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Monetary Policy and the Exchange Rate: Some Evidence

by

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Abstract

This paper examines the effects on real exchange rates of unanticipated money supply shocks. Such shocks are conventionally associated with monetary policy, although they may also arise from shifts in the desired reserve to deposit ratio of the banking system or in the public's desired currency to deposit ratio. They necessarily involve nominal exchange rate movements and, given price rigidity, real exchange rate movements as well. No evidence is found that unanticipated money supply shocks affected real exchange rates in nine major industrial countries during the flexible exchange rate period that began with the collapse of the Bretton Woods system. There also appears to be little support for the view that the major observed movements in real exchange rates were the result of anticipated money shocks. Real shocks related to technological change, real income cycles, commodity market developments and, quite possibly, government fiscal policies can explain virtually all the variability of real exchange rates. All sensible theories of real exchange rate behavior hold that, on account of temporary price level rigidity, exogenous unanticipated money shocks will necessarily affect real exchange rates. A useful explanation of the absence of such effects is that observed high-frequency monetary shocks are endogenous rather than exogenous, arising from the response of the authorities to stochastic shocks to the demand for nominal money holdings associated with interest rate and exchange rate speculation and other factors. On this interpretation, the evidence suggests that the authorities did a sufficiently good, though imperfect, job of smoothing financial markets to render the relationship between the real exchange rate and observed stochastic unanticipated money supply shocks statistically insignificant after other factors are taken into account.

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1 Introduction

This paper examines the evidence on the effects on real exchange rates of unanticipated money supply shocks and suggests an explanation of that evidence. Monetary shocks are conventionally associated with monetary policy although they may also arise from shifts in the desired reserve to deposit ratios of the banking system or in the public's desired currency to deposit ratio. Most international monetary analysis takes for granted that active monetary policy is frequently followed. Hardly a policy paper is written that does not at some point assert that the monetary authorities in one or other country have tightened or eased policy during some period, bringing about a change in economic activity or actual or expected inflation. While monetary policy is typically equated with movements in domestic interest rates, it is widely understood that exchange rate movements are necessarily involved as well. As Tobin states, "monetary policy in a floating exchange rate regime is exchange rate policy"[1] Given short-run price level stickiness, monetary shocks translate into real as well as nominal exchange rate movements.

It is unanticipated money supply shocks that are generally thought to affect real exchange rates, although a significant segment of professional opinion attaches importance to anticipated money supply changes as well, particularly for horizons of a year or so. There is also a body of opinion that attempts to explain major and persistent real exchange rate movements on the basis of shocks to the demand and supply of money, the implication being that endogenizing money shocks by fixing the exchange rate will stabilize real exchange rates and thereby reduce the uncertainty that arises from real exchange rate volatility.

All this suggests that at the very least we should be able to identify an impact of unanticipated shocks to the money supply on real exchange rates. The real exchange rate effects of unanticipated money shocks are not subject to the controversy surrounding nominal interest rate effects. The sign of the interest rate effects of unanticipated monetary growth shocks is generally regarded as ambiguous, depending upon whether agents view these shocks as temporary or permanent—if a positive unanticipated money growth shock is viewed as temporary there will be a Keynes or liquidity effect leading to a decline in interest rates while if agents view the shock as permanent, there

[1] James Tobin, "Eight Myths about the Dollar", in Stefan Gerlach and Peter A. Petrie, eds., *The Economics of the Dollar Cycle*, MIT Press, 1990, pp. 28–36.

will be a Fisher effect leading to an increase in nominal interest rates equal to the increase in the expected rate of future inflation with no effect on real interest rates. The effects on exchange rates, however, are unambiguous. In both cases the domestic currency will depreciate in nominal terms. The effect of a positive unanticipated money supply shock on the real exchange rate will be unambiguously negative, while the effect of a fully anticipated shock will be either zero or negative, depending upon the nature of contracts entered into before the new money growth regime became known.

The research reported here takes a different tack from recent work based on vector autoregression analysis that attempts to determine the full time-path of the response of the real and nominal exchange rates, output, interest rates, prices and other variables to exogenous monetary policy shocks.[2] Here, the goal is the much less ambitious one of attempting to uncover effects of unanticipated nominal money supply shocks in the current quarter. As shown below these effects should occur regardless of the underlying economic structure as long as the current account balance, income and non-traded goods prices cannot fully adjust within-quarter to excess money supply shocks.

The main conclusion is that unanticipated nominal money shocks, defined in a number of alternative ways, do not appear to significantly affect real exchange rates in the direction standard economic theory would postulate. This prompts the question as to why no relationship is found, and an explanation is put forward. Central banks' desire to minimize portfolio shocks—to maintain orderly capital markets and domestic financial stability in the immediate run—is suggested as a reasonable explanation of this phenomenon. Portfolio shocks to the exchange rate are avoided by providing the necessary accommodating finance. Observed unanticipated money supply shocks thereby represent shocks to the demand for money, accommodated by the central bank to prevent unnecessary short-term fluctuations in nominal exchange rates. Given this interpretation, evidence can then be ex-

[2]See, for example, C. A. Sims, "Interpreting the Macroeconomic Time Series Facts: The effects of Monetary Policy," *European Economic Review*, 36, 1992, pp. 975–1000, D. B. Gordon and E. M. Leeper, "The Dynamics of Monetary Policy: An Exercise in Tentative Identification," *Journal of Political Economy*, Vol. 102, No. 6, 1994, pp. 1228–1247, M. Eichenbaum and C. Evans, "Some Empirical Evidence on the Effects of Monetary Shocks on Exchange Rates," *Quarterly Journal of Economics*, Vol. 110, 1995, pp. 975–1009, and D. O. Cushman and T. Zha, "Identifying Monetary Policy in a Small Open Economy Under Flexible Exchange Rates," *Journal of Monetary Economics*, Vol. 39, 1997, pp. 433–448.

tracted from the data indicating the extent to which real exchange rate and money supply variability was due to accommodation or smoothing errors of the authorities in addition to shocks to the demand function for money.

2 The Determinants of the Real Exchange Rate

The real exchange rate is defined as the relative price of home output in terms of foreign output. The factors determining this relative price can be derived from a standard general equilibrium model of domestic and foreign production and consumption of traded and non-traded goods. Such derivations are technically straight-forward but extremely messy. Fortunately, the main results are easily seen intuitively. The intuition is presented here—the details can be found elsewhere.[3]

[3]John W. Johnston, "Real and Nominal Exchange Rate Determination in a Small Open Economy: An Empirical Investigation of the Canadian Case," Unpublished Ph.D. Dissertation, University of Toronto, 1992, Ch. 2 and Appendix 2.1. See also Peiter Korteweg, "Exchange Rate Policy, Monetary Policy, and Real Exchange Rate Variability,", *Princeton Essays in International Finance*, No. 140, Princeton University Press, 1980, Irving Kravis and Robert Lipsey, "Toward and Explanation of National Price Levels," *Princeton Studies in International Finance*, No. 52, Princeton University, 1983, and Robert Barro, "Real Determinants of Real Exchange Rates," Unpublished Manuscript, 1983. Much early work arose from attempts to test the purchasing-power-parity theory—see Paul A. Samuelson, "Theoretical Notes on Trade Problems," *Review of Economics and Statistics*, Vol. 46, May 1964, pp. 145–54, Bela Balassa (1964) "The Purchasing Power Parity Doctrine: A Reappraisal," *Journal of Political Economy*, Vol. 72, December 1964, pp. 584–96, and Lawrence H. Officer, *Purchasing Power Parity and Exchange Rates: Theory, Evidence and Relevance*, London and Greenwich Connecticut: JAI Press, 1982. More recently, the emphasis has been on representative agent models—see Allan C. Stockman "A Theory of Exchange Rate Determination," *Journal of Political Economy*, Vol. 88, No. 4, August 1980, and "Real Exchange Rates Under Alternative Exchange Rate Regimes," *Journal of International Money and Finance*, No. 2, 1983, pp. 147–66, Allan C. Stockman and Lars E. O. Svensson, "Capital Flows, Investment and Exchange Rates," *Journal of Monetary Economics*, Vol. 19, 1987, pp. 171–202, Elhanan Helpman, "An Exploration in the Theory of Exchange Rate Regimes," *Journal of Political Economy*, Vol. 89, No. 5, October 1981, pp. 865–890, Elhanan Helpman and Assaf Razin, "Dynamics of a Floating Exchange Rate Regime," *Journal of Political Economy*, Vol. 90, No. 4, August 1982, and Sebastian Edwards, *Real Exchange Rates, Devaluation, and Adjustment*, MIT Press, 1989. While they demonstrate rigorously the important role of real factors in determining the real exchange rate, these formulations are not able to address the data in any better way than the simple intuitive presentation here—Edwards, for example, ends up with an estimating equation

Domestic and foreign incomes affect the real exchange rate because an increase in income involves an increase in production of non-traded (home) and traded (home and foreign) goods as well as a positive income effect on the demand for all these goods—the effect on the relative price of home in terms of foreign output will depend upon the magnitudes of these technology and income effects on domestic and foreign traded and non-traded goods prices and on whether these effects are viewed as temporary or permanent. Home government consumption might be expected to increase the demand for home relative to foreign goods and vice versa abroad. The same holds for the government budget deficit under usual Keynesian assumptions. The terms of trade, which are determined in substantial part outside the domestic economy, directly affect the price of domestic output in terms of foreign output. Oil prices affect the terms of trade as well as the relative prices of non-traded goods in terms of traded goods both at home and abroad. An increased inflow of capital shifts world demand onto home output and increases its relative price in terms of output abroad. An exogenous unanticipated domestic monetary expansion causes a portfolio shift into foreign assets, leading to a depreciation of the domestic nominal exchange rate and, given sticky prices in the short-run, the real exchange rate. By the same argument, an exogenous unanticipated monetary expansion in the rest of the world leads to an appreciation of the domestic real exchange rate. Anticipated monetary changes are assumed at this point to affect the nominal exchange rate but not the real exchange rate.

Because they are central to the analysis above, the effects of exogenous unanticipated money shocks need further discussion. The basic conditions of portfolio equilibrium in a country are

$$M = P\,L(i, Y) \tag{1}$$

$$i = i^* + E_\pi + \rho \tag{2}$$

where M is the domestic nominal money stock, i and i^* are the domestic and foreign nominal interest rates, P is the domestic price level, Y is domestic income, E_π is the expected rate of change in the nominal exchange rate, defined as the price of foreign currency in terms of domestic currency, and ρ is a risk premium. The first equation says that domestic residents' actual and desired money holdings must be equal. Given the aggregate wealth constraint, this ensures that their desired and actual aggregate holdings of

of the same genre as mine.

non-monetary assets are also equal. The second equation states that domestic interest rates must adjust relative to foreign interest rates to ensure that the existing mix of domestic and foreign non-monetary assets is willingly held by world asset holders. For simplicity it is assumed that domestic and foreign residents hold home-country money balances only—relaxing this assumption would not change the results.

Suppose now that there is an exogenous increase in M. One or more variables on the right-hand side of (1) must adjust to maintain equilibrium. In the classical full-employment case, Y is fixed at its full-employment level and i is determined by the world nominal interest rate, the risk premium and the expected rate of depreciation of domestic currency—the latter will equal the difference between the domestic and foreign expected inflation rates plus the expected rate of decline in the real exchange rate, all of which, along with ρ, are assumed among the *ceteris paribus*. The entire adjustment falls on the price level, which rises in proportion to the increase in the nominal money stock.

In the short run, when P cannot adjust immediately, the adjustment must fall on output and employment. The standard mechanism through which this occurs involves a portfolio adjustment by domestic residents which creates an incipient balance of payments surplus and a devaluation of the domestic currency both in nominal and real terms. This devaluation increases exports relative to imports, causing aggregate demand and output to expand until Y has risen sufficiently on the right-hand side of (1) to maintain equality with the left side.

It is well known that adjustment of the trade balance also cannot occur immediately—indeed, it is often argued that the so-called J-curve effect will cause the current account balance to decline rather than increase in the very short run in response to a devaluation. To the extent that appropriate trade balance adjustment cannot occur, output cannot rise to maintain asset equilibrium and an infinite exchange rate adjustment would result.

Once we recognize that the relevant domestic price level is an index of domestic non-traded and traded goods prices, however, the exchange rate adjustment becomes bounded. Rewrite (1) as

$$M \;=\; P_u^{\alpha}(\pi P^*)^{1-\alpha}\, L(i, Y) \tag{3}$$

where the index of prices

$$\hat{P} = P_u^{\alpha}(\pi P^*)^{1-\alpha} \tag{4}$$

has been substituted for P, with P_u being the price index of domestic non-traded goods, P^* the price of traded goods in foreign currency, represented by the foreign price level, and π the nominal exchange rate defined as the domestic currency price of foreign currency. When neither P_u nor i nor Y can adjust, portfolio equilibrium now will be reestablished by an adjustment of π as long as $\alpha < 1$. This rise in π will be bounded at the point where $\hat{P}$ has risen in the same proportion as M. When $\alpha > 0$, this will imply an adjustment of π in the short-run greater than the ultimate adjustment of both P_u and π in the long-run when price flexibility rules. There will be exchange rate overshooting.[4]

It is important to notice that an immediate adjustment of the nominal and real exchange rates in response to an exogenous money supply shock or a shift of the demand function for money can occur in the short-run independently of changes in current output. Indeed, whether output changes or not, the nominal and real exchange rate movements are inevitable. All that is required for a real exchange rate adjustment to occur is price-level stickiness. This holds true for any formulation of real sector equilibrium one might choose, although a model in which the trade balance and output eventually respond to real exchange rate movements would seem to be a minimal requirement if the theory is to make sense.

Real and nominal exchange rate adjustments will also occur in response to aggregate exogenous monetary shocks in the rest of the world. A positive shock abroad will result in lower world, and hence domestic, interest rates and result in an excess demand for domestic money balances at the existing domestic money stock. This will lead to an immediate appreciation of the domestic nominal and real exchange rates to maintain condition (1).

[4] This overshooting may be moderated by a fall in the domestic interest rate if agents recognize that overshooting is occurring and thereby anticipate a subsequent appreciation of the domestic currency. See Rudiger Dornbush, "The Theory of Flexible Exchange Rate Regimes and Macroeconomic Policy," *The Scandinavian Journal of Economics*, Vol. 78, No. 2, 1976, pp. 255–275, for a development of this argument.

3 The Effects of Unanticipated Money Shocks

Standard OLS regressions of the real exchange rates of nine countries on the variables noted in the previous section are presented in Table 1. The unanticipated money shock variables are the forecast errors from a regression of current money on itself lagged one to eight quarters and nominal income lagged one to eight quarters. Of the 36 unanticipated money coefficients, 33 are insignificantly different from zero and 25 have the wrong signs. As alternative measures of unanticipated money, forecast errors from a simple AR8 process and ARIMA(1,1,1) and ARIMA(4,1,0) processes were tried. All forecasts are running forecasts in which the forecasted value for period t depends only on data from earlier periods. The results (not shown) indicate that the coefficients of the variables other than unanticipated money are not much affected by the type of unanticipated money variable used. Of the 144 instances including those shown in Table 1 (9 countries $\times$ 4 unanticipated money variables $\times$ 4 forecasting procedures), only 66 have the right sign, 6 are statistically significant with the right sign and 9 are statistically significant with the wrong sign. The conclusion is that unanticipated money shocks did not have effects on the real exchange rate that are significant or in the direction anticipated.

While one might have expected unanticipated money shocks to be significant determinants of temporary, year to year, real exchange rate shocks, there is good reason why unanticipated money shocks cannot be major determinants of observed real exchange rate movements extending over several years. As illustrated in Figure 1 which uses Canada as an example, the real exchange rate series (the solid line) tend to be low-frequency series showing substantial persistence, in most cases having unit roots, while the unanticipated money shock series (the dotted and dashed lines) tend to be high-frequency white noise series. As long as one believes that unanticipated money shocks are high-frequency series, unanticipated money can explain very little of the major movements in real exchange rates. This does not rule out the possibility that unanticipated money shocks could have high-frequency real exchange rate effects—they could well be related to the residuals of the cointegrating regressions of the real exchange rate on the non-stationary variables. The regression results in Table 1 suggest, however, that this is not the case.

The underlying model is, of course, a reduced form one which does not

Table 1: Real Exchange Rate Regressions: 1974:1 to 1991:3

	Canada		Australia		Austria	
Constant	8.29*	7.01*	-1.77	1.58	-0.10	-0.46
	(2.17)	(2.02)	(1.77)	(1.82)	(1.89)	(1.94)
Real Income	0.15	-0.17	-0.67	-0.49	2.11*	2.06*
	(0.63)	(0.61)	(0.47)	(0.49)	(0.49)	(0.53)
Real Income Abroad	-0.35	0.10	0.91	0.76	-1.93*	-1.91*
	(0.70)	(0.67)	(0.56)	(0.58)	(0.48)	(0.53)
Government	0.07*	0.05*	0.01	0.01	0.10*	0.09*
Consumption	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Gov't Consumption	-0.15*	-.12*	0.06	0.03	-0.09*	-0.07*
Abroad	(0.05)	(0.05)	(0.04)	(0.04)	(0.03)	(0.03)
Government Budget	.02*	0.016?	-0.001	-0.0004	0.01	0.01
Surplus	(0.01)	(0.008)	(0.005)	(0.005)	(0.008)	(0.007)
Government	-.05*	-.03	0.003	0.01	0.026	-0.02
Surplus Abroad	(0.02)	(0.02)	(0.02)	(0.02)	(.014)	(.014)
Oil Prices	-0.15*	-0.13*	0.005	0.01	-0.19*	-0.19*
	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)	(0.035)
Terms of Trade	-0.21	-0.11	0.91*	0.89*	1.04*	1.11*
	(0.24)	(0.23)	(0.15)	(0.15)	(0.31)	(0.32)
Net Capital	-.02*	-0.017	-0.001	-0.002	0.02*	0.02*
Outflow	(0.01)	(0.01)	(0.006)	(0.01)	(0.004)	(0.004)
Unanticipated M1	0.18		-0.58		0.93?	
	(0.43)		(0.37)		(0.37)	
Unanticipated M1	-1.96		-1.02		-0.13	
Abroad	(1.06)		(0.88)		(0.87)	
Unanticipated M2		-1.66		-1.42		0.99
		(0.91)		(0.83)		(0.84)
Unanticipated M2		-0.69		-0.76		-0.35
Abroad		(1.48)		(1.34)		(1.39)
Obs.	71	71	71	71	71	71
R^2	0.52	0.52	0.81	0.81	0.84	0.83
SEE	0.06	0.06	0.05	0.05	0.05	0.06
DW	0.59	0.61	0.76	0.74	1.24	1.25

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Table 1: Continued ....

	Germany		U.S.		U.K.	
Constant	-1.53	-1.75	-5.63*	-5.61*	-4.25*	-5.22*
	(1.77)	(1.78)	(1.70)	(1.75)	(1.64)	(1.52)
Real Income	1.11*	1.23*	1.59	1.83*	-0.22	0.45
	(0.53)	(0.53)	(0.86)	(0.88)	(0.92)	(0.86)
Real Income Abroad	-0.99*	-1.18*	-1.47?	-1.68*	-0.48	-1.04
	(0.46)	(0.47)	(0.77)	(0.78)	(0.75)	(0.71)
Government Consumption	-0.07*	0.06*	0.08*	0.07*	0.05*	0.05*
	(0.02)	(0.02)	(0.026)	(0.025)	(0.02)	(0.02)
Gov't Consumption Abroad	-0.08*	-0.06*	0.04	0.04	-0.05	-0.04
	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)
Government Budget Surplus	0.008	0.005	-0.02	-0.02	0.005	0.003
	(0.01)	(0.11)	(0.02)	(0.02)	(0.005)	(0.005)
Government Surplus Abroad	0.04*	0.036*	0.009	0.016	0.08*	0.08*
	(0.01)	(0.013)	(0.01)	(0.01)	(0.02)	(0.02)
Oil Prices	-0.02	-0.007	0.29*	0.29*	-0.29*	-0.29*
	(0.06)	(0.06)	(0.04)	(0.05)	(0.05)	(0.05)
Terms of Trade	1.30*	1.36*	1.38*	1.38*	2.92*	2.99*
	(0.27)	(0.28)	(0.23)	(0.23)	(0.34)	(0.33)
Net Capital Outflow	0.02*	0.02*	-0.03*	-0.03*	-0.007	0.005
	(0.007)	(0.007)	(0.01)	(0.014)	(0.009)	(0.009)
Unanticipated M1	0.86*		-0.89		0.95	
	(0.38)		(0.41)		(0.52)	
Unanticipated M1 Abroad	0.44		0.35		-0.95	
	(0.84)		(0.89)		(1.12)	
Unanticipated M2		1.24		-0.84		0.23
		(0.82)		(0.90)		(1.11)
Unanticipated M2 Abroad		0.27		0.43		-3.01
		(1.37)		(1.39)		(1.62)
Obs.	71	71	71	71	71	71
R^2	0.89	0.88	0.81	0.80	0.76	0.76
SEE	0.05	0.06	0.06	0.06	0.07	0.07
DW	1.17	1.08	1.00	0.97	1.25	1.29

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Table 1: Continued ....

	Japan		Italy		France	
Constant	-8.03*	-7.75*	0.64	0.20	-3.82?	-4.71*
	(1.12)	(1.13)	(1.27)	(1.33)	(1.96)	(1.96)
Real Income	-2.89*	-2.73*	1.75*	1.63*	2.37*	2.45*
	(0.38)	(0.40)	(0.49)	(0.54)	(0.48)	(0.50)
Real Income Abroad	4.51*	4.26*	-2.05*	-1.99*	-2.37*	-2.43*
	(0.48)	(0.49)	(0.55)	(0.59)	(0.35)	(0.38)
Government Consumption	0.07*	0.08*	0.01	0.02	0.001	-0.002
	(0.025)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)
Gov't Consumption Abroad	0.86*	0.09*	-0.06*	-0.05	0.03	0.05
	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)
Government Budget Surplus			-0.002	-0.000	0.01*	0.01*
			(0003)	(0.003)	(0.005)	(0.005)
Government Surplus Abroad			0.003	-0.002	0.05*	0.05*
			(0.015)	(0.02)	(0.02)	(0.02)
Oil Prices	-0.04	-0.04	-0.08	-0.06	0.007	-0.035
	(0.04)	(0.04)	(0.05)	(0.05)	(0.07)	(0.07)
Terms of Trade	0.82*	0.81*	1.41*	1.49*	1.77*	1.85*
	(0.085)	(0.08)	(0.21)	(0.224)	(0.38)	(0.40)
Net Capital Outflow	0.017	0.02*	0.006	0.006	-0.026*	-0.029*
	(0.007)	(0.007)	(0.004)	(0.005)	(0.012)	(0.013)
Unanticipated M1	0.39		0.69*		0.42	
	(0.31)		(0.31)		(0.42)	
Unanticipated M1 Abroad	-0.25		-1.53*		-1.29	
	(0.67)		(0.69)		(0.95)	
Unanticipated M2		1.16		0.60		0.34
		(0.71)		(0.75)		(1.01)
Unanticipated M2 Abroad		0.37		-0.64		0.13
		(1.04)		(1.10)		(1.46)
Obs.	71	71	71	71	71	71
R^2	0.94	0.94	0.88	0.86	0.81	0.80
SEE	0.05	0.05	0.05	0.05	0.06	0.06
DW	1.08	1.04	0.90	0.88	0.89	0.90

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Table 1: Continued ....

Notes:

a) Figures in brackets are standard errors. Those marked with a $*$ are significant at the 5 percent level or better, those marked with a ? are not far from being significant at the 5 percent level.

b) The dependent variable in all regressions is the real exchange rate.

c) All variables except the government budget deficit and the net capital inflow are in logarithms. The government consumption, government budget deficit and net capital inflow variables are expressed as fractions of real income.

d) The oil price variable is an index of U.S. dollar prices of Venezuelan crude oil, extended using Arabian crude oil prices after 1990, divided by an index of domestic import prices in U.S. dollars.

e) The unanticipated money variables are prediction errors from an autoregressive forecast using eight lagged values of the dependent variable and eight lagged values of nominal income as regressors.

Sources: *Cansim* for Canadian money and government budget surplus variables and the U.S. money variables, *Citibase* for the U.S. government surplus variable and IMF, *International Financial Statistics* for the remaining variables.

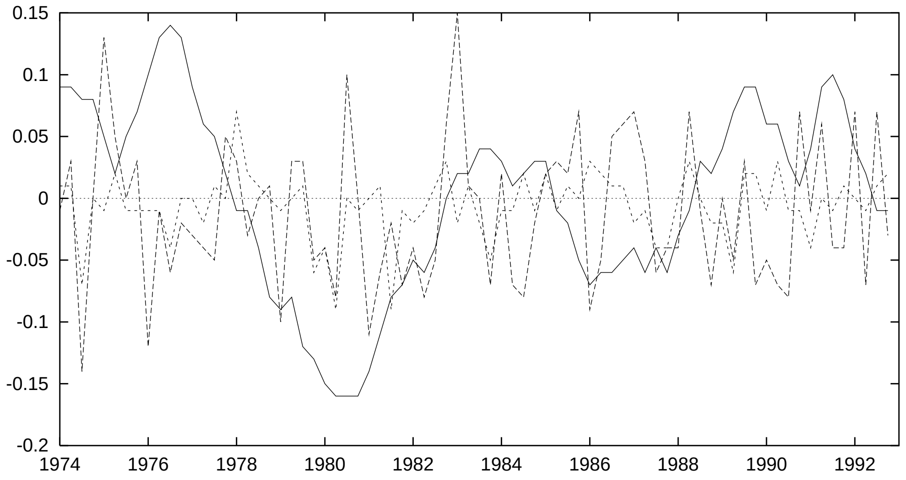

Figure 1: Detrended log real exchange rate (*solid line*), domestic unanticipated money (*dotted line*) and rest-of-world unanticipated money (*dashed line*), Canada, 1974–1992. Both unanticipated money series are scaled by a factor of 3. Sources: Cansim and *International Financial Statistics*.

permit us to identify the underlying structural parameters. This makes it impossible, for the most part, to establish *a priori* signs for the variables included. Moreover, many of the underlying exogenous variables are technology related and for measurement reasons cannot be properly proxied. The missing technology variable can covary with the independent variables in either direction, biasing coefficients and reversing signs. This effectively rules out the prospects for unraveling the underlying structure behind observed low-frequency real exchange rate movements using more sophisticated techniques. The purpose of including the wide range of real variables in the regressions is to help identify the influence of the monetary forces.

In neutralizing the non-monetary factors affecting the real exchange rates of the nine countries, we must establish that the regressions in Table 1 are not spurious.[5] This would imply non-stationary residuals from regressions of the real exchange rates on the non-stationary real factors, with the result that any relationship between high frequency components of the real exchange

[5]See C. W. J. Granger and Paul Newbold, *Forecasting Economic Time Series*, Academic Press Inc., 1986, and for a summary of recent work, David A. Dickey, Dennis W. Jansen and Daniel L. Thornton, "A Primer on Cointegration with an Application to Money and Income," *Review*, Federal Reserve Bank of St. Louis, March/April, 1991, pp. 58–78.

rate and the unanticipated money variables would be obscured. Application of tests suggested by Engle and Granger[6] indicates that it is unlikely that the results here are spurious. The hypothesis of no cointegration can be rejected at the 5% level or better in most cases and at the 10% level in the rest.

A potential area of criticism is the lack of power of the statistical test of the null hypothesis that unanticipated money has a zero effect. To conclude that these shocks have no effect, we should seek to reject the null hypothesis that they have an effect. Since the priors of most of the profession would be that unanticipated money has an effect, however, a null hypothesis of no effect would seem to be appropriate. If there is an effect it cannot be discerned in the data.[7]

It is also important to distinguish between economic significance and statistical significance. As a test of economic significance suppose counterfactually, again using the Canadian case, that the true coefficients of unanticipated money have the correct signs and are three times the standard errors estimated in Table 1. The projected effect on the real exchange rate of the movements in unanticipated money that actually occurred is given by the difference between the dotted and solid lines in Figure 2. The deviations in the real exchange rate attributable to such money shocks are not substantial. They might be of interest to a short-term market speculator, but do nothing to explain, for example, the large depreciation between 1976 and 1980, the appreciation between 1980 and 1984, and the depreciation after 1984 and subsequent appreciation, and they bear little relationship to the business cycle.

Finally, there is an econometric issue involving generated regressors. When predicted or residual values from one regression are used as regressors in a second regression, problems of efficiency and consistency and of making valid inferences with the standard errors provided as output from the second stage regression frequently arise.[8] These problems do not arise in the regressions

[6]Robert F. Engle and C.W.J. Granger, "Co-integration and Error Correction: Representation Estimation and Testing," *Econometrica*, Vol. 55, No. 2, March, 1987, pp. 251–276.

[7]It should be noted here that running the regressions with the non-stationary variables first differenced also yields no statistically significant influence of unanticipated money shocks.

[8]See Adrian Pagan, "Econometric Issues in the Analysis of Regressions with Generated Regressors," *International Economic Review*, Vol. 25, No. 3, February 1984, for a thorough discussion of these issues.

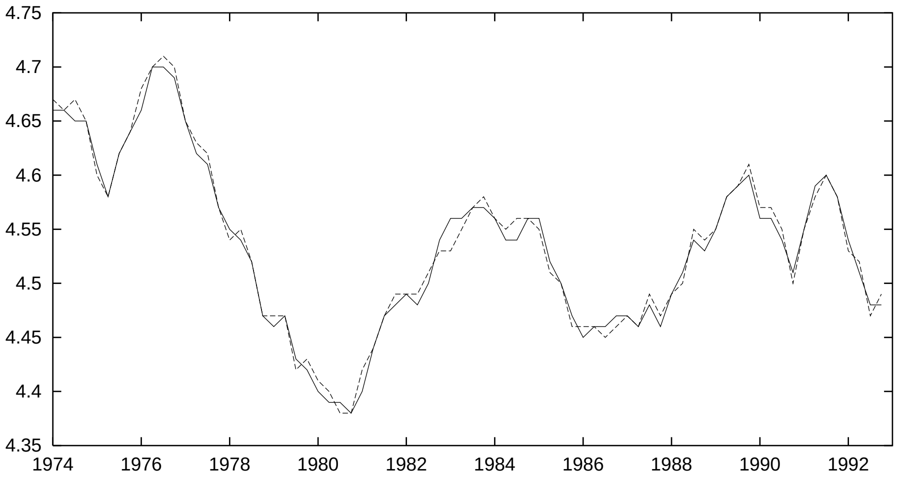

Figure 2: Logarithms of actual real exchange rate (*solid line*) and predicted real exchange rate (*dotted line*) generated by observed unanticipated money shocks with imposed coefficients correctly signed and equal to three times their standard errors, Canada, 1974–1992, 1963–66=100. Sources: *Cansim* and *International Financial Statistics.*

reported here, however, because only unlagged residuals from the preliminary regressions appear in the second stage.[9]

4 Anticipated Money Shocks

This line of analysis cannot establish that anticipated money shocks have no effect on real exchange rates. The anticipated money series here are the fitted series that are subtracted from the actual to obtain the unanticipated money shocks. Anticipated money would likely be statistically significant in the real exchange rate regressions, and could well take either sign, because it is a low frequency random-walk-type variable which, even if its true coefficient were zero, would pick up the specification errors in the other low-frequency independent variables that arise because we have no proxy for technological change, a major factor driving real exchange rates. This also precludes us

[9]See Pagan, *op. cit.*, p. 242. See also Frederic S. Mishkin, *A Rational Expectations Approach to Macroeconomics*, National Bureau of Economic Research, University of Chicago Press, 1983.

from adding lagged values of the unanticipated money variables to the regressions since it would be observationally equivalent to adding some portion of the variations in anticipated money.[10] This in no way detracts from the statistical insignificance of unanticipated money shocks, which is extremely important because capital and exchange rate markets are highly responsive to current monetary conditions.[11] There is no hope of unraveling the effects of anticipated money using the above methodology even apart from the observational equivalence problem—the difficulties of modeling technological change are insurmountable.

The argument that anticipated money matters for real exchange rate determination must postulate that contractual and other institutional rigidities prevent wage rates from adjusting to fully anticipated changes in aggregate demand conditions. To explain on this basis the major movements in the real exchange rates of the countries examined here, one would have to postulate institutional rigidities that extended over periods several years in length and persisted in the face of substantial changes in world inflation rates.

Figure 3 presents the real and nominal exchange rates and the ratios of the domestic to foreign price levels for nine industrial countries. For each country, the ratio of the domestic price level to the price level in the rest of the world is indicated by the solid line, and the nominal and real exchange rates by the dotted and dashed lines. The rest-of-world aggregate in each case consists of the remaining eight countries.[12] The correspondence of the real and nominal exchange rate movements and the high degree of both high and low frequency exchange rate as compared to relative price level variability is immediately evident. If the major real exchange rate movements were the result of monetary factors, either on the supply or demand side, one would expect to observe some correlation between real exchange movements and

[10] See T. J. Sargent "The Observational Equivalence of Natural and Unnatural Rate Theories of Macroeconomics," *Journal of Political Economy*, 84, 1976, pp, 631–640.

[11] The problem here is quite different than the one which arose in the debate about whether anticipated money mattered in determining U.S. aggregate employment. [See Frederic S. Mishkin, *A Rational Expectations Approach to Macroeconomics*, National Bureau of Economic Research, University of Chicago Press, 1983.] Here the issue is whether unanticipated money matters.

[12] The price levels are consumer price indexes with the rest-of-the-world price level being an index of all other countries' CPI's using 1980 output shares as weights. The real exchange rate is the ratio of the domestic CPI to a 1980 output-weighted average of the CPI's of all other countries after all CPI's have been multiplied by the U.S. dollar prices of the individual countries' currencies.

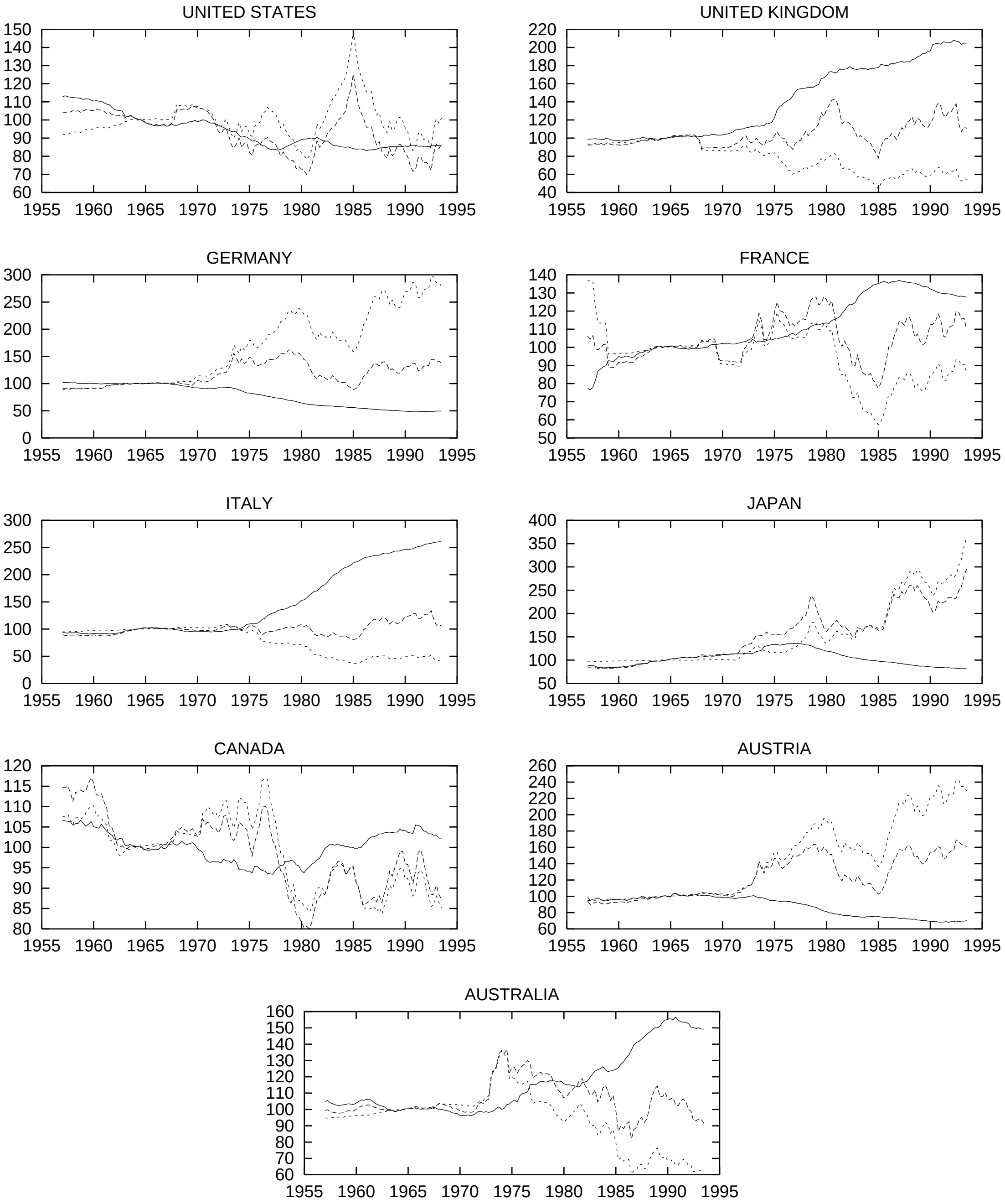

Figure 3: Real exchange rate (*dashed line*), nominal exchange rate (*dotted line*) and ratio of the domestic to rest-of-world price levels (*solid line*) for selected countries, 1957–1993, 1980 = 100. Source: *International Financial Statistics*.

subsequent movements in the ratios of domestic to foreign price levels. No such empirical relationships are apparent.

To pursue the matter further, consider the infamous real and nominal appreciation of the U.S. dollar during the period 1980–84. Over a four year period, the U.S. real exchange rate rose by more than fifty percent. Many arguments have been advanced attributing this variously to tight monetary policy, lax fiscal policy, and speculative bubbles.[13] All of these arguments necessarily depend on price level stickiness. Without sticky prices, a fifty percent appreciation of the U.S. real exchange rate not based on exogenous real factors would have eventually been eliminated by some combination of fifty percent fall in the price level in the United States and a fifty percent rise in the price level in the rest of the world. The panel at the top left in Figure 3 indicates clearly that very little downward movement of U.S. relative to foreign price levels occurred. Given what we know about price stickiness, it is hard to believe that a shift in the equilibrium relative nominal price levels of fifty percent would have had so little effect on actual price levels over a four year period.

Table 2 shows the inflation rates in the U.S. and abroad during the period. All countries shown experienced substantial reductions in their inflation rates between 1980 and 1984. For the price stickiness argument to hold here U.S. prices would have had to be sticky downward and foreign prices sticky upward. Yet foreign prices actually fell relative to where they would otherwise have been. Foreign inflation rates should have risen, or at least not fallen, had there been such a large shift in nominal aggregate demand. Existing theories of price rigidity apply to absolute price levels not relative price levels—there is no reason, for example, why the ratio of the German price level to the U.S. price level should have been rigid while the absolute price

[13] Jeffrey A. Frankel, "Six Possible Meanings of 'Overvaluation': The 1981–85 Dollar," *Princeton Essays in International Finance*, No. 159, December 1985, examines in detail various arguments that the dollar was "overvalued" during this period. Paul Krugman *Exchange Rate Instability*, MIT Press, 1989, advances the hypothesis that this overvaluation was a speculative "bubble". Peter Garber, "The Dollar as Bubble," in Stefan Gerlach and Peter A. Petrie, eds., *The Economics of the Dollar Cycle*, MIT Press, 1990, 129–47, takes issue with the bubble theory on grounds that our knowledge of the fundamental factors affecting the exchange rate is so poor [see Richard Meese and Kenneth Rogoff, "Empirical Exchange Rate Models of the Seventies: Do They Fit Out-of-Sample?", *Journal of International Economics*, 3–24, 1983.] that we have no way of separating fundamental effects from speculative effects. For a compendium of opposing views on the movements of the dollar in the 1980's, see the Gerlach and Petrie volume just cited.

Table 2: Inflation Rates of Selected Countries
Percent Per Year, 1980 and 1984

	1980	1984	Difference
United States	9	2	-7
United Kingdom	15	3	-12
Germany	6	0	-6
France	12	3	-9
Italy	17	5	-12
Sweden	14	4	-10

Sources: *Cansim* for Canada, *Citibase* for the U.S. and IMF, *International Financial Statistics* and OECD, *Main Economic Indicators* for the remaining countries.

levels were at the same time flexible.

5 An Explanatory Hypothesis: Orderly Markets, or Leaning Against the Wind

The analysis thus far has yielded three extremely important conclusions. First, it leaves no doubt that there is an empirical relationship between the world relative price structure and the real exchange rate. That relationship is not spurious and explains a large fraction of movements in the real exchange rates of the major industrial countries. Second, there are substantial identification problems in unraveling the influence of specific real factors on the real exchange rate. Third, and most important, unanticipated monetary factors do not provide any explanation of observed real exchange rate movements. Although the matter was not pursued econometrically, there is also no evidence to suggest that major movements of the real exchange rates of the nine countries examined can be explained by anticipated money shocks.

No sensible economist would argue that an exogenous unanticipated shock to the money supply would not affect that country's real and nominal exchange rates. Why, therefore, do we observe this phenomenon? Are unmeasurable left-out stationary real factors biasing the results? Clearly, the residuals of the cointegrating regressions underlying the results in Table 1 reflect rather deep specification problems in formulating those regressions. But it is not clear that the specification errors in the unit root variables that produce those residuals should be correlated in any particular way with the unanticipated money supply shocks. Since these left-out variables are as unidentifiable to the monetary authorities as they are to the researcher it makes little sense that they would base their monetary policy upon them.

High-frequency unanticipated shocks affecting the demand for money are likely to be at least partly observable to the authorities because they will affect financial markets and the exchange rate. If, in response to pressure from financial market participants, the authorities try to maintain financial market stability in the face of such shocks they will manage the money supply with reference to them. This tendency to smooth out the effects of exogenous demand shocks to the financial sector is well established in central bank folklore, variously described by the terms "orderly markets", "leaning against the wind", and "even keel". To properly identify the effects of exogenous unanticipated money supply shocks on the exchange rate we have to add proxies for high-frequency demand for money shocks to the regressions so that the response of the real exchange rate to excess supply shocks rate can be identified. This is not possible, of course, and specification bias results from leaving them out.

Given the omission of unanticipated demand for money shifts from the estimating equation, the estimated coefficient of the stochastic unanticipated money supply variable can be expressed

$$\hat{\beta}_s \quad = \quad \beta_s + \delta\, \beta_d \tag{5}$$

where β_s is the true coefficient of exogenous unanticipated money supply changes, β_d is the true coefficient of the stochastic changes in the demand for money, and δ is the regression coefficient in an auxiliary regression of the stochastic component of the demand for money on the unanticipated component of the money supply. The effect of a shock to the excess supply of money on the real exchange rate is the same whether that excess supply shock arises from a shift in the demand for money or a shift in the supply. Thus, $\beta_s = -\beta_d$ and (5) reduces to

$$\hat{\beta}_s \quad = \quad (1-\delta)\, \beta \tag{6}$$

where β is the true coefficient of an exogenous stochastic shock to the excess money supply in the real exchange rate regression. Suppose that the authorities, to eliminate overshooting effects of demand for money shocks on the exchange rate, continually adjust the money supply to offset them. The stochastic shocks to the supply of money are then identical to the speculative and other high frequency changes in the demand for money and $\delta = 1$. The observed coefficient of unanticipated money will therefore be zero, even though an exogenous independent unanticipated shift in the money supply would have the negative effect on the real exchange rate postulated by economic theory.[14]

[14] Richard Meese and Kenneth Rogoff, "Was it Real? The Exchange Rate-Interest Differential Relation over the Modern Floating-Rate Period," *Journal of Finance*, Vol. 13, No. 4, September 1988, pp. 933–48, study the exchange rate-interest differential relation and find evidence corroborating this. They examine the dollar/mark, dollar/yen, and dollar/pound rates over the period 1974–85 and find that while all the real exchange rates in question (as defined here) tend to be positively related to the real interest rate differential the relationship is not stable enough to be statistically significant. A positive relationship

This unrealistically implies, of course, that the authorities do a perfect job of smoothing out exogenous demand for money shocks. The quite reasonable possibility that the smoothing is imperfect and the authorities unwittingly introduce additional random excess money supply shocks raises a number of interesting questions. Is there evidence of smoothing errors? Have such errors led to greater unexpected variability of the nominal money supply under flexible exchange rates as compared to fixed rates where smoothing is automatic? Has the demand for money been more variable under flexible exchange rates than under fixed rates? And what are the implications of smoothing for the interdependence of countries' monetary policies?

Table 3 gives the variances of the unanticipated money shocks in periods of fixed and flexible exchange rates. Because of the unavailability of quarterly income data for some countries during the early 1960s the forecast error from regressions of money on itself lagged one to eight quarters (leaving out lagged nominal income) is used, along with the first differences of the logarithms of the actual money stock series. Unanticipated money is more variable under flexible exchange rates than fixed rates.[15]

There are two potential explanations for this. One is that the demand for money is more variable under flexible exchange rates than under fixed rates and these shocks are fully reflected in the observed money supply because of smoothing by the authorities when exchange rates are flexible and unavoidable endogeneity of the money supply when they are fixed. The other is that, though the stochastic shocks to the quantity of money demanded may be the same under both regimes, the authorities create additional variability of the observed money supply under flexible rates in their attempts at smoothing whereas perfect smoothing automatically occurs when the exchange rate is fixed.

Let us suppose that the stochastic component of the real exchange rate that will result from exogenous unanticipated monetary variations is some

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would be expected if unanticipated money shocks were exogenous. An unanticipated monetary expansion in the face of short term price level rigidity, for example, would drive down the real value of the domestic currency and create the expectation of a subsequent return of the exchange rate to its initially anticipated level. This expected future appreciation will drive down the domestic interest rate relative to the interest rate abroad. The theory behind these points goes back to Rudiger Dornbusch, "The Theory of Flexible Exchange Rate Regimes and Macroeconomic Policy," *The Scandinavian Journal of Economics*, Vol. 78, 1976.

[15] The only exception occurs in the case of broadly defined money for Canada.

Table 3: Variances of Unanticipated Money at Home and Abroad

FIRST DIFFERENCE OF LOGARITHMS

Narrowly Defined Money

		Fixed Rates		Flexible Rates	
	Share	Home	Abroad	Home	Abroad
U.S.	.390	.023	.007	.025	.011
Japan	.133	.027	.008	.047	.010
Germany	.108	.013	.008	.042	.009
France	.117	.040	.008	.080	.008
U.K.	.082	.058	.010	.060	.014
Italy	.097	.018	.007	.031	.009
Canada	.039	.014	.007	.038	.008
Australia	.025	.025	.007	.074	.008
Austria	.011	.012	.007	.047	.008

Broadly Defined Money

		Fixed Rates		Flexible Rates	
	Share	Home	Abroad	Home	Abroad
U.S.	.390	.005	.002	.009	.007
Japan	.133	.007	.003	.012	.006
Germany	.108	.004	.003	.024	.007
France	.117	.019	.002	.046	.005
U.K.	.082	.020	.002	.030	.008
Italy	.097	.005	.003	.022	.006
Canada	.039	.016	.002	.015	.006
Australia	.025	.006	.003	.034	.006
Austria	.011	.003	.002	.011	.006

........Continued Next Page

Table 3: Continued ....

ERRORS FROM AN AR8 FIT TO LOGARITHMS OF LEVELS

NARROWLY DEFINED MONEY

		Fixed Rates		Flexible Rates	
	Share	Home	Abroad	Home	Abroad
U.S.	.390	.006	.005	.015	.008
Japan	.133	.021	.004	.038	.007
Germany	.108	.011	.004	.039	.006
France	.117	.032	.004	.069	.006
U.K.	.082	.052	.006	.061	.013
Italy	.097	.013	.004	.023	.006
Canada	.039	.015	.004	.031	.006
Australia	.025	.020	.004	.065	.006
Austria	.011	.012	.004	.037	.006

BROADLY DEFINED MONEY

		Fixed Rates		Flexible Rates	
	Share	Home	Abroad	Home	Abroad
U.S.	.390	.003	.002	.005	.003
Japan	.133	.004	.002	.006	.002
Germany	.108	.004	.002	.022	.002
France	.117	.016	.002	.032	.002
U.K.	.082	.020	.003	.027	.005
Italy	.097	.004	.002	.013	.002
Canada	.039	.019	.002	.006	.002
Australia	.025	.003	.002	.024	.002
Austria	.011	.003	.002	.008	.002

Notes: The sample period for fixed exchange rates is 1960:1–1970:4 in Panel a) for all countries but Canada and 1963:1–1970:4 for Canada in Panel a) and all countries in Panel b); the sample period for flexible exchange rates is 1974:1–1992:4 for all countries in both panels.

Sources: *Cansim* for Canada, *Citibase* for the U.S. and IMF, *International Financial Statistics* for the remaining countries.

constant β times the excess supply of money. Then

$$z_t \;=\; \beta\,(M_t - M_t^d) = \beta\,(w_t - u_t) = \beta\,v_t \tag{7}$$

where z_t is the stochastic variation in the real exchange rate due to unanticipated monetary factors and u_t, w_t and v_t are normally distributed random variables with zero means and constant variances. $M_t^d = u_t$ and $M_t = w_t = u_t + v_t$ are, respectively, the stochastic variations in the quantities of money demanded by the public and created by the authorities. The stochastic variation in the excess supply of money is represented by v_t and the coefficient β is negative.

Under fixed exchange rates the authorities are constrained to maintain $w_t = u_t$ with the result that $v_t = 0$ —otherwise portfolio shifts would drive the exchange rate away from its parity and, given sticky prices in the immediate run, the real exchange rate would vary stochastically on account of these monetary disequilibria. When the exchange rate is flexible and the authorities do a perfect job of smoothing out the effects of demand for money shocks on the real exchange rate, w_t will again equal u_t and v_t will equal zero. Even if this were true, however, there are reasons to believe that the variance of u_t, and hence the variance of w_t will be higher than it would be under fixed exchange rates. When the rate is flexible, there is speculation as to the direction and extent to which it will move in the future. That speculation will reveal itself in currency substitutions by holders of foreign exchange reserves as well as shifts in forward premia, accompanied by changes in international interest rate differentials, causing the demand for home money to change.[16] Even if the domestic authorities are able to adjust the money supply to completely eliminate these shifts in the excess demand for money, the variance of the money supply will increase to match the increased variance of the demand for money.

Now consider the case where the authorities do an imperfect job of smoothing. Equation (7) implies

$$Var(z) \;=\; \beta^2\,Var(v) \tag{8}$$

[16]Speculation will also occur under fixed exchange rates but it will be of a different sort. The question will be whether or not the pegged rate is about to change, so the speculation will tend to be in one direction. For example, if the real exchange rate is rising and, given the fixed nominal rate, putting upward pressure on the domestic price level, the speculation might be that the authorities will free the rate and allow it to appreciate, thereby avoiding an increase in the domestic inflation rate.

so the variance of the real exchange rate necessarily increases. Table 4 gives evidence of this. As indicated in the two columns on the left, the variance of the quarter to quarter difference in the real exchange rate was higher under flexible rates than fixed rates. This proves little, however, because it could have resulted from a higher variance of real factors affecting the rate. Greater low frequency variability of the real exchange rate (and hence the price level under fixed exchange rates) could be the reason why a country would switch to a flexible exchange rate regime to begin with, and this variability will be reflected in the first differences of the real rate. What is needed is a measure of the high frequency variability that is likely to have resulted from monetary shocks. One approach is to use an eight quarter autoregressive process to filter out everything but the high frequency variations. The variances that result are shown in the two columns on the right. Again, there is substantially more variability of real exchange rates under flexible rates than fixed rates. This higher variability of real exchange rates under the flexible rate regime suggests that imperfect smoothing occurred and could be at least partly responsible for the greater variability of unanticipated money supply movements under flexible rates.

How, then, do we reconcile this with the fact that the coefficients of the unanticipated money shocks in Table 1 are not significantly different from zero. These regression results imply that the covariance between z_t and M_t is zero. That covariance can be expressed

$$Cov(M,z) \quad = \quad \beta\lambda(\lambda+\rho)Var(u) = \beta\,(1+\frac{\rho}{\lambda})\,Var(v) \tag{9}$$

where λ is the ratio of the standard deviation of v_t to the standard deviation

Table 4: Variance of the Real Exchange Rate

	Quarter to Quarter Differences		Forecast Errors from AR8 Process	
	Fixed Rates	Flexible Rates	Fixed Rates	Flexible Rates
U.S.	.012	.181	.012	.145
Japan	.013	.216	.015	.166
Germany	.019	.193	.013	.153
France	.024	.162	.016	.125
U.K.	.037	.286	.037	.230
Italy	.008	.147	.007	.126
Canada	.014	.054	.013	.039
Australia	.003	.162	.003	.139
Austria	.013	.160	.010	.134

Notes: The sample period is 1960:1–1970:4 for fixed exchange rates and 1974:1–1992:4 for flexible exchange rates. The calculations are based on the logarithms of the series.

Source: IMF, *International Financial Statistics*.

of u_t and ρ is the coefficient of correlation between v_t and u_t.[17] If the authorities do a perfect job of smoothing, $\rho = \lambda = 0$ and both $Var(v)$ and $Cov(M, z)$ will be zero. Since $\beta < 0$, smoothing errors uncorrelated with the stochastic demand for money shocks create a negative relationship between the observed money shocks and those shocks to the exchange rate not explained by real sector shocks. By themselves, these would lead to negative coefficients of the domestic unanticipated money variables (and positive coefficients of the foreign unanticipated money variables) in the regressions in Table 1. A zero relationship in the presence of these smoothing errors requires that the errors be negatively correlated with the stochastic demand for money shocks. The regression results in Table 1 therefore suggest that, on average, the authorities must have increased (reduced) the money supply in response to positive (negative) demand for money shocks, but insufficiently so to fully offset those shocks, thereby creating a negative correlation between the smoothing errors and the shocks. They sensed the underlying shifts in domestic relative to foreign monetary conditions but "leaned against" them insufficiently to completely offset their effects on the excess supply of money. Were it not for this negative correlation of the smoothing errors with the demand for money shocks, those errors would have induced a negative relationship between the observed money supply and the real exchange rate. The negative correlation of the smoothing errors with the demand for money shocks created positive relationships between those shocks and the observed money supply and the real exchange rate and, hence, a positive relationship between the latter two variables. The net effect on the covariance of the nominal money shock and the real exchange rate is zero when these two forces offset each other—that

[17] This relationship follows from the facts that

$$\begin{aligned} Cov(M, z) &= E\{(u_t + v_t - 0)(z_t - 0)\} \\ &= E\{(u_t + v_t)(\beta v_t)\} \\ &= \beta[Cov(u, v) + Var(v)]. \end{aligned}$$

and

$$\begin{aligned} Cov(u, v) &= \rho\sqrt{Var(u)}\sqrt{Var(v)} \\ &= \frac{\rho}{\lambda} Var(v) \\ &= \rho\lambda Var(u). \end{aligned}$$

is, when $\lambda = -\rho$.

We know that the real exchange rate showed greater high-frequency variability under flexible exchange rates than under fixed rates, suggesting that the authorities must have imperfectly smoothed out the effects of demand for money shocks when nominal exchange rates were flexible. These smoothing errors were sufficiently negatively correlated with the demand for money shocks to make the covariance between observed unanticipated money supply shocks and the real exchange rate zero. We also know that the variance of unanticipated money supply shocks was greater under flexible exchange rates than under fixed exchange rates. The question then is whether this additional high-frequency variability of the money supply under flexible exchange rates was solely the result of smoothing errors by the authorities or was affected in addition by greater high-frequency shocks to the demand for money under flexible exchange rates than under fixed exchange rates.

The variance of the observed money supply is given by

$$Var(M) \;=\; Var(u) + Var(v) + 2\,Cov(u,v). \tag{10}$$

Since the variance of the unanticipated money shocks increased with the move from fixed to flexible exchange rates,

$$\Delta Var(M) \;=\; \Delta Var(u) + \Delta Var(v) + 2\,\Delta Cov(u,v) > 0. \tag{11}$$

From the definition of λ plus the fact that

$$\Delta Cov(u,v) \;=\; \rho\sqrt{Var(u)}\,\sqrt{Var(v)} = \rho\lambda\,\Delta Var(u) \tag{12}$$

condition (11) reduces to

$$\Delta Var(M) \;=\; (1 + \lambda^2 + 2\,\rho\,\lambda)\,\Delta Var(u) > 0 \tag{13}$$

Substituting the implication from Table 1 that $\rho = -\lambda$ we obtain

$$\Delta Var(M) \;=\; (1 - \lambda^2)\,\Delta Var(u) > 0 \tag{14}$$

This condition can only hold if $\Delta Var(u) > 0$. The demand for money must have been more variable under flexible exchange rates than under fixed rates.

6 Conclusions and Suggestions for Further Work

No evidence has been found that unanticipated money shocks affected real exchange rates in nine major industrial countries during the flexible exchange rate period that began with the collapse of the Bretton Woods system. Real shocks related to technological change, real income cycles, commodity market developments and, quite possibly, government fiscal policies, explain virtually all the variability of real exchange rates. Unanticipated money shocks were nearly always statistically insignificant and, in more than half the cases, wrongly signed. All sensible theories of real exchange rate movements hold that exogenous unanticipated monetary shocks will necessarily affect real exchange rates in the short run. The most plausible rationale for what we observe is that observed high-frequency monetary shocks are endogenously determined responses of the monetary authorities to stochastic shocks to the demand for nominal money holdings associated with interest rate and exchange rate speculation and other factors. There is a long tradition in central banking of maintaining "orderly markets" or "leaning against the wind" in response to political pressure from the financial community, so short-run endogeneity of the money stock should not at all be surprising. Given this interpretation, the evidence suggests that the authorities did a sufficiently good, though imperfect, job of smoothing financial markets to render the relationship between the real exchange rate and observed stochastic unanticipated money supply shocks statistically insignificant after other factors are taken into account.

This raises extremely important questions about the determination of countries' price levels and their business cycles. Widespread endogeneity of money supply determination suggests that the authorities in every country continually adjust the domestic money supply to smooth out all stochastic shocks to the real exchange rate resulting from shocks to the demand for money. Any deviation of the supply of money from what agents wish to hold at existing world interest rates and current inflationary expectations will therefore be eliminated. When the authorities do this they finance the private sector's current expected inflation rate at the existing structure of world interest rates. If agents come to expect the inflation rate or the level of economic activity to change, the authorities will end up providing the finance. The inflation rate and the level of economic activity in each particular country will then be driven by private sector expectations. These expectations will presumably depend on predictions about world inflation rate changes together with predictions about the extent to which the domestic authorities will finance future government expenditures by printing money.

Since the individual countries' monetary authorities will typically provide local finance for world-wide monetary shocks, world inflation rates and the world business cycle will be determined by shifts in the aggregate world demand for liquidity together with world-wide real sector shocks. Although different countries' economies will adjust in different ways, their real exchange rates and possibly their inflation rates as well will reflect the impact of these world real shocks. And their real and nominal interest rates will reflect the risks and expected inflation costs of holding domestic assets in a world capital market given the expected, endogenously financed, response of domestic economic activity to world developments. Countries' long-term trend inflation rates will depend, of course, on underlying domestic decisions as to the fraction of current government expenditures that will be money financed. But against these long-term trends, individual inflation rates will vary in response to common world-wide demand for money shocks that all countries' authorities unwittingly finance.

These issues are too extensive to explore further here. The challenge is either to develop a rigorous theoretical analysis of them, an approach I pursue elsewhere,[18] or to show through further empirical work that countries follow independent short-term monetary policies after all.

[18] John E. Floyd "Stochastic Monetary Interdependence, Currency Regime Choice and the Operation of Monetary Policy," Department of Economics and Institute for Policy Analysis Working Paper No. UT-ECIPA-Floyd-98-01, University of Toronto, 1998.

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