THE EFFICACY OF MONETARY TARGETING: THE STABILITY OF DEMAND FOR MONEY IN MAJOR OECD COUNTRIES

Paul Atkinson, Adrian Blundell-Wignall, Manuela Rondoni and Helmut Ziegelschmidt

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The authors are, respectively, administrator, principal administrator, consultant and administrator in the Monetary and Fiscal Policy Division of the Economics and Statistics Department.

INTRODUCTION

During the 1970s many major central banks moved toward targeting monetary aggregates to facilitate the control of inflation. Reasons for this shift, which occurred in the years after the first oil price rise, were generally pragmatic rather than a reflection of strong "monetarist" views within central banks. One consideration was the difficulty of interpreting nominal interest rates as an indicator of the stance of monetary policy in a period of high inflation. A second consideration was the necessity to adjust interest rates more flexibly; because interest rate changes became endogenous in the context of the achievement of monetary targets, needed adjustments could be made more easily and earlier. Thus, monetary targeting provided a framework permitting the authorities to raise interest rates until they were appropriately restrictive. Third, it was hoped that there would be favourable effects on expectations from the announcement of targets for monetary aggregates. Nevertheless, it was recognized that ultimately the usefulness of monetary targeting would depend on the stability of the demand for money, and the choice of particular aggregates to be targeted was heavily influenced by this consideration. It was anticipated that a strong relationship between growth of monetary aggregates and nominal income (hence inflation) would emerge over the medium term[1].

The demand for money is the key to any reliable relationship between money and nominal income. If it is stable, fluctuations in the money-income relationship, or velocity, will be systematically associated with variations in the determinants of money demand. This, in turn, would have important implications for the efficacy of monetary aggregates as intermediate targets for monetary policy. In the medium term, the quantity theory of money should ensure a predictable relationship between the monetary target and nominal income. Provided that trends in the determinants of velocity are predictable (real income, interest rates, inflation expectations), *so* too will be the trend in velocity itself. With an appropriate allowance for expected velocity developments, a monetary target may be set to achieve potential output growth and the target rate of inflation in the longer run. In the short-term there may be substantial deviations from these long-run final objectives, as the economy is subjected to various real and pricing shocks. However, a money supply target will stabilize the economy in the face of such shocks[2]. For example, a wage shock which is not accommodated by monetary policy will force interest rates to rise, reducing expenditure, income and employment to the point where "wage resistance" is reduced. Eventually the trend in nominal income would tend to re-emerge. Since the longer-run growth of real output is supply constrained (equal to potential output growth), medium-term control of monetary aggregates should prove to be an efficient instrument for restraining inflation.

If, on the other hand, the economy is subjected to financial shocks that move velocity independently of the determinants of money demand, controlling the quantity of money will not be an efficient approach to achieving final objectives for output and inflation. In recent years, particularly in countries where financial innovations have been important, doubts have emerged about the stability of the demand for money. In the United States during 1982, for example, the income velocity of M1, M2 and M3 declined by 2.3, 4.9 and 5.9 per cent, respectively. These declines were large by historical standards, and occurred at a time when important financial innovations were taking place. Similar, though less extreme, examples may be found in other countries. These so-called "velocity puzzles" have led some central banks to retreat somewhat from previously firm commitments to monetary targets in favour of a more judgemental approach to policy formulation. This paper examines the extent to which such doubts about the stability of money demand have been justified.

Part I briefly surveys the experience of major countries with monetary targeting. Part II considers the likely implications of financial innovations on the demand for money. Part III uses a battery of econometric techniques to analyse the empirical stability of money demand equations in major OECD countries. These results are quite mixed. For a large number of monetary aggregates important instabilities do arise. In a few cases these are identified with periods of financial innovation. More frequently, however, they are shown to be associated with periods in which the intermediate objectives of monetary policy and/or the techniques of monetary control were changed. Notwithstanding these difficulties, however, it is shown that at least one aggregate exists for which a stable demand function can be identified in each of the major OECD economies.

I. THE EXPERIENCE WITH MONETARY TARGETING

In most major countries monetary targets have usually been achieved or have been missed by comparatively small amounts[3]. Principal deviations have not apparently reflected an inability to meet objectives in a technical (instrumental) sense. For example, the large overshoot in Germany in 1978 arose from concern about the likely adverse effect on competitiveness of excessive appreciation of the exchange rate. In the United Kingdom, during 1980-81, sterling M3 was allowed to overshoot partly because removal of the Special Supplementary Deposits scheme led to heavy reintermediation, and partly because developments in the real economy suggested that this aggregate was giving a misleading impression of the tightness of policy. Finally, substantial undershooting of target ranges in Canada in 1981-82 and overshooting in the United States in 1982-83 reflected a recognition of distortions to M1 in both countries, which were largely associated with financial innovations.

On the other Rand, as measured by the behaviour of nominal income and its split between prices and output, the experience with monetary targeting has been mixed. In some countries, notably Japan, the experience has been good. Inflation came down sharply after 1974-75, and its reacceleration after the second oil shock was iimited to little more than enough to transmit the inevitable terms of trade loss to users of oil. At the same time, while domestic demand was somewhat sluggish, growth of real output did not slow significantly until 1981-82 and, in any case, has remained substantially positive. Elsewhere, results have been less satisfactory. In the United States and the United Kingdom inflation was accelerating even before the second oil shock, and eventually reached rates which were well in excess of that attributable to oil prices. Overshooting of monetary targets contributed slightly, but both nominal income and inflation ran ahead of what actual monetary growth had been expected to accommodate. Other major countries also found prices rising faster than they had hoped would be consistent with their monetary targets. Monetary authorities perservered with non-accommodating policies in a targeting framework, which implied a tightening of monetary conditions, particularly during late 1980 and 1981. However, while this successfully reduced inflation, the costs in terms of output and employment tended to be greater than anticipated. More recently, in the United States and the United Kingdom in particular, nominal income has grown more slowly than would have been expected on the basis of monetary growth, leading to a somewhat puzzling behaviour of velocity.

A recurrent feature of widespread monetary targeting, which has been some cause for concern, is the tendency for exchange rates to move to levels that appear unwarranted on the basis of competitiveness considerations and to stay there for sustained periods. Where depreciations have seemed to proceed too rapidly, as in Canada in 1977, the United States in 1978-79 and, to a lesser extent, France more recently, the immediate inflationary impact has been worrisome. Where appreciations have apparently gone too far, as in Japan, Germany and Switzerland in 1978, the United Kingdom in 1980-81 and the United States in 1982-83, concerns about the likely deflationary impact of a weak competitive position have emerged. Fears have also arisen that particular sectors which are highly exposed to international competition might be seriously damaged by over-adjustment compared to fundamentals which would reassert themselves in the longer term. Furthermore, apparent substantial misalignment, as with the Japanese yen and the United States dollar at the moment, gives rise to pressures for protection. These issues may lead to conflicts in policy objectives between domestic growth and inflation on the one hand, and the real exchange rate on the other. However, this paper focuses on the domestic aspects of monetary targeting, i.e. the money/nominal income relationship, and not on its international implications[4].

II. THE PROBLEM OF FINANCIAL INNOVATIONS

A potential influence on the relationship between money and nominal income is the recent acceleration in the development of new financial techniques and instruments. This acceleration appears likely to continue in the near future, and may have implications for monetary policy. A number of factors lie behind this development, most important of which are the experience with high and variable inflation; volatile interest rates and exchange rates; the impact of regulatory structures; and rapid technological changes which have affected payment processes and the scope for more efficient cash management?

While not all countries have been importantly affected, the extent of financial innovations in some cases – notably the United States, the United Kingdom and Canada– has been substantial. In the United States the pressures created by ceilings on interest rates payable by banks at a time when market rates have been persistently above these ceilings have resulted in major changes. First, large classes of non-bank liabiiities which serve as money or quasi-money (notably money market mutual funds) emerged. Subsequently, these ceilings were progressively removed and a broad range of other controls over banking were dismantled. A number of interest-bearing chequeing accounts are now available at banks (NOW accounts, Super NOW accounts and money market deposit accounts), and competition has intensified as a wide range of financial services has become available from a variety of non-bank institutions.

In the United Kingdom an important change has been that the dividing line between banks and building societies has become increasingly less clear. The former have moved strongly into the mortgage market, while the latter have become more competitive in their efforts to attract funds. At the same time exchange controls have been abolished, making foreign currency deposits generally available to residents. Technologicai advance has also contributed to reducing the costs of handling transactions, facilitating a rapid rise in the availability of interest-bearing transactions accounts. In Canada, many banks have offered corporate customers facilities for consolidating current accounts across the country on a daily basis. In some cases, any surplus is transferred on an overnight basis to an interest-earning account or to reduce any outstanding operating loan with the bank. The personal sector has also benefited from improved services. Chequeing facilities are also now available on accounts earning a market rate of interest, provided that a minimum balance is maintained. Since late **1979** banks have also offered savings accounts that pay interest on a daily basis rather than on minimum monthly balances[6].

In some other countries the extent of financial innovations has been less pronounced, but may, nevertheless, still be of some importance. In Japan the loss of market share by financial institutions subject to controls and the widespread implementation of new computer technology have been the main stimuli to innovation. New developments include the availability of liquid deposit instruments with securities companies which can be withdrawn at short notice and without penalty, and the evolution of ordinary deposit accounts (*futsu yokin*) into general accounts (*sogo koza*) with overdraft facilities[7]. In France inflation-indexed deposits (*livrets d'épargne populaire*) have been available since June **1982,** although these are reserved for people with very low taxable incomes and are limited to a maximum amount. Liquid deposits which earn variable rates higher than those paid on traditional savings accounts* have also been offered since **1981.** Finally, the capital market has recently become broader and deeper due to

i) more favourable tax treatment of bonds;
ii) prohibition of remuneration on liquid deposits requiring less than six months notice: and
iii) higher real long-term interest rates.

In Italy a long-term trend toward increasing reliance on intermediation of financial flows by banks has been reversed as direct flows in the form of highly liquid instruments from households to firms and, especially, to the public sector, have expanded sharply.

These innovations have caused changes in both the pecuniary and non-pecuniary returns from holding monetary assets. The pecuniary rewards have changed because interest is available on transactions balances where this was previously not the case, or is available at market-related rates whereas previously these were subject to ceilings. The non-pecuniary rewards have changed because the range of instruments which offer facilities for serving as transactions balances has increased, and the liquidity of various non-transactions instruments has been enhanced as effective maturity periods have shortened and notice conditions on withdrawals have eased. In some countries these changes have led to redefinitions of existing monetary aggregates (the United States), and to a partial focusing of attention on newly-defined aggregates (Canada), or on wider aggregates which include liquid instruments of increasing importance (the United States, France, the United Kingdom and Italy).

These developments have potential implications for monetary policy. Where the demand for monetary services by the private sector is stable, as reflected historically in stable demand for money functions, a reasonable possibility, if not a presumption, now exists that these empirical relationships will be disturbed. While the uncertainties created by these disturbances may prove to be transitory, they have led some monetary authorities to conclude that precise targets for particular aggregates will be inappropriate in the near future, and that a more judgemental approach will be required.

The quantitative impact, and even the direction, of a particular set of innovations on money demand may be difficult to estimate. This makes the appropriate policy response difficult to judge. In previous situations where central banks have attempted to identify likely shifts in money demand, the results have been mixed. In some instances central banks have broadly anticipated developments. For example, in 1981 in the United States, it was anticipated that nationwide introduction of NOW accounts would raise the demand for M1 by about 3 per cent during the course of the year. In the event, a moderate deceleration of actual M1 occurred during 1981, whereas, shift adjusted, the deceleration was very sharp. The behaviour of the economy, which went into a serious recession as inflation came down rapidly, was broadly consistent with what would have been expected (shift adjusted) on the basis of past relationships.

Conversely, the long-run impact of institutional changes has at times been misjudged. When the United Kingdom made a number of regulatory adjustments designed to increase competition in financial markets and increase efficiency in credit allocation in 1971, it was anticipated that demand for the broad aggregate, M3, would rise, reflecting reintermediation and the availability of a new financial instrument, the marketable sterling certificate of deposit. In recognition of this, M3 was permitted to grow more rapidly than might have otherwise appeared appropriate, even given the expansionary policy stance adopted at the time. During 1974-1975 the ensuing inflation broadly restored the relationship between money and nominal income that had prevailed until 1971. The adoption of targets for a broad money aggregate (sterling M3) from 1976 reflected, at least in part, a view that despite econometric difficulties in identifying a stable demand for money since that time, this aggregate would be closely related to nominal income over the medium to longer term.

III. AN ECONOMETRIC ANALYSIS OF THE DEMAND FOR MONEY IN SEVEN MAJOR OECD COUNTRIES[9]

In order to examine the question of whether money demand has been sufficiently stable to provide a basis for aggregates-oriented monetary policies, money demand equations for narrow and broad definitions of money have been estimated for the major seven OECD countries. These equations are then submitted to a demanding battery of stability tests, and preferred equations are simulated dynamically to check their tracking performance.

The model

A standard specification which assumes a first order (Koyck) partial adjustment towards long-run real money demand $(M/p)^D$ is used:

$$D\ln\left(\frac{M}{p}\right) = \alpha\left[\ln\left(\frac{M}{p}\right)^D - \ln\left(\frac{M}{p}\right)_{-1}\right] \qquad (1)$$

where $$\ln\left(\frac{M}{p}\right)^D = \ln k + \beta_1 \ln y + \beta_2 \ln(1+r) + \beta_3 D\ln p^e \qquad (2)$$

and M is the money stock, y is real GDP, p is the price level (GDP deflator), r is a short-term interest rate, and p^e is the expected price level[10]. $D=d/dt$, and expected signs are $0 < \alpha \leqslant 1$, $\beta_1 > 0$; β_2, $\beta_3 < 0$. The simple Koyck lag used follows previous research, e.g. OECD (1979*b*). Nevertheless, for the preferred equations reported in Table 3 below, this lag structure was tested against a more general alternative which included lagged values of the independent variables. The Koyck restriction was accepted by the data[11]. By substituting (2) into (1), the equation used in estimation is obtained:

$$D\ln\left(\frac{M}{p}\right) = a_0 + a_1 \ln y + a_2 \ln(1+r) + a_3 D\ln p^e + a_4 \ln\left(\frac{M}{p}\right)_{-1} \qquad (3)$$

This equation is interpreted as capturing both transactions and wealth motives for holding money balances[12].

The financial innovations described in Part II, and the environment of variable inflation in which they have emerged, pose difficulties for modelling the opportunity cost arguments of money demand. With regard to interest rates, the introduction of chequeing deposits that pay a return may influence the interest rate elasticity of money demand. This has always been a problem with estimating demand equations for broad aggregates, which include various time deposits that pay interest, but it now applies to M1 in many countries. These difficulties have been exacerbated by the changes in the range of services offered by banks in most countries in recent years. These imply the possibility of shifts of the non-pecuniary return on holding various types of bank deposits. The correct opportunity cost argument for inclusion in money demand equations might be considered to be:

$$(1+r)' = \frac{1+r}{1+r_1+r_2} \qquad (4)$$

where r_1 is the pecuniary return on bank deposits, and r_2 is the non-pecuniary return (services, etc.). In light of the difficulties of measuring r_1 and r_2, however, it is assumed that $1 + r_1 + r_2$ may be approximated by a constant. Since the equations are estimated in logarithms, this term is assumed to be captured by the constant term in the money demand equation for each country.

Expected inflation, as the anticipated return on goods and services, is also an opportunity cost of holding money. Although it cannot be observed, this term is known to have been highly variable in recent years and should, in principle, be included as a specific argument of empirical money demand equations. In a previous study by the Secretariat, OECD (1979*b*), expectations are assumed to be static, *so* that the current inflation rate proxies the expected future inflation rate as in a random walk (RW) equation.

$$Dlnp^e = Dlnp_{-1} + \varepsilon \qquad (5)$$

These are referred to as "RW Price Expectations" in the results reported below. However, inflation rates are not, in general, random walks, implying the existence of information in the residuals of the random walk model which could improve agents forecasting of future inflation. Consequently, an alternative naive model of price expectations was formulated in terms of forecasts from autoregressive (AR) equations for the rate of inflation of the general form:

$$\begin{aligned} Dlnp^e = \text{const.} + \psi_1 Dlnp_{-1} + \psi_2 Dlnp_{-2} + \psi_3 Dlnp_{-3} \\ + \psi_4 Dlnp_{-4} + \psi_5 Dlnp_{-5} + \varepsilon \end{aligned} \qquad (6)$$

The estimated results are shown in Table A 1 of the Annex. The one period forecasts from the estimated equations were used as an alternative to the random walk measure of expected inflation, and are referred to as "AR Price Expectations" in the results reported below.

Estimation results

Both narrow and broad definitions of the money supply in the seven largest OECD countries were used to estimate equation (3) over a sample period beginning with the abandonment of fixed exchange rates. For most countries this was 1973.Q2-1983.Q 1, although for the United Kingdom and Canada the sample period begins somewhat earlier. Both the RW and AR price expectations variables were used. The results are reported in Tables A2-A5 of the Annex. The M1 equations with RW price expectations in all cases give rise to parameters with the expected a *priori* sign and, with the notable exception of the United States, plausible long-run elasticities for real income, interest rates and inflation. The near zero partial adjustment Koyck coefficient in the case of the United States gives rise to highly implausible results for that country. The real income elasticities are poorly determined in the cases of Japan and the United Kingdom. For France, the Durbin h-statistic suggests the presence of autocorrelation. With AR price expectations considerably more plausible estimates of the lag coefficients, interest and inflation elasticities are obtained for the United States, but autocorrelation is present in the residuals. However, for other countries the results were either indistinguishable from those obtained with the RW price expectations or less satisfactory. In particular, in the cases of Germany and the United Kingdom, the higher income elasticities are associated with estimates for the inflation expectations term which are positive and, in the case of Germany, significantly different from zero.

For the broad aggregates the results were less encouraging. Satisfactory equations were obtained only for M2 in the United States with RW and AR price expectations. For all other countries, regardless of the price expectations variable, at least some parameters are insignificant, of an inappropriate sign, and/or give rise to implausible long-run elasticities.

One reason why some of the results described above are less than satisfactory, particularly for broad aggregates, may be the existence of collinearity between the interest rates and expected inflation variables. In recent years inflation and short-term interest rates have had some tendency to move together, while inflation and output are often related inversely. Typically, inflation, once having been permitted to accelerate, has been countered at a relatively late stage by sharply rising interest rates, with adverse consequences for real activity. As the RW and AR forecasts used to proxy expected inflation are close to the actual inflation rate the equations may be unable to discriminate the separate effects of real income, interest rates and expected inflation on money demand. Moreover, nominal interest rates already include a substantial expected inflation premium, so inclusion of both these terms implies some "double counting" which may also give rise to collinearity problems. Finally the RW and AR approximations used may embody substantial measurement error in comparison to the "true" expected rate of inflation. Consequently, the term was suppressed and all equations were re-estimated over identical sample periods.

The M1 results with the inflation term suppressed are shown in Table A6 of the Annex. In relation to the previous "best" results, long-run elasticities and t-statistics associated with the income term are more plausible in the cases of the United States, Japan and Canada. For the interest rate term, t-statistics substantially improve in the cases of the United States and France, but autocorrelation remains problematic in the residuals of the latter. The lag parameter generally suggests slightly more rapid adjustment to long-run equilibrium when the inflation term is suppressed. In the case of the United Kingdom, the results are similar to those obtained with the AR price expectations variable, for which the parameter, as noted above, was insignificantly different from zero. Results with the inflation term suppressed are, therefore, similar to this earlier finding.

The results for the broad aggregates show much more substantial differences in comparison to those with the inflation expectations term included. For M2 in the United States the iong-run income and interest rate elasticities rise, but the possibility that these estimates are biased is underlined by the deterioration of the Durbin h-statistic. For M3 in Germany the parameter estimates show little change from the specification with AR price expectations but they are better determined.

For M2+CDs in Japan, and M2 in France, the previous inappropriate signs and/or magnitudes of the parameters on the income term are "corrected" by suppressing the inflation term. in the case of Japan, however, the Durbin h-statistic also rises markedly, possibly implying an inappropriate dynamic structure and/or a missing variables problem. For sterling M3 in the United Kingdom, and M2 in Canada, parameter estimates retain incorrect signs, while for M3 in Italy the speed of adjustment implied by the lag parameter remains implausibly small.

Table 1 summarizes the main findings of the detailed results shown in Tables A2 to A7 of the Annex. It is of some interest that a satisfactory M1 equation can be obtained for all of the major OECD economies, with the exception of France. Plausible estimates can also be obtained for broad aggregates in the United States, Germany and France. One possible explanation for the tendency for results to be better for narrower aggregates is that they are much more likely to be "demand-determined" at all points in time. Portfolio holders can switch relatively easily between transactions and time deposits in order to remain on their short-run narrow money demand functions in response to changes in interest rates, etc. In the case of broader aggregates, however, portfolio substitution requires switches into substantially more iiliquid assets, usually outside the banking system. Furthermore, policies of the monetary authorities which impact on overall bank credit expansion may have direct effects on broad aggregates. In these circumstances there may be important simultaneity problems in estimation between demand and supply factors which adversely affect the estimation of an equation for the broader aggregates.

Table 1. Overview of estimation results

A = Equation with RW price expectations preferred
B = Equation with AR price expectation preferred
C = Equation with inflation term suppressed preferred
– = No plausible result obtained

	M1	M2/M3
United States	B,C	A,B
Japan	C	–
Germany	A,C	C
France	–	C
United Kingdom	C	–
Italy	A,B,C	–
Canada	A,B,C	–

Stability analysis

As noted above, the usefulness of monetary aggregates for policy purposes depends heavily on the stability of money demand. Consequently, the demand for money equations reported above were extensively tested for evidence of instability. First a Chow test was used to examine the possibility that instability had emerged from the fourth quarter of 1979. This corresponds with the introduction of the new operating procedure in the United States, whereby more emphasis was to be placed on non-borrowed reserves as an operating instrument. This was expected to give rise to greater uncertainty and more interest rate variability with the United States and, through international financial linkages, other countries. Second, tests based on recursive regressions were used to test for changes in parameters that cannot be explained by random movements around a time-invariant true parameter value. Third, moving regression and time trend tests were carried out. Finally, Quandt's lag-likelihood ratio[13] was computed in order to identify periods where evidence of instability was most likely. Chow tests were then used to test for the significance of such instability. The test statistics are reported in Table A8 and detailed description of the results for the first three tests is provided in the Annex. The Chow test applied to the break points identified by the Quandt likelihood ratio was the most demanding of the tests, and the results are described below.

United States. Low points of the ratio for the M1 equations are mainly observed in late 1979, with the minimum occurring in the first quarter of 1980. This suggests that the switch to the new operating procedure by the Federal Reserve in October 1979 is more likely to have contributed to instability than subsequent financial innovations. A Chow test suggests that this break point is significant if AR price expectations are ignored, but not if they are included. For M2 there is some evidence of a break at later points in 1980 and 1981. This was a period when financial deregulation was moving ahead rapidly, notably with the nationwide introduction of NOW accounts and the beginning of a phaseout of Regulation Q interest rate ceilings following the passage of the Depository Institutions Deregulation and Monetary Control Act. However, these change points are only significant in those specifications which suppress price expectations and/or use the RW variable. In sum, both M1 and M2 specifications with AR price expectations appear stable, although it should be noted that the sample period ends just as money market deposit accounts and super-MOW accounts were introduced.

Japan. Low points of the Quandt ratio for both M1 and M2+CDs are concentrated in the mid-1970s, rather than in the more recent periods of financial innovations. This corresponds to the period when greater emphasis began to be placed on controlling M2+CDs, as opposed to interest rates, mainly through a strengthening of quantitative restrictions on bank lending. M2 growth of around 27 per cent at the end of 1972 was reduced to 10 per cent by the end of 1974, and has subsequently remained under firm control. It is interesting to note that Chow tests at these break points are significant for M2+CD, but not for M1.

Germany. Significant break points are found for M1 around the mid-1970s, approximately the time when central bank money was chosen as an intermediate target. For M3, however, *none* of the change points are associated with a significant Chow statistic.

France. Change points are mostly concentrated in the mid 1970s for both aggregates. Chow tests suggest that these are significant for M1 with AR price expectations, but for the broader aggregate – with the exception of the AR price expectations specification – Chow statistics at change points are insignificant.

United Kingdom. Change points for sterling M3 occur in 1973 Q4, and Chow statistics are significant in most cases. This period was associated with a greater emphasis being placed on controlling sterling M3, following its very rapid growth after the implementation of Competition and Credit Control in 1971 and the subsequent acceleration of inflation. It was also associated with the introduction of the Supplementary Special Deposit Scheme ("corset"), which imposed effective ceilings on the ability of banks to finance lending by bidding for interest bearing deposits. The break points for M1, on the other hand – with the exception of the AR price expectations specification – do not give rise to significant Chow statistics.

Italy. Significant change points occur for all specifications of the M3 equations in the middle and late 1970s. These may be associated with variability in the forcefulness with which credit ceilings were used in the conduct of monetary policy. Only the M1 specification without price expectations demonstrates consistent stability.

Canada. Highly significant change points occur for all specifications of the broad money demand equations, mostly around 1980 and 1981. This seems to be associated with financial innovation. However, with the exception of the RW price expectations specification, no change points are associated with significant Chow statistics in the case of the adjusted M1A aggregate.

Table 2. Overview of stability results

A = Equation with RW price expectations preferred
B = Equation with AR price expectation preferred
C = Equation with inflation term suppressed preferred
– = No stable equation

	M1	M2/M3
United States	A,B	B
Japan	A,B,C	–
Germany	C	A,B,C
France	–	A,C
United Kingdom	A,C	–
Italy	C	–
Canada	B,C	–

Table 3. Preferred equations

$$D\ln(\tfrac{M}{p}) = \text{const} + a_1 \ln y + a_2 \ln(1+r) + a_3 D\ln p^e + a_4 \ln(\tfrac{M}{p})_{-1}$$

Sample period: 1973 Q2-1983 Q1

	Const.	a_1	a_2	a_3	a_4	$\bar{R}^2$	h^a	$E_y{}^b$	$E_r{}^b$	$E_p{}^b$	RMSPE[c] of dynamic simulation
United States M2 (AR price)	0.343	0.341	–0.302	-0.537	–0.358	0.710	0.179	0.95	–0.07	–0.109	0.72
	(0.61)	(5.30)	(4.64)	(6.72)	(4.99)						
Japan M1 (AR price)	4.055	0.075	-0.378	–0.205	-0.205	0.474	–0.196	0.37	-0.13	-0.060	1.96
	(3.90)	(1.08)	(3.54)	(2.42)	(2.38)						
Germany M3	–1.958	0.177	-0.173	–	–0.109	0.202	0.099	1.62	-0.11	–	1.27
	(1.28)	(1.42)	(3.49)		(1.47)						
France M2	-0.007	0.180	-0.201	–	–0.182	0.279	0.600	0.99	-0.11	–	1.27
	(0.01)	(1.52)	(2.65)		(1.96)						
United Kingdom M1[d]	0.346	0.143	–0.814	–	-0.165	0.434	–0.540	0.87	-0.48	–	2.69
	(0.12)	(1.51)	(5.45)		(3.41)						
Italy M1	–1.015	0.249	–0.722	–	-0.220	0.518	-0.566	1.13	-0.42	–	2.08
	(0.60)	(4.00)	(6.38)		(3.88)						
Canada M1A[d]	2.055	0.127	-0.601	–	-0.225	0.447	–0.343	0.56	-0.24	–	2.09
	(2.06)	(3.04)	(4.89)		(4.24)						

a) Durbin-h statistic used to test for autocorrelation. If absolute value of h is greater than 1.645, hypothesis of zero autocorrelation is rejected at 5 per cent significance level.

b) E_y long-run real income elasticity of money demand; E_r long-run interest elasticity evaluated at mean interest rate: E_p long-run inflation elasticity evaluated at mean inflation rate.

c) Root-mean square percentage error.

d) For the United Kingdom sample period is 1972 Q3-1983 Q1 and for Canada it is 1970 Q3-1983 Q1.

The main findings from the various stability tests are summarized in Table 2. Most emphasis was placed on the Chow test applied to the break points identified by the Quandt log-likelihood ratio. In 23 out of 42 cases the estimated equations fail this test. However, at least one specification of money demand passes both the standard Chow test applied to the 1979 break point and that identified by the Quandt ratio. Furthermore, each of these specifications passes the cusum tests and, except for M2 in the United States with AR price expectations, the cusum of squares tests. Moreover, none of these specifications are rejected by the homogeneity and time trending regression tests that were applied. It is of some interest to note that with the exception of M2 in Canada, most change points identified by the Quandt ratio seem to have beers associated with changes in monetary policy targets and/or instruments, rather than with periods of innovation in financial markets. However, it should also be borne in mind that the statistical test employed to identify change points may not be sufficiently refined, particularly if the aggregates concerned have been affected by innovations that have been partially compensating in nature. Strong conclusions on the importance of financial innovations may not be warranted at this point in time.

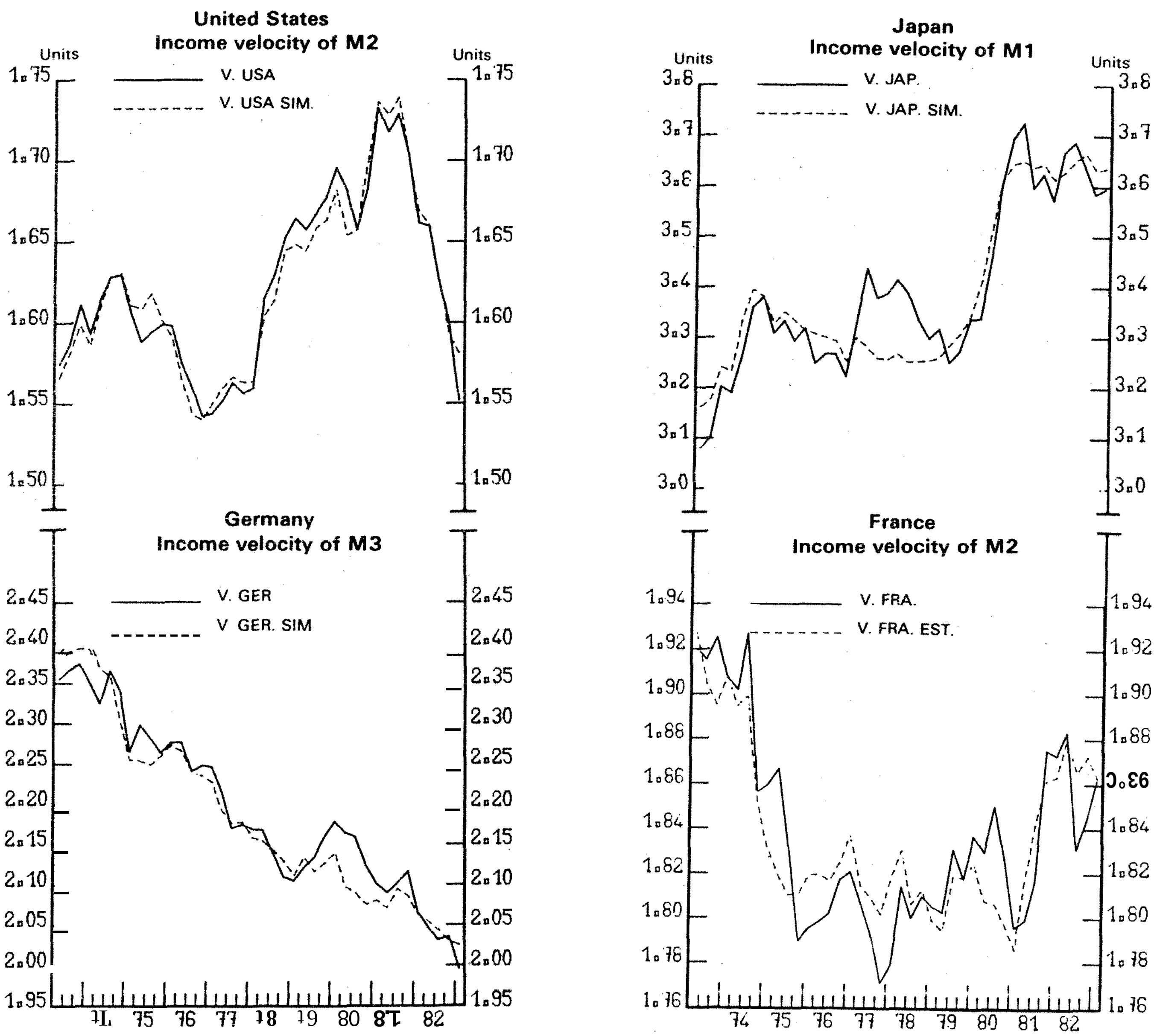
Choice of preferred equations and their simulation performance

Many of the estimated money demand equations for alternative aggregates and/or specifications of price expectations were rejected on theoretical grounds because inappropriate signs on coefficients resulted or because long-run elasticities and/or adjustment speeds seemed implausible. They were also rejected on statistical grounds when key parameters were insignificantly different from zero at a reasonable level of probability, or when significant autocorrelation was present. Moreover, some specifications which seemed acceptable on theoretical and statistical grounds (summarized in Table 1) were rejected when submitted to a battery of stability tests (compare Tables 1 and 2). Nevertheless, one specification for at least one monetary aggregate proved to be acceptable for each of the major OECD countries. These preferred results are reported in full in Table 3. In some countries the demand for real money balances without an expected inflation term was preferred: Germany, M3; France, M2; the United Kingdom, M1; Italy, M1; and Canada, M1A. In contrast, the price expectations term improved the explanatory power and stability of the preferred M2 equation for the United States and the M1 equation for Japan. In both cases the AR price expectations formulation was preferred.

To examine the predictive power of these preferred functions, dynamic simulations from 1973.Q1 to 1983.Q1 were carried out. Table 3 reports the root-mean-square percentage errors for these simulations. The range of the average

CHART 1

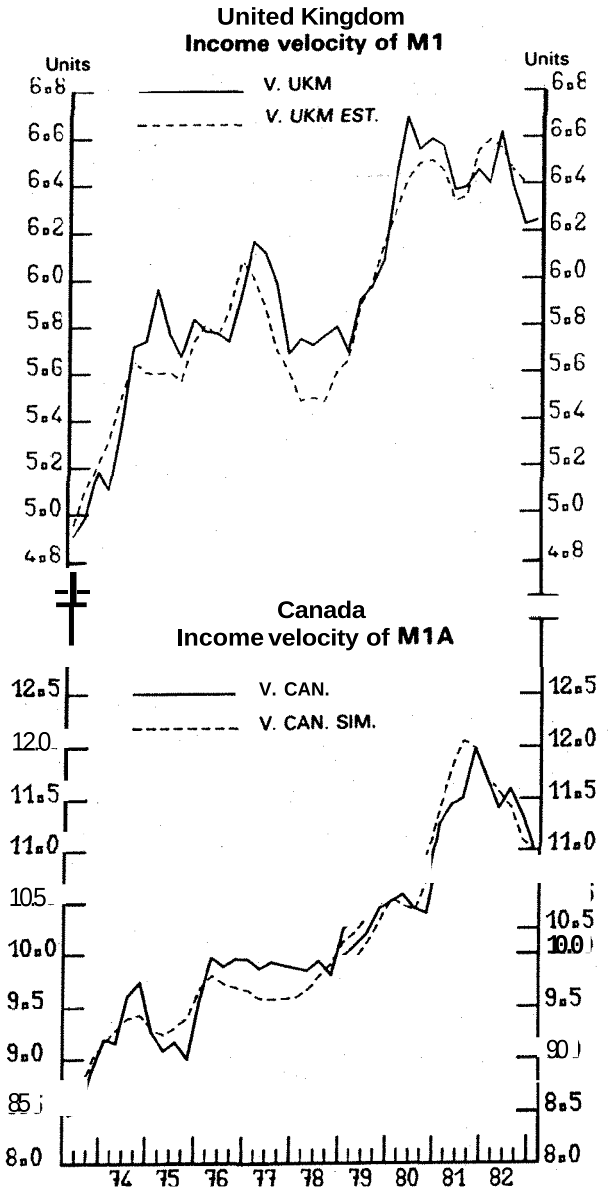
Dynamic simulations of velocity *

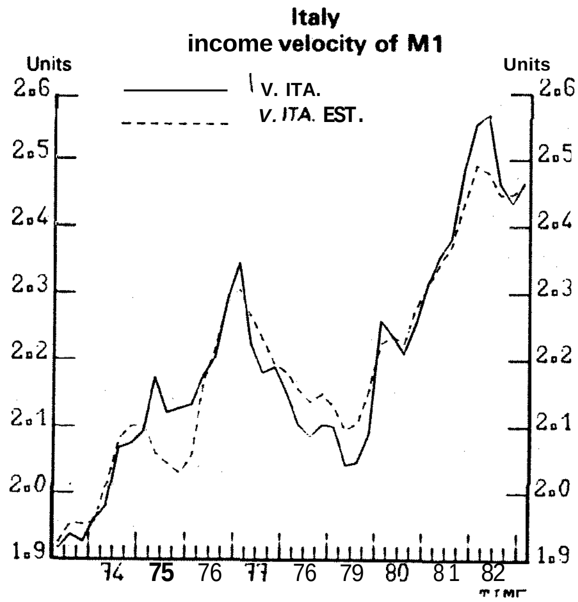


errors lies between 2 per cent and 23 per cent. Chart 1 presents graphs of the actual relationship between money and nominal income, i.e. velocity, and that which would be implied by the dynamic simulations of the money demand equations. These indicate that the simulated level of velocity tracks history reasonably well in all of the countries considered, suggesting that much of the puzzling behaviour of velocity noted in Part II, above, is explicable in terms of the behaviour of the

CHART 1 (cont.)

Dynamic simulations of velocity *





* In all cases the demand for money preferred on the basis of stability tests and other considerations was used to dynamically forecast the aggregate in question.

determinants of money demand. The relatively low mean errors for simulations with the US M2 function are reflected in a remarkably close relationship between actual and simulated velocity. The rise in the US income velocity of M2 from 1980 Q3 to 1981 Q1, and the steep fall thereafter, is particularly well explained by the arguments of the function. More generally, turning points are predicted reasonably well for all other countries.

CONCLUDING REMARKS

The recent experience with monetary targeting, particularly in countries where velocity has behaved in an unexpected way, and uncertainties implied by the unpredictable future effects of financial innovations have led to reservations about the reliability of any money-income relation. Part III of this paper examined the demand for main monetary aggregages in the seven largest OECD economies and, while evidence of instability in money demand was found in a number of cases, a reasonably stable equation was identified for each of the major seven countries,

Where instabilities of money demand were clearly identified, they seem often to have been associated with those aggregates which were importantly affected by changes in the techniques of monetary control and/or the use of quantitative controls such as credit ceilings etc., (M1 in the United States, M2+CDs in Japan, sterling M3 in the United Kingdom and M3 in Italy). Perhaps somewhat surprising in this context is the stability of the M2 equation in France, since this aggregate has been targeted by the central bank mainly through the use of quantitative controls (which tend normally to distort the M2 aggregate through a process of disintermediation).

Reservations about the usefulness of the money-income relationship have been reinforced by the extent to which nominal income growth has, in recent years, reflected price increases while real output stagnated or fell. Doubts, therefore, have been expressed about the efficacy of monetary targets as the centrepiece of monetary policy. One alternative approach, which has gained favour in some unofficial circles in recent years, would be to announce an explicit target for the growth of nominal GNP over the coming year at a rate consistent with objectives for output growth and inflation, and to adjust monetary policy to achieve that target[14]. Operational difficulties with this approach, however, have led most central banks to avoid it, although some have at times attempted to take likely velocity developments into account when setting targets.

The result of these considerations has been a more widespread stress on pragmatism in the implementation of monetary policy. In Germany there has always been a readiness to be flexible with regard to targets and to tolerate deviations for a period if, for example, exchange rate considerations made this appear desirable. In France the commitment to a fixed exchange rate has coexisted with monetary targets, at least since the formation of EMS in 1979. No conflicts have arisen in practice, the exchange rate having on occasion been adjusted to correct inflation differentials and external imbalances. In countries where commitments to a single monetary target had earlier been strongest these have been relaxed (the United States and the United Kingdom) or suspended (Canada)[15]. A more eclectic approach has evolved in those countries, involving multiple targeting and/or taking greater account of the information implicit in a broad range of indicators, including exchange rates and interest rates.

Despite the greater reliance on judgement, however, there remains a general reluctance among major central banks to move completely away from monetary targeting because control of monetary aggregates provides a nominal anchor which ensures a medium-term constraint on inflation. The findings reported in this study are consistent with this view. While any direct link between money and nominaf income is weak over a short period, the relationship is reasonably explicable in terms of fluctuations in real income, interest rates and expected inflation, to the extent that the aggregate concerned has a stable demand function. In this respect it is important to note that only in three countries (the United States, Germany and France) do the preferred money demand equations correspond to aggregates targeted by the authorities.

In cases where the targeted aggregate has a demand function which has been identified as less *stable,* the relationship is not always sufficiently tight to provide a full and reliable explanation of divergences between money and income. Since an alternative aggregate for which a stable demand function exists has been identified in each case (Table 3), it could be worth paying it some attention when monetary policies are being formulated. It may not follow, however, that the preferred functions would remain stable if the aggregate was subjected to strict monetary targeting. This would constitute a change in the objectives of monetary policy, instances of which in the past have often been associated with identifiable instabilities.

NOTES

1. For more details of the considerations which influenced central banks to adopt monetary targets see OECD (1979*a*).
2. See Poole (1970). This discussion excludes the case of destabilizing inflation expectations that may arise, for example, in a hyper-inflation.
3. See Chouraqui and Price (1984), Table 2.
4. For a more detailed discussion of such conflicts in policy objectives see Atkinson, Blundell-Wignall, Chouraqui and Hacche (forthcoming).
5. For a more detailed discussion, see Bank for International Settlements, (1984).
6. For more detail, see Freedman (1983).
7. For more detail, see Suzuki (1983).
8. 'Fonds commun de placement", "SICAV a court terme" and 'Codevi".

9. This section is based primarly on Blundell-Wignall, Rondoni and Ziegelschmidt (1984).

10. A number of additional variables were also tested. These include long-term interest rates and variables (purchasing power parity and the rate of change of the exchange rate) which were intended to capture the influence of exchange rate expectations. An inflation expectations variable derived from the term structure of interest rates was also tried. In all cases these specifications gave rise to counter-intuitive signs, statistically insignificant parameter estimates, and/or results which were inferior to those obtained for the basic specification discussed above. Since a large number of results are already reported in this paper, results for these alternative specifications have not been included.

11. A Chi square test of the log likelihood ratios suggested that the Koyck restriction was accepted by the data for all countries at the 1 per cent level, and for all countries other than the United Kingdom at the 5 per cent level. See Blundell-Wignall, Rondoni and Ziegelschmidt (1984).

12. See Masson and Blundell-Wignall (1984) for further results which show the difficulty of separating transactions and wealth motives. Since the equation is assumed to capture both wealth and transactions motives, a general deflator for income, from which savings are derived, is used instead of an expenditure deflator which would be more closely associated with transactions.

13. For as many observations as possible, depending on degrees of freedom. See Quandt, R.E. (1966). See also R.S. Brown, J. Durbin and J.M. Evans (1975) for a discussion of some of the other tests discussed above:

14. See, for example, Tobin (1983).

15. For more detailed expositions about the present attitudes of the monetary authorities in these countries, see Axilrod (1982), Fforde (1983), Coleby (1983) and Bouey (1982).

ANNEX

THE ANALYSIS OF MONEY DEMAND STABILITY

The question of whether the presented money demand functions are stable, i.e. the issue of constancy of the estimated coefficients over time, has been examined with several statistical tests. These are described below.

Chow test

A Chow test with sub-intervals from the starting date of the sample period to the third quarter of 1979, and from the fourth quarter of 1979 to the first quarter of 1983 has been applied to all specifications for all countries and monetary aggregates. The choice of date to break the sample period corresponds with the introduction of the new operating procedure in the United States, whereby more emphasis was to be placed on non-borrowed reserves as an operating instrument. The test statistics and critical values at a 5 per cent and 1 per cent level of significance are reported in Table A8. A majority of the demand for money equations pass this standard stability test. All aggregates and specifications are consistent with stability in the cases of Japan, Germany and the United Kingdom. For the United States, the hypothesis of stability is rejected only for M2 without the inflation expectations term. Conversely, the equation for M2 excluding the inflation term is consistent with stability for France. In the case of Italy, all M3 equations and the M1 function without the inflation term pass the Chow test. For Canada, all specifications for M1A pass, and all M2 equations fail.

Recursive regression tests

The Chow test suffers from the arbitrariness of the split of the complete estimation period into two sub-intervals. Consequently, recursive regressions were run to test for changes in parameters that cannot be explained by random movements around a time-invariant true parameter value. The technique of recursive regressions involved estimating regressions over a certain time span that is extended one period at a time. Subsequently, the cumulated sums of recursive residuals are computed. They are – up to a scaling factor – the errors in the values of each observation of the dependent variable predicted from a regression on all the preceeding observations. In other words, the one-step prediction errors are being analysed. The calculations can be done in two directions, forwards and backwards, providing two tests per techniques. The cumulative sums (cusums), and cusums of squares of these one-step prediction errors, display, under the hypothesis of stability, a random movement about the expected mean value. If the regression parameters are constant up to a certain point in time, but differ from these constant values subsequently, the recursive residuals will have a zero expectation up to this period but non-zero expectation afterwards.

The cusum test examines whether the normalised cumulative sums of recursive regression residuals significantly differ from zero. The hypothesis of stability of an equation is rejected at a 1 and 5 per cent levels of significance if the test statistic is greater than its critical values of 1.143 and 0.948, respectively (indicated by asterisks in Table A8). Consistent with the preliminary Chow test, the equations perform surprisingly well. All aggregates and equations pass the cusum test in the United States and France. Only one out of six equations fails the forward cusum test and none fails the backward test for Germany; all M1 specifications pass the test for Japan, the United Kingdom and Italy; and for Canada all specifications for M1 are satisfactory. Comprehensive rejections of stability with the cusum test may be observed for M2+CDs in Japan, M2 in Canada, and sterling M3 in the United Kingdom.

The supplementary cusum of squares test relates the cumulative sums of squared recursive residuals to its total sum, and examines whether these ratios significantly differ from its beta-distributed expected values. Its critical values depend on the degrees of freedom, and are shown in Table **A8** for the **1** and 5 per cent level of significance. The results for this test give rise to considerably more rejections of the null hypothesis of parameter stability. It should be kept in mind, however, that the cusum and cusum of squares tests are approximate, and that the latter is particularly biased, tending to reject the null hypothesis more frequently than an exact test would do. None of the United States' money demand functions pass the test, all **M2** equations fail for Japan, and all specifications are rejected for £M3 in the United Kingdom and **M3** in Italy. With the exception of the United States, however, there exists for all countries at least one specification of a money demand function which passes not only the cusum of squares test, but all the stability checks discussed so far. In this context, the stability of all specifications for **M1** in Japan, the United Kingdom and Canada, and for M3 in Germany, is impressive.

Moving regression and time trend tests

To further scrutinize the behaviour of regression coefficients over time, two more stability tests have been carried out. The "homogeneity statistic" is calculated by running regressions over successive intervals of a given length (moving regressions), using a variant of the analysis of variance test for non-overlapping groups. The F-distributed test statistic and critical values at a 1 per cent significance level are given in Table **A8.** The equations were also tested to see whether significantly better fits than those presented in Tables **A2** to **A7** could be obtained if the regression coefficients were assumed to be polynomials in time. The technique requires the calculation of the sum of squares removed by each of a set of nested hypotheses. The test statistic is again F-distributed, and is also presented in Table **A8,** along with its critical value at the 1 per cent level. For simplicity, the polynomials were restricted to degree 1, i.e. the regression coefficients were allowed to become linear functions of time.

The results of these two alternative tests largely corroborate previous findings. These tests rejected the null hypothesis of parameter stability only where it had already been rejected by the Chow or the two cusum tests. On the other hand, it is interesting to note that money demand equations for the United States which failed the cusum of squares test passed the homogeneity test for all specifications and the time-trending regression test in five out of six cases.

Table A1. AR price equation results[a]

$$Dlnp = const + \psi_1 Dlnp_{-1} + \psi_2 Dlnp_{-2} + \psi_3 Dlnp_{-3} + \psi_4 Dlnp_{-4} + \psi_5 Dlnp_{-5}$$

Sample period: 1960 Q1 to 1983 Q1

	Const.	ψ_1	ψ_2	ψ_3	ψ_4	ψ_5	RMSE
United States	0.0009 (1.49)	0.4615 (4.99)	0.1983 (1.96)	0.2529 (2.72)	–	–	0.0036
Japan	0.0034 (2.41	0.7539 (9.55)	–	–	–	–	0.0077
Germany	0.0030 (2.65)	–	0.2965 (3.15)	–	0.4048 (4.33)	–	0.0067
France	0.0059 (2.79)	0.3717 (3.63)	0.3204 (3.13)	–	–	–	0.0084
United Kingdom	0.0082 (3.03)	–	0.2413 (2.71)	–	–	0.3138 (3.49)	0.0189
Italy	0.0027 (1.59)	0.5360 (6.41)	–	0.3462 (4.13)	–	–	0.0107
Canada	0.0016 (1.66)	0.3199 (3.45)	0.2968 (3.13)	0.2537 (2.75)	–	–	0.0069

a) The reported parameters are maximum-likelihood estimates obtained from application of Box-Jenkins estimation procedures. The models were kept purely autoregressive for the sake of simplicity. In a second step it was tested whether or not these simple specifications were justified. This was done by analysing the residuals generated by the models. It turned out that the probability that the residuals are white noise is at least 95 per cent.

Table A2. Narrow **money (M1)**□ **demand**

$$Dln(\frac{M}{p}) = \text{const} + a_1 lny + a_2 ln(1+r) + a_3 Dlnp^e + a_4 ln(\frac{M}{p})_{-1}$$

Sample period: 1973 Q2-1983 Q1

	Random walk price expectations										
	Const.	a_1	a_2	a_3	a_4	$\bar{R}^2$	SEE	h [a]	E_Y [b]	E_r [b]	E_p [b]
United States	1.380	0.055	-0.107	-0.317	-0.005	0.53	0.008	–1.284	11.00	–1.83	–4.60
	(0.76)	(2.24)	(1.73)	(4.40)	(0.09)						
Japan	4.052	0.075	-0.378	-0.154	-0.205	0.47	0.014	-0.196	0.37	-0.13	-0.05
	(3.90)	(1.08)	(3.54)	(2.42)	(2.38)						
Germany	-0.367	0.388	-0.571	-0.181	-0.272	0.69	0.010	0.612	1.43	-0.15	-0.03
	(2.73)	(3.72)	(7.43)	(2.29)	(4.26)						
France	4.978	0.138	-0.096	-0.273	-0.333	0.51	0.009	3.474'	0.41	-0.03	-0.08
	(3.06)	(2.76)	(1.39)	(4.89)	(3.16)						
United Kingdom[c]	2.187	0.040	-0.628	-0.204	-0.132	0.80	0.013	0.613	0.30	-0.48	-0.20
	(1.26)	(0.69)	(6.84)	(8.44)	(4.51)						
Italy	–1.347	0.183	-0.542	-0.168	-0.141	0.60	0.015	0.742	1.30	-0.48	-0.19
	(0.87)	(2.96)	(4.45)	(2.82)	(2.40)						
Canada[c]	1.386	0.103	-0.494	-0.138	-0.172	0.46	0.017	-0.330	0.60	-0.29	-0.08
	(1.27)	(2.32)	(3.44)	(1.42)	(2.62)						

□ M1A is used in Canada instead of M1.

a) Durbin-h statistic used to test for autocorrelation. If absolute value of h is greater than 1.645, hypothesis of zero autocorrelation is rejected at 5 per cent significance level. This is marked by an *.

b) E_Y long-run real income elasticity of money demand; E_r long-run interest elasticity evaluated at mean interest rate; E_p long-run inflation elasticity evaluated at mean inflation rate.

c) For the United Kingdom sample period is 1972 Q3-1983 Q1 and for Canada it is 1970 Q3-1983 Q1.

Table A3. **Narrow money (M1)□ demand**

$$Dln(\frac{M}{p}) = const + a_1 lny + a_2 ln(1+r) + a_3 Dlnp^e + a_4 ln(\frac{M}{p})_{-1}$$

Sample period: 1973 Q2-1983 Q1

	AR price expectations										
	Const.	a_1	a_2	a_3	a_4	$\bar{R}^2$	SEE	h [a]	E_Y [b]	E_r [b]	E_p [b]
United States	0.734 (0.38)	0.041 (1.45)	−0.104 (1.40)	−0.320 (2.97)	−0.070 (1.27)	0.41	0.009	−1.730*	0.59	−0.13	−0.33
Japan	4.055 (3.90)	0.075 (1.08)	−0.378 (3.54)	−0.205 (2.42)	−0.205 (2.38)	0.47	0.014	−0.196	0.37	−0.13	−0.06
Germany	-4.929 (3.63)	0.418 (4.04)	−0.663 (8.83)	0.402 (2.43)	−0.257 (4.03)	0.69	0.010	−0.503	1.63	−0.18	0.07
France	7.182 (3.97)	0.207 (3.77)	−0.139 (1.90)	−0.430 (3.79)	−0.488 (4.18)	0.41	0.010	2.515*	0.42	−0.03	−0.09
United Kingdom[c]	−0.565 (0.185)	0.167 (1.70)	−0.817 (5.46)	0.094 (0.92)	−0.153 (3.02)	0.43	0.021	−0.007	1.09	−0.53	0.08
Italy	−0.712 (0.45)	0.158 (2.35)	−0.457 (0.315)	−0.307 (2.63)	−0.136 (2.22)	0.59	0.016	0.165	1.16	−0.43	−0.36
Canada[c]	1.596 (1.51)	0.109 (2.48)	−0.492 (3.28)	−0.167 (1.26)	−0.186 (3.02)	0.45	0.017	−0.549	0.59	−0.26	−0.08

□ M1A is used in Canada instead of M1.

a) Durbin-h statistic used to test for autocorrelation. If absolute value of h is greater than 1.645, hypothesis of zero autocorrelation is rejected at 5 per cent significance level. This is marked by an *.

b) E_Y long-run real income elasticity of money demand; E_r long-run interest elasticity evaluated at mean interest rate; E_p long-run inflation elasticity evaluated at mean inflation rate.

c) For the United Kingdom sample period is 1972 Q3-1983 Q1 and for Canada it is 1970 Q3-1983 Q1.

Table A4. **Broad money[□] demand**

$$Dln(\frac{M}{p}) = \text{const} + a_1 lny + a_2 ln(1+r) + a_3 Dlnp^e + a_4 ln(\frac{M}{p})_{-1}$$

Sample period: 1973 Q2-1983 Q1

	Random walk price expectations										
	Const.	a_1	a_2	a_3	a_4	$\bar{R}^2$	SEE	h [a]	E_Y [b]	E_r [b]	E_p [b]
United States	-0,353 (0.71)	0.218 (3.58)	-0.262 (4.14)	-0.373 (7.36)	-0.207 (3.15)	0.74	0.006	0.289	1.05	-0.11	-0.13
Japan	2.566 (2.76)	-0.130 (1.62)	-0.121 (3.02)	-0.279 (8.36)	0.053 (1.00)	0.84	0.006	0.559	2.45	0.17	0.33
Germany	0.227 (0.18)	0.029 (0.29)	-0.074 (1.76)	-0.306 (5.22)	-0.037 (0.64)	0.54	0.007	-0.298	0.68	-0.15	0.42
France	1.183 (1.86)	0.008 (0.09)	-0.025 (0.44)	-0.290 (6.94)	-0.050 (0.78)	0.69	0.006	1.425	0.16	-0.04	-0.58
United Kingdom[c]	4.563 (1.60)	-0.152 (1.70)	0.070 (0.61)	-0.306 (9.88)	-0.029 (0.79)	0.70	0.017	2.577*	-5.24	0.24	-1.34
Italy	-0.056 (0.06)	-0.009 (0.13)	-0.187 (3.85)	-0.965 (10.6)	0.013 (0.29)	0.85	0.007	2.088*	0.69	1.82	3.20
Canada[c]	-0.500 (1.12)	0.152 (3.61)	0.148 (2.25)	-0.192 (4.45)	-0.138 (4.24)	0.37	0.008	1.831*	1.10	0.11	-0.13

□ Aggregates used are as follows: United States, M2; Japan, M2+CDs; Germany, M3; France, M2; United Kingdom, £M3; Italy, M3; Canada, M2.

a) Durbin-h statistic used to test for autocorrelation. If absolute value of h is greater than 1.645, hypothesis of zero autocorrelation is rejected at 5 per cent significance level. This is marked by an *.

b) E_Y long-run real income elasticity of money demand; E_r long-run interest elasticity evaluated at mean interest rate; E_p long-run inflation elasticity evaluated at mean inflation rate.

c) For the United Kingdom sample period is 1972 Q3-1983 Q1 and for Canada it is 1970 Q3-1983 Q1.

Table A5. Broad money□ demand

$$Dln(\frac{M}{p}) = \text{const} + a_1 lny + a_2 ln(1+r) + a_3 Dlnp^e + a_4 ln(\frac{M}{p})_{-1}$$

Sample period: 1973 Q2-1983 Q1

	AR price expectations										
	Const.	a_1	a_2	a_3	a_4	$\bar{R}^2$	SEE	h^a	$E_Y{}^b$	$E_r{}^b$	$E_p{}^b$
United States	0.343	0.341	-0.302	-0.537	-0.358	0.71	0.007	0.179	0.95	–0.07	-0.11
	(0.61)	(5.30)	(4.64)	(6.72)	(4.99)						
Japan	2.566	-0.130	-0.121	-0.370	0.053	0.84	0.006	0.559	2.45	0.17	0.44
	(2.76)	(1.62)	(3.02)	(8.36)	(1.00)						
Germany	–1.895	0.173	-0.171	-0.013	-0.107	0.18	0.009	0.043	1.62	–0.11	–0.01
	(1.08)	(1.28)	(3.03)	(0.08)	(1.38)						
France	0.593	0.098	-0.081	-0.374	-0.120	0.48	0.008	0.101	0.82	-0.07	-0.31
	(0.74)	(0.95)	(1.14)	(3.88)	(1.49)						
United Kingdom[c]	4.516	–0.090	-0.129	-0.123	–0.091	0.04	0.031	1.700*	-0.99	-0.14	-0.17
	(0.76)	(0.50)	(0.61)	(0.80)	(1.24)						
Italy	0.569	-0.024	-0.121	-0.364	0.009	0.68	0.010	1.205	2.67	1.70	6.48
	(0.40)	(0.23)	(1.54)	(5.84)	(0.13)						
Canada[c]	-0.437	0.150	0.169	-0.229	-0.139	0.26	0.009	0.875	1.08	0.12	-0.16
	(0.89)	(3.13)	(2.14)	(3.19)	(3.69)						

□ Aggregates used are as follows: United States, M2; Japan, M2+CDs; Germany, M3; France, M2; United Kingdom, £M3; Italy, M3; Canada, M2.

a) Durbin-h statistic used to test for autocorrelation. If absolute value of h is greater than 1.645, hypothesis of zero autocorrelation is rejected at 5 per cent significance level. This is marked by an *.

b) E_Y long-run real income elasticity of money demand; E_r long-run interest elasticity evaluated at mean interest rate; E_p long-run inflation elasticity evaluated at mean inflation rate.

c) For the United Kingdom sample period is 1972 Q3-1983 Q1 and for Canada it is 1970 Q3-1983 Q1.

Table A6. Narrow money (M1)[□] demand

$$Dln(\tfrac{M}{p}) = const + a_1 lny + a_2 ln(1+r) + a_4 ln(\tfrac{M}{p})_{-1}$$

Sample period: 1973 Q2-1983 Q1

	Const.	a_1	a_2	a_4	$\bar{R}^2$	SEE	h [a]	E_y [b]	E_r [b]
United States	1.011 (0.47)	0.060 (2.00)	-0.225 (3.31)	-0.102 (1.71)	0.28	0.010	-0.884	0.59	-0.19
Japan	3.434 (3.20)	0.178 (3.05)	-0.476 (4.52)	-0.293 (3.52)	0.40	0.015	0.603	0.61	-0.12
Germany	-4.132 (2.94)	0.403 (3.66)	-0.621 (7.97)	-0.271 (4.01)	0.65	0.010	0.517	1.49	-0.16
France	5.742 (2.78)	0.173 (2.74)	-0.223 (2.74)	-0.399 (2.99)	0.19	0.011	2.116*	0.43	-0.05
United Kingdom[c]	0.346 (0.12)	0.143 (1.51)	-0.814 (5.45)	-0.165 (3.41)	0.43	0.022	-0.540	0.87	-0.48
Italy	-1.015 (0.60)	0.249 (4.00)	-0.722 (6.38)	-0.220 (3.88)	0.52	0.017	-0.566	1.13	-0.42
Canada[c]	2.055 (2.06)	0.127 (3.04)	-0.601 (4.89)	-0.225 (4.24)	0.45	0.017	-0.343	0.56	-0.24

□ M1A is used in Canada instead of M1.

a) Durbin-h statistic used to test for autocorrelation. If absolute value of h is greater than 1.645, hypothesis of zero autocorrelation is rejected at 5 per cent significance level. This is marked by an *.

b) E_y long-run real income elasticity of money demand; E_r long-run interest elasticity evaluated at mean interest rate.

c) For the United Kingdom sample period is **1972 Q3-1983 Q1** and for Canada it is **1970 Q3-1983 Q1**.

Table A7. **Broad money[□] demand**

$$Dln(\tfrac{M}{p}) = \text{const} + a_1 lny + a_2 ln(1+r) + a_4 ln(\tfrac{M}{p})_{-1}$$

Sample period: 1973 Q2-1983 Q1

	Const.	a_1	a_2	a_4	R^2	SEE	h [a]	E_y [b]	E_r [b]
United States	–1.325 (1.76)	0.279 (2.93)	–0.438 (4.75)	–0.234 (2.27)	0.36	0.010	3.400*	1.19	–0.16
Japan	–4.015 (4.78)	0.398 (4.72)	–0.221 (3.37)	–0.276 (4.49)	0.54	0.009	3.171*	1.44	–0.06
Germany	–1.958 (1.28)	0.177 (1.42)	–0.173 (3.49)	–0.109 (1.47)	0.20	0.009	0.099	1.62	–0.11
France	–0.007 (0.01)	0.180 (1.52)	–0.201 (2.65)	–0.182 (1.96)	0.28	0.010	0.600	0.99	–0.11
United Kingdom[c]	2.455 (0.46)	–0.031 (0.19)	–0.156 (0.74)	–0.068 (1.01)	–0.03	0.031	2.467*	–0.46	–0.23
Italy	–1.214 (0.63)	0.056 (0.39)	–0.355 (3.82)	–0.016 (0.18)	0.38	0.014	0.659	3.50	–2.81
Canada[c]	–0.009 (0.02)	0.071 (1.59)	0.021 (0.29)	–0.074 (2.14)	0.11	0.010	0.725	0.96	0.03

□ Aggregates used are as follows: United States, M2; Japan, M2+CDs; Germany, M3; France, M2; United Kingdom, £M3; Italy, M3; Canada, M2.

a) Durbin-h statistic used to test for autocorrelation. If absolute value of h is greater than 1.645, hypothesis of zero autocorrelation is rejected at 5 per cent significance level. This is marked by an *.

b) E_y long-run real income elasticity of money demand; E_r long-run interest elasticity evaluated at mean interest rate.

c) For the United Kingdom sample period is 1972 Q3-1983 Q1 and for Canada it is 1970 Q3-1983 Q1.

Table A8. Stability tests of money demand

		Price expectations[a]	Chow[b]	Min Quandt	Chow[c]	Critical value 5%	Critical value 1%	Cusum[d] f	Cusum[d] h	Cusum2[e] f	Cusum2[e] b	Critical value 5%	Critical value 1%	Homogeneity statistics[f]	Critical value 1%	Time trend[g] d=l	Critical value 1%
United States	M1	RW	1.134	14 Q4	0.156	2.53	3.10	0.308	0.462	0.499**	0.481**	0.246	0.311	1.05	3.10	1.85	3.10
		AR	1.026	80 Q1	2.041	2.53	3.10	0.311	0.513	0.476**	0.449**	0.246	0.311	3.81	3.10	1.74	3.10
		–	2.126	80 O1	4.146**	2.61	3.91	0.452	0.155	0.459**	0.310**	0.243	0.308	2.30	3.91	3.20	3.97
	M2	RW	1.929	80 Q2	4.068**	2.53	3.10	0.518	0.616	0.445**	0.262**	0.246	0.311	3.23	3.70	2.59	3.70
		AR	0.941	15 03	1.195	2.53	3.10	0.662	0.659	0.327**	0.299*	0.246	0.311	3.14	3.70	1.68	3.10
		–	4.950**	81 Q4	6.770**	2.61	3.91	0.513	0.834	0.345**	0.162	0.243	0.308	1.32	3.97	5.24**	3.97
Japan	M1	RW	0.489	14 Q3	1.691	2.53	3.10	0.132	0.583	0.187	0.083	0.246	0.311	2.31	3.70	1.22	3.10
		AR	0.489	14 Q3	1.691	2.53	3.10	0.132	0.583	0.181	0.083	0.246	0.311	2.31	3.70	1.22	3.10
		–	0.254	81 04	1.188	2.61	3.91	0.149	0.887	0.222	0.081	0.243	0.308	2.76	3.91	0.62	3.91
	M2+CD	RW	2.032	15 Q2	3.382*	2.53	3.10	1.168**	0.558	0.220	0.259*	0.246	0.311	7.83**	3.70	3.83**	3.10
		AR	2.033	15 02	3.382*	2.53	3.10	1.168**	0.558	0.220	0.259*	0.246	0.311	7.83**	3.10	3.83**	3.70
		–	1.243	14 04	9.348**	2.61	3.91	1.294**	0.352	0.195	0.407**	0.243	0.308	8.02**	3.91	2.85	3.97
Germany	M1	RW	0.152	77 Q1	3.427*	2.53	3.10	0.978*	0.791	0.121	0.123	0.246	0.311	3.25	3.70	2.25	3.10
		AR	0.117	80 03	3.098*	2.53	3.10	0.541	0.811	0.195	0.175	0.246	0.311	1.25	3.10	0.97	3.10
		–	0.195	81 04	1.841	2.61	3.91	0.148	0.641	0.133	0.113	0.243	0.308	3.05	3.91	2.06	3.91
	M3	RW	0.854	14 Q3	1.024	2.53	3.10	0.315	0.414	0.151	0.166	0.246	0.311	1.16	3.70	0.73	3.10
		AR	0.812	14 Q4	2.246	2.53	3.70	0.861	0.898	0.141	0.150	0.246	0.311	1.31	3.70	1.82	3.10
		–	1.118	14 Q2	1.944	2.61	3.91	0.199	0.611	0.154	0.151	0.243	0.308	1.70	3.91	2.40	3.91
France	M1	RW	5.141**	79 Q2	5.084**	2.53	3.10	0.343	0.503	0.211	0.259.	0.246	0.311	1.94	3.70	2.28	3.10
		AR	3.758**	15 Q2	4.633**	2.53	3.70	0.615	0.306	0.185	0.205	0.246	0.311	2.07	3.10	2.01	3.10
		–	2.274*	14 Q2	1.016	2.61	3.91	0.544	0.396	0.311*	0.291*	0.243	0.308	1.10	3.97	1.41	3.91
	M2	RW	2.100	81 Q3	1.641	2.53	3.10	0.380	0.452	0.119	0.150	0.246	0.311	0.42	3.10	1.55	3.10
		AR	3.557*	14 03	3.045.	2.53	3.10	0,118	0.887	0.173	0.265'	0.246	0.311	0.70	3.10	4.27**	3.10
		–	0.964	14 02	1.101	2.61	3.91	0.489	0.865	0.134	0.192	0.243	0.308	1.87	3.91	3.56	3.91
United Kingdom	M1	RW	0.811	73 Q4	0.530	2.50	3.64	0.411	0,810	0.141	0.165	0.238	0.301	2.10	3.64	1.06	3.64
		AR	1.899	14 Q1	2.856*	2.50	3.64	0.458	0.711	0.113	0.122	0.238	0.301	0.95	3.64	1.88	3.64
		–	0.898	73 Q3	1.111	1.64	3.91	0.652	0.602	0.118	0.129	0.235	0.298	0.69	3.91	1.03	3.91
	fM3	RW	2.227	73 Q4	4.188**	2.50	3.64	0.977*	0.569	0.133	0.313**	0.238	0.301	2.49	3.64	4.33**	3.64
		AR	0.875	13 04	2.481	2.50	3.64	1.044'	0.934	0.292.	0.287*	0.238	0.301	1.53	3.64	1.15	3.64
		–	0.925	13 04	3,483'	2.64	3.91	1.109*	0.948	0.268.	0.299**	0.235	0.298	0.34	3.91	1.45	3.91
Italy	M1	RW	2.771*	15 Q2	5.790**	2.53	3.10	0.894	0.366	0.250.	0.407**	0.246	0.311	2.10	3.10	1.96	3.70
		AR	2.825*	79 Q3	2.825*	2.53	3.70	0.852	0.522	0.200	0.269.	0.246	0.311	1.77	3.10	1.47	3.10
		–	2.665	81 Q4	0.153	2.61	3.91	0.629	0.564	0.118	0.216	0.243	0.308	1.58	3.97	1.08	3.91
	M3	RW	2.068	15 02	9.468**	2.53	3.10	0.642	0.112	0.192	0.423**	0.246	0.311	4.41**	3.70	5.91**	3.70
		AR	0.906	74 Q3	3.441*	2.53	3.70	1.254**	0.691	0.328**	0.298*	0.246	0.311	[illegible]	[illegible]	[illegible]	[illegible]

	AR	0,657	81 Q3	1.913	2.45	3.50	0.682	0.716	0.153	0.171	0.220	0.278	1.76	2.86	0.60	3.50
	–	0.967	71 Q3	2.010	2.59	3.79	0.809	0.534	0.135	0.101	0.218	0.276	1.58	3.01	1.07	3.79
M2	RW	3.700**	81 Q2	3.854**	2.45	3.50	0.789	1.198**	0.193	0.094	0.220	0.278	1.06	2.86	0.81	3.50
	AR	3.814**	81 Q3	3.753**	2.45	3.50	0.830	1.320**	0.230*	0.217	0.220	0.278	0.89	2.86	1.19	3.50
	–	3.439.	72 Q4	5.289**	2.59	3.79	0.915	1.216**	0.232*	0.154	0.218	0.276	2.04	3.01	4.29**	3.79

c) First sub-interval from start date to period with minimum of Quandt's log-likelihood ratio.
d) f = forward; b = backward. Critical value in all cases ,948 at 5 per cent significance level and 1,143 at 1 per cent level of significance.
e) f = forward; b = backward.
f) Homogeneity test statistic of moving regression technique.
g) Test statistic of regression technique with coefficients becoming polynomials in time.
* Stability of regression rejected at 5 per cent level of significance.
** Stability of regression rejected at 1 per cent level of significance.

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