SOME FURTHER RESULTS ON THE SOURCE OF SHIFT IN M1 DEMAND IN THE 1980s

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In recent years the public's demand for M1 has grown significantly more strongly than predicted by existing money demand regression equations. A number of explanations have been advanced in order to explain this strength in M1 demand. These include a rise in monetary policy uncertainty, strength in the stock market, an increase in financial transactions, disinflation of the 1980s, and financial deregulation. The purpose of this paper is to test these hypotheses. The analysis shows that none of these hypotheses can satisfactorily explain the strength in M1 demand, a result suggesting that there has been a fundamental change in the character of M1. M1 in the 1980s has become an instrument for saving as well as for effecting transactions, and this change is related to the introduction into M1 of checkable deposits that pay an explicit rate of interest. The analysis shows that one needs a broader monetary aggregate M2 in order to identify a stable money demand function.

The plan of this article is as follows. Section I presents various hypotheses that have been advanced to explain the behavior of M1 in the 1980s. Section II provides a test of these hypotheses and Section III contains conclusions. An appendix of the paper draws on recent developments in the theory of cointegrated processes to show that there continues to exist a long-run stable demand function for the stock of real M2 balances as a function of real income and a market rate of interest.

I.
HYPOTHESES ABOUT THE SOURCE OF THE RECENT STRENGTH OF M1 DEMAND

This section describes briefly some of the alternative hypotheses of the strength in M1 demand and derives their testable implications. The first is that such strength was caused by the increased volatility of money growth following the announced change in Federal Reserve operating procedures in October 1979. The main contention here is that increased volatility of money growth raised the degree of perceived uncertainty, thereby increasing the demand for money [see, for example, Mascaro and Meltzer (1983) and Hall and Noble (1987)]. An empirical implication of this hypothesis is that since M1 demand is influenced by the volatility of money growth, M1 demand regressions estimated including the volatility variable should exhibit stability.

The second hypothesis stresses the role of financial wealth and financial transactions [see, for example, Morgan Guaranty Trust (1986), Wenninger and Radecki (1986), Kretzmer and Porter (1986), and Friedman (1987)]. The strength in M1 has been accompanied by strength in the stock market, and an increased volume of financial transactions. The argument here is that the real income variable commonly used in money demand regressions does not capture adequately the increased volume of financial transactions that might have been financed by M1. Furthermore, the rise in stock prices raised the financial wealth of the households and thereby could have contributed to the strength in M1 demand. An empirical implication of this hypothesis is that conventional M1 demand regressions should contain additional variables that capture the influences of financial transactions and wealth on money demand.

The third hypothesis considered in this study attributes the strength in M1 demand to the decline in the expected rate of inflation which occurred over the 1980s [Judd (1983), Tatom (1983a, 1983b) and Rasche (1987, 1989)]. The argument here is that the demand for real money is inversely related to the expected rate of inflation. Since actual inflation (and presumably the expected rate of inflation as well) has declined over the 1980s, the demand for money has increased. This argument implies that conventional M1 demand regressions estimated including an inflation variable should exhibit parameter stability.

The fourth hypothesis relates instability in M1 demand to the nationwide introduction of interest-bearing checkable deposits in 1981. There are two versions of this hypothesis. One version emphasizes the partial nature of interest rate deregulation and the impact such deregulation had on the interest elasticity of M1 demand. There is no change, according to this view, in the nature of balances kept in M1, which remain primarily a vehicle for effecting transactions. The second version emphasizes a change in the nature of balances held in M1; such balances are now an instrument for saving as well as for effecting transactions.

Consistent with the first version is the view that since 1981 M1 demand has become more interest sensitive. The argument here is that when interest-bearing checkable deposits were introduced nationwide in 1981, rates payable on them were regulated and set below market rates (rates payable on demand deposits were still held fixed at zero). In that case, a given change in market rates causes a larger proportional change in the opportunity cost of holding interest-bearing checkable deposits than of holding demand deposits. As a result, changes in market rates might induce larger changes in checkable deposits than in demand deposits, thereby increasing the interest responsiveness of M1 as a whole as checkable deposits become a larger fraction of M1 [Simpson (1984) and Mehra (1986)]. An empirical implication of this hypothesis is that the strength observed in M1 during the 1980s should be explained by a combination of the heightened interest sensitivity of M1 demand and the sharp fall in money market rates relative to the rates offered on checkable deposits. Furthermore, since interest-bearing checkable deposits are at the source of increase in the interest elasticity of M1 demand, this view, if correct, also implies that the demand for M1-A (which is M1 minus interest-bearing checkable deposits) should have retained its structural stability over the 1980s.

An alternative view consistent with the second version is that balances held in M1 have become highly substitutable with savings-type deposits held in the non-M1 component of M2 [Judd and Trehan (1987) and Hetzel and Mehra (1989)]. This view thus attributes the strength in M1 demand to an increase in such substitutions during the 1980s. Because such substitutions net out at the level of aggregation of M2, the M2 demand function should, according to this view, continue to exhibit stability.[1]

II.
EMPIRICAL RESULTS

This section presents the results of tests of various hypotheses discussed in the previous section.

[1] In this case, M1 could also appear more interest sensitive than before because savings balances held in M1 are more sensitive at the margin to swings in interest rates. Moreover, the demand function for M1-A could also appear unstable if economic agents decide to switch between demand deposits and interest-bearing checkable deposits.

An M1 Demand Regression and the Evidence on its Instability in the 1980s

The regression that underlies tests of various hypotheses is:

$$\begin{aligned}\Delta \ln/(M/P) = a &+ \sum_{s=0}^{n1} b_s\, \Delta \ln(Y/P)_{t-s} \\ &- \sum_{s=0}^{n2} c_s\, \Delta(R-RM)_{t-s} \\ &- \sum_{s=0}^{n3} d_s\, \Delta INF_{t-s} + U_t \qquad (1)\end{aligned}$$

where M is the nominal money stock; P, the price level; Y, nominal income; R, a market rate of interest; RM, the own rate of return on the money stock[2]; and INF (the difference in the log of the price level), the rate of inflation. The symbol ln denotes the natural logarithm, Δ the first difference operator and Σ the summation operator. The left-hand variable in equation (1) is real money balances. The right-hand variables are a constant, real income, the difference between the yield on a money market instrument and the own rate of return on the money stock, and the rate of inflation. The equation includes contemporaneous and several lagged values of these variables. The inflation rate measures the nominal rate of return to physical assets that are held directly. If such assets are substitutes for money, then inflation would influence money demand. In that case, the sum of coefficients that appear on the inflation variables in (1) should be statistically different from zero.[3]

The results of estimating (1) for M1 over 1952Q1 to 1980Q4 are shown in the upper panel of Table I. The regression is estimated including three additional dummy variables: SHFT, CC1, and CC2. The SHFT variable captures the shift in M1 demand over 1973Q2 to 1976Q4, and CC1 and CC2 variables capture transitory effects of the credit controls in 1980Q2 and 1980Q3. The real income variable used is nominal personal income deflated by the price level, and the yield on a money market instrument is measured by the 4-6 month commercial paper rate. Both income and opportunity cost variables are statistically significant.

[2] The own rate of return on the money stock is defined as the weighted average of the explicit own rates of return on the various components of the money stock.

[3] Inflation should have no long-run effect on money demand if physical assets are not substitutes for money. However, inflation could still appear to influence money demand in the short run if money demand adjusts with a lag to a change in the price level [Goldfeld and Sichel (1987)].

Table I

EVIDENCE ON INSTABILITY IN REAL M1 DEMAND

Real M1 demand regression

$$\Delta(M1/P) = -.004 + \underset{(4.5)}{.74}\,\Delta y \underset{(-3.2)}{-.74}\,\Delta(R-RM1) - \underset{(-1.9)}{1.27}\,\Delta INF - \underset{(-2.2)}{.005}\,SHFT - \underset{(-5.0)}{.03}\,CC1 + \underset{(3.3)}{.02}\,CC2$$

Estimation period: 1952Q1-1980Q4 $\bar{R}^2 = .68$ DW = 1.9 RHO = .38(3.8)

Coefficients on Dufour Dummies

Year/Quarter	Coefficient (t value)	Year/Quarter	Coefficient (t value)
1981/Q1	−.007(−1.0)	1985/Q1	.009 (1.5)
1981/Q2	.008 (.9)	1985/Q2	.006 (1.0)
1981/Q3	−.000 (.6)	1985/Q3	.026 (4.2)
1981/Q4	−.008 (−.9)	1985/Q4	.016 (2.7)
1982/Q1	.004 (.6)	1986/Q1	.010 (1.8)
1982/Q2	−.012(−1.7)	1986/Q2	.028 (5.0)
1982/Q3	.008 (1.3)	1986/Q3	.029 (5.1)
1982/Q4	.018 (2.9)	1986/Q4	.033 (5.9)
1983/Q1	.002 (.4)	1987/Q1	.019 (3.4)
1983/Q2	.013 (1.8)	1987/Q2	.008 (1.3)
1983/Q3	.018 (3.0)	1987/Q3	−.004(−.7)
1983/Q4	.005 (.9)	1987/Q4	.001 (.2)
1984/Q1	.005 (.9)	1988/Q1	−.003(−.5)
1984/Q2	.007 (1.2)	1988/Q2	−.005 (1.0)
1984/Q3	.004 (.7)	1988/Q3	.001 (.2)
1984/Q4	−.003 (−.5)	1988/Q4	−.000(−.1)

FD (32,95) = 3.08**

** Significant at .01 level

Notes: The real M1 demand regression tabulated in the upper panel is estimated over 1952Q1 to 1980Q4. P is the implicit deflator for personal consumption expenditures; y, nominal personal income deflated by p; R, the 4-6 month commercial paper rate; RM1, the own rate of return on M1; and INF, the rate of inflation. All variables are in natural logarithms except R and RM1. SHFT is 1 from 1973Q2 to 1976Q4 and zero otherwise. CC1 and CC2 are respectively 1 in 1980Q2 and 1980Q3 and zero otherwise. All the variables are entered as simple distributed lags with 5 contemporaneous and lagged values and the sum of the estimated coefficients is tabulated. Parentheses contain t values. A Hildreth-Lu procedure is used to estimate the regression. The coefficients on Dufour dummies reported in the lower panel of Table I are from the real M1 demand regression that is estimated over 1952Q1 to 1988Q4. Dufour dummies are zero-one dummy variables defined for each observation over 1981Q1 to 1988Q4. FD is the F statistic that tests the null hypothesis that Dufour dummy variables do not enter the M1 demand regression equation.

The structural stability of this regression is investigated using the Dufour test [Dufour (1980)], which is a variant of the Chow test and uses an F statistic to test the joint significance of dummy variables introduced for each observation of the interval for which structural stability is examined. A small F statistic indicates structural stability.

The results of performing the Dufour test for the period 1981Q1 to 1988Q4 appear in the lower panel of Table I. That is, the regression equation (1) was reestimated over the period 1952Q1 to 1988Q4 with separate shift dummies introduced for each quarter from 1981Q1 to 1988Q4. The F statistic for Dufour dummies used in this regression [FD (32,95), Table I] is 3.08, which exceeds the 5 percent critical value of 1.6. This result implies that the M1 demand regression is not stable. A look at the estimated coefficients and the associated t values on these Dufour dummies, also tabulated in Table I, indicates observations whose mean values are inconsistent with the regression equation (1). Such observations are found in years 1982, 1983, 1985, 1986, and 1987. These coefficients are mostly positive, implying strength in real M1 that could not be explained by the M1 demand regression.

Tests of Various Hypotheses

The first and second explanations of the strength in M1 demand in the 1980s are tested by estimation of regression equation (1) augmented by the addition of the relevant variable suggested by each explanation. These regressions were first estimated over 1952Q1 to 1988Q4 and F statistics were calculated to test the significance of relevant variables. Structural stability of the expanded M1 demand regressions is then investigated by the Dufour test.

Column (1) of Table II shows the estimation over 1952Q1 to 1988Q4 of the real M1 demand regression equation that contains a variable measuring the volatility of money growth (VOL1). This variable VOL1 is calculated as an eight-quarter moving standard deviation of M1 growth [Hall and Noble (1987)]. The maintained hypothesis is that changes in VOL1 and money demand are positively correlated. The estimated coefficient on VOL1, though positive, is not statistically significant. The t value for the sum of coefficients on VOL1 is .5 and the F value for their joint-significance is 1.1 (see F1 values in Table II). These values are below the relevant 5 percent critical values. The F statistic for the Dufour dummies is 2.7, which is significant at the 1 percent level (see the FD value in Table II). These estimates thus suggest that the strength observed in M1 demand in the 1980s could not be explained by the rise in the volatility of M1 growth.[4]

Columns (2), (3), and (4) of Table II show estimation over 1952Q1 to 1988Q4 of the real M1 demand regression equation with variables measuring respectively the real value of stocks (SP), the real value of financial transactions on the New York Stock Exchange (SVP) and the real net worth of the households (W).[5] It is hypothesized that changes in

[4] Another way to test this hypothesis is to examine the effect of the volatility of money growth on M1 velocity. This relationship has recently been reexamined in Mehra (1989) and Brocato and Smith (1989). The evidence presented there is not favorable to the hypothesis that the decline observed in the velocity of M1 in the 1980s was caused by the increased volatility of M1 growth.

[5] SP is calculated as the Standard and Poor's 500 composite index divided by the price level used to deflate money balances. SVP is the product of the volume of shares traded on the NYSE and the Standard and Poor's 500 composite index divided by the price level used to deflate M1. W is calculated as the net worth of households divided by the price level. These variables have been employed previously by various authors.

Table II

REAL M1 DEMAND REGRESSION EQUATION: TESTING ALTERNATIVE HYPOTHESES

Independent Variables	(1)	(2)	(3)	(4)	(5)
constant	−.004(−1.8)	−.004(−1.5)	−.004(−1.9)	−.004(−1.6)	−.004(−1.8)
Δy	.92 (3.9)	.81 (3.2)	.80 (3.5)	.79 (3.0)	.87 (3.9)
Δ(RCP−RM1)	−1.41 (−4.9)	−1.21 (−4.2)	−1.15 (−4.4)	−1.25 (−4.8)	−1.31 (−5.5)
ΔINF	−1.55 (−1.9)	−1.75 (−2.1)	−1.77 (−2.3)	−1.39 (−1.6)	−1.69 (−2.4)
ΔVOL1	.001 (.5)				
ΔSP		.03 (1.0)			
ΔSPV			.03 (1.99)		
ΔW				.08 (.6)	
SER	.00597	.00608	.00595	.00605	.00586
$\bar{R}^2$	.69	.68	.69	.68	.69
F1	1.1 (5,115)	.24 (5,115)	1.24 (5,115)	.4 (5,115)	4.3**(5,127)
FD	2.7** (32,83)	2.92**(32,83)	2.82**(32,83)	3.3** (32,83)	3.1** (32,95)

** significant at .01 level

Notes: The regressions tabulated here are estimated over the period 1952Q1 to 1988Q4. SP is the real price of stocks; SPV, the real value of the product of volume of shares traded on the NYSE and the Standard and Poor's common price index; W, the real net worth of households; RM1, the own rate of return on M1; and VOL1, the eight-quarter moving standard deviation of M1 growth. Other variables are defined as in Table I. Five contemporaneous and lagged values of these variables enter the money demand regression. F1 tests the hypothesis that the additional variable suggested by the relevant hypothesis does not enter the M1 demand regression. FD is the statistic for the Dufour test applied to the expanded M1 demand regression over 1981Q1 to 1988Q4.

these variables and money demand are positively correlated. As can be seen, however, the only variable that does attain statistical significance is SVP (t value on the sum of coefficients on SVP is 1.9). But none of the variables is significant by the F test. The Dufour test results indicate that the expanded M1 demand regressions are not stable over the period 1981Q1 to 1988Q4 (see FD values in columns (2) through (4) of Table II).

Column (5) of Table II shows the estimation of the real M1 demand regression with the inflation variables (INF). The variable INF is statistically significant (both t and F values are significant at the 5 percent level). This suggests that part of the observed strength in M1 in the 1980s is due to a decline in the rate of inflation. However, as indicated by the Dufour test, this regression remains structurally unstable over the period 1981Q1 to 1988Q4 (see the FD value in Column (5) of Table II).

Column (6) of Table III presents the estimation of the real money demand regression over 1952Q1 to 1988Q4 with real M1 as the dependent variable and with the additional variable (D88*R – RM1) that is the product of a zero-one dummy (D88)and the opportunity cost variable (R – RM1). D88 equals one over 1981Q1 to 1988Q4 and zero otherwise. The dummy variable, D88*R – RM1, captures a possible change in the interest elasticity of M1 demand in the 1980s. As can be seen, this variable is statistically significant, suggesting a heightened interest sensitivity of M1 demand. However, even after allowing for a rise in the interest elasticity of M1 demand, the expanded M1 demand regression does not explain all of the strength of M1 in the 1980s, a result indicated by the Dufour test applied over the interval 1985Q1 to 1988Q4.[6] The coefficients that appear on Dufour dummies and the F statistic for the Dufour test are presented in Table IV. The F value is large and indicates continuing structural instability.

Furthermore, removing interest-bearing checkable deposits from the definition of money does not render the money demand equation stable either. Column (7) of Table III shows the estimation of a real money demand equation over 1952Q1 to 1988Q4 with M1-A as the dependent variable. The Dufour test

[6] This amounts to estimating the expanded M1 demand regression over 1952Q1 to 1984Q4 and examining its stability over 1985Q1 to 1988Q4. The assumption implicit in this approach is that the expanded estimation period (1952Q1 to 1984Q4) is long enough to provide reliable estimates of the new interest elasticity of M1 demand.

Table III

REAL MONEY DEMAND REGRESSION EQUATIONS: TESTING ALTERNATIVE HYPOTHESES

Independent Variables	Dependent Variable (6) (M1/p)	(7) (M1A/p)	(8) (M1/p)	(9) (M2/p)
constant	–.006(–3.0)	–.009(–4.0)	–.006(–2.7)	.000 (.01)
Δy	.95 (4.7)	1.1 (4.8)	.91 (4.5)	1.0 (6.6)
ΔINF	–1.73 (–2.5)	–1.0 (–1.2)	–1.32 (–1.9)	–2.21 (–4.2)
ΔR		–.012(–4.8)		
Δ(R – RM1)	–.79 (–2.9)		–1.26 (–5.7)	
Δ(R – RM2)				–2.07 (–8.7)
D88	.003 (1.4)		.006 (2.43)	
D88*(R – RM1)	–1.34 (–3.1)			
SER	.00555	.00696	.00578	.00442
$\bar{R}^2$	.72	.64	.70	.78
DW	1.94	1.97	1.95	1.99

Notes: D88 is a dummy variable, taking values 1 in 1981Q1 to 1988Q4 and zero otherwise. D88*(R – RM1) is the product of D88 and (R – RM1). RM2 is the own rate of return on M2 and is calculated as a weighted average of the explicit rates paid on components of M2. Other variables are defined as before. The regressions tabulated above are estimated over the period 1952Q1 to 1988Q4.

Table IV

COEFFICIENTS ON DUFOUR DUMMIES IN REAL MONEY DEMAND REGRESSIONS

Year/Quarter	Eq. 6	Eq. 7	Eq. 9	Year/Quarter	Eq. 6	Eq. 7	Eq. 9
1981/Q1		−.066(−9.5)	−.008(−1.9)	1985/Q1	.012 (2.0)	−.001 (−.1)	.007 (1.4)
1981/Q2		−.021(−2.6)	.002 (.4)	1985/Q2	.013 (2.1)	−.000 (−.0)	−.009(−1.9)
1981/Q3		−.013(−1.7)	.004 (.7)	1985/Q3	.018 (2.9)	.013 (2.1)	.000 (0.0)
1981/Q4		−.018(−2.2)	−.005 (−.9)	1985/Q4	.005 (.8)	.009 (1.5)	−.003 (−.7)
1982/Q1		−.009(−1.3)	−.006(−1.1)	1986/Q1	.005 (.9)	.003 (.5)	−.003 (−.7)
1982/Q2		−.013(−1.8)	−.007(−1.4)	1986/Q2	.024 (4.1)	.017 (3.1)	.006 (1.3)
1982/Q3		−.011(−1.6)	.002 (.4)	1986/Q3	.027 (4.5)	.014 (2.5)	.007 (1.4)
1982/Q4		.004 (.7)	.003 (.7)	1986/Q4	.030 (5.1)	.016 (2.8)	.004 (.8)
1983/Q1		−.011(−1.8)	.024 (5.0)	1987/Q1	.015 (2.4)	.001 (.2)	.000 (.8)
1983/Q2		−.001 (−.2)	.000 (0.0)	1987/Q2	.000 (.1)	−.001 (−.1)	−.000 (−.1)
1983/Q3		.005 (.8)	−.003 (−.6)	1987/Q3	−.006(−1.0)	−.009(−1.6)	−.002 (−.4)
1983/Q4		.002 (.3)	.000 (0.0)	1987/Q4	.001 (.2)	.001 (.3)	−.002 (−.4)
1984/Q1		−.006(−1.1)	−.003 (−.7)	1988/Q1	.003 (.6)	−.007(−1.2)	.001 (.2)
1984/Q2		.002 (.4)	.001 (.2)	1988/Q2	.007 (1.2)	−.004 (−.8)	.001 (.2)
1984/Q3		.006 (.1)	−.002 (−.5)	1988/Q3	.004 (.7)	−.002 (−.0)	−.008(−1.6)
1984/Q4		−.007(−1.1)	−.001 (−.3)	1988/Q4	−.000 (.0)	−.003 (−.5)	−.008(−1.6)
FD1					3.1**(16,105)		
FD2						1.7*(28,95)	
FD3							1.4(31,95)

Notes: The regression equations 6, 7, and 9 above correspond respectively to regressions reported in columns 6, 7, and 9 of Table III. These regressions are reestimated including Dufour dummy variables. Regressions 7 and 9 include Dufour dummies defined over 1981Q1 to 1988Q4, whereas the regression 6 includes Dufour dummies defined over 1985Q1 to 1988Q4. FD1, FD2, and FD3 are the F statistics that test the joint significance of the relevant Dufour dummy variables.

when applied to this regression over 1982Q1 to 1988Q4[7] does not indicate structural stability (see Table IV for the coefficients that appear on Dufour dummies and for the relevant F statistic). The M1-A regression fails to explain the strength of M1-A in 1985 and 1986.

Column (8) of Table III shows the estimation of a real money demand regression over 1952Q1 to 1988Q4 with real M1 as the dependent variable and with the addition of a dummy variable (D88) that takes values unity over 1981Q1 to 1988Q4 and zero otherwise. This regression incorporates the hypothesis that there was a one-time shift in the drift of real M1 demand over the 1980s. However, even after one allows for this shift in the constant term, the real M1 demand regression remains unstable, a result indicated by the Dufour test applied to this regression over 1985Q1 to 1988Q4. The F statistic [(16,110)] is 3.2, which is above the 5 percent critical value of 1.7.

Column (9) of Table III shows the estimation of a real money demand regression with real M2 as the dependent variable. This regression incorporates the hypothesis that a broader definition of money is needed in order to capture increased substitutions between components of M1 on the one hand and savings-type deposits included in M2 on the other [Hetzel and Mehra (1989)]. The results of applying the Dufour test to this regression over 1981Q1 to 1988Q4 are presented in Table IV (see column under Eq. 9). Except for one large coefficient that appears on the Dufour dummy for 1983Q1, the other coefficients are small and not significant. The F statistic [31,95] for these other coefficients is 1.4, which is below the 5 percent critical value of 1.5. This result

[7] In order to avoid distorting effects of the nationwide introduction of NOW accounts in January 1981, the observations for the year 1981 are excluded in computing the F statistic for the Dufour test.

implies that except for one-time shift in 1983Q1 M2 demand has been stable in the 1980s.[8] Additional evidence consistent with the existence of a stable long-run M2 demand function over 1952Q1 to 1988Q4 is presented in the Appendix.

III. CONCLUDING REMARKS

This article has examined empirically several explanations of the instability in M1 demand of the 1980s. The econometric evidence presented here does not support explanations that assign a key role to the behavior of the volatility of M1 growth, the rate of inflation, the real value of stocks, the volume of financial transactions, or the financial wealth of households.

The most probable cause of the shift in M1 demand thus is the introduction into M1 of checkable deposits that pay interest. One view is that this development might have raised the interest elasticity of M1 demand while having no effect on the demand of M1-A (currency plus demand deposits). The evidence does not support this view. True, M1 demand does appear more interest sensitive. But the M1 demand regression estimated including the variable that captures this shift in the interest elasticity of M1 demand does not explain all the strength in money demand. Moreover, it also appears that the demand for M1-A shifted in the 1980s.

The other view, which receives considerable support here, is that the financial deregulation has altered the character of M1 demand. M1 has become an instrument for saving as well as for effecting transactions. As a result, elements of M1 are highly substitutable with the savings instrument included in the non-M1 component of M2. An empirical implication of this view is that the broader monetary aggregate M2, which internalizes such substitutions, has a stable demand function. The evidence presented in the text and the Appendix is consistent with this implication.

[8] This one-time shift in M2 demand is due to the introduction of MMDAs in December 1982 and Super-NOWs in January 1983.

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APPENDIX

COINTEGRATION AND THE EXISTENCE OF A STABLE LONG-RUN M2 DEMAND FUNCTION

Introduction

This appendix presents alternative statistical evidence consistent with the existence of a long-run M2 demand function during 1952Q1 to 1988Q4. The evidence consists of showing that real M2 balances are cointegrated[9] with real income and a market rate of interest, which means that there exists a stable long-run demand function for real M2 balances as a function of real income and a market rate of interest.

A Long-Run Money Demand Equation

The transactions models of money demand suggest that the public's demand for real money balances depends upon a scale variable commonly measured by real income and an opportunity cost variable commonly measured by a market interest rate. Consider, for example, the following linear semi-log specification (1)

$$\ln(M/P)_t = a + b \ln y_t - c R_t + u_t \qquad (1)$$

where M is the nominal stock of money; P, the price level; y, real income; R, a market rate of interest; and u, the error-term. The symbol ln denotes the natural logarithm. The variables in (1) are the long-run determinants of real money demand. In the short run, actual real money balances could differ from the value suggested by such determinants. This is implied by the presence of the error term u_t in (1). However, if equation (1) is true, then u_t is a stationary zero mean process.

It should be pointed out that if the parameter b in (1) is unity, then (1) could be expressed as a velocity equation (2)

$$\ln(Py/M) = a' + c' R_t + e_t \qquad (2)$$

where all variables are as defined above.

Testing the Existence of a Long-Run M2 Demand Function: The Issue of Cointegration

The variables in the money demand equation (1) above have stochastic trends and hence are nonstationary. The proposition that this equation describes the long-run relationship among the variables can be interpreted to mean that the stochastic trend in real money balances is related to stochastic trends in real income and the nominal rate of interest. This implication is related to the concept of cointegration discussed in Granger (1986), which states that cointegrated multiple time series share common stochastic trends. Hence, the existence of a stable long-run M2 demand function (1) can be examined using the test of cointegration discussed in Engle and Granger (1987).

This test for cointegration consists of two steps. The first tests whether each variable in equation (1) has a stochastic trend. One does this by performing a unit root test on the variables. The second step tests whether stochastic trends in these variables are related to each other. In particular, the question of interest here is whether the stochastic component in real M2 balances is related to stochastic components in real income and the nominal rate of interest. This can be examined by estimating the cointegrating regression of the form (3)

[9] Let X_{1t}, X_{2t}, and X_{3t} be three time series, each first difference stationary. Then these series are said to be cointegrated if there exists a vector of constants (α_1, α_2, α_3) such that $Z_t = \alpha_1 X_{1t} + \alpha_2 X_{2t} + \alpha_3 X_{3t}$ is stationary. The intuition behind this definition is that even if each time series is nonstationary, there might exist linear combinations of such time series that are stationary. In that case, multiple time series are cointegrated and share some common stochastic trends. We can interpret the presence of cointegration to imply that long-run movements in these multiple time series are related to each other.

$$\ln(M/P) = \gamma_0 + \gamma_1 \ln y_t + \gamma_2 R_t + U_t \qquad (3)$$

and then testing whether the residual U_t has a unit root. If U_t does not appear to have a unit root while the left-hand and right-hand variables have a unit root, then the variables are said to be cointegrated. In that case, ordinary least squares estimates of (3) are consistent and can be used to calculate long term elasticities.

Test Results for Cointegration

The test used to detect a unit root in a given time series X_t is the Augmented Dickey-Fuller (ADF) test [Fuller (1976)] and is performed estimating the following regression

$$\Delta X_t = e + f\,T + \sum_{s=1}^{n} g_s\, \Delta X_{t-s} + h\, X_{t-1} + \epsilon_t \qquad (4)$$

where ϵ_t is an independent and identically distributed disturbance and n is the number of lagged values of first differences that are included to allow for serially correlated errors. If there is a unit root in X_t, then the estimated coefficient h in (4) should not be different from zero. The results of estimating (4) for real M2 balances, M2 velocity, real income, the opportunity cost variable and the nominal rate of interest are presented in Table V. These test results shown are consistent with the presence of a unit root in each of the relevant variables. The only exception is the opportunity cost variable measured as the difference between the market rate of interest (R) and the own rate of return on M2 (RM2). This variable, R – RM2, appears stationary over the period 1952Q1 to 1988Q4. Hence, in tests for cointegration the opportunity cost of holding M2 is measured by the market rate of interest (R).

Table VI presents results of regressing real M2 balances on levels of real income and the market rate of interest and M2 velocity on the level of the market rate of interest. Regressions are presented for two measures of income, real personal income and real GNP. The results of applying the formal ADF test for detecting a unit root in the residual series are also reported there. The estimated coefficient that appears on the lagged level of the residual in the relevant regressions range between –.10 to –.20 and are generally significantly different from zero at the 5 percent level (see coefficient values $\hat{h}$ and the associated t values in panels 1 though 4 in Table VI). This result implies that the residuals U_t in (3) and e_t in (2) are stationary.

Table V

UNIT ROOT TEST STATISTICS

Augmented Dickey-Fuller Equation

$$\Delta X_t = e + f\,T_t + \sum_{s=1}^{n} g_s\, \Delta X_{t-s} + h\, X_{t-1}$$

X	h	t statistic (h=0)	Q(sl)
lnrM2	–.02	–1.40	32.8(.62)
lnrM22	–.03	–1.90	42.7(.20)
lnrpy	–.01	–.9	28.3(.81)
lnry	–.04	–2.0	18.8(.99)
R	–.14	–2.9	30.1(.74)
R – RM2	–.23	–3.90*	36.9(.42)
lnVM2	–.067	–2.6	41.4(.25)
lnVM22	–.10	–2.7	43.3(.18)

Notes: The Augmented Dickey-Fuller regression is estimated over the period 1952Q1 to 1988Q4. ln is the natural logarithm. rM2 is M2 deflated by the implicit price deflator for consumption expenditures; rM22, M2 deflated by the implicit GNP deflator; ry, real GNP; rpy, real personal income; R, the 4-6 commercial paper rate; VM2, nominal personal income divided by M2; VM22, nominal GNP divided by M2; T, time trend; and RM2, the own rate of return on M2. RM2 is a weighted average of the rates payable on components of M2. h is the estimated coefficient that appears on the lagged level of the variable in question and the 5% critical value of the t statistics is 3.45 [Fuller (1976), Table 8.5.2)]. Q(sl) is the Ljung-Box Q-statistic based on 36 autocorrelations of the residual and sl is the significance level.

The long-run real M2 balances predicted by the cointegrating regression are shown in Charts 1 and 2 along with actual real M2 balances. Chart 1 uses real personal income and Chart 2 real GNP in the relevant cointegrating regression. As can be seen, there are differences between actual and estimated long-run real M2 balances but these differences appear stationary.

The results on unit roots presented above imply that levels of the variables entering the M2 demand regression (3) and velocity regression (2) are nonstationary but cointegrated. The parameter estimates of the regressions (3) and (2) presented in Table VI are therefore consistent. The coefficient that is estimated on real income (measured either by real personal income or by real GNP) is unity, suggesting that the income elasticity of money demand is unity. The long-run value of the coefficient estimated on the market rate of interest in real M2 demand regression is approximately –1. This estimate implies that when the market rate of interest rises by 100 basis points, real demand for M2 balances rises by 1 percent in the long run.

Table VI

TEST STATISTICS FOR COINTEGRATION OF REAL M2 AND M2 VELOCITY

Semi-Log Specification

1. Cointegrating Regression: $\ln(M2/p)_t = -.6 + 1.0 \ln rpy_t - 1.2 R_t + \hat{u}_t$

   Augmented Dickey-Fuller Regression: $\Delta\hat{u}_t = h\,\hat{u}_{t-1} + \sum_{s=1}^{n} \Delta\hat{u}_{t-s}$

   Lag length n:4 Estimated $\hat{h} = -.11$ Test statistic for $\hat{h} = 0$: -2.6 Q(sl) = 30.6(.58)

   5% critical value for $\hat{h}$: 3.6 [Engle and Yoo (1987), Table 3]

2. Cointegrating Regression: $\ln(M2/p2)_t = -5.9 + 1.1 \ln ry_t - 1.1 R_t + \hat{u}_t$

   Augmented Dickey-Fuller Regression: $\Delta\hat{u}_t = h\,\hat{u}_{t-1} + \sum_{s=1}^{n} \Delta\hat{u}_{t-s}$

   Lag length n:0 Estimated $\hat{h} = -.20$ Test statistic for $\hat{h} = 0$: -4.1 Q(sl) = 36.2 (.45)

   5% critical value for $\hat{h}$: 3.9 [Engle and Yoo (1987), Table 2]

3. Cointegrating Regression: $\ln(GPY/M2)_t = .2 + .78 R_t + \hat{e}_t$

   Augmented Dickey-Fuller Regression: $\Delta\hat{e}_t = h\,\hat{e}_{t-1} + \sum_{s=1}^{n} \Delta\hat{e}_{t-s}$

   Lag length n:4 Estimated $\hat{h} = -.10$ Test statistic for $\hat{h} = 0$: -3.13 Q(sl) = 29.0 (.66)

   5% critical value for $\hat{h}$: 3.17 [Engle and Yoo (1987), Table 2]

4. Cointegrating Regression: $\ln(GNP/M2)_t = .5 + .24 R_t + \hat{e}_t$

   Augmented Dickey-Fuller Regression: $\Delta\hat{e}_t = h\,\hat{e}_{t-1} + \sum_{s=1}^{n} \Delta\hat{e}_{t-s}$

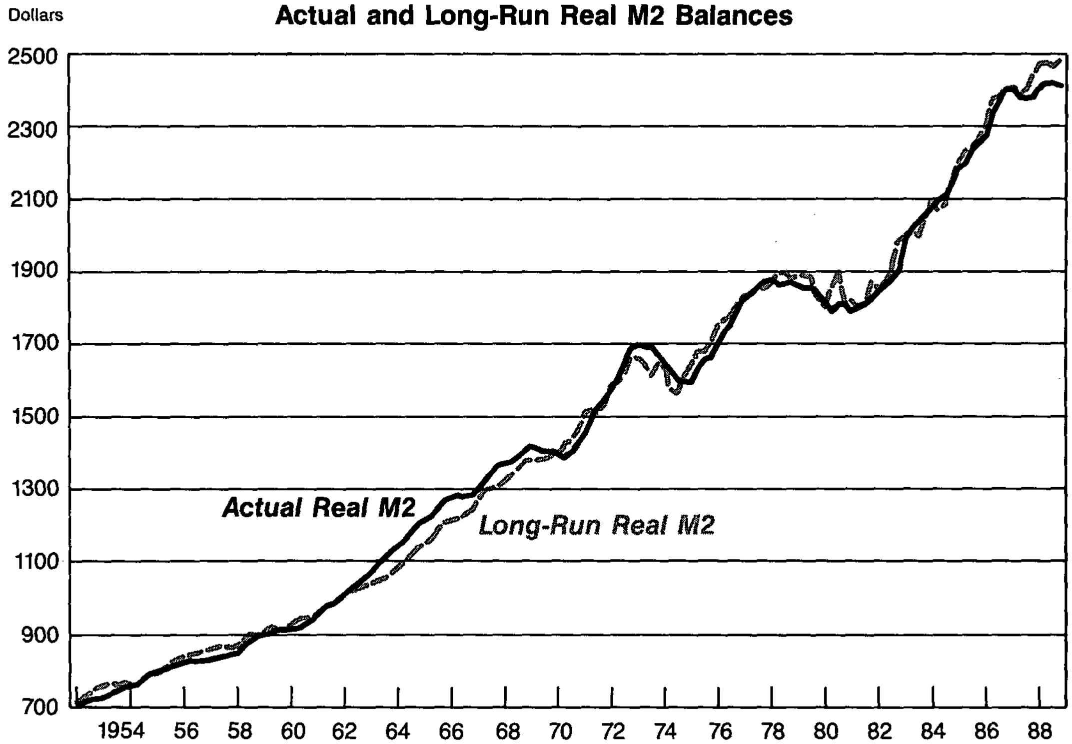
   Lag length n:4 Estimated $\hat{h} = -.10$ Test statistic for $\hat{h} = 0$: -3.21 Q(sl) = 4.7 (.10)

   5% critical value for $\hat{h}$: 3.17 [Engle and Yoo (1987), Table 2]

Notes: The cointegrating regressions are estimated over the period 1952Q1 to 1988Q4. p is the deflator for consumption expenditures; p2, the implicit GNP deflator; GNP, nominal GNP; and GPY, nominal personal income. See Note in Table V for definition of other variables.

Chart 1

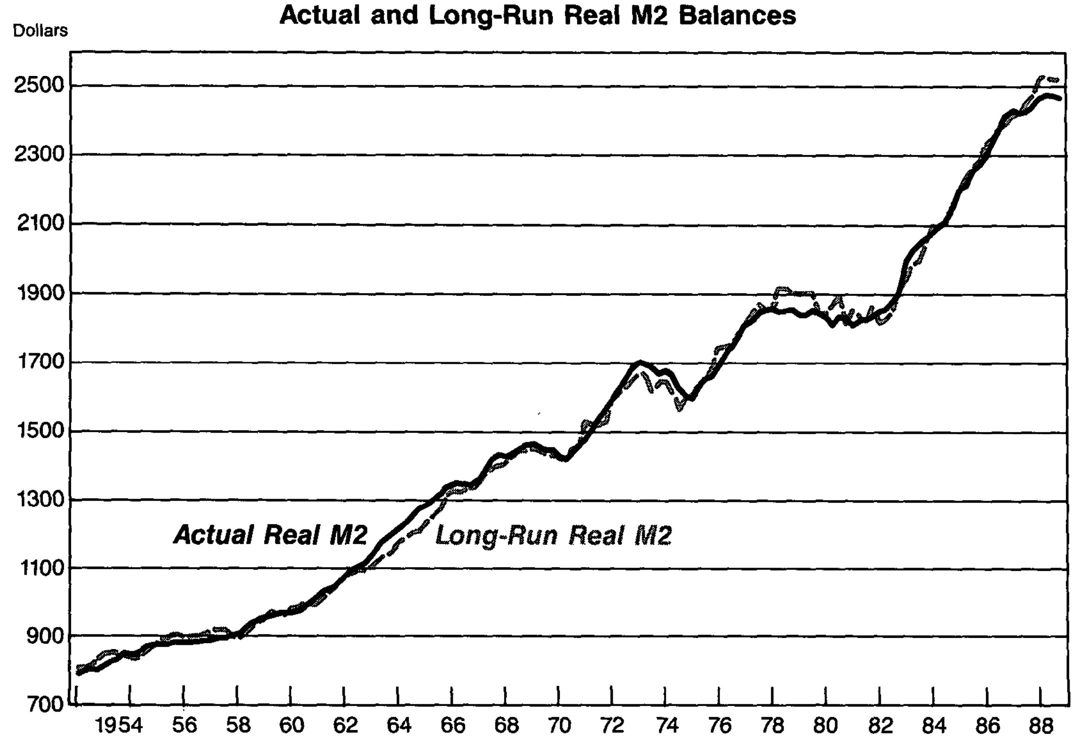
Actual and Long-Run Real M2 Balances



Note: Long run is the value predicted from a regression of real M2 on real personal income and the commercial paper rate.

Chart 2

Actual and Long-Run Real M2 Balances



Note: Long run is the value predicted from a regression of real M2 on real GNP and the commercial paper rate.