THE RELATIONSHIP OF OPPORTUNITY COST TO THE INTEREST ELASTICITY OF MONEY DEMAND

Steven R. Cunningham
University of Connecticut

INTRODUCTION

It is puzzling to monetary economists that the velocity of M1, which increased at a rate of about 3 percent per year in the 1970s, became erratic in the 1980s, alternately rising and falling in spurts and stops. This is an important and widely debated issue, and noted economists have offered rationales for the observed behavior [Darby et al., 1987], some arguing that the demand for money is "clearly" unstable.[1]

A growing number of researchers have suggested that the money demand relation is stable but has shifted in recent years as a result of the deregulation of the financial industry. Some aggregates, like M1, that previously did not include money held in interest-bearing accounts, now include such accounts (NOW and superNOW accounts). This has altered the opportunity cost of holding money in two ways that may account for the shift in the demand for money. Firstly, the opportunity cost of holding money included in such aggregates, as compared with another aggregate such as M2, is reduced. If this *relative price effect* predominates, then the interest elasticity of the demand for such aggregates should fall. Secondly, the introduction of an interest-bearing component in the aggregates has also raised the average interest paid on the aggregates. Moreover, interest rates rose across the board as a result of the deregulation. If the response to this interest rate change dominates, then the interest elasticity should rise. Many researchers have focused on this *interest rate effect* as the predominant factor explaining the change in money demand behavior.

Mehra [1986], for example, focuses on the interest rate effect. He argues that the key relationship between this deregulation and money demand is that depository institutions have begun to pay interest on noncommercial demand accounts (through NOW and superNOW accounts) and to permit check-writing on savings accounts. He argues that these interest-paying accounts may have raised the interest elasticity of money demand; M1 now contains assets "potentially suitable for savings" [1986, 13]. Furthermore, "changes in market rates might induce larger changes in NOWs than in demand deposits, thereby increasing the interest responsiveness of M1 as a whole as NOWs become a larger fraction of M1" [Ibid]. Mehra estimates money demand functions on growth rates computed from monthly observations dating from 1961:01 to 1985:03. Using t-tests on dummy variables, he constructs a straightforward case that the income elasticity of M1 has not changed significantly since the introduction of interest-on-checking in 1981, but that the interest elasticity of M1 has increased substantially.

In a recent article in this *Journal*, Baytas and Marty [1989] adopt a similar approach to argue that the development of interest-bearing M1 accounts has caused the interest elasticity of M1 demand to rise, causing a shift in the growth rate of velocity. Using quarterly series dating from 1950:1 to 1987:2, they extend the earlier effort of Hafer and Hein [1984] to provide empirical evidence that the interest elasticity of the demand for M1 has increased, particularly from 1978:1 to 1987:2.

Both of these studies confuse the proxy, that is, some interest rate, with the opportunity cost of holding money which is the incentive variable. The true opportunity cost is the differential rate of interest paid on the various monetary aggregates; it is the relative price effect that dominates.

In their landmark study, Friedman and Schwartz [1982] argue that the demand for real M2 (per capita) has been remarkably stable. They estimate money demand in both log-levels and growth rates using cycle averages constructed from annual series from 1873-1975. Because they limit themselves to M2 they cannot examine the impact of changes in M1 composition. While their dummy variables partly allow for differing monetary regimes, they do not consider directly the effects of changing opportunity costs on elasticities or the relationship of the interest elasticity to the narrowness of the money stock measure.[2]

This paper examines the impact of changing opportunity costs on the money demand relation proposed by Friedman and Schwartz [1982]. Using lengthy annual data from 1880-1986, it is possible to reconsider the issue of explaining the recent behavior of the velocity of M1 without a significant risk of historical myopia. The Friedman-Schwartz specification for log-level real per capita money demand is estimated across regimes that alternately have permitted and prohibited interest payments on demand accounts. By extending the Friedman-Schwartz effort to include estimates of the demand for the monetary base and M1, it is also possible to observe the effects of differing opportunity costs on money demand through time. It is demonstrated that it is the relative price effect that dominates. The introduction of interest-bearing accounts into M1 has changed the opportunity cost of holding (demanding) M1 *relative to the alternatives.*

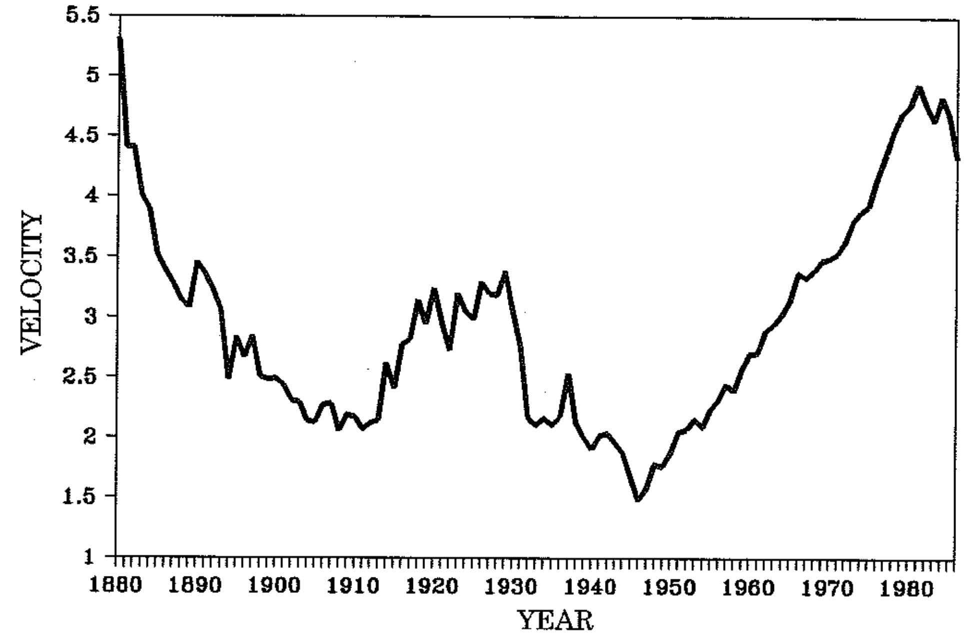
CONSTRUCTION OF THE ARGUMENTS

A graphical analysis of the behavior of the velocities of the monetary base (VB), of M1 (V1), and of M2 (V2), based upon unadjusted money stock and net national product (NNP), offers some insights.[3]

As presented in Figure 1, V1 is computed with no lag between money and output. The strong, stable growth of V1 since World War II is apparent.

From this simple graphical analysis, it is easy to understand the prevalent view that V1 was stable until the 1980s, when it fell dramatically. That is only part of the story. The period from 1880 to 1913, one in which the opportunity costs of holding money were more like the present, is marked by an equally steep decline in V1. The period from the founding of the Federal Reserve System (1914) to the Great Depression (1929) was similar to that from World War II to 1980, when V1 growth was positive.

FIGURE 1
The Velocity of M1 (NNP/M1)

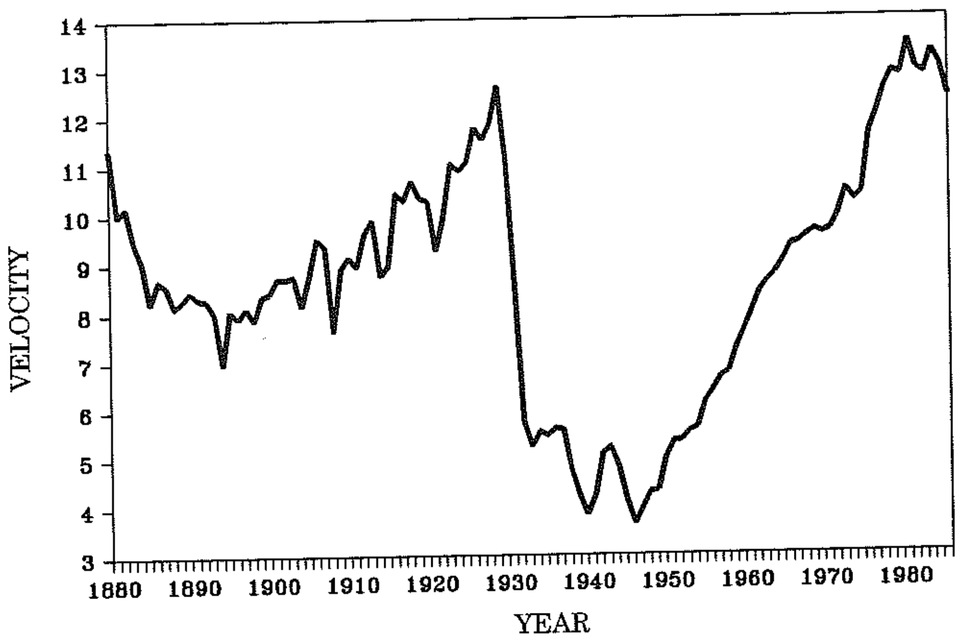


With the Federal Reserve Act of 1914 and the founding of the Federal Reserve System came the first standard definitions of time and savings deposits. [Cagan, 1965, 167] This effectively put an end to the payment of interest on demand accounts, although the formal proscription came with the Banking Acts of 1933 and 1935. Interest was paid on some demand deposits before 1933, though generally only on interbank deposits and to some extent on large commercial deposits. Furthermore, interest paid on demand deposits in the 1920s was effectively higher than recorded, because some banks allowed favored customers to use time deposits to some extent as demand deposits by retaining a copy of the passbook at the bank and honoring drafts against the account.[4]

The financial deregulation of the 1970s removed these restrictions in 1981. Therefore, the years prior to 1914 and the years after 1981 are all associated with monetary regimes that permitted interest on demand accounts. The years 1914-81 are associated with experiences with monetary regimes prohibiting such interest payments.

Thanks to Fed tightening during the Great Depression, primarily by encouraging depository institutions to reduce risk in their loan portfolios and increase excess reserves, M1 fell. But Figure 1 clearly shows, NNP fell even more rapidly. The velocity of high-powered money (VB) in Figure 2 shows NNP outpacing reserves growth from the 1890s until the Great Depression. During the early years of the Depression, the monetary base expanded but M1 fell. The growth of the monetary base is often interpreted as proof that the Fed followed a policy of loose money

FIGURE 2
The Velocity of MB (NNP/MB)



during the Depression, but as argued above, M1 fell as a direct result of other Fed actions. Following World War II, growth of the base was met with faster growth of NNP.

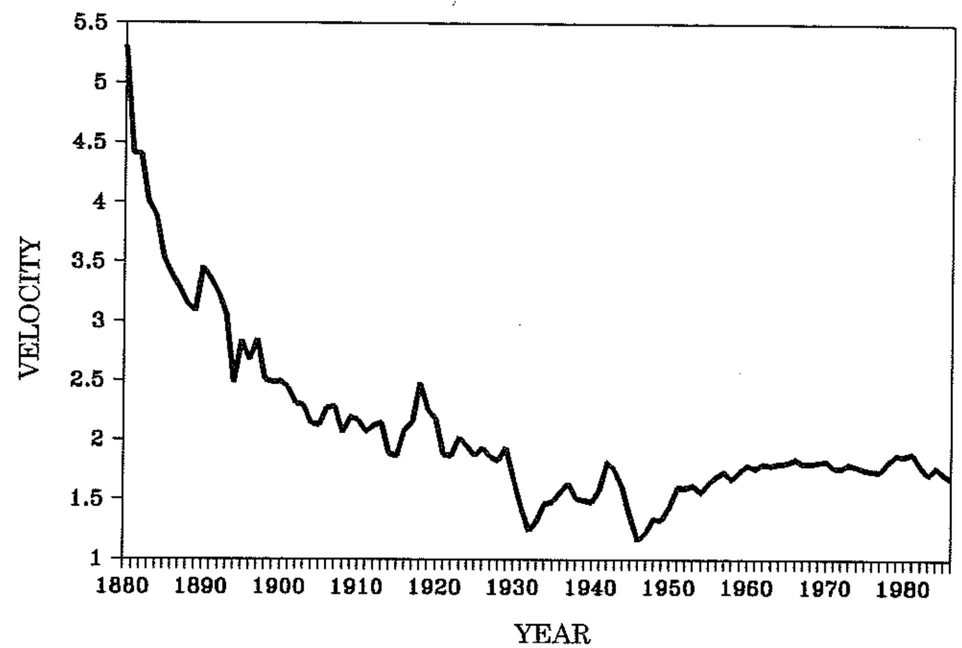
The income velocity of M2 is shown in Figure 3. As argued by Friedman and Schwartz [1982], V2 appears to exhibit a lower variance than the other velocity measures. This might be due to a greater stability in the money demand function that determined V2. Prior to 1904, Friedman and Schwartz argue that the declining V2 was the result of growing financial sophistication in the U.S. In fitting money demand relations they rescale this period and use a dummy variable to fit the anomolous demand from 1929-54 caused by depression and two wars. What is left is a relatively "flat" V2.

For this study, the unconditioned, unscaled (raw) data from 1880-1913 and 1981-86 are pooled since all represent observations on policy regimes in which interest was paid on demand accounts; this will be referred to as Pool I in the discussion that follows. The 1947-81 period (excluding 1929-46) represents observations on policy regimes in which interest on demand accounts was forbidden; this will be referred to as Pool II.[5]

Friedman and Schwartz [1982], following a careful analysis, offer the following specification for the money demand relation:

(1) $LPRM2 = \beta_0 + \beta_1 LPRNNP + \beta_2 GNNP + \beta_3 ACMCL2 + \beta_4 DumD + \beta_5 DumGD$

FIGURE 3
The Velocity of M2 (NNP/M2)



where LPRM2 is the logarithm of real per capita M2, *LPRNNP* is the logarithm of real per capita NNP, *GNNP* is the growth rate of NNP, *ACMCL2* is the commercial paper rate adjusted according to the proportion of M2 *not held* in high-powered money, *DumD* is a post-war-demand-surge dummy variable, and *DumGD* is a Depression/WWII dummy variable.[6]

A modified Friedman-Schwartz specification is used here because it is well supported by their extensive work, it does not use lagged money, and, since the data used in this paper are extensions of the Friedman-Schwartz database, useful comparisons can be made.

The Friedman and Schwartz results have been criticized. They never published Durbin-Watson statistics for their regressions, casting doubt on the efficiency of their estimates, and their estimates were made on cycle-averages of the raw annual data [Mayer, 1982; Goodhart, 1982; Hall, 1982]. These doubts appear unwarranted. In Table 1, the first column reports the original Friedman-Schwartz estimates for the demand for the natural logarithm of real per capita M2, along with its associated Durbin-Watson statistic. The cycle-averaged data, or "phases" for each of the series involved, as listed in *Monetary Trends*, were used to re-estimate the relation. At a 95% confidence level, the hypothesis that autocorrelation is present in the residuals can be rejected. Column 2 lists Friedman's own [1988] estimate of the annual data, conditioned by the rescaling of pre-1904 observations. The results suggest that no significant distortions could be attributed to the cycle-averaging process. Column 3 reports the estimated relation on the raw data [1880-1986] with no rescaling or dummy variables. The same information for M1 and the monetary base (MB) is shown in columns four and five respectively.

Estimates of the income elasticity of money demand differ significantly from unity. The interest elasticity of M2 for the raw data and on the cycle-averaged data are very close. A comparison of the last three columns suggests that the interest elasticity of money demand declines in absolute value as the monetary aggregate narrows in definition. These results confirm the international cross-sectional study done by Macesich and Tsai [1982].

Each of the regressions presented in the last three columns are corrected for autocorrelation. Estimates for rho were made via maximum likelihood estimation (MLE). In each case rho was near unity, suggesting first differencing. Even after the correction, M2 and the monetary base display significant first-order autocorrelation. This may be indicative of omitted variables.

While the relationships between incentives and behavioral responses remain consistent through time and various regulatory regimes, the resulting structural relations change with changing incentive structures. This conjecture is evaluated empirically by introducing a dummy variable as a proxy for the omitted variable. This dummy variable captures the effect of interest payments on demand accounts. Specifically, a dummy variable *D1* is introduced that is 0 for for all observations in Pool I, and 1 for all observations in Pool II. To capture cross effects, the products of *D1* and each of the original variables are added. Thus, the specification for this study can be given as

$$(2)\quad LPRMx = \beta_0 + \beta_1\, LPRNNP + \beta_2 GNNP + \beta_3 ACMCLx + \beta_4 D1 + \beta_5 D1xY + \beta_6 D1xGY + \beta_7 D1xR$$

where *LPRNNP* and *GNNP* are the same as in equation (1); *LPRMx* is the logarithm of the real per capita monetary base, M1, or M2; *ACMCLx* is the commercial paper rate adjusted according to the proportion of the aggregate under discussion (Mx) that is held in high-powered money (H); and *D1xY, D1xGY,* and *D1xR* are the products of *D1* and *LPRNNP*, *GNNP*, *ACMCLx* respectively.[7]

T-tests on the dummy variable and its products will determine the statistical significance of these variables, and an improvement in the Durbin-Watson statistic (after correction for first-order autocorrelation via maximum likelihood estimates of rho) would support an improvement in stability, suggesting less chance of omitted variables.

EMPIRICAL RESULTS

In all cases, it was necessary to apply the MLE procedure to correct for autocorrelation. Once done, however, "stable" results were obtained. (See Table 2.) In every case the Durbin-Watson statistic was improved, suggesting that autocorrelation in the residuals was reduced by the inclusion of the pooling dummy variable. In all cases, autocorrelation can be rejected at the 95 percent confidence level.

TABLE 1
Regression Results
Comparison of Estimates of the Demand for the Natural Logarithm of Real Per Capita Money
(t-statistics are given in parentheses)

	M2: Friedman et al. 1873-1975 Cycle-Averaged Data	M2: Friedman 1886-1985 Annual Data	M2: 1880-1986 Raw Data Without Dummies	M1: 1880-1986 Raw Data Without Dummies	MB: 1880-1986 Raw Data Without Dummies
Constant	-1.53	-1.55	0.87	-1.16	-2.18
	(19.6)	(19.6)	(1.90)	(5.32)	(11.0)
LPRNNP	1.15	1.16	0.88	0.90	0.82
	(50.7)	(99.3)	(18.6)	(14.4)	(12.7)
GNNP	-0.59	-0.51	-0.42	-0.31	-0.42
	(3.5)	(7.9)	(9.0)	(5.1)	(6.6)
ACMCLx	-8.82	-11.90	-8.13	-6.30	-1.60
	(4.4)	(6.4)	(5.7)	(5.0)	(3.3)
DumD	0.025	0.023			
	(3.8)	(5.6)			
DumGD	-0.17	0.138			
	(6.9)	(7.1)			
Sample Size	52	100	107	107	107
R-squared	0.994	--	0.982	0.920	0.900
Durbin-Watson	1.86	--	1.33	1.69	0.96
Rho	--	--	0.9964	0.9810	0.9778

Variable List

Constant	Constant term.
LPRNNP	Natural log of real per capita NNP.
GNNP	Growth rate of NNP; proxy for the return to real assets.
ACMCLx	Commercial paper rate; adjusted according to the proportion of each monetary aggregate not held in high-powered money.
DumD	Post-war demand surge dummy variable (Friedman-Schwartz only).
DumGD	Depression/WWII dummy variable (Friedman-Schwartz only).

TABLE 2
Stability Analysis
Comparison of Estimates of the Demand for the Natural Logarithm of Real Per Capita Money

	M2	t-ratio	M1	t-ratio	MB	t-ratio
Constant	-0.84[a]	3.06	-1.17[a]	5.54	-2.19[a]	18.02
LRNNP	1.08[a]	15.95	1.05[a]	11.41	0.92[a]	10.35
GNNP	-0.48[a]	4.82	-0.48[a]	3.40	-0.54[a]	2.78
ACMCLx	-4.38[a]	2.22	-3.36	1.46	-1.95	1.63
D1	0.20[a]	2.79	0.19	1.61	0.39[a]	2.71
D1xY	0.43	0.59	0.46[a]	3.57	0.33[a]	2.34
D1xGY	0.13	0.92	0.06	0.31	0.11	0.38
D1xR	-11.76[a]	3.17	-9.17[a]	2.94	-4.54[a]	3.09
Sample Size	90	--	90	--	90	--
Durbin-Watson	2.16	--	2.03	--	1.77	--
Rho	0.9861	--	0.9652	--	0.9422	--

Variable List

Constant	Constant term.
LPRNNP	Natural log of real per capita NNP.
GNNP	Growth rate of NNP; proxy for the return to real assets.
ACMCLx	Commercial paper rate; adjusted according to the proportion of each monetary aggregate not held in high-powered money.
D1	Pooling dummy variable: 1880-1913 and 1981-1986 = 0; 1914-1929 and 1947-1980 = 1.
D1xY	*D1* times *LPRNNP*.
D1xGY	*D1* times *GNNP*.
D1xR	*D1* times *ACMCLx*.

Note: [a] indicates significance at the 5 percent level.

In the analysis of MB and M1, the interest elasticities were significantly different in the two pools. In contrast to Mehra [1986], the interest elasticities were larger (in absolute value) when interest payments were prohibited, perhaps as a result of the larger opportunity costs of holding money. When interest payments are prohibited on these accounts, at a given interest rate the opportunity cost of holding cash balances is higher than otherwise. In either case, the larger the interest rate, the larger the opportunity cost of holding money, and the less cash balances are desired; hence, the interest rate variable is inversely related to money demand, and its sign is negative.

Moreover, the interest rate is significant only during periods in which interest was not paid on demand accounts and the opportunity cost between the assets increased. The shifts that appear in the income elasticities are likely a result of the structural changes posited earlier.

For M2, the interest rate is significant in all years (both pools). This makes sense because a great deal of the substitution among assets would be subsumed in M2. The same rationale also explains why the income elasticity of M2 is not significantly different between the two pools, while differences between the pools do occur for narrower definitions of money.

CONCLUSIONS

Through graphical and statistical analyses, arguments are made that it is the change in the opportunity costs related to the relative price effects resulting from the policy change allowing interest payments on demand accounts that caused a large part of the observed shift in money demand (or, equivalently, in velocity) since 1981. This was caused by a normal reaction to a change in an economic incentive structure.

The interest elasticity of money demand is highly dependent on both the regulatory regime and the narrowness of the definition of money. The income elasticity of M2 demand is independent of regulatory regime, whereas the income elasticities of the monetary base and M1 are not. This, at least partly, may explain the observed empirical stability of M2 demand relative to the demand for other monetary aggregates, given that substitutions between assets caused by financial deregulation are likely subsumed in M2.

The stability of the money demand relation is improved by the inclusion of a proxy that captures the regulatory regime regarding interest-on-checking. Autocorrelation problems are eliminated.

Along the way, the Friedman and Schwartz [1982] result is vindicated; their estimation of the money demand function is not "tainted" by the existence of autocorrelation. The conditioning they performed on their data (cycle-averaging, rescaling prior to 1904, etc.) and the dummy variables they added had no significant qualitative effects on the estimated elasticities.

NOTES

The author would like to express his appreciation to Phillip Cagan, Milton Friedman, George Macesich, Milton H. Marquis, and Anna J. Schwartz for helpful comments, suggestions, and corrections on early drafts. The author bears sole responsibility for any remaining errors.

1. A number of investigators have attempted to demonstrate the long-run stability or instability of the demand for money. Khan [1974] applies the Brown-Durbin-Evans (BDE) cosum-of-squares technique to growth rates computed from annual U.S. data from 1901-65 to argue that it is stable. Garbade [1977] reconstructs Khan's work applying the Cooley-Prescott varying parameter (VPR) technique, which he argues is more robust, to reach the same conclusion. Laumas and Mehra [1977] use the VPR technique to evaluate annual data in log-levels for the period from 1900-74. Their results weakly support stable M2 demand, but only when lagged money is included among the regressors. Laumas and Fackler [1987] revisit the issue using both the VPR and BDE tests to support stability for growth rates of quarterly observations dating from 1908-80, but to support instability for log-level data with lagged money as one of the regressors. They argue that "...the demand for money remains stable until some outside event occurs; economic agents change their behavior and the new, stable behavior pattern persists until the next event shocks a change in behavior" [1987, 250] Through trial and error, Laumas and Fackler were able to construct ten periods, ranging from about four to about fifteen years, during which the demand for money was stable by their criteria.
2. Friedman and Schwartz do analyze differences in monetary regimes by comparing the results of the cycle-average analyses for the United States and Great Britain.
3. For convenience and consistency, all reals have been deflated by the NNP price deflator. All data is from Friedman and Schwartz [1982], and from the Board of Governors of the Federal Reserve System. The data for M1 for 1880-1913 are identical to the data for M2 for that period; prior to the Federal Reserve Act of 1913 no clear distinctions were made between time and demand deposits.
4. To test the importance of this point, the regressions were also computed after omitting the data from 1914-29. No significant change in the estimates resulted.
5. The starting point for the estimations (1880) was chosen so as to post-date the period of financial turmoil following the U.S. Civil War. Despite money supply growth, prices collapsed through the decade of the 1870s. In 1874, reserve requirements against national bank notes were eliminated, increasing free reserves, encouraging a rise in the deposit-reserve ratio. The Resumption Act of 1875 forced the resumption of the specie standard at pre-Civil War parity. After 1877, the Treasury was active in making large-scale gold purchases. From 1877-1889, the Treasury refunded about half the outstanding interest-bearing public debt. Because this period is anomolous, and likely includes sporadic disequilibria in the money markets, it has been omitted.
   The period spanning the Great Depression and World War II (1929-1946) is also generally regarded as anomolous in monetary history, and is omitted. The period was likely distorted by bank runs, hoarding of cash, unusually low interest rates, deficient demand, etc.
6. For more details on this specification and the arguments leading to it, see Friedman and Schwartz [1982].
7. The variable GNNP is somewhat peculiar to Friedman-Schwartz. All of the regressions were re-estimated without this variable to test the sensitivity of the results to this specification. The results were qualitatively unchanged.
   The use of the adjustment procedure in forming *ACMCLx* has been challenged by Carlson and Frew [1980] as a source of possible bias, arguing that it improves regression results because *ACMCLx* is a function of the money supply variable under study. Unfortunately, if an adjustment is not made to the interest rate variable, then the interest rate response may be overstated. The Carlson-Frew critique depends upon a high correlation between the dependent variable Mx and H/Mx. In the model presented here, the dependent variable is the logarithm of real per-capita money, a variable not well correlated with H/Mx. Moreover, the empirical test of the importance of the critique provided by Carlson and Frew relies on regression analyses with significantly low Durbin-Watson statistics, making any inferences based upon their estimates suspect.

REFERENCES

Baytas, A., and Marty, A. L. The Interest Elasticity of Money Demand: Further Evidence. *Eastern Economic Journal*, April/June 1989, 107-11.

Cagan, P. *Determinants and Effects of Changes in the Stock of Money 1875-1960*. New York: Columbia University Press for National Bureau of Economic Research, 1965.

Carlson, J. A., and Frew, J. R. Money Demand Responsiveness to the Rate of Return on Money: A Methodological Critique. *Journal of Political Economy*, June 1980, 598-607.

Darby, M. R., Poole, W., Lindsey, D. E., and Friedman, M. Recent Behavior of the Velocity of Money. *Contemporary Policy Issues*, January 1987, 1-33.

Friedman, M. Money and the Stock Market. *Journal of Political Economy*, April 1988, 221-45.

Friedman, M., and Schwartz, A. J. *Monetary Trends in the United States and the United Kingdom: Their Relation to Income, Prices, and Interest Rates, 1867-1975*. Chicago, IL: The University of Chicago Press, 1982.

__________. *Monetary Statistics of the United States*. New York: Columbia University Press for NBER, 1970.

Garbade, K. Two Methods for Examining the Stability of Regression Coefficients. *Journal of the American Statistical Association*, March 1977, 54-63.

Goodhart, C. A. Monetary Trends in the United States and the United Kingdom: A British Review. *Journal of Economic Literature*, December 1982, 1540-51.

Hafer, R. W., and Hein, S. E. Financial Innovation and the Interest Elasticity of Money Demand: Some Historical Evidence. *Journal of Money, Credit and Banking*, May 1984, 246-52.

Hall, R. E. Monetary Trends in the United States and the United Kingdom: A Review from the Perspective of New Developments in Monetary Economics. *Journal of Economic Literature*, December 1982, 1552-6.

Khan, M. S. The Stability of the Demand-for-Money Function in the United States 1901-1965. *Journal of Political Economy*, November/December 1974, 1205-19.

Laumas, G. S., and Fackler, J. S. Economic Instability and the Demand for Money, 1908-1980. *Eastern Economic Journal*, July/September 1987, 249-57.

Laumas, G. S., and Mehra, Y. P. The Stability of the Demand for Money Function 1900-1974. *Journal of Finance*, June 1977, 911-6.

Macesich, G., and Tsai, T. *Money in Economic Systems*. New York: Praeger, 1982.

Mayer, T. Monetary Trends in the United States and the United Kingdom: A Review Article. *Journal of Economic Literature*, December 1982, 1528-39.

Mehra, Y. P. Recent Financial Deregulation and the Interest Elasticity of M1 Demand. *Economic Review (of the Federal Reserve Bank of Richmond)*, July/August 1986, 13-24.