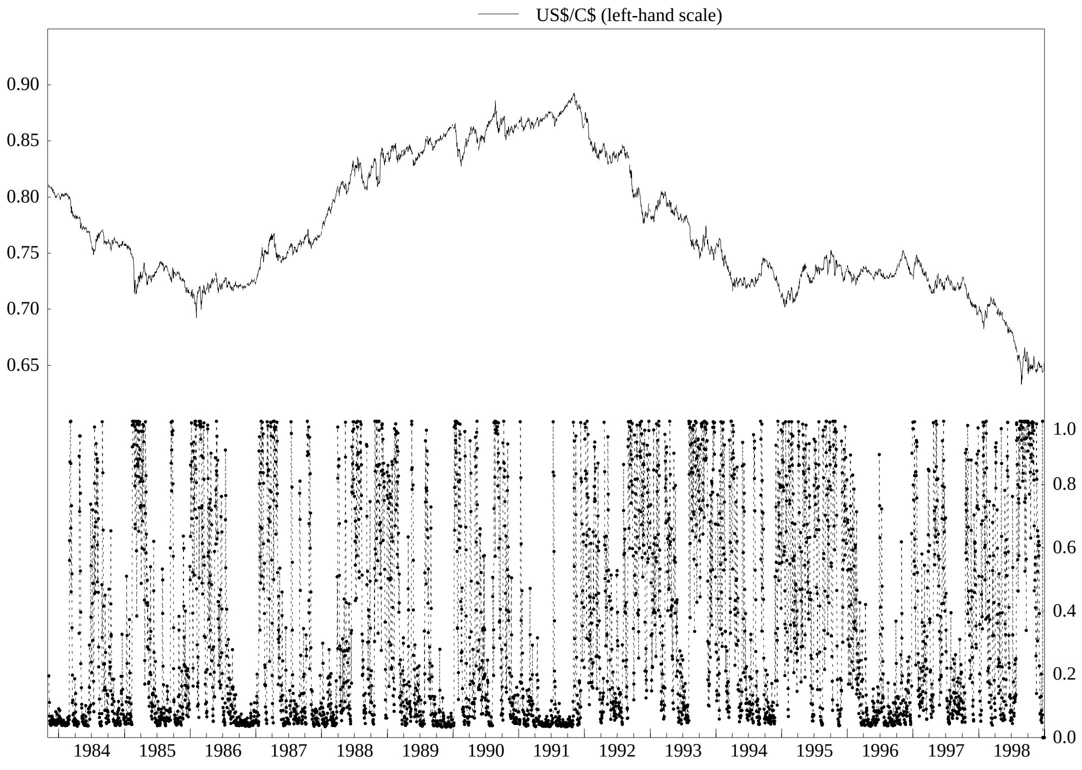
[17] *enetot* had a positive (perverse) sign, but this was expected from our earlier regressions.

Re-running the model with data drawn from the last three years should allow us to determine if the same qualitative results still 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.

The results for both the original regression and the more recent time period are shown in Table 6. As the reader can see, parameter estimates for the two samples are virtually identical. 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 upwards or downwards. Fundamentalists are more prominent during turbulent periods, in which the exchange rate displays greater volatility and moves in a more exaggerated manner.

Graphs 6 and 7 plot movements in the actual exchange 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 graphs 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 (1997Q4–1998Q1 and August 1998) appear to have been dominated by fundamentalists.

Graph 6: Exchange rate and probability of fundamentalist regime

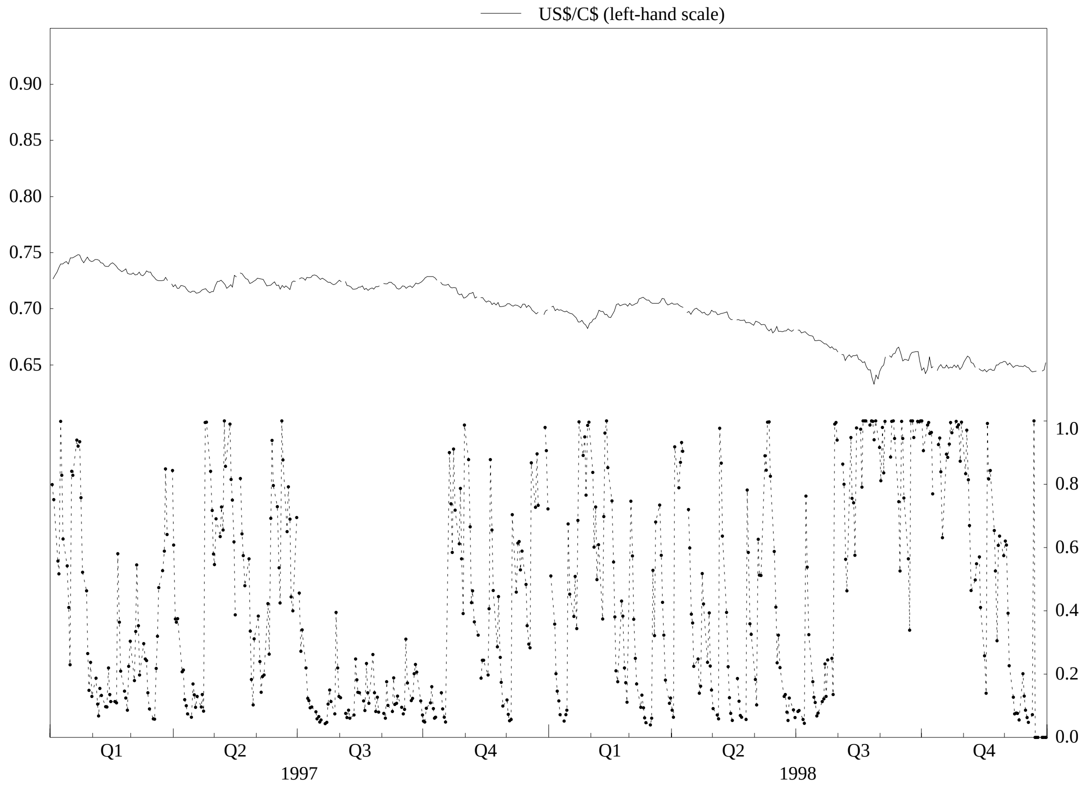


Note: The dotted line (right-hand scale) indicates the probability of being in a fundamentalist regime.

Anecdotal evidence in support of this more benign interpretation of recent events can be found in the trading volumes reported for various government securities and the Canadian dollar. The latter suggest that trading volumes were unusually heavy through this period (i.e. reduced market liquidity was not a problem) and that the ratio of interbank to customer business was not out of line with recent trends (i.e. dealers did not have any difficulty absorbing the large order flow and did not have to rely on the interbank market to take them out of positions). While bid-ask spreads widened through much of 1997 and 1998, and domestic interest rates peaked towards the end of August 1998, these developments were not peculiar to Canada and may have simply reflected a normal adjustment of the real risk premium during a period of increased uncertainty. (Graphs A1 through A9 in Appendix 3 document these changes in greater detail.)

It is important to note that this evidence and the empirical results reported above are only suggestive and cannot speak to the issue of whether or not the Bank of Canada's actions over this period were necessary or helpful. Had it not been for the tactical operations that were undertaken, it is possible that markets would have become seriously destabilized after the collapse of the Russian rouble. Since we cannot perform a true counterfactual experiment, we will never know. In the end, such tactical manoeuvres must always rely on judgment and gut instinct. Given the uncertain nature of the market through the latter part of August and early September 1998, one could regard the 1% increase in official interest rates as prudent insurance, which was unwound shortly thereafter and had little effect on the real economy. It also provided cover for the severe dislocations that were experienced in world financial markets immediately after the problems of Long-Term Capital Management became public.

Graph 7: Exchange rate and probability of fundamentalist regime

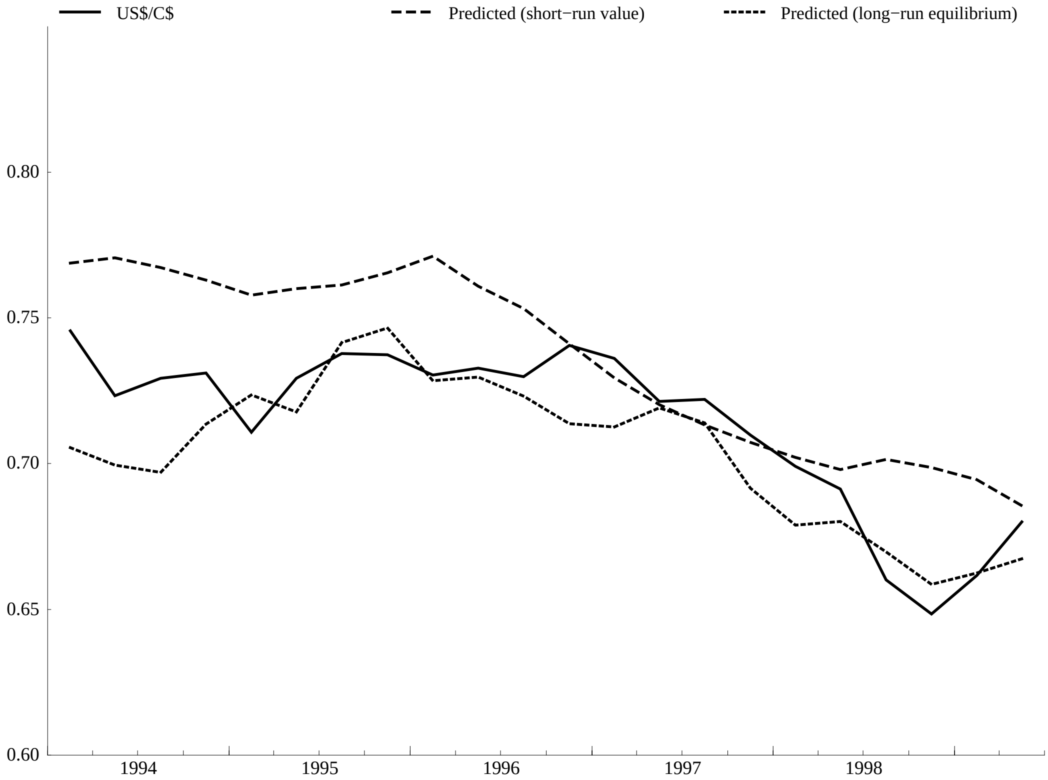


Note: The dotted line (right-hand scale) indicates the probability of being in a fundamentalist regime.

Another question that might be asked regarding the results of our work is how fundamentalists could be seen dominating the market at a time when the actual exchange rate appears to have been somewhat lower than the value predicted by our exchange rate equation (see, for example, Graph 2). More specifically, if the equation that the fundamentalists were using to guide their activities suggests that the dollar was undervalued, why, according to the regime-switching model, were they in the market driving it even lower? The answer hinges on the distinction between short-run and long-run equilibria. While the exchange rate equation captures the average speed of adjustment of *rfx* to external shocks, and indicates where the real exchange rate is expected to be at time *t*, there may be times when the speed of adjustment accelerates or becomes non-linear. The turbulent episodes described above may represent such periods. To give the reader a better idea of how this might operate, Graph 8 plots the actual exchange rate, its predicted short-run value, and its long-run equilibrium value. Viewed in this way, the seeming inconsistency between the results reported above and those reported in Sections 2 and 3 appears to disappear. While the actual exchange rate lies below the short-run values predicted by our model, it is very close to the long-run equilibrium values that the equation generates.

The main message from this work is that periods of volatility are not necessarily associated with instability and exchange rate overshooting. They may be the result of re-equilibrating forces that are trying to correct some earlier mispricing of the exchange rate. It could be a mistake, therefore, to automatically blame any sharp movements in *rfx* on destabilizing speculators.

Graph 8: Predicted short−run and long−run values



5. Policy lessons and conclusions

The empirical results reported in Sections 2, 3 and 4 do not provide any new or convincing evidence of exchange rate misbehavior over the most recent period. While the simulations in Section 2 indicate that the Canadian dollar *might* have been underpriced at certain times during the past two to seven years, the deviations between the actual and fitted values are typically quite small and may have been driven by fundamentals not captured in our simple equation. The determinants of the exchange rate are one of the most difficult things to model in economics, and precise judgments about where the dollar should be at any point in time are beyond our capability. The most significant result reported in the paper, however, is not the extent to which our currency might have been undervalued, but rather the large share of the Canadian dollar's movements that can be explained by two or three fundamental variables. For whatever comfort it provides, the basic equation indicates that the exchange rate is now close to (albeit still slightly below) its equilibrium value, given the fundamentals currently in place. Tests based on the regime-switching model described in Section 4 were also reassuring, and suggest that turbulent periods often coincide with necessary market corrections and should not, therefore, be a source of concern. Indeed, through much of the 1997–98 Asian and Russian crises, fundamentalists as opposed to chartists appeared to be guiding exchange rate movements.

The lessons that policymakers might take from this analysis are threefold. First, and most obviously, international financial crises are difficult, if not impossible, to predict. Any exchange rate forecast is risky and subject to a large margin of error, no matter how reliable the underlying equation might be. Second, most movements in the Canadian dollar (and, one hopes, other exchange rates) are guided by fundamentals as opposed to animal spirits. In an environment where inflation expectations are firmly anchored, policymakers should be wary of resisting them, and should instead consider adjusting their desired monetary policy track rather than automatically raising interest rates in response to any exchange rate pressure. Third, market turbulence does not necessarily imply exchange rate instability. Tactical manoeuvres, in which official interest rates are temporarily increased to support the exchange rate and calm market expectations, should be used sparingly, where such insurance is clearly necessary and the remedial interest rate increases can be quickly reversed.

Our future work in this area will concentrate on two topics. The first will involve a more comprehensive search for alternative explanatory variables that might improve the performance of our exchange rate equation. The second will involve further extensions and testing of Robert Vigfusson's regime-switching model, to see if it can be used to provide reliable real-time guidance to the Bank of Canada in its day-to-day operations.

Appendix 1

Unit root and cointegration tests on the original specification

Amano and van Norden began their search for a new and more reliable exchange rate equation in 1990 by first testing the dependent variable for stationarity. Their results showed that the real exchange rate was non-stationary in levels and was characterized by a unit root. Similar tests conducted over a somewhat longer sample period for purposes of the present paper appear to confirm these earlier results. Based on the Augmented Dickey-Fuller (ADF) tests shown in Table A1, we cannot reject the null hypothesis of a unit root for *rfx*.[18]

The fact that the dependent variable has a unit root is significant for at least three reasons. First, it implies that purchasing power parity does not hold – even in the long run. Second, it implies that cointegration techniques must be used in the analysis to avoid drawing incorrect and misleading inferences from the regression results. Third, it implies that only variables that are also integrated of order one, I(1), can play a role in determining the long-run behavior of the real exchange rate.

Unit root tests conducted on the three explanatory variables in our equation suggest that only *enetot* and *comtot* are I(1), while *intdif* is stationary in levels. As a result, only the first two variables can appear in the error-correction term. *intdif* has to be left outside the parentheses, influencing the short-term dynamics of the real exchange rate but not its long-run value.

Table A1
Tests for unit roots
(1973Q1–1997Q4)

Variable	No. of lags	ADF
rfx	3	–1.040
comtot	5	–1.801
enetot	3	–1.360
intdif	6	–3.280
5% critical value		–2.890
10% critical value		–2.580

If *enetot* and *comtot* are to play a critical role in determining the value of *rfx*, it is not sufficient simply to show that they have a unit root. We must also demonstrate that the dependent variable and the prospective explanatory variables are linked by a stable long-run relationship (or are cointegrated). Although several different approaches can be used to test for cointegration, the most popular and reliable method is the Johansen-Juselius test, which applies maximum likelihood estimation techniques to a full vector-autoregressive system of equations. The results of this test, estimated over the sample period 1973Q1 to 1997Q4, are shown below in Table A2.

Based on the λmax statistics reported in Table A2, only one cointegrating vector can be identified at the 5% critical value. (More specifically, we cannot reject the hypothesis that there are fewer than two cointegrating vectors.) There is no guarantee, however, that this vector links *enetot* and *comtot* to *rfx*. It is possible that the two explanatory variables are cointegrated with one another, and have no influence on the long-run behavior of *rfx*.

To check for this possibility, a separate Johansen-Juselius test was run just on *enetot* and *comtot*. Since no cointegrating vector was identified for these two variables (see Table A3), it appears that they are

[18] This is indicated by the fact that the ADF value shown opposite *rfx* is less than both the 5% and 10% critical values for the ADF test statistic.

only related to *rfx*. Because they are also found to be weakly exogenous, any estimation and inference that is conducted on equation (1) is equivalent to estimating a full system of equations in which *enetot* and *comtot* are also treated as separate dependent variables.[19] We do not have to worry, therefore, about any endogeneity or feedback running from the exchange rate to energy and non-energy commodity prices.

Table A2

Johansen-Juselius test for cointegration on *rfx*, *comtot* and *enetot*

No. of cointegrating vectors under the null hypothesis	λmax statistic	5% critical value
Fewer than 1	32.88	15.59
Fewer than 2	9.47	9.52
Fewer than 3	2.76	2.86
Test for weak exogeneity	LR test	Chi-square critical value
rfx	2.93	3.84
comtot	8.96	3.84
enetot	4.42	3.84

Note: Number of lags for J-J test = 20.

Table A3

Johansen-Juselius test for cointegration *comtot* and *enetot*

No. of cointegrating vectors under the null hypothesis	λmax statistic	5% critical value
Fewer than 1	6.34	9.52
Fewer than 2	4.45	2.86

Note: Number of lags for J-J test = 15.

[19] Weak exogeneity is tested at the bottom of Table 2 with the Chi-square statistic.

Appendix 2

Unit root and cointegration tests for the extended model

As with the original specification, it is important to determine if the new variables, *debtdif* and *proddif*, are stationary in levels or have unit roots. Tests based on the same Augmented Dickey-Fuller procedure that was used earlier in Section 2 indicate that both variables are I(1), and are therefore integrated of the same order as *rfx* (see Table A4).

Table A4
Tests for unit roots (1973Q4–1997Q4)

Variable	No. of lags	ADF
debtdif	8	–1.288
proddif	5	0.613
5% critical value		2.89
10% critical value		2.58

In order to improve the long-run explanatory power of the equation, it is also important that *debtdif* and *proddif* be cointegrated with *rfx*. When the Johansen-Juselius test was applied to the expanded variable list, a second cointegrating relationship was found. However, it is not obvious that the second vector indicates a long-run relationship between one or both of the new variables and the exchange rate. It is possible, as in the basic equation, that the two new variables are simply linked to one another. In order to test the nature of the relationship, separate cointegration tests were run on *debtdif* and *proddif*. The results are reported in Tables A5 and A6.

Table A5
Johansen-Juselius tests for cointegration on *rfx, comtot, enetot, debtdif* and *proddif*

No. of cointegrating vectors in the null hypothesis	Trace statistic	5% critical value
Fewer than 1	88.76	55.44
Fewer than 2	45.36	36.58
Fewer than 3	12.22	21.63
No. of cointegrating vectors under the null hypothesis	λmax statistic	5% critical value
Fewer than 1	43.40	27.62
Fewer than 2	33.15	21.58
Fewer than 3	9.29	15.59

Note: Number of lags for J-J test = 8.

Table A6
Johansen-Juselius tests for cointegration on *debtdif* and *proddif*

No. of cointegrating vectors under the null hypothesis	trace statistic	5% critical value
Fewer than 1	12.16	10.47
Fewer than 2	0.67	2.86
No. of cointegrating vectors under the null hypothesis	λmax statistic	5% critical value
Fewer than 1	11.49	9.52
Fewer than 2	0.67	2.86

Note: Number of lags for J-J test = 16.

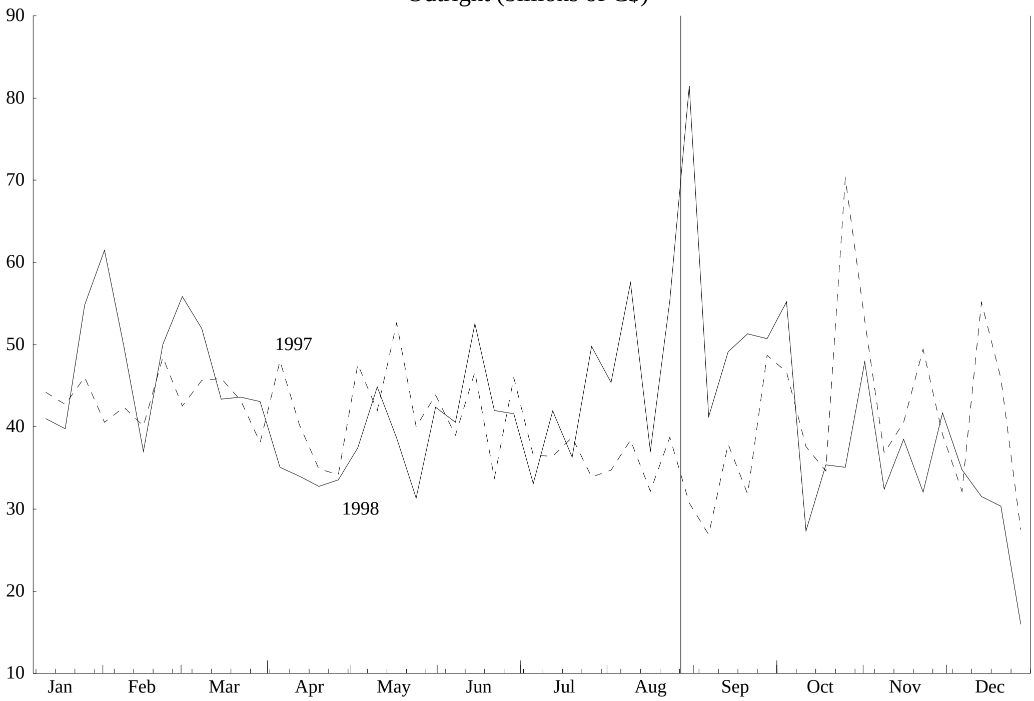
Based on the trace and λmax statistics, the two new variables appear to be related to one another as opposed to *rtf*. While there was not enough time to explore the nature of this relationship in any detail, it would not be surprising if the two were negatively correlated and if higher government debt was seen to cause lower productivity. Pierre St-Amant and David Tessier (1998) have shown in an earlier Bank of Canada Working Paper that higher trend rates of government spending in Canada than in the United States can explain much of the difference in the long-run rates of unemployment in the two countries. Although higher unemployment does not necessarily translate into lower productivity, productivity is known to be procyclical, and increased government regulation and spending are often believed to reduce potential output.

Appendix 3

Trading volumes and ratios of customer to interbank business for government of Canada securities and the Canadian dollar

Graph A1: Customer FX transaction volumes against the C$

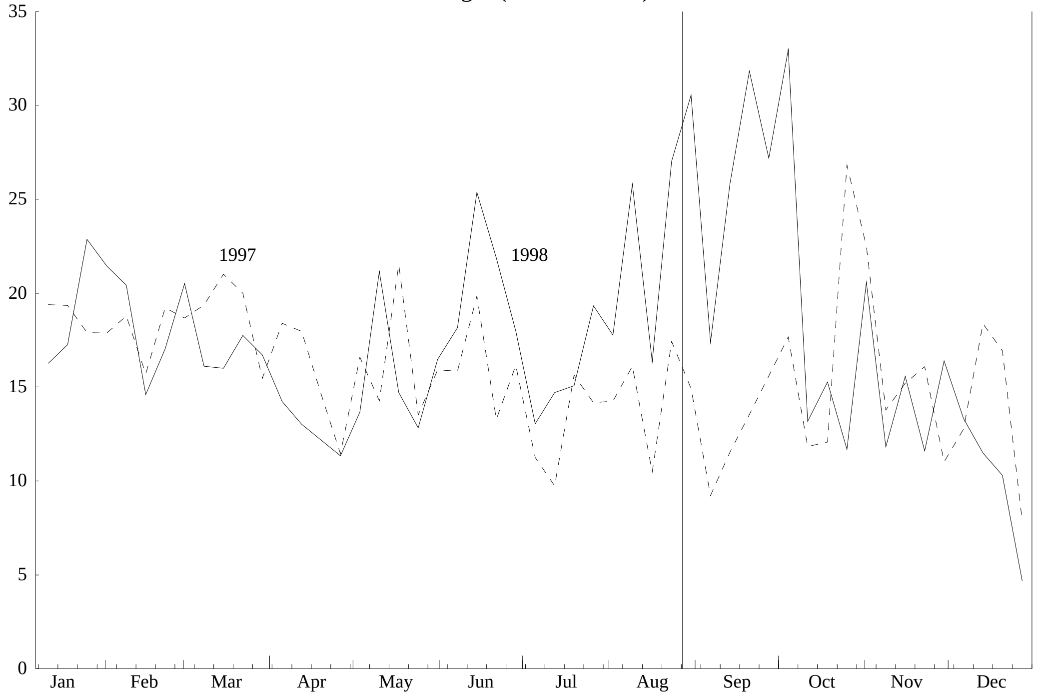
Outright (billions of C$)



Note: Vertical line corresponds to the August 1998 Bank Rate increase.
Source: Weekly transaction volumes reported by Canadian banks each Wednesday.

Graph A2: Interbank FX transaction volumes against the C$

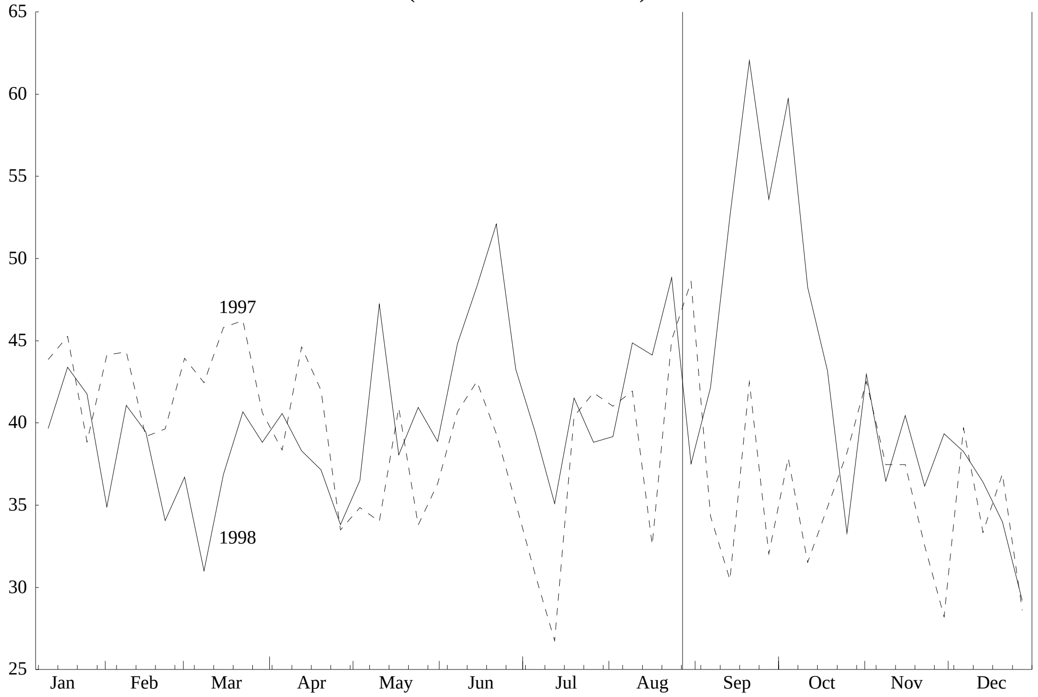
Outright (billions of C$)



Note: Vertical line corresponds to the August 1998 Bank Rate increase.
Source: Weekly transaction volumes reported by Canadian banks each Wednesday.

Graph A3: Interbank FX transaction volumes

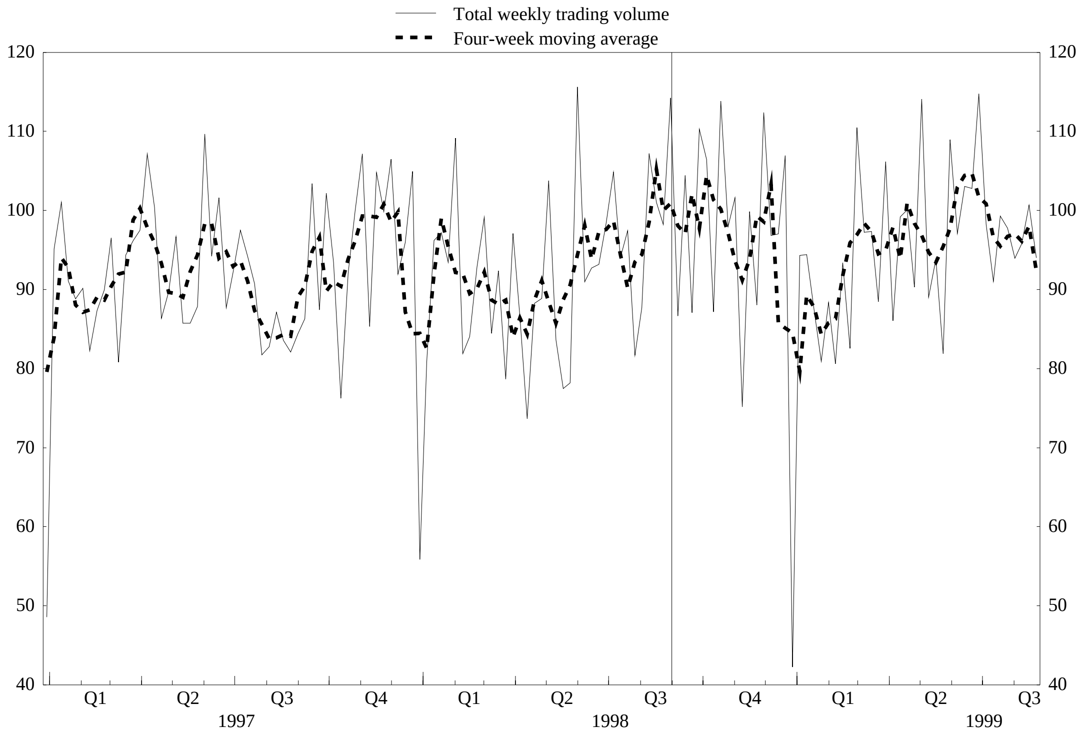
(% of customer volume)



Note: Vertical line corresponds to the August 1998 Bank Rate increase.
Source: Weekly transaction volumes reported by Canadian banks each Wednesday.

Graph A4: Government of Canada weekly T-bill trading volume

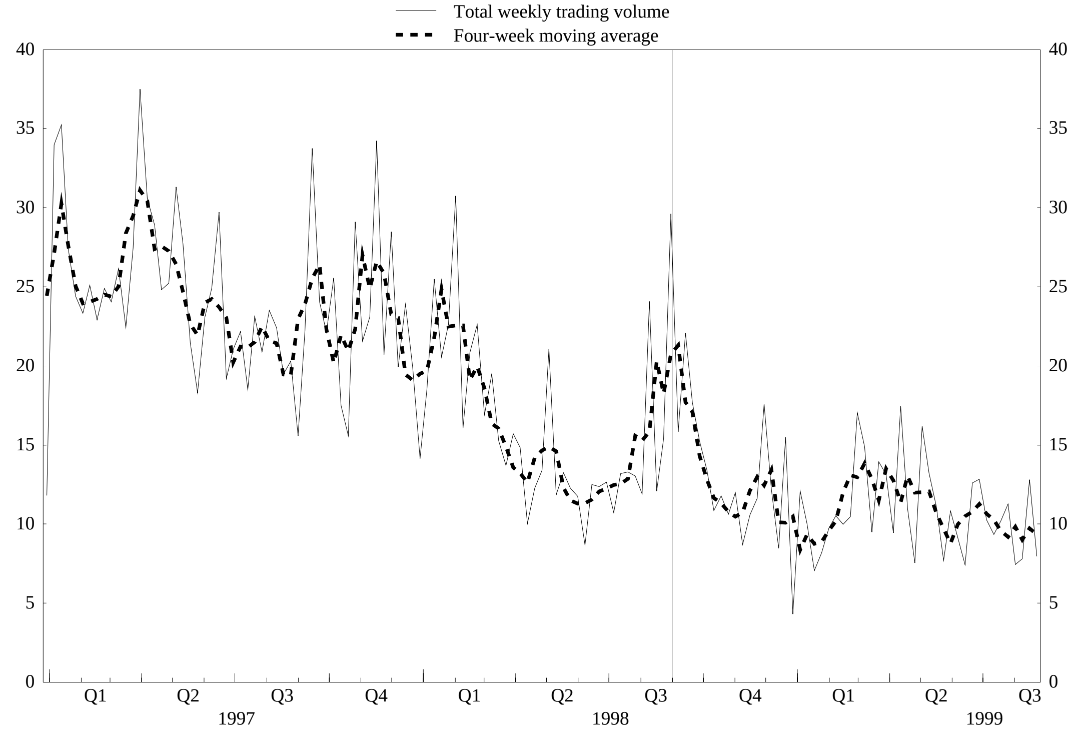
Customer (billions of dollars)



Vertical line refers to August 1998 Bank Rate increase

Graph A5: Government of Canada weekly T-bill trading volume

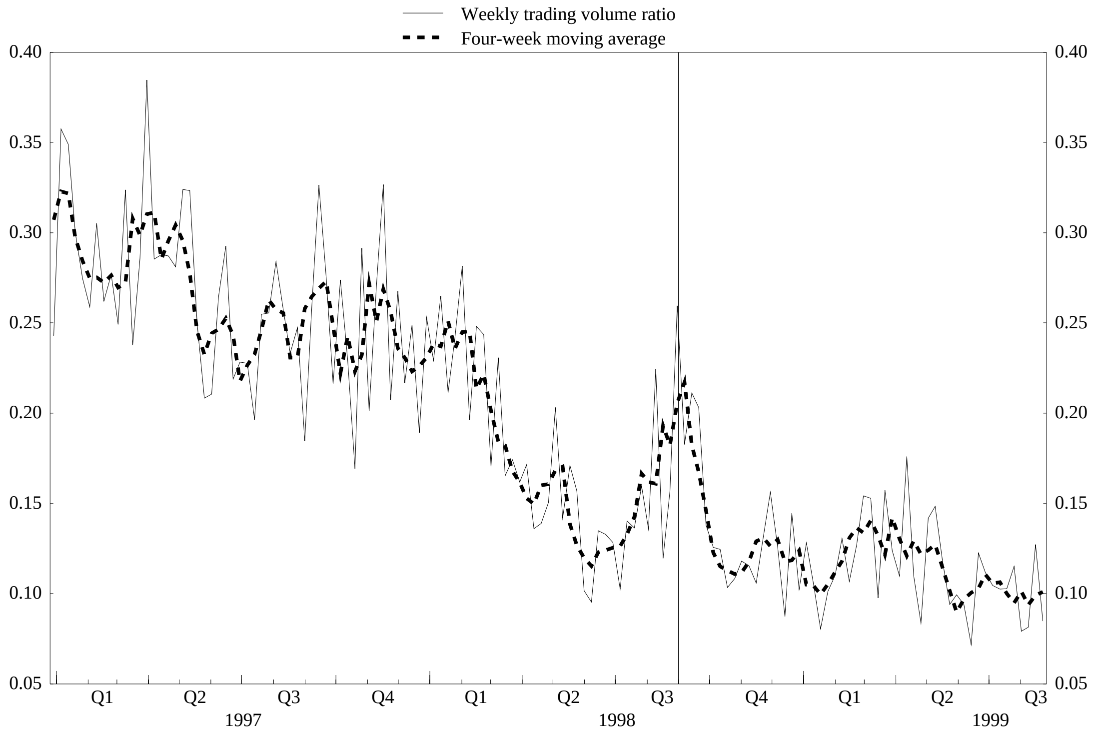
Interdealer (billions of dollars)



Vertical line refers to August 1998 Bank Rate increase

Graph A6: Government of Canada weekly T-bill trading volume

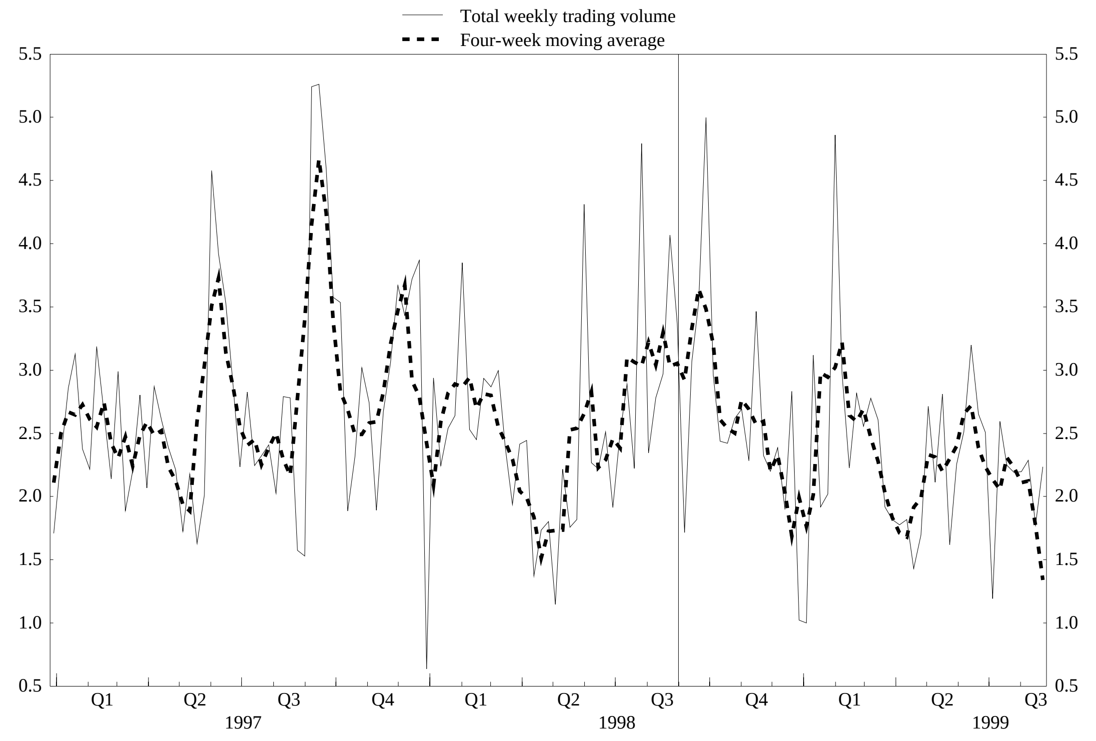
Ratio of interdealer to customer trading volume



Vertical line refers to August 1998 Bank Rate increase

Graph A7: Government of Canada weekly bond trading volume

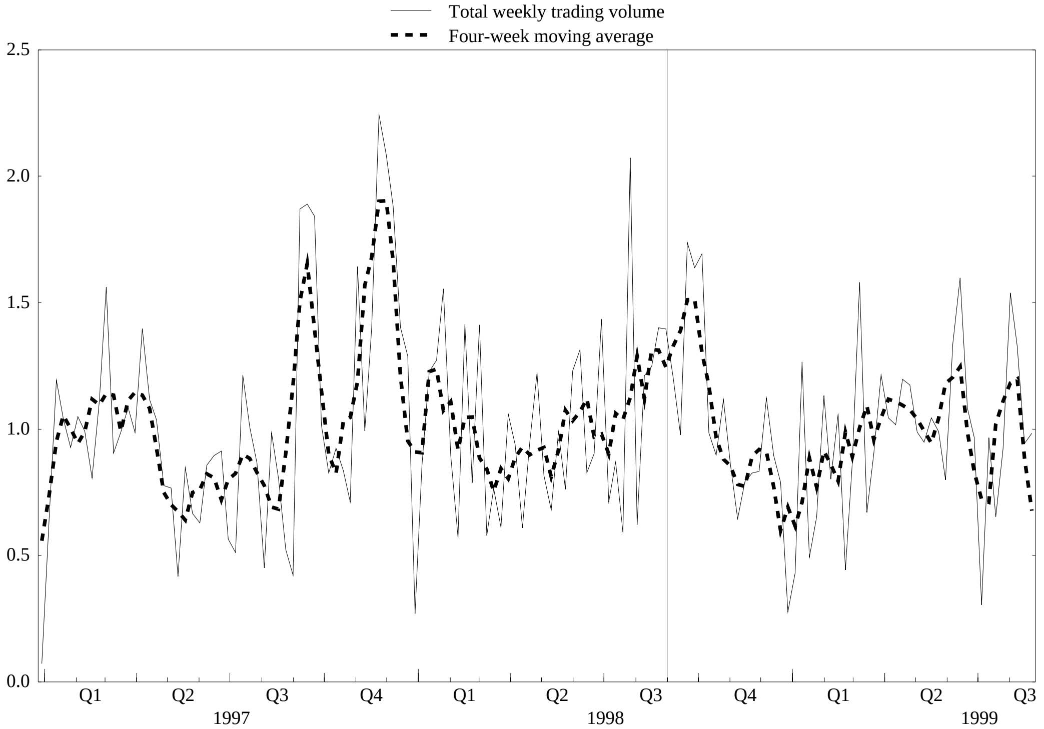
Customer (billions of dollars)



Vertical line refers to August 1998 Bank Rate increase

Graph A8: Government of Canada weekly bond trading volume

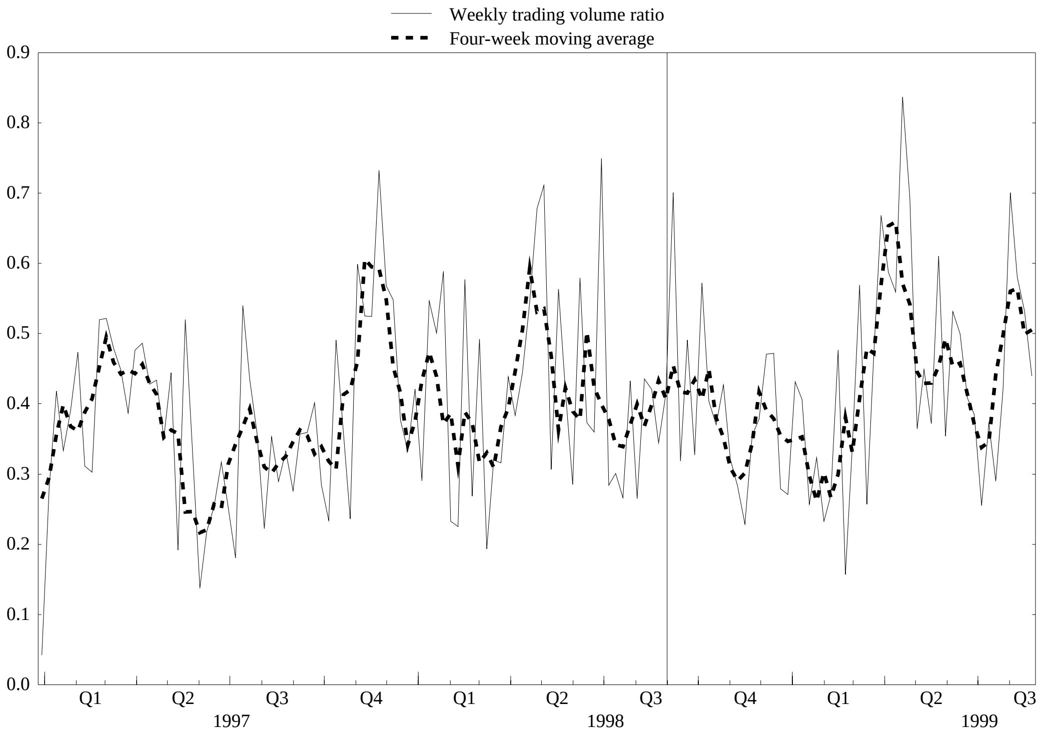
Interdealer (billions of dollars)



Vertical line refers to August 1998 Bank Rate increase

Graph A9: Government of Canada weekly bond trading volume

Ratio of interdealer to customer trading volumes



Vertical line refers to August 1998 Bank Rate increase

Bibliography

Amano, R and S van Norden (1993): "A Forecasting Equation for the Canada-U.S. Dollar Exchange Rate", in *The Exchange Rate and the Economy*, proceedings of a conference held at the Bank of Canada, 22–23 June 1992, Bank of Canada.

Clinton, K and M Zelmer (1997): "Constraints on the Conduct of Canadian Monetary Policy in the 1990s: Dealing with Uncertainty in Financial Markets". *Bank of Canada Technical Report*, No. 80.

Dickey, D A and W A Fuller (1979): "Distributions of the Estimators for Autoregressive Time Series with a Unit Root". *Journal of the American Statistical Association*, 74, pp. 427-31, June.

Dornbusch, R (1979): "Monetary Policy Under Exchange Rate Flexibility", in *Managed Exchange-Rate Flexibility: The Recent Experience*, Federal Reserve Bank of Boston Conference Series No. 20, Federal Reserve Bank of Boston.

International Monetary Fund: "World Economic Outlook". October 1996, May 1997 and August 1999.

Johansen, S (1988): "Statistical Analysis of Cointegration Vectors". *Journal of Economic Dynamics and Control*, 12, pp. 231-54, June-September.

Johansen, S and K Juselius (1990): "Maximum Likelihood Estimation and Inference on Cointegration with Applications to the Demand for Money". *Oxford Bulletin of Economics and Statistics*, 52, pp. 169-210, May.

McCallum, J (1998): "Government Debt and the Canadian Dollar". Royal Bank of Canada Current Analysis, Vol. 2, No. 10, September.

Macklem, T (1993): "Terms of Trade Shocks, Real Exchange Rates Adjustment, and Sectoral and Aggregate Dynamics", in *The Exchange Rate and the Economy*, proceedings of a conference held at the Bank of Canada, 22–23 June 1992, Bank of Canada.

Muller, P and M Zelmer (1999): "Greater Transparency in Monetary Policy: Impact on Financial Markets". *Bank of Canada Technical Report*, No. 86.

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

Orr, D (1999): "Why Do Such Bad Things Happen to Such a Good Economy?" WEFA Canada, May.

Rubin, J and P Buchanan (1996): "Do Fundamentals Justify An 80 Cent C$?" Wood Gundy *Economics Occasional Report*, No. 16, 3 December.

St-Amant, P and D Tessier (1998): "Tendance des dépenses publiques et de l'inflation et évolution comparative du taux de chômage au Canada et aux États-Unis". *Bank of Canada Working Paper*, No. 98-3.

Tessier, D and R Djoudad (1999): "Certaines évidences empiriques relatives à l'évolution du taux de change Canada/É.U." Bank of Canada, February.

Vigfusson, R (1996): "Switching Between Chartists and Fundamentalists: A Markov–Switching Approach". *Bank of Canada Working Paper*, No. 96-1.

Zelmer, M (1996): "Strategies Versus Tactics for Monetary Policy Operations", in *Money Markets and Central Bank Operations*, proceedings of a conference held by the Bank of Canada, November.