Advanced Topic 7:
Exchange Rate Determination IV

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Our major task here is to look at the evidence regarding the effects of unanticipated money shocks on real exchange rates.[1] Given the propensity for overshooting, we would expect positive unanticipated excess domestic money supply shocks to have substantial negative effects on real exchange rates as home residents re-balance their portfolios by buying assets abroad. In addition, it is necessary to determine whether such positive exogenous unanticipated monetary shocks have had downward effects on domestic relative to U.S. interest rates as is widely claimed in the financial press. We must keep in mind that nominal exchange rates and price levels, but not real exchange rates, will change through time as a result of correctly anticipated monetary shocks.

The first problem is to identify the portions of observed changes in the monetary aggregates that are unanticipated—that is, the percentage deviations of the monetary aggregates from their expected levels. Five alternative methods of establishing the expected levels of each monetary aggregate are used here. Logarithms of the levels of the monetary aggregates and nominal GDPs of the U.S., Canada, the U.K., Japan, France and Germany were used in the calculations noted blow. The alternative expected levels of each monetary aggregate in each quarter are the predicted values generated by one of the following five processes:[2]

[1] The expected levels are those predicted by 10-year running regressions of the actual level of the monetary aggregate on the levels of itself and nominal GDP in the previous eight quarters.

[2] The expected levels are those predicted by 10-year running regressions of the level of the monetary aggregate on its own levels in the previous eight quarters.

[3] The expected levels are those predicted by regressions of the current level of the aggregate on those of the eight past periods of itself and of GDP that are statistically significant. For each regression the statistically significant lags are obtained by starting with 8 lags and successively dropping the least significant of these lags in repeated test runs of the regression until all

[1] The material discussed here is discussed in much more detail in Chapters 11 and 12 of J. E. Floyd, *Interest Rates, Exchange Rates and World Monetary Policy*, Springer-Verlag 2010.

[2] These unanticipated money shock series were calculated in `XLispStat` using the batch files `uamonus.lsp`, `uamonca.lsp`, `uamonuk.lsp`, `uamonjn.lsp`, `uamonfr.lsp` and `uamongr.lsp` and saved in forms that were read into the `XLispStat`, `Excel` and `Gretl` data files `jfumdata.lsp`, `jfumdata.xls` and `jfumdata.gdt`. In the process the above batch files created the output files `uamonus.lou`, `uamonca.lou`, `uamonuk.lou`, `uamonjn.lou`, `uamonfr.lou` and `uamongr.lou`.

remaining lags are significant at the 5% level. The first period's regression, which produces the expected level of the relevant monetary aggregate for the first quarter of 1974, uses all available data prior to that date, with an additional quarter of data added for each subsequent period's regression.

[**4**] The expected level of each aggregate is determined by a process identical to the one immediately above except that no more than 10 years of data are used in each period's regression. Once a date is reached for which the running regression uses 10 years of data, the addition of the each subsequent quarter of data is accompanied by the removal of the earliest quarter to maintain the sample size at 40 quarters.

[**5**] The expected levels are determined by running trend projections of the level of the aggregate using its values in the previous 8 quarters.

The above unanticipated money shock series are then added, one-by-one, to the regressions of real exchange rates on the real factors that were found in *Advanced Topic 6: Exchange Rate Determination III* to affect them. They are also added to the domestic with respect to U.S. interest rate differential regressions in the above previous topic to determine if domestic money shocks have the negative effects on interest differentials postulated by those who argue that monetary policy operates through its effects on interest rates. Also the previous periods' actual quarter-over-quarter and year-over-year rates of money growth are added to the interest rate differential regressions to determine whether they have affected expectations of inflation and thereby domestic relative to U.S. interest rates. In addition, regressions of the rates of money growth on the interest rate differentials alone are run to determine if a negative relationship between domestic money growth and these interest rate differentials is evident. Corresponding U.S. monetary variables are also included in all the above regressions.

In the case of Canada with respect to the United States, the unanticipated money supply shocks, calculated in the five different ways, were added to the regression presented in the left-most column of Table 1 of *Advanced Topic 6: Exchange Rate Determination III.* The magnitudes and statistical significance of the original variables in that regression were not much affected by the addition of the unanticipated money shock variables. The evidence presented in Table 1 below provides no basis for concluding that unanticipated money supply shocks have had negative effects of importance on the real exchange rate.[3] The signs of the Canadian anticipated money shock variables were nearly everywhere positive, the opposite of what one would expect, and in some cases statistically significantly so.

In Table 2 below, there is evidence that last period's quarter-over-quarter Canadian M2 growth when added to the short-term interest rate differential regressions produced in *Advanced Topic 6: Exchange Rate Determination III* was positively related to current domestic minus U.S. interest rate differentials and were therefore

[3]The calculations here were performed the `Gretl` and `XLispStat` files `rexcaus.inp` and `rexcaus.lsp` that were used in the previous Topic, using the data files `jfdataqt.gdt` and `jfdataqt.lsp` together with the previously noted specially constructed data files `jfumdata.gdt` and `jfumdata.lsp`. The output files are, as before, `rexcaus.got` and `rexcaus.lou`.

Table 1: The signs and statistical significance of unanticipated money shocks added to the basic Canada vs. U.S. real exchange rate regression.

Expectations Formation	Canadian Base	U.S. Base	Canadian M1	U.S. Base	Canadian M2	U.S. Base
[1]	$+^{**}$	+	+	+	+	+
[2]	+	+	+	+	−	+
[3]	+	+	+	+	$+^{*}$	+
[4]	+	+	+	+	+	+
[5]	−	+	+	+	−	+
		U.S. M1		U.S. M1		U.S. M1
[1]	$+^{***}$	−	+	−	$+^{*}$	−
[2]	+	−	+	−	−	−
[3]	+	+	−	+	$+^{*}$	+
[4]	$+^{*}$	−	+	−	+	+
[5]	−	−	+	−	−	−
		U.S. M2		U.S. M2		U.S. M2
[1]	$+^{***}$	$-^{*}$	+	$-^{*}$	+	−
[2]	+	−	+	−	−	−
[3]	+	−	+	−	$+^{*}$	−
[4]	$+^{*}$	$-^{*}$	+	$-^{**}$	+	$-^{*}$
[5]	−	$-^{**}$	+	$-^{***}$	−	$-^{***}$

Notes: The superscripts *, ** and *** denote significance at the 10 percent, 5 percent and 1 percent levels respectively.

good predictors of expected Canadian relative to U.S. inflation. And year-over-year Canadian M2 growth was positively related to the interest differentials on long-term government bonds, and treasury bill rate differentials as well. There is little evidence that, holding Canadian money growth constant, last period's U.S. money growth had any significant effects on the interest rate differentials. This suggests that lagged U.S. money growth was either poorly related to inflationary expectations in the United States, which would seem unlikely, or equally affected inflation expectations in both countries, therefore leaving Canada vs. U.S. interest rate differentials unaffected.

Table 2: The signs and statistical significance of 1-period lagged quarter-over-quarter and year-over-year money growth added to the basic Canada vs. U.S. interest rate differential regressions.

Monetary Aggregate		Interest Rate Differential: Canada minus U.S.							
		1-Month Corporate Paper		3-Month Corporate Paper		Treasury Bill		Long-Term Government Bonds	
Canada	U.S.	Quarter-Over-Quarter: Lagged One Quarter							
Base	Base	−	−	−	−	−	−	$-^{**}$	+
	M1	−	−	−	+	−	−	$-^{**}$	+
	M2	−	+	−	+	−	−	$-^{**}$	$-^{**}$
M1	Base	−	−	−	−	−	−	−	−
	M1	−	−	−	+	−	−	$-^{*}$	+
	M2	−	+	−	+	−	+	−	−
M2	Base	$+^{**}$	−	$+^{**}$	−	$+^{***}$	−	+	−
	M1	$+^{**}$	−	$+^{**}$	−	$+^{***}$	−	+	+
	M2	$+^{**}$	−	$+^{**}$	−	$+^{***}$	−	+	$-^{*}$
		Year-Over-Year: Lagged One Quarter							
Base	Base	+	−	+	−	+	−	−	+
	M1	+	−	+	+	+	+	−	$+^{*}$
	M2	+	−	+	−	+	−	−	$-^{**}$
M1	Base	−	−	−	−	−	−	−	+
	M1	−	+	−	+	$-^{*}$	+	−	$+^{*}$
	M2	−	−	−	−	−	−	−	$-^{***}$
M2	Base	+	−	+	−	$+^{**}$	−	$+^{**}$	−
	M1	+	+	+	+	$+^{**}$	+	$+^{**}$	$-^{*}$
	M2	+	−	+	−	$+^{**}$	−	$+^{*}$	$-^{**}$

Notes: The superscripts *, ** and *** denote significance at the 10 percent, 5 percent and 1 percent levels respectively. The magnitudes and statistical significance of the original variables in that regression are not much affected by the addition of the lagged money growth variables.

Finally, there is clear strong evidence in Table 3 below that unanticipated Canadian base money shocks, when added to basic regressions determining interest rate differential in Table 3.1 of the previous Topic noted above, were negatively related to Canada minus U.S. interest rate differentials and a negative relationship also was present for Canadian M1 in a few cases.[4].

Table 3: The signs and statistical significance of unanticipated money shocks added to the basic Canada vs. U.S. interest rate differential regressions.

	1-Month Corporate Paper Rate					
Expectations Formation	Canadian Base	U.S. Base	Canadian M1	U.S. Base	Canadian M2	U.S. Base
[1]	−**	+	−	−	+	−
[2]	−***	−	−*	−	+	−
[3]	−***	+	−**	−	+	−
[4]	−	+	−**	−	−	−
[5]	−***	+	−	−	+	−
		U.S. M1		U.S. M1		U.S. M1
[1]	−**	+	−	+	+	−
[2]	−***	−	−	−	+	−
[3]	−**	−	−**	+	+	−
[4]	−*	+	−***	+	−	+
[5]	−***	+	−	−	+	−
		U.S. M2		U.S. M2		U.S. M2
[1]	−**	+*	−	+**	+	+
[2]	−***	+	−*	+	+	+
[3]	−**	+	−*	+	+	+
[4]	−*	+*	−**	+**	−	+**
[5]	−***	+	−	+	+	+

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[4]The magnitudes and significance of the varibles in those regressions were not much affected by addition of the unanticipated money shock variables. Even though the negative relationship between unanticipated Canadian M1 shocks and the interest rate differentials is weaker and a negative relationship of Canadian M2 shocks and the interest rate differentials essentially non-existent, this empirical evidence is important because it is the stock of base money that the Bank of Canada directly controls

Table 3 continued from previous page.

	3-Month Corporate Paper Rate					
Expectations Formation	Canadian Base	U.S. Base	Canadian M1	U.S. Base	Canadian M2	U.S. Base
[1]	$-^{**}$	$-$	$-$	$-$	$+$	$-$
[2]	$-^{***}$	$+$	$-$	$-$	$+$	$-$
[3]	$-^{***}$	$+$	$-^{**}$	$-$	$+$	$-$
[4]	$-^{*}$	$+$	$-^{**}$	$-$	$-$	$-$
[5]	$-^{***}$	$+$	$-$	$-$	$+$	$-$
		U.S. M1		U.S. M1		U.S. M1
[1]	$-^{**}$	$+$	$-$	$+$	$+$	$+$
[2]	$-^{***}$	$+$	$-$	$-$	$+$	$-$
[3]	$-^{***}$	$+$	$-^{**}$	$+$	$+$	$-$
[4]	$-^{*}$	$+$	$-^{**}$	$+$	$-$	$+$
[5]	$-^{***}$	$+$	$-$	$-$	$+$	$-$
		U.S. M2		U.S. M2		U.S. M2
[1]	$-^{**}$	$+^{*}$	$-$	$+^{**}$	$+$	$+^{**}$
[2]	$-^{***}$	$+$	$-$	$+$	$+$	$+$
[3]	$-^{**}$	$+$	$-^{**}$	$+$	$+$	$+$
[4]	$-^{*}$	$+$	$-^{**}$	$+^{**}$	$+$	$-^{*}$
[5]	$-^{***}$	$+$	$-$	$+$	$+$	$+$

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Table 3 continued from previous page.

	Treasury Bill Rate					
Expectations Formation	Canadian Base	U.S. Base	Canadian M1	U.S. Base	Canadian M2	U.S. Base
[1]	$-^{*}$	$+$	$-^{*}$	$-$	$+^{**}$	$-$
[2]	$-^{***}$	$-$	$-^{**}$	$-$	$+$	$-$
[3]	$-^{***}$	$-$	$-^{***}$	$-$	$+^{***}$	$-$
[4]	$-^{*}$	$-$	$-^{**}$	$-$	$+$	$-$
[5]	$-^{***}$	$-$	$-$	$-$	$+$	$-$
		U.S. M1		U.S. M1		U.S. M1
[1]	$-^{**}$	$+$	$-^{*}$	$+$	$+$	$+$
[2]	$-^{***}$	$-$	$-^{*}$	$+^{*}$	$+$	$-^{*}$
[3]	$-^{***}$	$+$	$-^{***}$	$+$	$+$	$-$
[4]	$-^{*}$	$+$	$-^{**}$	$+$	$-$	$+$
[5]	$-^{***}$	$-$	$-$	$-$	$+$	$-$
		U.S. M2		U.S. M2		U.S. M2
[1]	$-^{**}$	$+$	$-^{*}$	$+^{*}$	$+$	$+^{*}$
[2]	$-^{***}$	$+$	$-^{*}$	$+$	$+$	$+$
[3]	$-^{**}$	$+$	$-^{**}$	$-$	$+$	$-$
[4]	$-^{**}$	$+$	$-^{*}$	$+$	$-$	$+$
[5]	$-^{***}$	$+$	$-$	$+$	$+$	$+$

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Table 3 continued from previous page.

	Long-Term Government Bond Rate					
Expectations Formation	Canadian Base	U.S. Base	Canadian M1	U.S. Base	Canadian M2	U.S. Base
[1]	$-^{**}$	$+^{**}$	$-$	$+$	$+$	$+^{*}$
[2]	$-^{**}$	$+$	$-$	$+$	$+$	$+$
[3]	$-^{***}$	$+$	$-^{**}$	$+$	$+$	$+$
[4]	$-^{*}$	$+^{**}$	$-$	$+^{**}$	$-$	$+^{***}$
[5]	$-^{***}$	$+$	$-$	$-$	$-$	$-$
		U.S. M1		U.S. M1		U.S. M1
[1]	$-^{*}$	$+^{***}$	$-$	$+^{***}$	$+$	$+^{***}$
[2]	$-^{**}$	$+^{**}$	$-$	$+^{***}$	$-$	$+^{**}$
[3]	$-^{**}$	$+$	$-^{***}$	$+^{**}$	$+^{*}$	$+$
[4]	$-$	$+^{**}$	$-$	$+^{**}$	$-$	$+^{*}$
[5]	$-^{***}$	$-$	$-$	$-$	$-$	$-$
		U.S. M2		U.S. M2		U.S. M2
[1]	$-$	$+$	$-$	$+^{**}$	$+$	$+$
[2]	$-^{**}$	$+$	$-$	$+$	$-$	$+$
[3]	$-^{**}$	$+$	$-^{**}$	$+$	$+^{*}$	$+$
[4]	$-$	$+$	$-$	$+$	$-$	$+$
[5]	$-^{***}$	$+$	$-$	$-$	$-$	$+$

Notes: The superscripts *, ** and *** denote significance at the 10 percent, 5 percent and 1 percent levels respectively.

Despite this evidence, however, we can not conclude that the Bank of Canada controls domestic interest rates by making changes in base money that are unanticipated by market participants. This is because there is no evidence of effects of such unanticipated base money shocks on Canada's real exchange rate with respect to the U.S. Any negative effect on interest rates of a positive base money shock has to arise because resulting excess money holdings lead to attempts to re-balance portfolios by purchasing non-monetary assets. In an open world capital market, this has to lead to purchases of assets abroad and resulting downward pressure on nominal and real exchange rates. The fact that no effects on the real exchange rate can be found implies that such re-balancing of portfolios was not necessary which, in turn, implies that no unanticipated money shock in fact occurred. This means that the observed unanticipated base money shocks must have been undertaken to maintain portfolio equilibrium in the face of movements in domestic relative to U.S. interest rates that occurred as a result of other forces. That is, the observed money supply shocks should be viewed as Bank of Canada responses to changes in domestic interest rates, not the other way around. This makes it reasonable to believe that the Bank of Canada has avoided overshooting effects of monetary

shocks to the real exchange rate, arising through interest rate changes and other forces, by appropriately adjusting base money in response to demand for money shocks.

Table 4 below presents the results of simple regressions of unanticipated base money shocks on the alternative Canada minus U.S. interest rate differentials and on the Canadian interest rate levels by themselves.

Table 4: OLS Regression analysis of the relation between unanticipated Canadian base money shocks, Canadian interest rates and Canada minus U.S. interest rate differentials, 1974:Q1 to 2007:Q4

Independent Variables	Dependent Variable Unanticipated Canadian Base Money Shock			
Constant	0.076 (0.104)	0.503 (0.173)***	0.097 (0.104)	0.521 (0.176)***
1-Month Corporate Paper Rate Differential	-0.103 (0.050)**			
Canadian 1-Month Corporate Paper Rate		-0.070 (0.020)***		
3-Month Corporate Paper Rate Differential			-0.117 (0.051)**	
Canadian 3-Month Corporate Paper Rate				-0.072 (0.020)***
Number of Observations	136	136	136	136
R-Square	.020	.051	.024	.053

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Independent Variables	Dependent Variable Unanticipated Canadian Base Money Shock			
Constant	0.143 (0.105)	0.503 0.174***	0.126 (0.154)	0.558 (0.280)**
Treasury Bill Rate Differential	-0.122 (0.050)**			
Canadian Treasury Bill Rate		-0.072 (0.021)***		
Long Term Government Bond Rate Differential			-0.166 (0.116)	
Canadian Long-Term Government Bond Rate				-0.070 (0.033)**
Number of Observations	136	136	136	136
R-Square	.028	.051	.010	.027

Notes: The unanticipated money supply shock is the percentage deviation from an expected level calculated process [3] in the text. The figures in brackets are the heteroskedastic and autocorrelation adjusted standard errors calculated by the Gretl statistical program, which chose a band width of 3 and a bartlett kernel. The superscripts ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively, according to a standard t-test.

As expected on the basis of the earlier results, a strong negative relationship exists for all domestic interest rate levels and all interest rate differentials except the long-term government bond rate differential.

Table 5 below presents the signs and statistical significance of United Kingdom and United States unanticipated M0 and M2 shocks when included in the basic real exchange rate regression shown in the left-most column of Table 4 in *Advanced Topic 6: Exchange Rate Determination III.* The sample period was shortened to end with the first quarter of 2006 because the British monetary aggregate series were unavailable beyond that quarter.[5] The magnitudes and statistical significance of the original variables in the regression were not much affected by the addition of the unanticipated money shock variables.

Table 5: The signs and statistical significance of unanticipated money shocks added to the basic United Kingdom vs. United States real exchange rate regression for the sample period 1974:Q1 through 2006:Q1.

Expectations Formation	U.K. M0	U.S. Base	U.K. M2	U.S. Base
[1]	+	+	−	+
[2]	−***	+	−	−
[3]	−	+	−*	+
[4]	−	+	−	+
[5]	−***	+**	−	+
		U.S. M1		U.S. M1
[1]	+	−	−	−
[2]	−***	+	−	+
[3]	−	+	−*	+
[4]	+	−*	−	−*
[5]	−***	+***	−	+***
		U.S. M2		U.S. M2
[1]	+	+*	−	−*
[2]	−***	−	−	−
[3]	−	−	−*	−
[4]	+	−**	−	−**
[5]	−***	−	−	−

Notes: The superscripts *, ** and *** denote significance at the 10 percent, 5 percent and 1 percent levels respectively.

[5]The calculations here were performed in the previously noted `Gretl` and `XLispStat` input files `rexukus.inp`, `idfukus.inp`, `rexukus.lsp` and `idfukus.lsp` and the results are in the associated output files noted earlier. The data files are the ones used in the previous analysis of the Canada vs. United States case.

The signs of the unanticipated shock to the U.K. M0 aggregate were negative in two-thirds of the regressions and those of the U.K. M2 aggregate were everywhere negative. But statistically significant negative coefficients for the unanticipated M0 shock occurred only when the two crude measures of expectations generation were adopted based on regressions using eight lags of the aggregate itself, and eight quarter trend projections. The unanticipated U.K. M2 shock was only statistically significant at the 10% in three cases. The U.S. unanticipated base money shock was positively signed and statistically significant in a case where U.K. M0 shocks were significant. Since there are six statistically significant negative U.K. M0 shock coefficients and no statistically significant positive ones, the case for concluding that U.K. unanticipated money shocks have impacted on the real exchange rate has some merit.

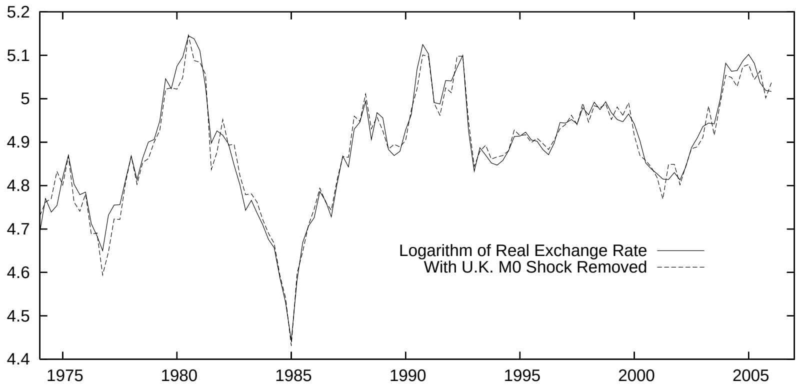

Figure 1: Effects of observed unanticipated United Kingdom M0 shocks, generated using expectations estimation form [2], on that country's real exchange rate with respect to the United States.

As can be seen from Figure 1 above, however, even in the strongest case a trivial portion of the variations of the real exchange rate of the United Kingdom with respect to the United States is accounted for by these unanticipated U.K. M0 shocks. If, as argued in the situation with regards to Canada, the Bank of England is adjusting base money to offset overshooting effects of variations of the U.K. demand for money on the exchange rate, which would be the only reason to make seemingly random adjustments of the M0 aggregate, only the portion of the observed M0 shock that does not offset a corresponding shock to the demand for the aggregate will represent an excess supply shock and thereby affect the real exchange rate. The negative coefficient suggests that the Bank of England has tended to over-compensate for demand-for-money shocks, thereby introducing some minor excess money supply shocks to the real exchange rate in the same direction as the demand-for-money shock.

Turning now to the question of whether U.K. money growth has had an observable effect on the excess of U.K. over U.S. short-term interest rates, the results of adding the growth of the the monetary aggregates to the treasury bill and short-term government bond interest rate differentials regressions are presented in Table 6 below. The magnitudes and statistical significance of the original variables in that regression were not much affected by the addition of the unanticipated money shock variables. The complete lack of statistical significance of the coefficients of the U.K. money growth provides no support for the view that unanticipated money growth negatively affects interest rates.

Table 6: The signs and statistical significance of 1-period lagged quarter-over-quarter and year-over-year money growth added to the basic U.K. vs. U.S. interest rate differential regressions for the sample period 1974:Q1 through 2006:Q1.

Monetary Aggregate		Interest Rate Differential: U.K. minus U.S.							
		Treasury Bill		Long-Term Government Bonds		Treasury Bill		Long-Term Government Bonds	
U.K.	U.S.	Quarter-Over-Quarter, Lagged One Quarter				Year-Over-Year, Lagged One Quarter			
M0	Base	$-$	$+$	$+$	$-$	$-$	$+$	$+$	$-$
	M1	$-$	$+^{***}$	$+$	$+$	$-$	$+^{***}$	$+$	$+$
	M2	$-$	$-$	$+$	$-^{**}$	$-$	$-$	$+^{*}$	$-^{***}$
M2	Base	$+$	$+$	$-$	$-$	$-$	$+$	$-$	$-$
	M1	$+$	$+^{***}$	$-$	$+$	$-$	$+^{**}$	$-$	$-$
	M2	$+$	$-^{*}$	$-$	$-^{**}$	$-$	$-$	$-$	$-^{***}$

Notes: The superscripts *, ** and *** denote significance at the 10 percent, 5 percent and 1 percent levels respectively.

The signs and statistical significance of unanticipated shocks to U.K. M0 and M2 when these are added, along with the unanticipated shocks to the U.S. monetary aggregates, to the left-most and right-most U.K. minus U.S. interest rate differential regressions in Table 3.5 in *Advanced Topic 6: Exchange Rate Determination III* are presented in Table 7 on the next page. Although the signs of the original variables in those regressions were unaffected and the magnitudes of the coefficients not substantially affected, the statistical significance of the energy price variable was eliminated in almost every treasury bill rate differential regression. The unanticipated U.K. M0 shock bears a negative relationship to both U.K. minus U.S. interest rate differentials in every regression in which it is included although it is statistically significant at the 5% level or better in only five of the 30 regressions, all of which involve the treasury bill rate differential. And all of these five cases involve the same two crude measures of the unanticipated M0 shock as had

Table 7: The signs and statistical significance of unanticipated money shocks added to the basic U.K. vs. U.S. interest rate differential regressions for the sample period 1974:Q1 through 2006:Q1.

	Treasury Bill Rate					
Expectations Formation	U.S. Base	U.K. M0	U.S. M1	U.K. M0	U.S. M2	U.K. M0
[1]	$+^{***}$	$-$	$+$	$-$	$+$	$-$
[2]	$+$	$-^{***}$	$+$	$-^{***}$	$+$	$-^{***}$
[3]	$+$	$-$	$+^{***}$	$-^{*}$	$-$	$-$
[4]	$+^{**}$	$-$	$+$	$-$	$-$	$-$
[5]	$+^{**}$	$-^{**}$	$+^{**}$	$-^{**}$	$-$	$-^{*}$
		U.K. M2		U.K. M2		U.K. M2
[1]	$+^{***}$	$-$	$+$	$-$	$+$	$-$
[2]	$+$	$+$	$+$	$+$	$+$	$+$
[3]	$+$	$-$	$+^{***}$	$-$	$-$	$-$
[4]	$+^{**}$	$+$	$+$	$-$	$-$	$-$
[5]	$+$	$+$	$+^{**}$	$+$	$-$	$+$
	Long-Term Government Bond Rate					
Expectations Formation	U.S. Base	U.K. M0	U.S. M1	U.K. M0	U.S. M2	U.K. M0
[1]	$+$	$-$	$+$	$-$	$+$	$-$
[2]	$+$	$-$	$+$	$-$	$+^{*}$	$-$
[3]	$+$	$-$	$+^{*}$	$-$	$-$	$-$
[4]	$+$	$-$	$+$	$-$	$+$	$-$
[5]	$+$	$-$	$+$	$-$	$+$	$-$
		U.K. M2		U.K. M2		U.K. M2
[1]	$+$	$-$	$+$	$-$	$+$	$-$
[2]	$+$	$-$	$+$	$-$	$+^{*}$	$-$
[3]	$+$	$-^{*}$	$+^{*}$	$-^{*}$	$+$	$-^{*}$
[4]	$+$	$-^{**}$	$+$	$-^{**}$	$+$	$-^{**}$
[5]	$+$	$+$	$+$	$+$	$+$	$+$

statistically significant negative coefficients in the real exchange rate regressions. The coefficients of the unanticipated U.S. base money shocks were positive in all the regressions that contained them, statistically significantly so in a small number of cases, all of which involved the treasury bill rate differential.

These U.K. results differ in an important way from the Canadian results. There it was concluded that the failure of Canadian unanticipated base money shocks to have observable negative effects on that country's real exchange rate with respect to the United States ruled out the possibility that their observed negative coefficients in the Canada minus U.S. interest rate differentials regressions could represent the effect of unanticipated base money shocks on interest rates. Instead, it was concluded that the observed variations of base money were a response by the Bank of Canada to prevent overshooting exchange rate movements arising from the demand-for-money effects of changes in interest rates arising from other causes. Here in the U.K. situation, the observed negative relationship between unanticipated M0 shocks and the real exchange rate with respect to the U.S. rules is consistent with base money shocks having negative effects on both the real exchange rate and short-term U.K. minus U.S. interest rate differentials in conformity with conventional arguments in the popular press although those arguments rarely mention the exchange rate.

While the observed results do not permit a rejection of the popular view noted above, it also not possible to reject the view suggested by the theory developed here, that unanticipated base money shocks were a response to shocks to the demand for money in order to avoid exchange rate overshooting. This view requires that the observed unanticipated U.K. M0 shocks be a response of the Bank of England to demand for money changes, some arising from interest rate changes occurring in response to other forces in the world economy. Results of regressions of unanticipated M0 shocks on the treasury bill interest rate differential and the U.K. treasury bill rate alone are shown in Table 8 on the next page. Only the two crude measures of the unanticipated M0 shock that were significant in the earlier regressions are used. The expected negative coefficients appear but the results are not strong. A strong negative relationship appears only when the expected M0 level from which unanticipated M0 shocks are derived is a simple eight quarter trend projection.

Table 8: OLS Regression analysis of the relation between unanticipated United Kingdom base money shocks and the U.K. treasury bill rate and U.K. minus U.S. treasury bill rate differential, 1974:Q1 to 2006:Q1

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Independent Variables	Dependent Variable Unanticipated U.K. Base Money Shock [2]		[5]	
Constant	0.099	0.262	0.112	0.975
	(0.133)	(0.225)	(0.249)	(0.332)***
Treasury Bill Rate Differential	-0.084		-0.074	
	(0.043)*		(0.060)	
U.K. Treasury Bill Rate		-0.043		-0.122
		(0.028)		(0.040)***
Number of Observations	129	129	129	129
R-Square	.041	.027	.021	.138

Notes: The unanticipated money supply shocks are the percentage deviations from expected levels calculated according to processes [2] and [5] in the text. The figures in brackets are the heteroskedastic and autocorrelation adjusted standard errors calculated by the Gretl statistical program, which chose a band width of 3 and a bartlett kernel. The superscripts ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively, according to a standard t-test.

Given that the negative coefficients of the unanticipated M0 shock are statistically significant in the real exchange rate and interest rate differential regressions when only two of the five measures of that shock are used, the support for either of these two hypotheses—that money shocks generated by the Bank of England caused the domestic interest rates to change, or alternatively, that interest rate changes caused the Bank of England to adjust the base money stock to prevent overshooting—is weak. Nevertheless, one solid conclusion does emerge. Only tiny portions of observed real exchange rate variability can be accounted for by money supply shocks.

The signs and statistical significance of Japanese and United States unanticipated money shocks when added to the basic regression of the Japanese real exchange rate with respect to the United States on the range of real factors that would be expected to determine it are presented in Table 9 below.[6] The regression to which the unanticipated money shock variables are added is presented in the left-most column of Table 7 in the previous Topic. The magnitudes and statistial significance of the original variables in that regression were not much affected by the addition of the unanticipated money shock variables.

Table 9: The signs and statistical significance of unanticipated money shocks added to the basic Japan vs. U.S. real exchange rate regression.

Expectations Formation	Japanese Base	U.S. Base	Japanese M1	U.S. Base	Japanese M2	U.S. Base
[1]	+	$-^{**}$	+	$-^{*}$	−	$-^{*}$
[2]	+	$-^{**}$	+	$-^{*}$	$+^{***}$	$-^{*}$
[3]	+	$-^{**}$	+	−	+	$-^{*}$
[4]	$+^{*}$	$-^{***}$	+	$-^{*}$	$+^{*}$	$-^{*}$
[5]	+	$-^{*}$	−	−	+	−
		U.S. M1		U.S. M1		U.S. M1
[1]	+	−	+	−	−	+
[2]	+	−	+	−	$+^{***}$	−
[3]	+	−	+	−	+	−
[4]	+	−	+	−	$+^{*}$	−
[5]	+	$-^{***}$	+	$-^{**}$	+	$-^{**}$
		U.S. M2		U.S. M2		U.S. M2
[1]	+	−	+	−	−	−
[2]	+	+	+	+	$+^{***}$	+
[3]	−	−	+	−	+	−
[4]	+	−	+	−	$+^{*}$	−
[5]	+	+	+	−	$+^{*}$	+

Notes: The superscripts *, ** and *** denote significance at the 10 percent, 5 percent and 1 percent levels respectively.

In contrast to the Canadian and British cases, the signs of the Japanese unanticipated base money shock variable is positive in all but one case, but significantly so only once at even the 10% level. And the Japanese unanticipated M1 and M2 shocks also typically have positive signs, significantly so in a few cases involving M2. The U.S. unancitipated base money shock variables have negative signs in all

[6]The statistical calculations presented in this section are performed in the respective `Gretl` and `XLispStat` input files `rexjnus.inp`, `idfjnus.inp`, `rexjnus.lsp` and `idfjnus.lsp` for which the respective output files are `rexjnus.got`, `idfjnus.got`, `rexjnus.lou`, and `idfjnus.lou`. The data files used are the prevously noted ones.

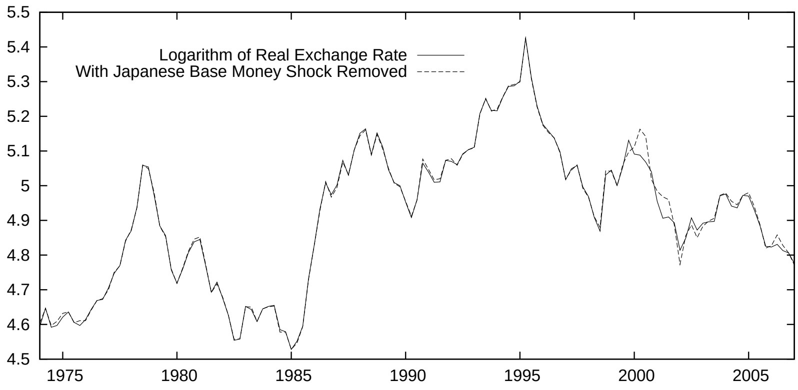

Figure 2: Effects of observed unanticipated Japanese base money shocks, generated using expectations estimation form [5], on that country's real exchange rate with respect to the United States.

15 cases and are statistically significant in four of the five regressions in which the Japanese unanticipated base money shock also appears. The signs of the unanticipated U.S. M1 and M2 shocks are negative in all regressions in the case of M1 and in 10 of the 15 regressions involving M2. There are three statistically significant negative coefficients in the case of U.S. M1, all involving the determination of the expected level by 8 quarter trend projections, and no statistically significant coefficients for U.S. M2.

The positive relationships between the unanticipated Japanese base money shocks and that country's real exchange rate with respect to the U.S. are consistent with an association of positive unexpected domestic money shocks with decreases, not increases in the excess supply of money. This would imply that the Japanese authorities adjusted base money to offset shocks to the demand for money to avoid overshooting, but fell short on average from the full adjustment required. In other words, base money was adjusted in the same direction as changes in the demand for money but by not quite enough to offset completely effect of the changes in the demand for money on the exchange rate. This is in contrast to the British case where the Bank of England seemingly over-adjusted base money by a slight amount.

The negative effects of U.S. money shocks on the Japanese real exchange rate with respect to the U.S. are a bit of a puzzle. One would expect that an unanticipated U.S. money expansion would reduce, not increase, the U.S. real exchange rate with respect to all countries. While negative signs of unanticipated U.S. base money shocks added to the Canadian real exchange rate with respect to the U.S. were frequent, the signs of this variable were typically positive in the case of the U.K. real exchange rate with respect to the U.S. All that can be concluded here is that unanticipated U.S. monetary expansion typically occurred during periods when the Japanese real exchange rate with respect to that country was falling.

As can be seen in Figure 2 above, one clear conclusion does emerge. The effects of unanticipated money supply shocks on the Japanese real exchange rate with respect to the U.S. were of trivial magnitude as compared to the effects of real shocks. The anticipated level of Japanese base money used in generating the data was obtained using OLS projections based on the significant lags of base money and nominal GDP over the previous 10 years. This was the only case in which the unanticipated base money shock was statistically significant at the 10% level or better.

Table 10: The signs and statistical significance of one-period lagged quarter-over-quarter and year-over-year money growth added to the basic Japan minus U.S. interest rate differential regression.

Monetary Aggregate		Long-term Government Bond Rate Differential			
Japan	U.S.	Quarter-Over-Quarter Lagged One Quarter		Year-Over-Year Lagged One Quarter	
Base	Base	$-^{**}$	$+^{**}$	$-$	$+^{**}$
	M1	$-^{*}$	$+^{***}$	$+$	$+^{***}$
	M2	$-$	$+$	$+$	$-$
M1	Base	$-$	$+$	$-$	$+^{**}$
	M1	$-$	$+^{***}$	$-$	$+^{***}$
	M2	$-$	$+$	$-$	$-$
M2	Base	$+^{***}$	$+$	$+$	$+^{**}$
	M1	$+^{**}$	$+^{***}$	$-$	$+^{***}$
	M2	$+^{***}$	$+$	$+$	$-$

Notes: The superscripts *, ** and *** denote significance at the 10 percent, 5 percent and 1 percent levels respectively.

Table 10 above presents the signs and statistical significance of one-period lagged quarter-over-quarter and year-over-year Japanese and United States money growth when added to the regression of the Japanese minus U.S. long-term government bond interest rate differential on various real factors presented in the left-most column of Table 3.8 in *Advanced Topic 6: Exchange Rate Determination III.* The matnitudes and statistical significance of the original variables in the regression were not much affected by the addition of the lagged money growth variables. Japanese quarter-over-quarter M2 growth was positive and statistically significant, as consistent with it having a positive effect on expectations of Japanese inflation. Japanese quarter-over-quarter base money growth, lagged one period, had negative signs and was statistically significant at the 5% level in one of the three cases, suggesting the possibility of negative effects on real interest rates consistent with

the popular view of the effects of monetary expansion. It turns out, however, that the correlation between quarter-over-quarter base money growth in the current period and lagged one period is not statistically significantly different from zero—it is current period base money growth that should negatively affect current interest rates.

The positive effects of Japanese unanticipated money shocks on the real exchange rate with respect to the United States are inconsistent with a negative portfolio-adjustment effect on domestic interest rates of that domestic monetary expansion.

Japanese M1 growth, both quarter-over-quarter and year-over-year always has a negative sign but is never statistically significant. United States quarter-over-quarter money growth is always positive and statistically significant at the 5% level or better in 4 of the 9 cases while U.S. year-over-year base money and M1 growth both have statistically significant positive signs in every case. This says that higher expected Japanese relative to U.S. inflation was associated with more rapid U.S. money growth, which makes no sense from a causal point of view.

The Japanese and U.S. unanticipated money shock variables were added to the basic Japanese minus U.S. long-term interest rate differential regression in the left-most column of Table 3.8 in above-noted previous topic and the signs and statistical significance of the unanticipated money shock variables are presented in Table 11 below. The magnitudes and statistical significance of the original variables in the regression were not much affected by the addition of the unanticipated money shock variables. The Japanese unanticipated base money shock has everywhere a negative sign but is statistically significant at the 5% level or better in only 1 of the 15 cases, which uses 8 quarter trend projections as the estimate of the expected base money levels. Because of the positive relationship of these unanticipated base money shocks to the Japanese real exchange rate with respect to the U.S., one cannot conclude that this represents evidence for the popular view of the negative effects of domestic unanticipated money expansion on domestic relative to foreign interest rates. The evidence is consistent with the view that the Japanese monetary authorities have tended to adjust base money in response to changes in the demand for money to avoid overshooting effects on the exchange rate.

Notice also in Table 11 that the effects of U.S. unanticipated base money shocks on the Japan minus U.S. long-term government bond rate differential were positive in four-fifth of cases but statistically significantly so in only one. Positive signs for unanticipated U.S. M1 shocks were present in all relevant regressions but the relationship was statistically significant in only one-third of the cases. For unanticipated U.S. M2 shocks, there were positive signs in only about one-third of the cases with half of those statistically significant. This evidence is too weak to permit any conclusion regarding the effects of unanticipated U.S. money supply shocks.

Table 11: The signs and statistical significance of unanticipated money shocks added to the basic Japan minus U.S. interest rate differential regression.

	Long-Term Government Bond Rate					
Expectations Formation	Japanese Base	U.S. Base	Japanese M1	U.S. Base	Japanese M2	U.S. Base
[1]	−	+	−	+	−***	+
[2]	−	−	−	−	+	−
[3]	−	+	−	+	−***	+
[4]	−	+	−	+	−***	+
[5]	−**	+**	−	+	−	+
		U.S. M1		U.S. M1		U.S. M1
[1]	−	+	−	+	−***	+
[2]	−	+**	−	+**	+	+**
[3]	−	+*	−	+*	−***	+
[4]	−	+	−	+	−***	+
[5]	−*	+**	−	+**	−	+
		U.S. M2		U.S. M2		U.S. M2
[1]	−*	−	−	−	−***	−
[2]	−	+	−	+	−	+
[3]	−	−	−	−	−**	−
[4]	−	−	−	−	−***	−
[5]	−	+***	−	+***	−	+***

Notes: The superscripts *, ** and *** denote significance at the 10 percent, 5 percent and 1 percent levels respectively.

Table 12 below indicates a statistically significant negative relationship between the Japanese unanticipated base money shock and the Japan minus U.S. interest rate differential on long-term government debt, and a negative though not statistically significant relationship between the unanticipated base money shock and the level of Japanese long-term government bond rates. The overall lack of statistical significance of the Japanese unanticipated base money shock in Table 11, however, weakens any conclusion that the Japanese authorities have adjusted base money in response to changes in domestic interest rates.

Table 12: OLS Regression analysis of the relation between unanticipated Japanese base money shocks and the interest rate on Japanese long-term government bond and the Japan minus U.S. interest rate differential on long-term government bonds.

Independent Variables	Dependent Variable Unanticipated Japanese Base Money Shock Expectations Generating Process [5]	
Constant	-1.899	0.688
	(0.831)**	(1.419)
Long-Term Gov't Bond Rate Differential	-0.507	
	(0.235)**	
Japanese Long-Term Gov't Bond Rate		-0.238
		(0.156)
Number of Observations	135	135
R-Square	.031	.017

Notes: The unanticipated money supply shocks are the percentage deviations from expected levels calculated as eight quarter trend projections. The figures in brackets are the heteroskedastic and autocorrelation adjusted standard errors calculated using XLispStat with a truncation lag of 4. The superscripts ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively, according to a standard t-test.

As in the cases of Canada and the United Kingdom vs. the United States, the main conclusion of our analysis is that Japanese unanticipated money supply shocks can explain only a trivial proportion of the variations of country's observed real exchange rate with respect to the United States.

The signs and statistical significance of unanticipated French and United States money supply shocks when added to the factors determining the French real exchange rate with respect to the U.S. that were presented in the left-most column of Table 9 in the previous Topic are shown in Table 13. The magnitudes and statistical significance of the original variables in that regression are not much affected by the addition of the unanticipated money shock variables.[7] The unanticipated French money supply shocks are never statistically significant at the 5% level or better. And, as shown in Fig. 3 below, the magnitudes of the effects are trivial although a careful examination indicates that the real exchange rate was observably higher as a result of the presence of unanticipated French base money shocks during the 1990s when the country was adjusting its inflation rate downward in preparation for joining the European Monetary System. With respect to the U.S. unanticipated money suppy shocks, statistical significance occurs at the 5% level only 3 times. The signs of the French unanticipated base money shocks are negative in all but one statistically insignificant case as would be consistent with the conclusion that the French authorities slightly over-compensated for demand for money adjustments in managing the stock of base money. They might better be explained, however, by the tightening in the 1990s in preparation for European monetary union. Apart from this important situation, unless one were to believe that the response of the real exchange rate to exogenous base money changes is virtually zero, there is no basis for believing that the observed shocks were exogenous and independent of demand for money changes.

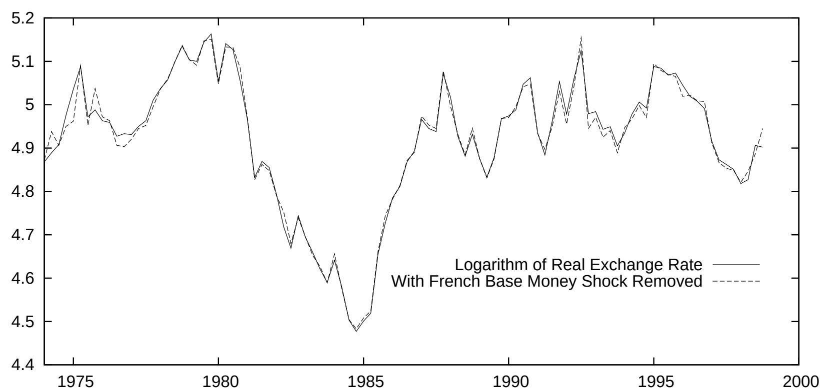

Figure 3: Effects of observed unanticipated French base money shocks, generated using expectations estimation form [3], on that country's real exchange rate with respect to the United States.

[7]The statistical calculations in this section were performed in the `Gretl` and `XLispStat` input files `rexfrus.inp`, `idffrus.inp`, `rexfrus.lsp` and `idffrus.lsp` and the results are in the respective output files `rexfrus.got`, `idffrus.got`, `rexfrus.lou` and `idffrus.lou`. The data files are those used throughout this Topic.

Table 13: The signs and statistical significance of unanticipated money shocks added to the basic France vs. U.S. real exchange rate regression.

Expectations Formation	French Base	U.S. Base	French M1	U.S. Base	French M2	U.S. Base
[1]	−*	+	+	+	−	+
[2]	−	+	+*	+	−	+
[3]	−*	+	+	+	+	+
[4]	−	+	+	+	−	+
[5]	−	+	−	+	−	+
		U.S. M1		U.S. M1		U.S. M1
[1]	−*	+	+	−	−	−
[2]	−	+	+*	+	−	+
[3]	−*	+	+	+	+	+
[4]	−	−	+	−	−	−
[5]	−	+**	−	+**	−	+**
		U.S. M2		U.S. M2		U.S. M2
[1]	−*	−	−	−	−	−
[2]	−	+	+	+	−	+
[3]	−	+	+	+	+	+
[4]	−	+	+	+	−	+
[5]	+	+	−	+	−	+

Notes: The superscripts *, ** and *** denote significance at the 10 percent, 5 percent and 1 percent levels respectively.

Unlike the cases involving Canada, the United Kingdom and Japan, the addition of one-period-lagged quarter-over-quarter and year-over-year money growth rates to the French interest rate differential regressions in Table 3.10 in *Advanced Topic 6: Exchange Rate Determination III* substantially changed the statistical significance of the originally present variables in many cases. Accordingly, insignificant variables were dropped and new equations thereby formed. The equations with the highest degrees-of-freedom-adjusted R-Squares are presented in Table 14 below along with the original basic regressions. It turned out that the best regression of the long-run government bond rate differential was one whose original variables were not much affected by the addition of year-over-year money growth. In that case French year-over-year money growth came in with a positive sign and the sign of U.S. year-over-year money growth was negative, as would be expected by positive effects of domestic and foreign money growth on domestic and foreign expected inflation rates. In the best regression having the treasury bill differential

Table 14: OLS Regression analysis of real and monetary factors on interest rate differentials: France vs. United States, 1974:Q1 to 1998:Q4

Independent Variables	Dependent Variable: Interest Rate Differential Treasury Bills		Long-Term Gov't Bonds	
Constant	83.713 (17.291)***	7.589 (0.978)***	1.822 (5.420)	1.333 (5.083)
Log of Commodity Prices	-12.795 (2.734)***		-2.762 (1.158)**	-2.779 (0.834)***
Log of Energy Prices	-4.223 (1.353)***			
Gov't Expenditure Difference	-0.837 (0.228)***	-0.868 (0.123)***	-0.229 (0.064)***	-0.304 (0.056)***
Real Net Capital Inflow	0.544 (0.217)**		0.211 (0.057)***	0.173 (0.053)***
Log of Real Exchange Rate			2.641 (0.894)***	2.897 (0.813)***
Intflation Rate Differential	0.333 (0.121)***	0.860 (0.121)***	0.217 (0.054)***	0.307 (0.058)***
Year-Over-Year Base Money Growth: France				0.021 (0.009)**
Year-Over-Year M2 Growth: France		-0.366 (0.063)***		
Year-Over-Year M2 Growth: U.S.		-0.225 (0.091)**		-0.115 (0.030)***
Observations	100	100	100	100
Adjusted R-Square	.449	.610	.643	.701

Note: The construction of the variables is explained in the text. The figures in brackets are the heteroskedastic and autocorrelation adjusted standard errors calculated in the Gretl statistical program, which chose a band width of 3 and a bartlett kernel. The first and third regressions from the left are reproductons from Table 3.10 of the previous topic. The superscripts ***, ** and * have the usual meaning.

Table 15: The signs and statistical significance of unanticipated money shocks added to the basic France vs. U.S. interest rate differential regressions.

	Treasury Bill Rate					
Expectations Formation	French Base	U.S. Base	French M1	U.S. Base	French M2	U.S. Base
[1]	−	+***	−	+***	−	+***
[2]	−	+***	−*	+***	−	+***
[3]	−	+***	−**	+***	−	+***
[4]	−	+***	−	+***	−	+***
[5]	+	+***	−	+**	−**	+***
		U.S. M1		U.S. M1		U.S. M1
[1]	−	+	−	+	+	+
[2]	−	+	−**	+	−**	+
[3]	−	+	−***	+	−	+
[4]	−	−	−**	−	−	−
[5]	+	+	−**	+	−***	+
		U.S. M2		U.S. M2		U.S. M2
[1]	−	−	−	−	+	−
[2]	−	−	−**	−	−**	−
[3]	−	−	−***	+	−	−
[4]	−	−	−**	+	−	−
[5]	+	−*	−*	−	−***	−*

Continued on Next Page

as the dependent variable, French year-over-year M2 growth took a negative sign. This is consistent with the occurrance of monetary expansion by the French authorities in response to declines in the domestic interest rate resulting from other causes—the simple correlation between the current and one-period lagged French year-over-year money growth rates is over 0.95 and statistically significant at the 1% level. Yet one also cannot reject the popular notion that the change in the treasury bill rate in France compared to the U.S. was the consequence of French monetary expansion although there is no theoretical basis for that view.

Table 15 above presents the signs and statistical significance of unanticipated French and U.S. money supply shocks when added to the interest rate differential regressions in Table 14. French unanticipated base money shocks had negative signs in over two-thirds of the 30 regressions but none of the signs were statistically significant. French unanticipated M1 shocks had negative signs in all of the treasury bill differential regressions and these were statistically significant at the 5% level or better in over half the regressions. Negative signs occurred in only 6 of the 15 long-term government bond rate differential regressions and the unanticipated M1

Table 15 continued from previous page.

	Long-Term Government Bond Rate					
Expectations Formation	French Base	U.S. Base	French M1	U.S. Base	French M2	U.S. Base
[1]	−	$+^{***}$	+	$+^{***}$	$+^{***}$	$+^{***}$
[2]	−	$+^{**}$	+	$+^{**}$	+	$+^{**}$
[3]	−	$+^{**}$	−	$+^{**}$	$+^{**}$	$+^{**}$
[4]	−	$+^{***}$	+	$+^{***}$	$+^{***}$	$+^{***}$
[5]	−	$+^{***}$	−	$+^{***}$	−	$+^{***}$
		U.S. M1		U.S. M1		U.S. M1
[1]	−	+	+	+	$+^{***}$	+
[2]	−	+	+	+	+	+
[3]	−	+	−	+	$+^{*}$	+
[4]	+	+	+	+	$+^{**}$	+
[5]	+	+	−	+	−	+
		U.S. M2		U.S. M2		U.S. M2
[1]	−	−	+	−	$+^{**}$	−
[2]	−	+	+	−	+	−
[3]	−	−	−	−	$+^{*}$	−
[4]	+	−	+	−	$+^{**}$	−
[5]	+	+	−	+	−	−

Notes: The base regressions to which the uanticipated money shocks are added are presented in Table 14. For each interest rate differential, the right-most regression is used as the base. The superscripts *, ** and *** have the usual meaning.

shocks were never statistically significant. In the case of unanticipated French M2 shocks, negative signs occurred in all but 2 of the 15 treasury bill rate differential regressions and 5 of these negative signs were statistically significant at the 5% level or better. In the 15 long-term government bond rate differential regressions, unanticipated French M2 supply shocks had positive signs in 12 of the 15 cases and these signs were statistically significant about half the time. United States unanticipated base money shocks had statistically significant positive effects on both of the interest rate differentials while U.S. unanticipated M1 and M2 shocks had no effects that were statistically significant and the signs were about half positive and half negative.

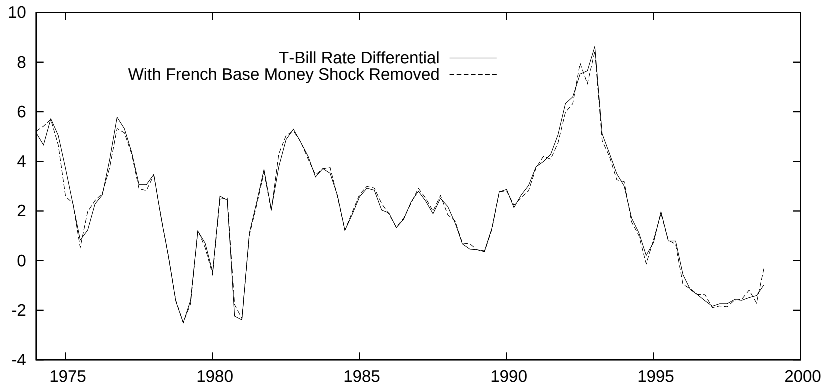

Figure 4: Effects of observed unanticipated French base money shocks, generated using the third method of expectations estimation, on that country's T-bill rate differential with respect to the United States.

The question arises as to whether the evident effects of the quite possibly exogenous French unanticipated base money shocks on the real exchange rate in the 1990s are matched by corresponding effects on the treasury bill rate differential that would indicate the positive effect of monetary contraction on that interest rate differential predicted by the popular view of the operation of monetary policy. The effect on the T-bill rate differential of the same base money shocks as were used for Figure 3 are shown in Figure 4. No obvious persistent positive effect on the T-bill rate differential during the 1990s is present, although it must be kept in mind that the coefficient of the monetary shock here is not statistically significant. And the overall effects of monetary shocks are trivial although, because of a few extreme instances, the standard-deviation of the associated difference in the treasury bill rate differential is about 25 basis points.

Again, the strong basic conclusion is that unanticipated money shocks had trivial effects on the French real exchange rate with respect to the United States. And again, one cannot reject empirically either the popular view that the monetary authority influenced interest rates or the view espoused here that the French authorities adjusted the money stock in response to demand for money shocks, some due to interest rate changes, in order to prevent exchange rate overshooting. As in the cases of Canada, the U.K. and Japan vs. the U.S., the interest rate differential regressions are too weak statistically for firm conclusions to be drawn—unanticipated money supply shock variables are not statistically significant and the independent variables in the regression are present because of their apparent correlation with the domestic and U.S. expected inflation rates rather than their direct causal relationship to the interest rate differentials.

The addition of unantipated German and United States money supply shocks to the real exchange rate regressions in the left-most column of Table 12 in the previous Topic yield the signs of these shocks shown in Table 16.[8] No statistically significant effects of German unanticipated base money shocks are found and the signs are for the most part positive. Unanticipated German M1 shocks are statistically significant only in the cases where the expected level of M1 is a linear trend projection of past values and the signs are negative in these cases. Only in these plus two additional cases are the corresponding unanticipated U.S. money supply shocks statistically significant, and in all these cases the signs are positive. The magnitudes and significance of the original variables in the regression were not much affected by the addition of the unanticipated money supply shock variables.

Table 16: The signs and statistical significance of unanticipated money shocks added to the basic Germany vs. U.S. real exchange rate regression.

Expectations Formation	German Base	U.S. Base	German M1	U.S. Base	German M2	U.S. Base
[1]	$+$	$+$	$+$	$+$	$+^{*}$	$+$
[2]	$-$	$+$	$+$	$+$	$+$	$+$
[3]	$+$	$+$	$-$	$+$	$+$	$+$
[4]	$+$	$+^{*}$	$+$	$+^{*}$	$+$	$+^{*}$
[5]	$-$	$+^{**}$	$-^{***}$	$+^{***}$	$-^{*}$	$+^{**}$
		U.S. M1		U.S. M1		U.S. M1
[1]	$+$	$-$	$+$	$-$	$+$	$-$
[2]	$+$	$+$	$+$	$+$	$+$	$+$
[3]	$+$	$-$	$-$	$-$	$+$	$-$
[4]	$+$	$-$	$+$	$-$	$+$	$-$
[5]	$-$	$+$	$-^{***}$	$+^{**}$	$-^{*}$	$+$
		U.S. M2		U.S. M2		U.S. M2
[1]	$+$	$-$	$+$	$-$	$+^{*}$	$-$
[2]	$+$	$-$	$+$	$-$	$+$	$-$
[3]	$+$	$-$	$-$	$-$	$+$	$-$
[4]	$+$	$-$	$+$	$-$	$+$	$-$
[5]	$+$	$-$	$-^{**}$	$-$	$-$	$-$

Notes: The superscripts *, ** and *** denote significance at the 10 percent, 5 percent and 1 percent levels respectively.

[8] The statistical calculations in this section were performed in the `Gretl` and `XLispStat` input files `rexgrus.inp`, `idfgrus.inp`, `rexgrus.lsp` and `idfgrus.lsp` and the results are in the respective output files `rexgrus.got`, `idfgrus.got`, `rexgrus.lou` and `idfgrus.lou`. The data files are those used throughout this Topic.

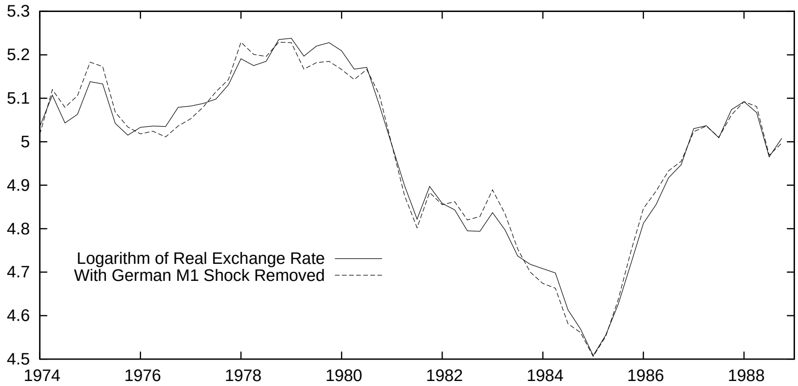

Figure 5: Effects of observed unanticipated German base M1 shocks, generated using trend projection expectations estimation, on that country's real exchange rate with respect to the United States.

The effects of the unanticipated German M1 shocks on the real exchange rate in the statistically significant case where unanticipated U.S. base money also appears in the regression are plotted in Figure 5 above. The effects are more pronounced than in the relevant plots for the other four countries but the unanticipated money supply shocks are still not a major determinant of movements in the German real exchange rate with respect to the United States. And it must be kept in mind that unanticipated shocks to German base money, which is the aggregate that the domestic authorities directly control, are everywhere statistically insignificant.

The signs and statistical significance of one-period-lagged quarter-over-quarter and year-over-year German and U.S. money growth when added to the two basic interest rate differential regressions, first and third from the left in Table 13 in *Advanced Topic 6: Exchange Rate Determination III*, are shown in Table 17. The coefficients of the German money growth variables are always negative, but statistically significantly so in one sixth of the cases. The U.S. lagged quarter-over-quarter money growth variables are positive in two-thirds of the cases, significantly so only one-sixth of the time. Only 2 of the 9 negative signs are statistically significant. Given the absence of any statistically significant effects of German unanticipated money shocks on the country's real exchange rate with respect to the United States, the best interpretation of the negative signs of German money growth is as a response of the money stock to interest rate changes generated by other forces, not as a response of interest rates to money growth. It should be kept in mind that if the observed German money growth rates were fully anticipated by market participants their effects on the interest rate differential would have been positive.

Table 17: The signs and statistical significance of 1-period lagged quarter-over-quarter and year-over-year money growth added to the basic Germany vs. U.S. interest rate differential regressions.

Monetary Aggregate		Interest Rate Differential: Germany minus U.S.							
		Treasury Bill		Long-Term Government Bonds		Treasury Bill		Long-Term Government Bonds	
Germany	U.S.	Quarter-Over-Quarter Lagged One Quarter				Year-Over-Year Lagged One Quarter			
Base	Base	$-$	$-^{**}$	$-$	$+$	$-$	$-$	$-$	$+^{*}$
	M1	$-^{**}$	$-^{*}$	$-$	$+^{**}$	$-$	$-$	$-$	$+^{***}$
	M2	$-^{*}$	$-$	$-$	$+$	$-$	$+$	$-$	$+$
M1	Base	$-^{**}$	$-^{*}$	$-$	$+$	$-^{*}$	$+$	$-$	$+^{*}$
	M1	$-^{***}$	$-$	$-$	$+^{**}$	$-^{**}$	$+$	$-$	$+^{***}$
	M2	$-^{***}$	$-$	$-$	$+$	$-^{**}$	$+$	$-$	$+$
M2	Base	$-$	$-^{**}$	$-$	$+$	$-$	$-$	$-$	$+^{*}$
	M1	$-$	$-$	$-$	$+^{**}$	$-^{*}$	$+$	$-$	$+^{***}$
	M2	$-^{*}$	$-$	$-$	$+$	$-^{*}$	$+$	$-$	$+$

Notes: The superscripts *, ** and *** denote significance at the 10 percent, 5 percent and 1 percent levels respectively. The magnitudes and statistical significance of the original variables in that regression are not much affected by the addition of the unanticipated money shock variables.

The signs and significance of unanticipated German and U.S. money supply shocks when added to the basic interest rate differential regressions are shown in Table 18 below. The unanticipated German base money shock is negative in 29 of the 30 cases but statistically significantly so at the 5% level in only one case. The unanticipated German M1 shock is negative in 27 of the 30 cases but significantly so in only 3 of those cases. German unanticipated M2 shocks are everywhere negative, and significant at the 5% level in 9 of the 30 cases. Unanticipated shocks to the U.S. monetary aggregates are positive in about one-third of the 30 cases representing each aggregate—the only instance of statistical significance occurs in one of these cases.

Table 18: The signs and statistical significance of unanticipated money shocks added to the basic German vs. U.S. interest rate differential regressions.

	Treasury Bill Rate					
Expectations Formation	German Base	U.S. Base	German M1	U.S. Base	German M2	U.S. Base
[1]	−	−	+	−	−	−
[2]	−*	−	−	−	−	−
[3]	−	−	−	−	−*	−
[4]	−	−*	−	−*	−*	−
[5]	−	−	−	−	−	−
		U.S. M1		U.S. M1		U.S. M1
[1]	−	−	+	−	−	−
[2]	−*	−	−	−	−	−
[3]	−	−	−	−	−**	−
[4]	−*	−	−	−	−	−
[5]	−*	−	−	−	−*	−
		U.S. M2		U.S. M2		U.S. M2
[1]	−	+	+	+	−	+
[2]	−	+	−	+	−	+
[3]	−*	+	−	+	−**	+
[4]	−	+	−	+	−*	+
[5]	−**	+	−*	+	−*	+

Continued on Next Page

Table 18 continued from previous page.

	Long-Term Government Bond Rate					
Expectations Formation	German Base	U.S. Base	German M1	U.S. Base	German M2	U.S. Base
[1]	−	+	−	−	−**	−
[2]	−	−	−	−	−	−
[3]	−	−	−	−	−**	−
[4]	−	−	−**	−	−**	−
[5]	+	+	−	+	−	+
		U.S. M1		U.S. M1		U.S. M1
[1]	−	−	−*	−	−**	−
[2]	−	+	−	+	−	+
[3]	−	−	−	−	−*	−
[4]	−	−	−**	−	−*	−
[5]	−	+	−	+	−**	+**
		U.S. M2		U.S. M2		U.S. M2
[1]	−	−	−	−	−*	−
[2]	−	−	−	−	−	−
[3]	−	−	−	−	−**	−
[4]	−	−	−**	−	−**	−
[5]	−	+	−	+	−*	+*

Notes: The base regressions to which the uanticipated money shocks are added are presented in Table 3.13. For each interest rate differential, the right-most regression is used as the base. The superscripts *, ** and *** have the usual meaning.

The fact that German unanticipated money supply shocks are positively related to that country's real exchange rate with respect to the United States, and not significantly so, in the majority of the 45 cases and statistically significantly negative in only three cases where the anticipated level of the money stock is estimated as a trend projection of the past eight values, suggests that any negative relationships between the money shock and interest rates must have resulted from a response of the German monetary authorities to interest rate changes arising from other sources, and not from a response of interest rates to money supply shocks. Moreover, the high fraction of positive relationships between the money shocks and the real exchange rate suggests that the German authorities tended to bring about adjustments of the money stocks that were slightly insufficient to compensate for demand for money changes resulting from the whole range of factors that resulted in demand for money shocks.

Again, the inescapable conclusion is that, as was the case with respect to the other countries, a trivial portion of the overall changes in the German real exchange rate with respect to the United States can be accounted for by unanticipated money supply shocks.

What about the possibility that the absence of effects of unanticipated money supply shocks on real exchange is a result of the fact that those shocks are of trivial magnitude? Table 19 below presents the averages of the standard deviations of the quarterly percentage unanticipated shocks of the monetary aggregates of the six countries, where the standard deviations being averaged are those associated with our five methods of calculating unanticipated money shocks.[9] The standard deviations of the percentage base money shocks are in excess of unity for all countries other than Germany and the United States, and are as high as 6 percent for Japan and France. The standard deviations of the unanticipated M1 shocks as percentages of expected levels everywhere substantially exceed unity as do those of unanticipated M2 shocks for Canada, the U.K., Japan and France.

Table 19: Averages of the standard deviations of the alternatively calculated unanticipated money supply shocks for each country for the time periods used in the regressions.

Country	Unanticipated Money Supply Shocks Percentages of Expected Levels		
	Base	M1	M2
United States	0.954	1.242	0.801
Canada	1.395	2.528	1.462
United Kingdom	1.278		3.131
Japan	6.675	2.640	1.899
France	6.430	1.834	1.263
Germany	0.989	1.683	0.911

Notes: For each monetary aggregate, the standard deviations were calculated for each of the five measures of the unanticipated shock and then averaged.

It is difficult to imagine how unanticipated exogenous liquidity shocks of this magnitude would not substantially affect real exchange rates if overshooting was not compensated for by money supply adjustments.

[9] These statistics are calculated in the `XLispStat` and `Gretl` files `stdmshks.lsp` and `stdmshks.inp` and the results can be found in `stdmshks.lou` and `stdmshks.got`.

Table 20 below presents the average of the percentage shocks to the real exchange rate resulting from one percent changes in the five alternative measures of each unanticipated money supply shock calculated in the regressions we have been referring to.[10] The table also gives the number of coefficients taking each sign and the number with each sign being statistically significant. The averages of the point estimates of these exchange rate effects are negative in only 4 of the 14 cases and exceed unity only in the case of U.K. base money. In all but three of the cases the percentage change is less than one-third the magnitude of the percentage unanticipated money supply shock.

Table 20: Average percentage changes in the real exchange rate with respect to the United States associated with one percent unanticipated monetary shocks in Canada, United Kingdom, Japan, France and Germany, together with the number of positive and negative changes and their statistical significance, using five alternative measures of the unanticipated shock to each monetary aggregate and holding constant the corresponding unanticipated shocks to the U.S. monetary aggregates.

	Canada	U.K.	Japan	France	Germany
Base Money					
% Change	0.314	-1.057	0.111	-0.144	0.279
Positive	12	5	14	1	12
Significant	3	0	0	0	0
Negative	3	10	1	14	3
Significant	0	6	0	0	0
M1					
% Change	0.104		0.213	0.161	-0.092
Positive	14		14	11	9
Significant	0		0	0	0
Negative	1		1	4	6
Significant	0		0	0	3
M2					
% Change	0.242	-0.279	0.710	-0.203	0.522
Positive	9	0	12	3	7
Significant	0	0	1	0	1
Negative	6	15	3	12	8
Significant	0	0	0	0	0

Notes: The unanticipated money supply shocks are percentage deviations from expected levels calculated according to the five processes discussed in the text. The numbers of positive and negative effects and their statistical significance are obtained from Tables 1, 5, 9, 13 and 16.

[10] These calculations were performed in the `Gretl` and `XLispStat` files in which the regression results were produced.

This is, of course, consistent with the observation that real exchange rates are not much affected by unanticipated money supply shocks, as opposed to shocks to the range of real variables studied. It appears that countries' monetary authorities could generate unanticipated money supply shocks of the magnitudes observed without having major effects on real and nominal exchange rates. But if they did so, where is the evidence of overshooting?

It is reasonable to believe that not all of the observed unanticipated money supply shocks represent shocks to the excess supply—that is, changes in the excess of the supply of liquidity over the demand for it. Suppose, for example, that the authorities of a country adjust the domestic base money aggregate upward by 0.9% in response to a 1% increase in the demand for base money. An excess demand for money of a tenth of one percent will arise. If the resulting percentage increase in the real exchange rate is one percent, the associated overshooting will be in the order of 10 times the excess money demand shock. The fact that most of the average percentage changes in the real exchanges rates with respect to the U.S. are positively, not negatively, related to the individual countries' unanticipated money shocks suggests that these shocks cannot be the result of an attempt to pursue monetary policy—they are in the wrong direction! The conclusion that observed money shocks are responses of the authorities to demand for money changes to prevent overshooting would seem inescapable.

Further evidence on the magnitude of money supply shocks to real exchange rates can be obtained using the vector autoregression analysis developed by Olivier Blanchard and Danny Quah. The application of this technique also incorporates the possibility that demand for money shocks may have had effects on the real exchange rates quite apart from unanticipated changes in the countries' monetary aggregates.[11]

Consider two time series, each of which is a function of the current value of the other, p lagged values of itself and the other time series, and an error term whose individual elements are independently and identically distributed.

$$\begin{aligned} \mathbf{y}_t \;&=\; \mathbf{a} + \mathbf{A_0}\,\mathbf{y}_t + \mathbf{A_1}\,\mathbf{y}_{t-1} + \mathbf{A_2}\,\mathbf{y}_{t-2} + \mathbf{A_3}\,\mathbf{y}_{t-3} + \cdots \\ &\qquad\qquad \cdots\cdots\cdots + \mathbf{A_p}\,\mathbf{y}_{t-p} + \mathbf{e}_t \end{aligned} \tag{1}$$

where $\mathbf{y}_t$, $\mathbf{a}$ and $\mathbf{e}_t$ are 2×1 column vectors and $\mathbf{A_0}$, $\mathbf{A_1}$, $\mathbf{A_2}$, $\cdots$ $\mathbf{A_p}$ are 2×2 matrices of coefficients. The vector $\mathbf{e}_t$ is a 2-element vector of white noise residuals that satisfies $E\{\mathbf{e}_t\mathbf{e}_t{}'\} = \mathbf{D}$, where $\mathbf{D}$ is a diagonal matrix which, with appropriate scaling of the elements of $\mathbf{y}$, becomes an identity matrix. The above system of equations is a structural VAR which can be solved simultaneously to yield the standard form

$$\mathbf{y}_t = \mathbf{b} + \mathbf{B_1}\,\mathbf{y}_{t-1} + \mathbf{B_2}\,\mathbf{y}_{t-2} + \mathbf{B_3}\,\mathbf{y}_{t-3} + \cdots + \mathbf{B_P}\,\mathbf{y}_{t-p} + \mathbf{u}_t \tag{2}$$

where $\mathbf{b} = (\mathbf{I} - \mathbf{A_0})^{-1}\mathbf{a}$, $\mathbf{B_1} = (\mathbf{I} - \mathbf{A_0})^{-1}\mathbf{A_1}$, $\mathbf{B_2} = (\mathbf{I} - \mathbf{A_0})^{-1}\mathbf{A_2}$, $\cdots$ etc., and $\mathbf{u}_t = (\mathbf{I} - \mathbf{A_0})^{-1}\,\mathbf{e}_t$. All this assumes, of course, that the matrix $(\mathbf{I} - \mathbf{A_0})$ has an inverse.

[11] For details, see Chapter 12 of *Interest Rates, Exchange Rates and World Monetary Policy.*

Given that $E\{\mathbf{e}_t\mathbf{e}_t{}'\} = \mathbf{D}$, the variance-covariance matrix of the vector of residuals $\mathbf{u}_t$ equals

$$\begin{aligned}
\mathbf{\Omega} &= E\{\mathbf{u}_t\mathbf{u}_t{}'\} \\
&= E\{[(\mathbf{I}-\mathbf{A_0})^{-1}\mathbf{e}_t][(\mathbf{I}-\mathbf{A_0})^{-1}\mathbf{e}_t]'\} \\
&= E\{[(\mathbf{I}-\mathbf{A_0})^{-1}]\mathbf{e}_t\mathbf{e}_t{}'[(\mathbf{I}-\mathbf{A_0})^{-1}]'\} \\
&= [(\mathbf{I}-\mathbf{A_0})^{-1}]E\{\mathbf{e}_t\mathbf{e}_t{}'\}[(\mathbf{I}-\mathbf{A_0})^{-1}]' \\
&= [(\mathbf{I}-\mathbf{A_0})^{-1}]\,\mathbf{D}\,[(\mathbf{I}-\mathbf{A_0})^{-1}]'
\end{aligned}$$

The two equations in (2) are estimated by ordinary least squares, with the appropriate lag length chosen on the basis of likelihood-ratio tests and the Akaike and Schwartz-Bayesian criteria. After estimation, this standard form can be manipulated to produce a moving average version that expresses each the current value of each variable as a moving average of the current and past values of the residuals.

$$\mathbf{y}_t = \mathbf{C_0}\,\mathbf{u}_t + \mathbf{C_1}\,\mathbf{u}_{t-1} + \mathbf{C_2}\,\mathbf{u}_{t-2} + \cdots\cdots + \mathbf{C_s}\,\mathbf{u}_{t-s} + \mathbf{y_0}. \tag{3}$$

where $\mathbf{y_0}$ is some initial value of $\mathbf{y}_t$ and s is the chosen length of the moving average representation. This representation does not, however, give a proper indication of how the system responds to shocks to the individual structural equations. One cannot determine what the effects on the two variables of a shock to one structural equation alone would be because each observed u_t will represent combined shocks to both equations, as can be seen from the fact that

$$\mathbf{u}_t = (\mathbf{I}-\mathbf{A_0})^{-1}\,\mathbf{e}_t.$$

In order to determine the effects of a shock to an individual structural equation of the system one has to be able to obtain $(\mathbf{I}-\mathbf{A_0})^{-1}$. This will enable an operation on (3) to transform the $\mathbf{u}_{t-j}$ in into $\mathbf{e}_{t-j}$. In the process, the matrices $\mathbf{C_j}$ will also be transformed into a useful representation of the impulse-responses—that is, the responses of the two variables through time to a shock to each one of them past periods. The task is to find the $\mathbf{G}$ for which

$$\mathbf{G} = (\mathbf{I}-\mathbf{A_0})^{-1}.$$

so that (3) can be written as

$$\mathbf{y}_t = \mathbf{Z_0}\,\mathbf{e}_t + \mathbf{Z_1}\,\mathbf{e}_{t-1} + \mathbf{Z_2}\,\mathbf{e}_{t-2} + \mathbf{Z_s}\,\mathbf{e}_{t-s} + \mathbf{y_0} \tag{4}$$

where $\mathbf{Z_j} = \mathbf{C_j}\,\mathbf{G}$ and $\mathbf{e}_{t-j} = \mathbf{G}^{-1}\,\mathbf{u}_{t-j}$.

To obtain the matrix $\mathbf{G}$ we do a Choleski decomposition of the matrix $\mathbf{\Omega}$ which yields the matrix $(\mathbf{I}-\tilde{\mathbf{A}}_\mathbf{0})^{-1} = \mathbf{G}$ and hence $\tilde{\mathbf{A}}_\mathbf{0} = \mathbf{I}-\mathbf{G}^{-1}$ where $\tilde{\mathbf{A}}_\mathbf{0}$ is a representation of $\mathbf{A_0}$ after scaling of the variables to render $\mathbf{D} = \mathbf{I}$. A Choleski decomposition requires that the system is recursive so that

$$\mathbf{A_0} = \begin{bmatrix} 0 & 0 \\ a_{21} & 0 \end{bmatrix}$$

and the current level of y_1 is not affected by the current level of y_2 while the current level of y_2 does depend on the current level of y_1. Both y_1 and y_2, of course, continue to be affected by their own and each other's past values.

The problem with the assumptions required for a Choleski decomposition in an analysis which uses the real and nominal exchange rates as the two variables, is that it is clear that the two exchange rates will move together in the current period regardless of which one is shocked—the system is not recursive. The Blanchard-Quah approach replaces the assumption that either a_{12} or a_{21} equals zero with an alternative identifying assumption—that one shock, in this case the monetary shock, has only a temporary effect on one of the variables, in this case the real exchange rate, but a permanent effect on the other variable, here the nominal exchange rate, while the other shock, in this case called the real shock, has permanent effects on both variables. Letting the real exchange rate be the first variable and the monetary shock the first shock, the requirement imposed is that the top-left elements in $\mathbf{Z_0} = \mathbf{C_0}\,\mathbf{G}$, $\mathbf{Z_1} = \mathbf{C_1}\,\mathbf{G}$, $\mathbf{Z_2} = \mathbf{C_2}\,\mathbf{G}$, $\cdots\cdots\cdots\cdots$, $\mathbf{Z_s} = \mathbf{C_s}\,\mathbf{G}$, sum to zero.[12]

The Blanchard-Quah decomposition yields appropriate $\mathbf{Z_i}$ matrices in equation (4). Using these matrices, it is then possible to obtain impulse-response functions giving the sequence of responses of the real and nominal exchange rates over a future time horizon to monetary and real shocks of one standard-deviation magnitude in an initial period. And the future-period error variances of current-period forecasts of real and nominal exchange rates based on these impulse-responses can also be obtained. The one-period-ahead forecast is based on the lagged values of the real and nominal exchange rates in the current period. Those forecasted values then become the lagged values for the forecasts for the following period, and so forth. The forecast-error-variances of initial period forecasts will get larger as the future unfolds because of the cumulation through time of the random shocks $\mathbf{e_t}$. Finally, it is possible to historically decompose the actual movements of the real and nominal exchange rates over the sample period into the movements that have resulted from real and monetary shocks respectively.

A Blanchard-Quah analysis of the real and nominal exchange rates with respect to the United States of the countries being studied was performed using the procedure outlined above.[13] The responses of the real exchange rates to monetary shocks are shown in the top panels of Figures 6 through 10, and the historical decompositions of the real and nominal exchange rates into the portions due to monetary and real shocks are shown in the middle and bottom panels.

[12] It matters not which shock is assumed to be the monetary one. If the second shock is the monetary one then the requirement is simply that the sum of the top right elements of the above matrices equal zero.

[13] All the calculations in this chapter were performed in `XLispStat` using the batch files `bqvarcau.lsp`, `bqvaruku.lsp`, `bqvarjnu.lsp`, `bqvarfru.lsp` and `bqvargru.lsp` for Canada, the U.K., Japan, France and Germany, respectively, with respect to the U.S. and the results are in files having the same names except for the suffix `.lou`. `Gretl` could not be used because that program does not support Blanchard-Quah VAR analysis.

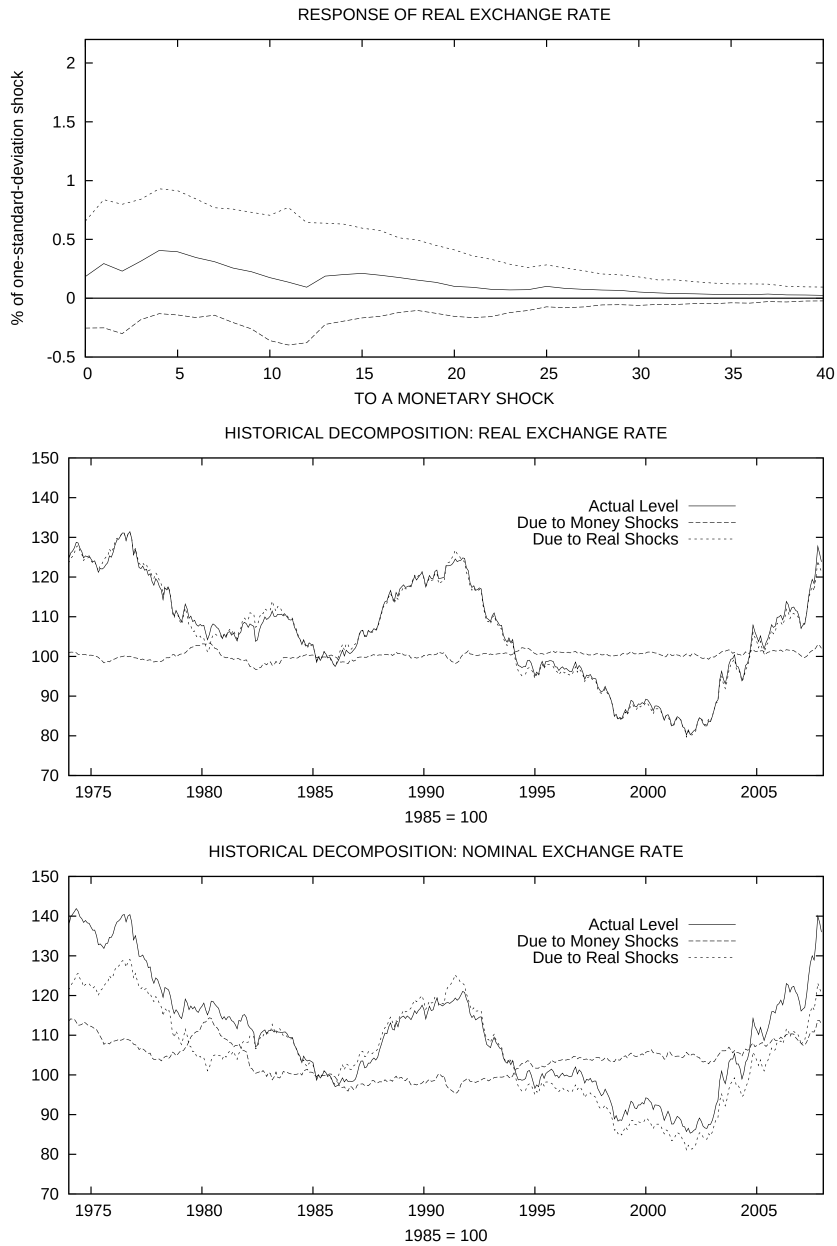

Figure 6: Blanchard-Quah-VAR historical decompositions of Canada's real and nominal exchange rates with respect to the U.S. dollar into the movements attributable to real and money shocks and the response of the real exchange rate to money shocks.

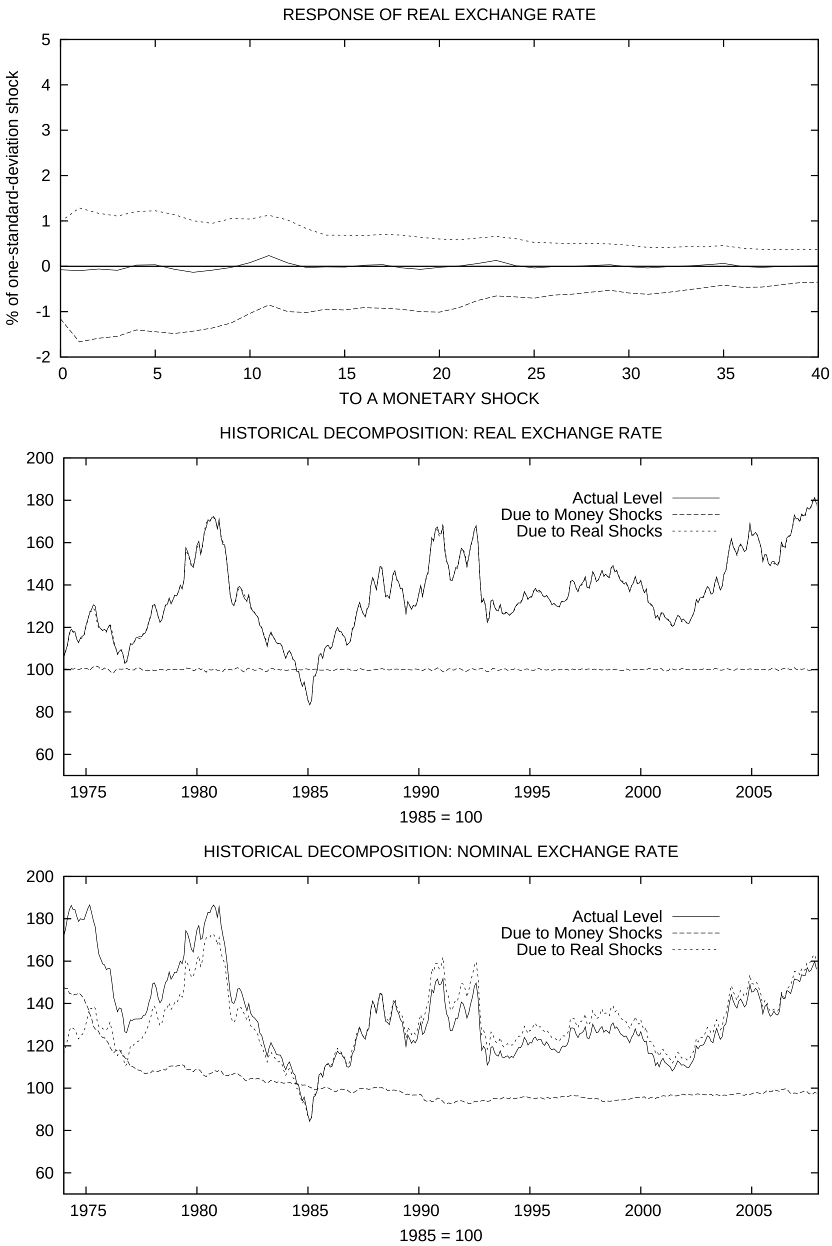

Figure 7: Blanchard-Quah-VAR historical decompositions of Britain's real and nominal exchange rates with respect to the U.S. dollar into the movements attributable to real and money shocks and the response of the real exchange rate to money shocks.

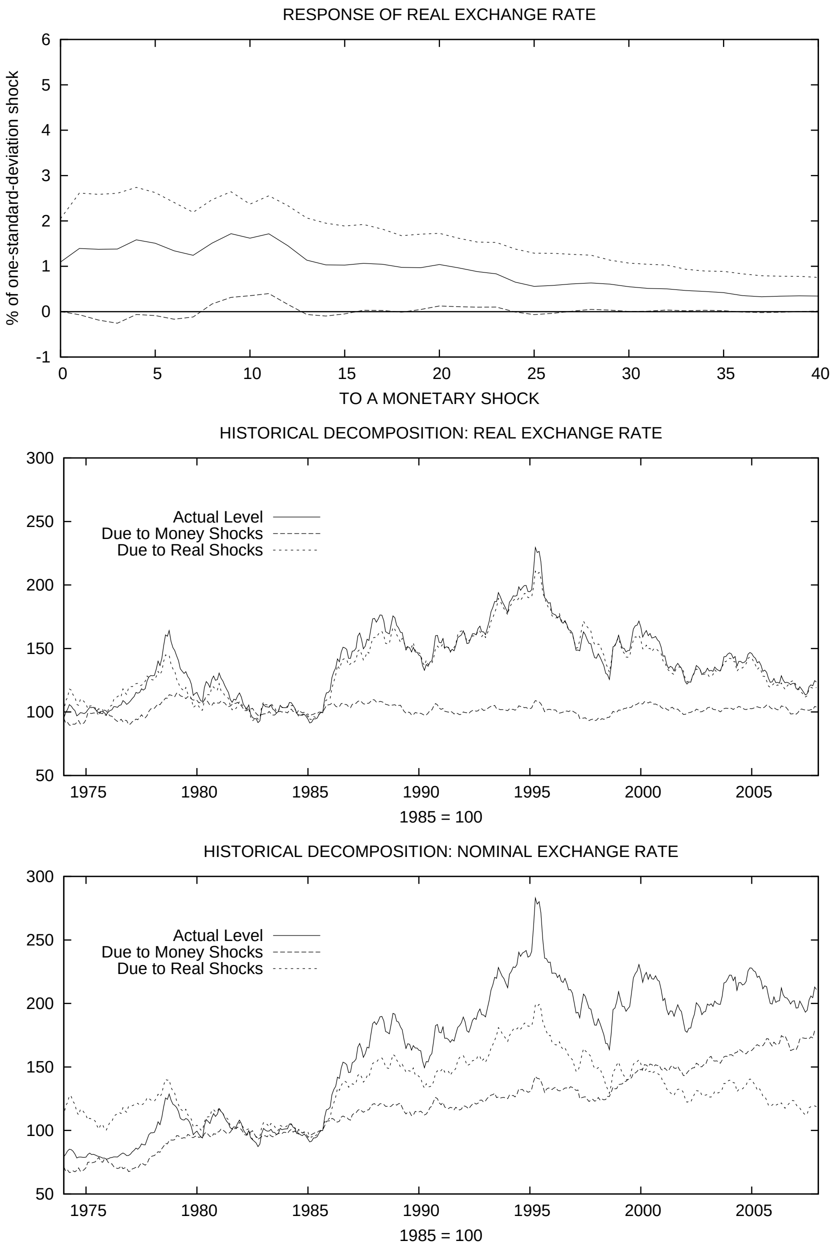

Figure 8: Blanchard-Quah-VAR historical decompositions of Japanese real and nominal exchange rates with respect to the U.S. dollar into the movements attributable to real and money shocks and the response of the real exchange rate to money shocks.

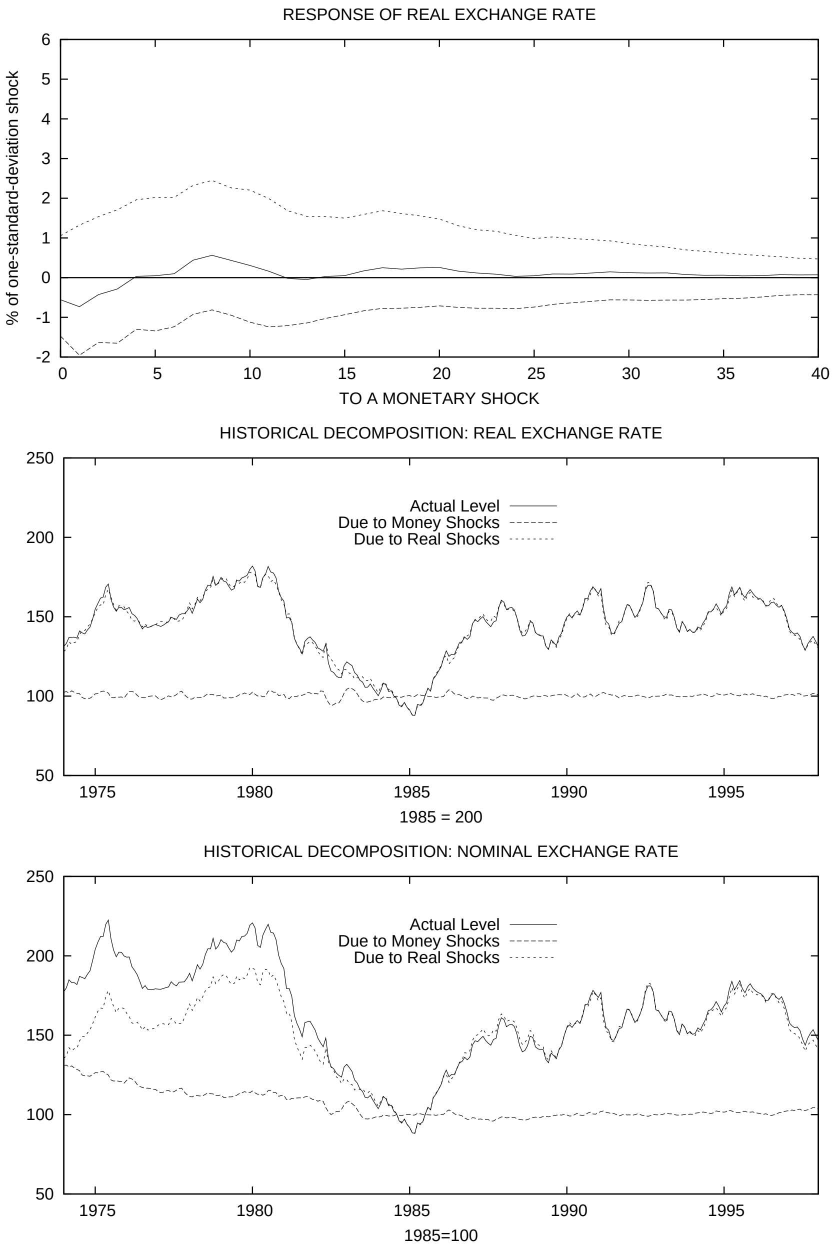

Figure 9: Blanchard-Quah-VAR historical decompositions of French real and nominal exchange rates with respect to the U.S. dollar into the movements attributable to real and money shocks and the response of the real exchange rate to money shocks.

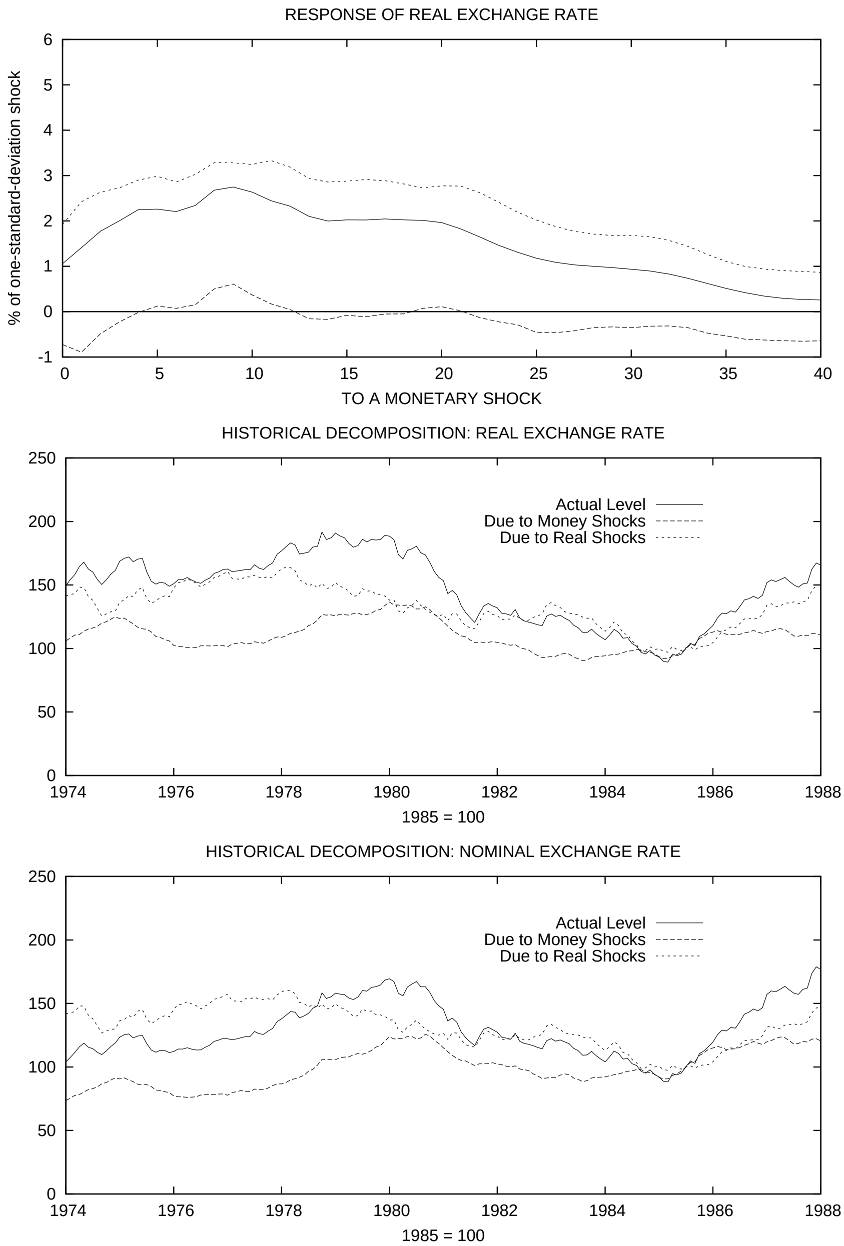

Figure 10: Blanchard-Quah-VAR historical decompositions of German real and nominal exchange rates with respect to the U.S. dollar into the movements attributable to real and money shocks and the response of the real exchange rate to money shocks.

It is clear from the top panels of the first, second and fourth figures that no statistically significant responses to monetary shocks of the real exchange rates of Canada, the U.K. and France with respect to the U.S. are found. In the cases of Japan and Germany, in the third and fifth figures, there is some evidence of a response. Essentially the same conclusion arises with respect to the historical decompositions of the real exchange rate movements. In the cases of Canada, the U.K. and France, the portions of the real exchange rate movements that can be ascribed to monetary shocks are tiny. Apart from some small effects of nominal shocks on the real exchange rate during the late 1970s, the same is true of Japan. In the German case quite significant effects of monetary shocks on the real exchange rate with respect to the United States are evident. These effects are very smooth, with no evidence of sharp movements that one would associate with overshooting.

With respect to the effects of monetary shocks on the nominal exchange rate, the German historical decomposition indicates that monetary shocks were every bit as important as real shocks. In the case of Japan, monetary shocks were also important but their effect was almost completely confined to trend—real shocks were clearly responsible for all major year-to-year movements in the nominal exchange rate with respect to the U.S. With respect to Britain and France, the monetary shocks had very smooth effects on the nominal exchange rates, reflecting increased control over the domestic inflation rates relative to U.S. inflation in the late 1970s and early 1980s. Monetary shocks also had important effects on the Canadian nominal exchange rate with respect to the U.S. during the late 1970s and early 1980s—the negative and then positive effects of real shocks on the nominal exchange rate over a five year period were offset by nominal shocks. Apart from this short period in the case of Canada, real shocks were clearly the major determinant of year-to-year nominal exchange rate movements in every country examined other than Germany.

The differences between the maximum and minimum levels of the decomposed real exchange rates produced by monetary shocks for the five countries are presented in Table 21 where the maximum and minimum levels are expressed as percentages of the average levels. For Japan the difference between the maximum and minimum effect of monetary shocks on the real exchange rate with respect to the United States is about 25 percent of the average level and for Germany the difference is 42 percent of the average level. It is clear from the middle panel of Fig. 8 that the minimum and maximum for Japan both occurred during the late 70s when real shocks were affecting the real exchange rate in the same direction. In the German case, the minimum and maximum were separated by about four years during the same general period—from about 1977 through 1981.

Since no sharp within-year movements of the real exchange rates of the sort one might associate with overshooting are apparent during this period, it would seem that the authorities of Japan and Germany were essentially 'leaning against the exchange rate' in their conduct of monetary policy during these years. Indeed, the smooth yet substantial observed monetary effects on the German real exchange rate with respect to the U.S. over all the years examined suggest that the Bundesbank may have been operating in that way during the entire period.

Table 21: Historical Decomposition: Changes in Real Exchange Rate Levels Due to Monetary Shocks

	Maximum Level	Minimum Level	Maximum Less Minimum
Canada	103.078	96.405	6.674
U.K.	101.609	98.379	3.231
Japan	112.628	87.703	24.925
France	104.958	93.759	11.120
Germany	124.692	82.576	42.116

The percentages of the forecast-error-variances of the real exchange rates of the five countries with respect to the U.S. that were due to monetary shocks are presented in Table 22 below. While these are substantial—in the order of 20 to 25 percent—for Japan and Germany, one would have to conclude that real shocks still account for the major fraction of the forecast error variances with respect to these countries as well as Canada, the United Kingdom and France.

Table 22: Percentages of the forecast-error-variances of the Real Exchange Rate Due to Monetary Shocks for monthly horizons

Horizon	U.K.	Canada	France	Japan	Germany
0	0.101	2.388	5.364	18.121	18.101
1	0.097	3.072	5.458	17.832	19.252
2	0.119	3.336	6.825	17.818	20.851
3	0.132	3.787	7.039	17.731	21.414
4	0.343	4.297	8.470	18.192	21.979
5	0.343	4.299	8.462	18.253	21.958
6	0.496	4.448	8.498	18.487	21.993
7	0.567	4.523	10.110	18.525	22.197
8	0.605	4.626	10.265	19.312	23.431
9	0.662	4.685	10.472	19.742	23.426
10	0.838	4.740	10.669	19.843	23.099
11	1.221	4.733	10.942	19.751	23.283
12	1.621	4.841	11.360	20.073	23.398
13	1.781	5.339	11.358	21.099	23.760
14	1.784	5.348	11.433	21.191	23.870
15	1.784	5.352	11.437	21.175	23.873
16	1.812	5.367	11.623	21.169	23.872
17	1.814	5.384	11.704	21.171	23.867
18	1.891	5.410	11.719	21.215	23.864
19	1.908	5.428	11.732	21.215	23.856
20	1.937	5.490	11.732	21.263	23.878
21	1.950	5.493	11.840	21.314	24.045
22	1.998	5.507	11.872	21.382	24.349
23	2.074	5.508	11.882	21.397	24.649
24	2.272	5.508	11.921	21.695	24.857
25	2.314	5.552	11.924	21.781	25.025
26	2.326	5.568	11.950	21.782	25.104
27	2.327	5.571	11.950	21.787	25.133
28	2.333	5.573	11.959	21.791	25.129
29	2.336	5.574	11.971	21.797	25.122
30	2.366	5.584	11.978	21.828	25.124