MONEY, INCOME, PRICES AND INTEREST RATES AFTER THE 1980S

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Economists have long understood that the quantity of money, or its growth rate, can play a useful role in the monetary policy process only to the extent that fluctuations in money over time regularly and reliably correspond to fluctuations in income, or prices, or whatever other aspects of economic activity the central bank seeks to influence. The same is true, of course, for any other financial quantity -- non-money assets, for example, or measures of credit -- or, for that matter, interest rates and any other financial prices. Especially in the case of money, a rich literature developed over many years has investigated in some detail the requirements that the relationships connecting money to income and/or prices must satisfy in order to warrant focusing monetary policy on money in any of several specific ways.[1] An equally rich empirical literature has repeatedly sought to establish whether these requirements have actually been satisfied at specific times and in specific places.[2]

Different ways of conceptually basing the monetary policy process on money place different empirical requirements on the relationships between money and the economic variables that are of ultimate policy concern. These relationships in turn depend on such basic dimensions of economic behavior as the nature of the economy's aggregate supply process, the degree of price flexibility, the interest and wealth elasticities of aggregate demand, and, importantly, the public's money demand behavior and the banks' money supply behavior. For example, under familiar circumstances using money as an "intermediate target" -- that is, determining the money growth rate most likely ex ante to be consistent with the central bank's macroeconomic policy objectives, and then conducting monetary policy operations during some time interval as if achieving money growth along that path were itself the policy objective -- is the closer to being optimal as the demand for money is the closer to being both nonstochastic and interest inelastic. Looser relationships suffice for it to be optimal to use money as an "information variable" -- that is, adjusting policy operations during some interval in response to actual money growth that departs from the ex ante path, and perhaps also in response to analogous departures for other variables, but in any case not in a way designed necessarily to restore money growth to the ex ante path.[3]

What is essential to either of these ways of proceeding, however -- and to others besides -- is that there be at least some reliably exploitable connection between money and either income or prices, so that observed departures of money from some ex ante path bear a systematic implication for income or prices in the future. Otherwise money, as a variable that the central bank cannot set directly as a policy instrument, has no role in the policy process. From an information-variable perspective, there is no point to the central bank's reacting to fluctuations in money if those fluctuations bear no implication for subsequent movements in income or prices. From an intermediate-target perspective, there is even less point to making policy as if controlling money were stochastically equivalent to controlling income and prices if in fact there is no relation between them.

It is for just this reason that the events of the 1980s have proved so subversive to what had almost come to be standard ways of formulating and implementing monetary policy, not just in the United States but in many other countries as well. While there was never any lack of debate about the strength or weakness of the empirical relationships connecting money to income and prices, and therefore about the appropriate role of money in the monetary policy process, before the 1980s there was widespread agreement that fluctuations in money did contain at least potentially useful information about future income and price movements. In the 1980s, however, the empirical basis underlying that agreement has disappeared. Empirical investigation based on sample periods that include the 1980s simply does not lead to results corroborating what were commonly accepted as facts of economic behavior not so many years earlier. It is not surprising that in this environment some central banks, including the Federal Reserve System in the United States, have altered or abandoned the ways in which they had previously relied on money to make policy.

The object of this paper is to show how the passage of time -- in particular, the experience since 1980 -- has altered familiar empirical relationships previously taken to support a central role for money in the monetary policy process. Section I reports results for a variety of conventional autoregression tests, based on quarterly data, in each case seeking to establish whether fluctuations in money are useful for predicting subsequent fluctuations in income or prices. Here the consistent finding is that the positive results familiar from earlier time periods do not hold up when the sample is extended to include data from the 1980s. Section II reports on similar tests based on monthly data. Results for this finer time frame largely confirm those for the more conventional quarterly unit. Section III digresses to focus on the role of interest rates, and in particular the private-public interest rate spread, in these tests. Here the main results are that relationships between income and interest rates have held up better than have relationships between income and money, and that the private-public spread variable is an especially powerful predictor of real income in particular. Section IV shifts the paper's focus to long-run relationships, reporting results for tests of the co-integration of movements of money and income. Here, as in Sections I and II, the relationships that would have to hold in order to warrant using money as the central focus of monetary policy disappear when the analysis includes data from the 1980s. Section V briefly concludes by drawing together the implications of these respective findings for monetary policy.

I. Autoregression Tests Based on Quarterly Data

Ever since the early work of Sims (1972), empirical consideration of whether money (or any other aggregate) can usefully play a role in the monetary policy process has appropriately focused not just on whether fluctuations of money help predict future fluctuations of income (or prices, and so on) but on whether they help predict future fluctuations of income that are not already predictable on the basis of fluctuations of income itself and/or other readily observable variables. Especially in the context of the information-variable approach to monetary policy, this interpretation of Sims-type autoregression tests is precisely what is at issue, and the much debated question of whether such tests constitute valid tests of "causality" is beside the point. As long as movements in money do contain information about future movements in income beyond what is already contained in movements in income itself, monetary policy can exploit that information by responding to observed money growth regardless of whether the information it contains reflects true causation, reverse causation based on anticipations, or mutual causation by some independent but unobserved influence.

The first three lines in the upper panel of Table 1 present F-statistics for tests, across different time periods, of the null hypothesis that all of the coefficients on the lagged growth of either M1, M2 or credit (that is, all of the β_i) are zero in autoregressions of the form

$$\Delta y = \alpha + \sum_{i=1}^{4} \beta_i \Delta m_{t-1} + \sum_{i=1}^{4} \gamma_i \Delta g_{t-1} + \sum_{i=1}^{4} \delta_i \Delta y_{t-1} + u_t \qquad (1)$$

where y, m and g (all in natural logarithms) are, respectively, nominal income, the financial variable indicated, and high-employment federal expenditures; α,

TABLE 1

F-STATISTICS FOR QUARTERLY NOMINAL INCOME EQUATIONS

	1960:II-1979:III	1960:II-1988:IV	1970:I-1988:IV
Fiscal Variable Included			
M1	5.84***	3.08**	1.88
M2	4.20***	3.95***	1.67
Credit	4.06***	.52	.39
Paper Rate	1.42	4.69***	3.69***
Bill Rate	1.48	3.85***	3.03**
Paper-Bill Spread	3.79***	4.64***	2.39*
Fiscal Variable Excluded			
M1	5.97***	2.92**	1.50
M2	4.32***	4.47***	2.02
Credit	3.53**	.53	.72
Paper Rate	1.73	4.92***	3.64***
Bill Rate	1.78	3.92***	2.81**
Paper-Bill Spread	4.38***	3.81***	3.08**

* Significant at .10 level
** Significant at .05 level
*** Significant at .01 level

the β_i, the γ_i and the δ_i are coefficients to be estimated; and u is a disturbance term.[4] The lower panel of the table shows F-statistics based on analogous equations excluding the government spending variable. The results reported are based on standard quarterly data, for three sample periods: 1960:II-1979:III, 1960:II-1987:II and 1970:I-1987:II.

For the sample spanning 1960:II-1979:III -- that is, from the earliest time for which the Federal Reserve provides data corresponding to its current definitions of the monetary aggregates, until the introduction of its new monetary policy procedures in October 1979 -- the F-statistics in the first column of Table 1 show that each of M1, M2 and credit contained information about future income movements that was statistically significant at either the .01 or (in one case) the .05 level, regardless of whether the analysis includes the fiscal variable. Extending the sample to include data through yearend 1988 reduces the significance of M1, and eliminates it altogether for credit. Going on to drop the observations from the 1960s -- thereby focusing on the period since such key institutional changes as the removal of the Regulation Q ceiling on interest paid on large certificates of deposit, and the (sporadic) targeting of money growth for purposes of monetary policy -- renders not one of the resulting F-statistics, for any of the three aggregates, significant even at the .10 level.[5,6]

For purposes of comparison, Table 1 also presents F-statistics for analogous autoregressions in which variable Δm in (1) is replaced by, successively, the interest rate on prime 4-6 month commerical paper, the 90-day Treasury bill rate, and the difference between these two interest rates.[7] These relationships too have changed with the passage of time, although in the case of the two interest rates the changes have been at least partly in the direction of stronger, rather than weaker, ability to predict income. For the sample ending in 1979, neither the commercial paper rate nor the Treasury bill rate contained information about future fluctuations in income that was significant at any plausible level. By contrast, the spread between the two rates contained information about income that was significant at the .01 level. For the 1960-88 sample, the information contained in all three variables is significant at the .01 level. Dropping the data from the 1960s, however, weakens the significance for all three variables.

Tables 2 and 3 present analogous results based on equations in which the variable whose movements are to be explained is, in turn, real income and then the price level, and the equation includes lagged values of both real income and the price level as regressors.[8] As is consistent with much of the existing literature, the pre-1980 evidence for the three aggregates is mixed, depending on which one the equation includes and on whether the dependent variable is income or prices.[9] Including data through 1988 mostly eliminates these positive results for M1 and does so entirely for credit, although it actually strengthens the significance of the information about real income contained in M2. Dropping the data from the 1960s eliminates the significance of the three aggregates altogether, however, except for one F-statistic (one out of twelve -- about what would be expected in the context of no systematic relationship whatsoever) that remains significant at the .10 level.[10]

The F-statistics reported for the three interest rate variables in Tables 2 and 3 -- especially Table 2 -- again tell a quite different story. In the 1960-79 sample, neither interest rate contained information about future movements in real income. For the 1960-88 sample, however, this relationship is significant at the .01 level for either interest rate, and it remains significant (albeit more weakly so) when the observations from the 1960s are dropped. By contrast, whatever information these interest rates contained about

TABLE 2

F-STATISTICS FOR QUARTERLY REAL INCOME EQUATIONS

	1960:II-1979:III	1960:II-1988:IV	1970:I-1988:IV
Fiscal Variable Included			
M1	2.25*	2.14*	1.50
M2	3.60**	4.44***	2.04
Credit	1.74	.44	.25
Paper Rate	1.54	5.50***	3.78*
Bill Rate	1.51	3.70***	2.73**
Paper-Bill Spread	4.31***	5.38***	2.97**
Fiscal Variable Excluded			
M1	2.08*	1.90	1.15
M2	3.61**	4.72***	2.38*
Credit	1.35	.46	.36
Paper Rate	1.95	5.59***	3.99***
Bill Rate	1.77	3.78***	2.74**
Paper-Bill Spread	4.91***	5.77***	3.77***

* Significant at .10 level
** Significant at .05 level
*** Significant at .01 level

TABLE 3

F-STATISTICS FOR QUARTERLY PRICE EQUATIONS

	1960:II-1979:III	1960:II-1988:IV	1970:I-1988:IV
Fiscal Variable Included			
M1	3.42**	.81	.81
M2	.92	.34	.27
Credit	2.75**	1.30	1.59
Paper Rate	2.41*	2.13*	2.18*
Bill Rate	2.44*	1.81	1.74
Paper-Bill Spread	.64	.38	.67
Fiscal Variable Excluded			
M1	3.40**	.81	.70
M2	.99	.46	.40
Credit	2.63**	1.25	1.37
Paper Rate	2.51*	2.05*	2.22*
Bill Rate	2.64**	1.77	1.89
Paper-Bill Spread	.64	.35	.43

* Significant at .10 level
** Significant at .05 level
*** Significant at .01 level

the price level in the 1960-79 sample is less apparent in either sample including the 1980s.

Finally, perhaps the single most striking result in the entire analysis is the strong relationship between real income (though not the price level) and the interest rate spread variable. The difference between the commercial paper rate and the Treasury bill rate contains information about future fluctuations in real income that is highly significant in each of the three samples.

II. Autoregression Tests Based on Monthly Data

Although the calendar quarter has traditionally been the most common level of time aggregation used either in economic research on the money-income relationship or in practical discussions of monetary policy, there is no reason why information that might be contained only in finer observations of money could not also be exploited for monetary policy purposes. The officially published data for virtually all monetary and credit aggregates are monthly, and the Federal Reserve System has on a fairly timely schedule (but does not publish) weekly data for the monetary aggregates. Not surprisingly, a substantial empirical literature has also explored the money-income relationship on a monthly basis.[11]

The top panel of Table 4 presents F-statistics for tests of the null hypothesis that all of the coefficients on the lagged growth of either M1, M2 or credit are zero in autoregressions of the form

$$\Delta y_t = \alpha + \sum_{i=1}^{6} \beta_i \Delta m_{t-i} + \sum_{i=1}^{12} \gamma_i \Delta r_{t-i} + \sum_{i=1}^{12} \delta_i \Delta y_{t-i} + u_t \qquad (2)$$

where y is the logarithm of a monthly proxy for nominal income, formed as the product of the producer price index and the index of industrial production, m is in turn the logarithm of each of the aggregates, r is the commerical paper rate, and all variables are observed monthly. Given the finding by Stock and Watson (1989) that variables like the logarithm of money are, at best, difference-stationary around a deterministic time trend, the middle panel of Table 4 presents analogous results for a version of (2) including a linear time trend, while the bottom panel presents results for a further expanded version including both linear and quadratic trends.[12]

TABLE 4

F-STATISTICS FOR MONTHLY NOMINAL INCOME EQUATIONS

	1960:2-1979:9	1960:2-1988:12	1970:1-1988:12
No Time Trend			
M1	2.52**	1.06	.87
M2	4.45***	2.15**	.71
Credit	3.70***	2.15**	2.60**
Linear Time Trend			
M1	1.16	1.20	.96
M2	3.12***	2.14**	.64
Credit	2.15**	2.24**	2.67**
Linear and Quadratic Time Trends			
M1	1.26	1.00	.94
M2	3.11***	1.52	.62
Credit	2.43**	2.23**	2.63**

* Significant at .10 level
** Significant at .05 level
*** Significant at .01 level

The results presented in Table 4 correspond to sample periods that are the monthly equivalents of those used in Tables 1-3 above. For the sample running from 1960 through September 1979, M2 contained information about fluctuations in nominal income that was statistically significant at the .01 level regardless of the presence or absence of time trends, while the information about income contained in credit was significant at either the .01 or the .05 level. The results for M1 were significant only when the equation included no time trend. Extending the sample through the 1980s eliminates the significance of M1 altogether, and of M2 when the equation includes both linear and quadratic trends. Excluding the observations from the 1960s eliminates the significance of M2 altogether. Among the three aggregates, only credit contains information about income that remains statistically significant across all three samples in these monthly autoregressions.

Table 5 presents analogous results relating each of M1, M2 and credit to real income (proxied by industrial production) on a monthly basis. The most interesting aspect of these results is the extent to which the appearance of a relationship to real income in the pre-1980 sample -- a relationship that the literature of the early 1980s sometimes interpreted as evidence that fluctuations in money growth caused business cycles -- depended on the absence of a time trend from the equation. Otherwise, the results shown in Table 5 ultimately lead to the same end point as in Table 4, with only credit among the three aggregates containing any significant information about fluctuations in real income (and that only at the .10 level) for the sample spanning the most recent 19 years of monthly observations.

TABLE 5

F-STATISTICS FOR MONTHLY REAL INCOME EQUATIONS

	1960:2-1979:9	1960:2-1988:12	1970:1-1988:12
No Time Trend			
M1	1.91*	.92	.88
M2	3.58***	2.08*	1.02
Credit	3.10***	.72	1.87*
Linear Time Trend			
M1	.80	1.03	.88
M2	2.11*	2.11*	1.02
Credit	1.57	.78	1.88*
Linear and Quadratic Time Trends			
M1	.85	.91	.88
M2	2.11*	1.77	1.01
Credit	1.76	.78	1.87*

* Significant at .10 level
** Significant at .05 level
*** Significant at .01 level

III. The Paper Rate, the Bill Rate or the Spread?

The F-statistics shown in Tables 1 and 2 for the commerical paper rate and the Treasury bill rate reinforce earlier literature in suggesting that market interest rates contain statistically significant information about future fluctuations in income.[13] Parallel results based on monthly data are more mixed. The F-statistics for the interest rate coefficients in (2) are uniformly significant at the .01 level for the 1960-79 sample, as is consistent with the findings of earlier literature, but are significant only irregularly for the two later samples.

A potential role for market interest rates in providing information about future income is hardly surprising a priori. Money growth, after all, is not the only potential source of information about the state of financial markets, nor the only potential measure of whatever effects financial phenomena may be exerting on real economic activity. It makes sense, therefore, to broaden the class of financial variables considered to be potentially of use in this context to include not just financial quantity variables, like money or credit, but also financial price variables including interest rates.

Although the inclusion of an interest rate in empirical work of this kind has therefore become fairly standard, the literature has devoted little attention to the question of just which interest rate is appropriate. Moreover, what little discussion there is has focused on such matters as the difference between long-term rates (with their inherent anticipatory properties) and short-term rates, rather than on apparently more mundane questions like which short-term rate is superior.[14] Nor has actual practice been uniform in this respect. Sims (1980) and Friedman (1983) both used the commercial paper rate, while Litterman and Weiss (1985), Eichenbaum and Singleton (1986) and Stock and Watson (1989) all used the Treasury bill rate.[15] None of these authors, however, offered substantive arguments in support of the selection made.

Just as different monetary aggregates correspond to different conceptual ways of measuring financial market quantity information, different short-term interest rates correspond to different conceptual ways of measuring financial market price information. In the case of the commerical paper rate -- that is, the interest rate on short-term unsecured borrowing by corporations in nonfinancial lines of business -- and the Treasury bill rate -- that is, the analogous unsecured borrowing rate for the U.S. Government -- there are substantive grounds on which to argue that either one or the other may provide the better gauge of financial prices that matter for the determination of real economic activity.

At the most obvious level, the commercial paper rate more directly reflects the cost of finance corresponding to potentially interest-sensitive expenditure flows than does the Treasury bill rate. To the extent that interest rates matter for nonfinancial economic activity primarily because they affect the spending behavior of private-sector borrowers, therefore, any influence that causes these two rates to covary imperfectly will make the commercial paper rate superior to the Treasury bill rate as a measure of this effect. For example, when changes in the perceived creditworthiness of the average business alter the spread between the rate on potentially defaultable commercial paper and that on presumably default-free Treasury bills, as happens over the course of a typical business cycle, it is the commercial paper rate that conveys more information about the borrowing costs that may affect spending flows. By contrast, to the extent that interest rates matter for nonfinancial activity primarily by affecting the behavior of those who save and invest, rather than of those who borrow, the Treasury bill rate is plausibly more relevant because it more nearly represents the returns available to most savers.

The interest rates on commercial paper and Treasury bills covary imperfectly for reasons other than time-varying perceptions of creditworthiness, however, and many of the other sources of this imperfect covariation reflect institutional technicalities of the Treasury bill market rather than anything directly bearing on the behavioral role of interest rates in affecting nonfinancial economic activity. Short-term fluctuations in the Treasury's cash flow alternately swell the supply of bills or increase the demand (by forcing banks to present eligible collateral against enlarged tax and loan account balances). These fluctuations occur in part on a seasonal basis, but also in part irregularly. Fluctuations in the volume of advance debt refundings by state and local governments, as sometimes occur in anticipation of changes in tax legislation, also affect the demand for Treasury bills (because of legal restrictions on these borrowers' options for temporarily re-investing the proceeds of advance refundings). So do fluctuations in the Federal Reserve's open market operations (because most open market purchases and sales take place in Treasury securities). So do most exchange market interventions by foreign central banks (because most central banks, though nowadays not all, hold a disproportionately large share of their dollar portfolios in Treasury bills compared to the portfolio of the typical private market participant). So do the "window dressing" activities of banks and other private investors that choose to sacrifice a few days' interest differential in order to show atypically large Treasury bill holdings on their year- or even quarter-end financial statements. The effect of each of these institutional distortions is presumably to make movements in the Treasury bill rate less likely to correspond to what matters in financial markets for nonfinancial economic activity than movements in the commerical paper rate.

Table 6 presents the results of a series of tests designed, in the first

TABLE 6

F-STATISTICS FOR EXPANDED MONTHLY REAL INCOME EQUATIONS

	1960:2-1979:9	1960:2-1988:12	1970:1-1988:12
Equation with M1			
M1	.80	1.19	1.01
Rcp	2.09**	1.01	.89
Rtb constraint	3.16***	3.83***	3.25***
Spread	3.29***	2.97***	2.09***
Equation with M2			
M2	1.60	1.07	.73
Rcp	2.42***	.94	.79
Rtb constraint	2.57***	2.52***	2.60***
Spread	3.05***	2.35***	1.85**
Equation with Credit			
Credit	.84	1.06	2.20**
Rcp	2.05**	1.41	1.25
Rtb constraint	3.55***	4.34***	3.65***
Spread	2.89***	3.03***	2.22**

* Significant at .10 level
** Significant at .05 level
*** Significant at .01 level

instance, simply to address the question of whether the commercial paper rate or the Treasury bill rate contains superior information about future fluctuations in real income. The table shows F-statistics, for the usual three sample periods, based on autoregressions of the form

$$\Delta x_t = \alpha + \sum_{i=1}^{6} \beta_i \Delta m_t + \sum_{i=1}^{12} \gamma_i \Delta rcp_{t-i}$$

$$+ \sum_{i=1}^{12} \delta_i \Delta(rcp_{t-i} - rtb_{t-i})$$

$$+ \sum_{i=1}^{12} \Theta_i \Delta x_{t-i} + \sum_{i=1}^{12} \varphi_i \Delta p_{t-i}$$

$$+ \psi t + u_t \tag{3}$$

where x is the logarithm of the index of industrial production; m is, in turn, the logarithm of M1, M2, or credit; rcp and rtb are the commercial paper rate and Treasury bill rate, respectively; p is the logarithm of the producer price index; and variable t as a regressor represents a linear time trend. Apart from the addition of the distributed lag on the difference between the two interest rates, therefore, these autoregressions are identical to those underlying the middle panel of Table 5.

Table 6 presents F-statistics separately for each version of (3) depending upon the aggregate used to define m, although in the end which aggregate is included does not affect the results in any interesting way. The first F-statistic reported in each panel of the table, for the null hypothesis that the β coefficients are uniformly zero, indicates that with the sole exception of credit in the 1970-88 sample, none of the three aggregates contains information about income that is statistically significant in this context, even at the .10 level, in any of the three samples. These results are roughly consistent with those reported in Table 5, based on autoregressions that are identical to (3) except for the interest rate spread term. The second F-statistic reported in each panel of Table 6 (testing the null hypothesis that the γ coefficients are all zero) indicates that the commercial paper rate contained highly significant information about income in the early sample, but does not in the later two. These results too are roughly consistent with the F-statistics (not shown) for the commercial paper rate in the equations underlying Table 5.

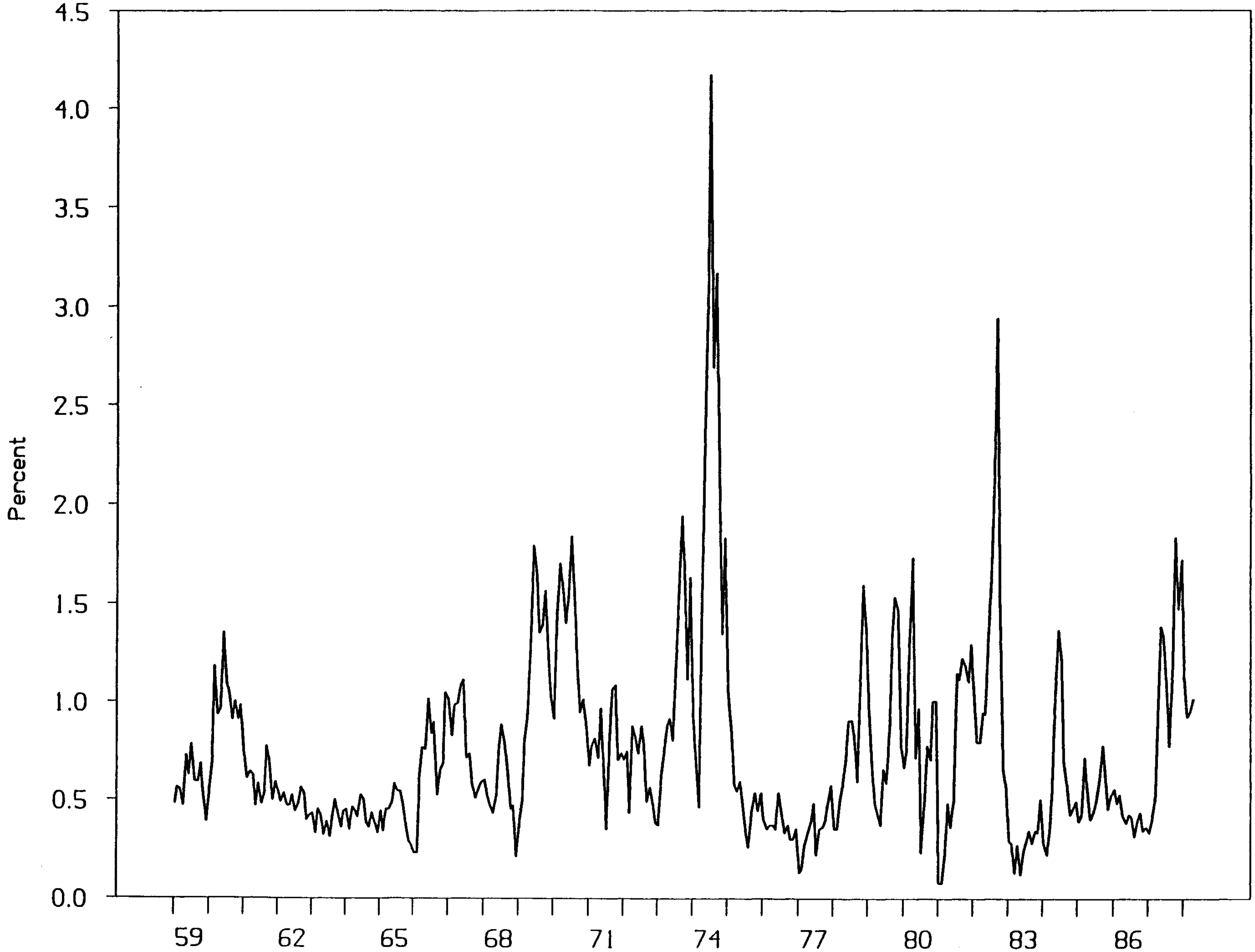
The third F-statistic reported in each panel of Table 6 is for a test of the null hypothesis that the respective pairs of γ and δ coefficients in (3) are each equal in magnitude and opposite in sign -- in other words, that the correct specification of (3) includes the Treasury bill rate but excludes the commerical paper rate. The results uniformly warrant rejecting this constraint at the .01 level in each of the three samples, regardless of which aggregate the equation includes.

The last F-statistic reported in each panel is simply for the null hypothesis that all of the δ coefficients are zero -- in other words, that the interest rate spread term, like whichever aggregate is included, contains no information about future fluctuations in real income. Here again, the results uniformly warrant rejecting this constraint at the .01 level in the two samples including the 1960s and at the .05 level for the later sample, regardless of which aggregate the equation includes. Together with the results reported immediately above, these results indicate not only that the paper-bill spread contains highly significant information about future real income, but also that this finding does not merely reflect the inadvertant specification of the underlying equation with the "wrong" interest rate.

Figure 1 plots the monthly difference between the commercial paper rate and the Treasury bill rate, for data spanning 1959-88. Following the discussion above, the variations in this spread over time reflect a combination of familiar behavioral influences -- most obviously, the market's assessment of the probability of default on unsecured borrowing by investment-grade private corporations -- and institutional technicalities. The results reported here cannot answer the question of just which determinants of the spread account for its strong information content with respect to future real income. (A conjecture is that market participants' changing perceptions of business creditworthiness is a major part of the story.) They do suggest, however, that the imperfect covariation between the commercial paper rate and the Treasury bill rate captures more of the relevant information about the aspects of financial markets that matter for the determination of real output than do movements in either of these interest rates by itself -- or, for that matter, fluctuations in money.[16]

FIGURE 1

PAPER-BILL SPREAD, 1959-1988



IV. The Co-Integration of Money and Income

The empirical tests reported in Sections I-III all focus on short-run relationships connecting the growth rate of money (or some other financial aggregate) to the growth rate of income or prices. Formulating these tests in terms of growth rates is appropriate in light of the repeated finding that in fact money, income, prices and interest rates are all appropriately modeled as integrated series, with no tendency for the respective levels of these variables to return to a specific value or to a deterministic trend.[17] By contrast, for some questions of potential importance in the practical conduct of monetary policy -- especially those that arise in a multi-year context -- what matters is the long-run relationship between the level of money and the level of income or prices.

The relationship between the respective levels of money and of income or prices is especially relevant in the context of the "base drift" problem that inevitably arises when the central bank uses as an intermediate target a money (or credit) aggregate that is endogenous over short time horizons. In particular, whenever actual money growth has differed from the growth rate targeted ex ante, the central bank must decide whether to "let bygones be bygones" and simply conduct monetary policy so as best to achieve the targeted growth rate thereafter, or, instead, seek to return the chosen aggregate itself to the previously targeted path, thereby offsetting the initial unplanned deviation of actual from targeted money growth by a subsequent, deliberately engineered deviation in the opposite direction.[18] As Walsh (1986) has shown, which of these two strategies is preferable depends on whether whatever disturbance to the money-income (or money-price) relationship has accompanied the original departure from the targeted path is more likely to prove permanent or transitory, and a strategy of offsetting observed deviations only in part will, in general, dominate either one. Offsetting in full all observed deviations of actual from targeted money growth is optimal only if all disturbances to the money-income relationship are transitory.

The answer to the "base drift" dilemma therefore depends on whether the relationship between the respective <u>levels</u> of money and income -- in its simplest and most familiar form, the ratio of money to income, or vice versa -- is stationary. The fact that money and income are both individually nonstationary need not, of course, imply that the ratio of one to the other is also nonstationary. In statistical terms, two series are co-integrated whenever they are individually integrated yet there exists a linear combination of the two that is stationary. A stationary money-income ratio therefore means that money and income are co-integrated in logarithms, although this particular relationship would represent only one special case among the more general set of possibilities exhibiting co-integration.

For example, if the logarithms of money and income are each individually integrated, but jointly obey a simple equilibrium relationship of the form

$$m = \alpha + \beta y \qquad (4)$$

and the deviations of m and y from (4) are stationary, then the two variables are co-integrated (for any non-zero value of coefficient β) in that either y or m will tend to adjust, so as to restore the equilibrium relationship in (4), after any realized disturbance. (Only if β=1, which corresponds to the familiar classical assumption of a unit income elasticity of money demand, is the money-income ratio also stationary.) Alternatively, if any disturbance producing a deviation from (4) is as likely to increase or decrease from each period's realized value, then y and m have no tendency to return to an equilibrium relationship, and hence are not co-integrated.

An alternative statement of what co-integration implies that is especially useful for applications to questions about monetary policy puts the point in terms of error correction. As Engle and Granger (1987) have shown, if two variables are co-integrated then it is possible to express the relationship between them as an error-correction process in which the change in either variable is a function of current and past deviations, from the equilibrium value, of the appropriately specified linear combination of the two variables' respective levels. For example, for income chosen as the variable that changes in response to disturbances, the equilibrium money-income relationship (4) leads to the error-correction representation

$$A(L)\Delta\tilde{y}_t = \lambda\ (\tilde{m}_{t-1} - \beta\tilde{y}_{t-1}) + u_t \qquad (5)$$

where A(L) is a polynominal in the lag operator; λ us a scalar coefficient; u is a disturbance term, which may be serially correlated; and $\tilde{m}$ and $\tilde{y}$ express variables m and y in terms of deviations from their respective means so that coefficient α in (4) becomes irrelevant. (As the discussion below makes clear, which is the "dependent" variable in this setting is an arbitrary matter of normalization.) Subject to the lags embodied in A(L), (5) implies that income will adjust fully to any persistent change in the stock of money, eventually restoring the equilibrium relationship in levels represented by (4). If (4) and (5) constitute a valid description of the money-income relationship, then the level of the money stock is an appropriate intermediate target of monetary policy if the ultimate policy objective is to affect the level of income.

The maximum likelihood procedure proposed by Johansen (1988) for testing co-integration amounts to testing the dimensionality of the space spanned by whatever co-integrating vectors exist for the set of variables in question. This is equivalent to determining the number of error-correction terms in (5), while accounting for the joint estimation of all parameters (like β) that appear in them. In the context of monetary policy issues along the lines of the "base drift" discussion, the relevant question is whether money and income are co-integrated at all -- that is, whether any co-integrating vector exists. The applicable test statistic is therefore Johansen's J(0) likelihood ratio statistic, which tests the null hypothesis that no co-integrating vector exists against the alternative hypothesis that the true dimensionality is one or more.

Specifying an appropriate vector of variables to test for co-integration between money and income involves several disparate issues. First, the limiting distributions of the Johansen test statistic tabulated by Myungsoo Park and used in King et al. (1989) are based on the assumption that each of the series being tested for co-integration is individually integrated of order one. As King et al. have shown, while evidence suggests that the logarithms of nominal income and nominal money balances are each integrated of order two (that is, Δy and Δm are themselves nonstationary), real income and real money balances both appear to be difference stationary. Testing for co-integration in terms of real magnitudes is therefore necessary to allow the use of the standard critical values for the Johansen likelihood ratio statistic.

Second, unless the demand for money is interest insensitive or interest rates are stationary, neither or which assumptions has received much support from the relevant empirical literature, money and income should not be expected to exhibit co-integration unless the co-integrating equation also includes an interest rate. Third, however, as Lucas (1988) has pointed out in a different but parallel context, the comovement of interest rates and income during the post-war period -- especially in conjunction with the increased volatility of interest rates during the last decade or so -- makes estimating the income elasticity of money demand (equivalent to β in (5) above) problematic when the relationship also includes an interest rate. Lucas' solution to this problem was to include the interest rate but then simply to impose a unit income elasticity a priori, rather than jointly estimate both income and interest elasticities.

In light of these considerations, the top panel of Table 7 presents $J_\tau(0)$ statistics (the zero-dimensionality Johansen statistic computed with not only means but also linear trends removed from all variables) testing for co-integration, with $\beta=1$ imposed a priori, among quarterly values of real income, the commercial paper rate and the real values of each of four financial aggregates -- M1, M2 and credit, as usual, plus the monetary base -- based on the co-integrating equation

$$(\hat{m}_t - \hat{p}_t) - \hat{x}_t - \gamma\hat{r}_t = e_t \tag{6}$$

where e is a disturbance term and the ^ indicates that all variables are measured as deviations from a linear time trend.[19] As above, the table presents results for each of three sample periods. For the sample ending just before the introduction of new monetary policy procedures in 1979, the evidence suggests that each of these four aggregates was co-integrated with real income in the sense that the Johansen likelihood ratio statistic in each case warrants rejecting the "no co-integration null" at either the .05 or the .01 level.[20] Merely adding observations through mid 1982, to incorporate the period when the Federal Reserve was employing its new monetary policy procedures, eliminates these positive results altogether. Not one of the $J_\tau(0)$ statistics is significant even at the .10 level. Further extending the sample through 1988

TABLE 7

JOHANSEN STATISTICS FOR CO-INTEGRATION WITH REAL INCOME

	1959:I-1979:III	1959:I-1982:II	1959:I-1988:IV
Based on Co-Integrating Equation $(m-p) - x - \gamma r = e$			
Monetary Base	23.8**	19.4	14.2
M1	24.6**	17.9	14.9
M2	25.2**	18.9	19.4
Credit	30.1***	17.6	11.3
Based on Co-Integrating Equation $(m - p) - \beta x - \gamma r = e$			
Monetary Base	40.4**	29.0	27.1
M1	34.0	25.1	25.2
M2	40.8**	31.8	33.6
Credit	51.0***	44.2**	30.5
Based on Co-Integrating Equation $(m - p) - \beta x = e$			
Monetary Base	10.70	9.62	9.06
M1	10.40	6.77	8.89
M2	20.1	19.1	22.4*
Credit	26.8**	23.5*	17.9

* Significant at .10 level
** Significant at .05 level
*** Significant at .01 level

again results in failure to reject the "no co-integration null" for each aggregate.[21]

It is always possible, of course, that these results are subject to distortion because of the imposition of a unit income elasticity. To check this possibility, the middle panel of Table 7 presents analogous $J_\tau(0)$ statistics based on the co-integrating equation

$$(\hat{m}_t - \hat{p}_t) - \hat{\beta} x_t - \hat{\gamma} r_t = e_t. \tag{7}$$

With income elasticity β free to be estimated from the data, each of the aggregates <u>except</u> <u>M1</u> was co-integrated with income at the .05 level or better in the 1959-79 sample.[22] Once again, merely adding observations through mid 1982 eliminates these positive results, however -- except now for credit, for which the $J_\tau(0)$ statistic remains significant at the .05 level. Further adding observations through yearend 1988 renders none of the four aggregates significantly co-integrated with income, even at the .10 level.[23]

Finally, it is also possible that at least for aggregates like M2 and credit, for which sensitivity to interest rates is presumably small, including the interest rate in the co-integrating vector reduces the power of the test of the "no-cointegration null" against the alternative that the aggregate and income are co-integrated. Indeed, the familiar injunction to the central bank to set any given year's money growth target so as to offset any error in achieving the previous year's target, thereby eliminating any "base drift," implicitly rests on the assumption not only that money and income are co-integrated but also that the co-integrating vector does not include an interest rate. (If the co-integrating vector does include an interest rate, it would be appropriate to offset only that part of the prior year's difference between actual and targeted money growth not due to permanent changes in the interest rate.)

As a check again the possibility that the negative results reported in the first two panels of Table 7 might be due to the inclusion of the interest rate, the table's bottom panel presents $J_\tau(0)$ statistics based on the co-integrating equation

$$(\hat{m}_t - \hat{p}_t) - \beta\hat{x}_t = e_t. \tag{8}$$

With the interest rate excluded, credit is now the only aggregate for which the 1959-79 sample exhibits any significant evidence of co-integration with income. Extending the sample through mid 1982 reduces the significance of this lone positive result to the .10 level. Further extending the sample through 1988 eliminates the evidence that credit and income are co-integrated, but does render the $J_\tau(0)$ statistic for M2 significant at the .10 level.[24,25]

In sum, whatever the situation may have been before the 1980s, it is no longer possible to discern from the data a stable long-run relationship between income and any of these four aggregates, either with or without allowance for the effect of interest rates. To be sure, because the statistical substance of these results is the failure to reject the null hypothesis of no co-integration, they do not (and cannot) prove that no such relationship now exists.[26] But they do show that any presumption in favor of such a relationship must reflect prior beliefs, rather than the evidence contained in the data. If for some reason the central bank happens to be conducting monetary policy by using any of these aggregates as an intermediate target, these results therefore show that the data no longer provide an empirical basis for the injunction to resist in full the "base drift" that arises from past failures to achieve the targeted growth rate.

V. Summary of Conclusions and Policy Implications

The empirical findings presented in this paper consistently show that evidence based on the most recent U.S. experience does not indicate a close or reliable relationship between money and nonfinancial economic activity. Merely extending the analysis to include data from the 1980s sharply weakens the time-series evidence from prior periods showing that such relationships existed between money and nominal income, or between money and either real income or prices considered separately. Focusing on data from 1970 onward destroys this evidence altogether. The deterioration of the evidence supporting a relationship to either real or nominal income, or to prices, appears not just for M1 but for other monetary aggregates and for credit as well. Evidence from earlier samples indicating co-integration of real income and real money balances (with due allowance for the effect of interest rates) also disintegrates when the sample extends into the 1980s.

These results bear strongly negative implications for monetary policy frameworks that focus the design and implementation of policy on money (or credit) in any formally systematic way. There is no longer empirical evidence to support the existence of relationships that would warrant making monetary policy in such ways. The point is not just that the money-income relationship does not satisfy the stringent conditions that would be required to render optimal the strict use of money as an intermediate target. More importantly, there is no evidence to show that fluctuations in money contain any information about subsequent movements in income or prices. Further, even if the central bank did choose for some reason to base monetary policy on the use of money as an intermediate target, in the absence of evidence indicating that money and income are co-integrated there would be no empirical grounds on which to resist "base drift."

The paper's one finding with potentially positive implications for monetary policy is that the spread between the commerical paper rate and the Treasury bill rate does contain information about future movements in real income, information that is highly significant regardless of the sample period under investigation. It is difficult to imagine that the Federal Reserve System could use this interest rate spread as an intermediate policy target, and doubtful that the relationships found here would continue to hold if it did. By contrast, in a world in which previously standard financial quantities can no longer serve as policy information variables because they no longer contain information about the macroeconomic outcomes that monetary policy seeks to affect, policymakers must somehow fill the resulting vacuum by exploiting information from wherever they happen to find it.

Footnotes

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1. See, for example, the literature surveyed by Friedman (forthcoming).

2. See, for example, the literature surveyed by McCallum (1985).

3. Kareken et al. (1973) first formally introduced the information variable concept into the analysis of monetary policy. See Friedman (1975) for a formal analysis of the intermediate target variable procedure.

4. The two "M's" are based on the conventional Federal Reserve Board definitions. Credit is the outstanding indebtedness of domestic nonfinancial borrowers. Income is gross national product. (Substituting domestic absorption for gross national product does not systematically change the results reported here, or in most of the tables introduced below; see, however, footnote 25.) All data are seasonally adjusted.

5. Parallel analysis based on simpler "St. Louis" regressions, which exclude the lagged values of income as regressors, delivers analogous results. See Friedman (1988).

6. Including a dummy variable for the 1980s (a suggestion made by an anonymous referee) makes only a small difference for these results. In the 1970-88 equations for M1, for example, adding a dummy variable equal to 1 beginning in 1979:III results in F-statistics of 2.31 when the fiscal variable is included and 1.71 without the fiscal variable. The former value is significant at the .10 level, but the latter is not. The F-statistics in the corresponding M2 equations are 1.43 and 1.72, respectively. Neither of these values is significant at the .10 level.

7. We are grateful to Bennett McCallum for suggesting the inclusion of interest rates in this analysis for purposes of comparison.

8. Real income is gross national product in 1982 dollars. The price level is the corresponding deflator.

9. The sensitivity of the results of such tests to these and other aspects of the underlying specification are well known. See, for example, Zellner (1985).

10. In these equations as well, including a dummy variable for the 1980s (see again footnote 6) makes little difference. None of the significance levels reported in Tables 2 and 3 for M1, M2 or credit changes. In the only case (out of twelve) in which the aggregate is significant at the .10 level,

adding the dummy variable reduces the F-statistic for M2 in the real income equation (without fiscal variable) from 2.38, as reported in Table 2, to 2.07.

11. See, for example, Sims (1980), Eichenbaum and Singleton (1986), and Stock and Watson (1989).

12. The specification of the monthly autoregression follows that used by Stock and Watson (1989). Their experimentation indicated that the combination of six lags on the money variable and twelve lags on the other variables was most likely to be favorable to finding a significant role for money in predicting fluctuations in income. The use of three variants differing according to the treatment of time trends also follows Stock and Watson.

13. See, for example, Sims (1980).

14. See Friedman (1984) for a comparative treatment of long-versus short-term interest rates, and Eichenbaum and Singleton (1986) for a discussion of the use of equity prices, in this context.

15. Eichenbaum and Singleton were incorrect in stating (p. 125) that Sims had used the Treasury bill rate; see Sims (p. 252).

16. Some subsequent work by other researchers has likewise shown a powerful predictive role for the paper-bill spread, or something very like it. Stock and Watson's (1989) new index of leading indicators, for example, prominently includes the paper-bill spread. Bernanke and Blinder (1989) have found similar results using the spread between the federal funds rates and the Treasury bill rate.

17. See, for example, Nelson and Plosser (1982). In more precise statistical terms, a series is integrated if differencing is required to render it covariance-stationary (a covariance-stationary random variable is, in turn, one whose variances and autocovariances are finite and time-invariant); see, for example, Fuller (1976).

18. The origin of the label "base drift" for this problem was the complaint, often voiced during the late 1970s, that the Federal Reserve System was accommodating rising inflation by pursuing a "bygones" strategy in which the targeted rate of money growth was low each year but actual money growth on a multi-year basis was high because, with repeated upward errors, each year's <u>target</u> growth was calibrated from the higher "base" level resulting from the previous year's <u>actual</u> growth.

19. As King et al. (1989) pointed out, removing any deterministic trends and then applying the Johansen methodology to detrended data is likely to be superior, at least in this context, in that doing so focuses the test on the stochastic movements in the data. Results based on Johansen's $J_{\mu}(0)$ statistic, computed without detrending the variables, typically differ little from those shown. The reason for including the monetary base in these results is that, in one interesting case, results for the base differ sharply from the corresponding results for M1; elsewhere throughout the paper, results for the base parallel those for M1. The critical values for

the $J_\tau(0)$ series used in Table 7 are those computed by Myungsoo Park, using Monte Carlo methods; we are grateful to him and to Mark Watson for making these values available to us.

20. Further, for this sample period the estimated interest semi-elasticity is both economically reasonble and statistically significant for each aggregate. The estimated values of γ are -.077 for the monetary base, -.108 for M1, -.009 for M2 and -.008 for credit. The relevant χ^2 statistics indicate that the value for M2 is significantly different from zero at the .10 level, and that each of the other three values is significant at the .01 level.

21. Poole (1988), among others, has advocated the use of a long-term rather than short-term interest rate in the money demand function. If the corporate bond rate is used for r in (7), the resulting $J_\tau(0)$ statistic is significant at the .05 level for credit but not even at the .10 level for any of the other three aggregates for the 1959-79 sample, and significant at the .01 level for M2 but not even at the .10 level for any of the other three aggregates for the 1959-88 sample.

22. It is difficult to judge which of these two results -- that reported in the upper or the middle panel of the table -- provides the better guide to the behavior of M1 during this period (1959-79). When β and γ are both estimated freely, as in (7), the estimated value of β is 4.14, and the relevant χ^2 statistic warrants rejecting β=1 at the .05 level. As other authors have found, however, disentagling deterministic trends from stochastic comovements among these data is highly problematic. When β and γ are both estimated freely but with non-detrended data, the estimated values of both β and γ have "wrong" signs (β=-1.08, γ=0.16), but the relevant χ^2 statistic warrants rejecting the joint restriction β=1 and γ=-0.1 (correspondong to the values given by estimation of (6) for this sample) only at the .10 level. (The associated $J_\mu(0)$ statistic in this case is not significant even at the .10 level, so that there is no evidence of co-integration based on (7) regardless of whether or not the data are detrended.) Given that Lucas (1988) was working with M1 data, the contrast between the results based on (7) and those based on (6) provide an additional perspective on his rationale for imposing β=1.

23. Substituting the corporate bond rate for the commercial paper rate in (8) renders $J_\tau(0)$ significant at the .05 level for each of the four aggregates (including M1) for the 1959-79 sample. The $J_\tau(0)$ statistic is significant at the .10 level for the 1959-88 sample for M2, but not for any of the other aggregates. If r is the corporate bond rate and the variables are not detrended, the resulting $J_\mu(0)$ statistic is significant at the .05 level for credit in the 1959-79 sample, and for both credit and M2 in the 1959-88 sample; none of the other five $J_\mu(0)$ statistics for the two samples is significant for this case, even at the .10 level.

24. The $J_\mu(0)$ statistic for M2 is not significant at the .10 level in any of the three sample periods, however.

25. Substituting domestic absorption in place of gross national product slightly strengthens the evidence for co-integration with M2 in the 1959-88 sample. The $J_\tau(0)$ statistic is then 23.8 (versus 22.4 as shown in Table 7), which is significant at the .05 level. The corresponding $J_\mu(0)$ statistic is still not significant even at the .10 level.

26. As Engle and Granger (1987) demonstrated in the case of the augmented Dickey-Fuller test, tests of the null hypothesis of no co-integration tend to display low power against alternatives corresponding to co-integration. For example, if disturbance e in the co-integrating equation is stationary but autocorrelated with first-order coefficient .9, and the sample is of size 100, the Dickey-Fuller test at the .05 level would, on average, reject the "no co-integration" null hypothesis only 15% of the time. (Corresponding test results for the Johansen statistic are not available.) For the purposes of monetary policy, however -- including in particular the question of what to do about "base drift" -- it matters little whether shocks to the money-income relationship are truly permanent or only very highly persistent. First-order autocorrelations of e equal to .95 or .99, for example, still imply shocks with half-lives equal to 13.5 quarters or 69 quarters, respectively.

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