MORE EVIDENCE ON THE MONEY-OUTPUT RELATIONSHIP

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Recent studies have found that money loses its explanatory power over output if the 1980s are included in the sample. Interest rates, not money, appear to predict output. Using annual data for 1915–1993 and quarterly data for 1960–1993, we demonstrate that the supposed breakdown in the money-output relationship stems from the type of stationary assumption imposed on the data. Assuming difference-stationary produces results found in the literature. Assuming trend-stationary produces results indicating that money and output remain statistically related. Moreover, the change in the stationarity assumption greatly affects the quantitative importance of interest rates in explaining output.

I. INTRODUCTION

The empirical relationship between money and real output continues to produce conflicting evidence. Stock and Watson [1989], using monthly U.S. data for the period 1960–85, report that while actual money growth (M1) does not Granger cause the growth of industrial production, its detrended component does. Krol and Ohanian [1990] internationalize Stock and Watson's study and find that both actual and detrended M1 growth Granger cause output growth in the U.K., but that neither series affects output growth in Japan, Canada and Germany. Friedman and Kuttner [1992a; 1992b; 1993] question the role of money in explaining output behavior. They report [1993] that, even though the Stock-Watson specification is used, simply updating the sample through 1990 yields the result that detrended M1 growth no longer explains output growth. Friedman and Kuttner also argue that the commercial paper rate or the spread between the three-month Treasury bill and the commercial paper rate provides a better gauge for output's reaction to monetary policy changes. Replacing the Treasury bill rate used by Stock and Watson with the commercial paper rate or the spread, Friedman and Kuttner find that M1 growth has no marginal explanatory power over output.

A feature of recent investigations of the money-output link is the general use of a VAR specification based on the presumption that the series are difference-stationary (e.g., Feldstein and Stock [1994]). Several recent studies, however, have questioned this presumption due to the low power of unit-root tests (Dejong et al. [1992], Dejong [1992], Dejong and Whiteman [1991a; 1991b], and Rudebusch [1993]). These studies suggest that it is difficult to distinguish between difference-stationary as the null and trend-stationary as the alternative hypothesis.

Given the uncertainty about the existence of a unit root in economic time series, we re-examine the money-output relation by specifically considering the affect of assuming that the series are trend-stationary or difference-stationary. Such an investigation is important to determine if permanent (temporary) changes in money and other series create permanent (temporary) shifts in real output. For example, if real output and money contain a unit root (i.e., they are best represented by the difference-stationary model), permanent money shocks may produce perma-

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nent shifts in output. Put another way, permanent money shocks may have a long-run impact because they affect the stochastic trend component of output and thus change the output level for all future horizons. On the other hand, if output and other series are represented by a trend-stationary model, fluctuations around a trend level of these series are stationary (mean-reverting). Under this model, a transitory money shock may only have a short-run impact on output as it quickly returns to its trend level.

To analyze the sensitivity of results to different stationarity assumptions used, we estimate two VAR systems. One system uses the log-levels of the variables along with a deterministic time trend. The other uses the log-difference of the series and excludes the trend term. The first system represents the trend-stationary specification and the second one represents the difference-stationary specification. There is some evidence that the money-output link may be sensitive to the presence of a deterministic trend term (e.g., Eichenbaum and Singleton [1986], Stock and Watson [1989]). Even so, our study provides a direct comparison based on identical data sets of the effects that the two different stationarity specifications have on the money-output results.

While testing the robustness of the money-output connection is our main focus, we also provide some different perspectives on the debate. One is to use both long- and short-term data sets. Most studies limit the analysis to quarterly data from the post-1960 era. We study the link between money, interest rates and output using annual data over the extended period 1915–1993.[1] We also investigate the relationship for the more commonly used 1960–1993 quarterly sample. Another difference is our use of both M1 and M2 money measures, even thought the recent focus is on M1. Given recent work comparing the long-run properties of M1 and M2 (e.g., Hallman et al. [1991], Hafer and Jansen [1991] and Roberds and Whiteman [1992]), it seems useful to investigate the robustness of earlier findings by using both measures.

In the next section some methodological issues regarding inferences based on unit-root tests are discussed. After a description of the data in section III, we examine the statistical relationship between money, the interest rate and output using Granger causality tests. Section IV provides evidence on the quantitative significance of the variables by using variance decompositions. The results in both sections are based on VARs estimated with a time trend using the log-levels of the series and without a time trend using the log-difference of the series. Section V takes a closer look at the money-output relationship during 1980s, and concluding remarks close the paper in section VI.

II. METHODOLOGICAL ISSUES

Prior to the influential paper of Nelson and Plosser [1982] it generally was assumed that most economic time series are stationary around a deterministic time trend. In other words, they are best represented by a trend-stationary model. Nelson and Plosser apply Dickey-Fuller type tests to fourteen U.S. time series and, with the exception of the unemployment rate, were not able to reject the hypothesis that the series contain a unit root. This implies that the series have a stochastic time trend and are best represented by a difference-stationary model. Recent versions of unit-root tests which allow for serial autocorrelation or heteroscedasticity (e.g., the augmented Dickey-Fuller tests or Phillips-Perron tests) have not reversed the conclusion that there exists a unit root for most macroeconomic time series.

The classical approach to hypothesis testing assumes that the null hypothesis is correct unless there is sufficient information in the data to reject the hypothesis. In standard unit-root tests, the null hypothesis is the existence of a unit root versus the

1. Our study limits itself to the period beginning in 1915 since M1 data are available only since that time.

alternative that the data are trend-stationary. One possible reason for the failure of standard unit-root tests to reject the null of a unit root is that the sample data do not provide enough information regarding the existence of a unit root. DeJong et al. [1992], for example, examined the power of the augmented Dickey-Fuller and the Phillips and Perron tests. Based on Monte Carlo experiments, they show that these conventional integration tests have low power against trend-stationary alternatives.

In addition to the classical integration analysis, a Bayesian approach can be used to test for the presence of a unit root in the data. DeJong and Whiteman [1991a] use such an approach to determine how fragile the inferences derived from classical unit-root tests are. When a zero-trend prior is assigned to trend-stationary alternatives, DeJong and Whiteman find that the data support the unit-root hypothesis. When this prior is relaxed, however, the data often reject the unit-root hypothesis. DeJong and Whiteman also experiment with different priors to determine how robust their results are to these changes. Despite the variety of priors used, they find most of the series to be trend-stationary and conclude that "the death of trend-stationarity appears to have been greatly exaggerated." (p. 252)[2] In contrast, Ohanian [1991] uses a simulation procedure to study the sensitivity of results to assuming a difference-stationary or trend-stationary specification. He concludes that assuming trend-stationarity may bias test results, leading researchers to not reject causality too often. Rudebusch [1993] uses simulated data from a trend-stationary model and a difference-stationary model, reporting that a unit-root test is not able to distinguish between the two specifications.

The economic implications of using a trend-stationary versus a difference-stationary specification makes it important to note the findings of Christiano and Ljungqvist [1988]. Using monthly data from September 1948 to December 1985, they tested the link between money and output in a bivariate framework. Their study indicates that money Granger causes output under the difference-stationary specification when first differences of the logs are used. Christiano and Ljungqvist's bootstrap simulations show that *F*-statistics based on first differences suffer from lack of power and fail (incorrectly) to detect the causal relation between money and output.[3] On the other hand, the *F*-statistics based on log-level data have greater power and thus reflect the Granger causality between money and output that is actually in data. Looking forward, our multivariate results based on a longer period, including the much debated 1980s, corroborate the findings of Christiano and Ljungqvist [1988].

The uncertainty over the issue of stationarity invites a direct comparison of alternative VAR specifications to see how sensitive the recent rejection of a money-output linkage is to the assumption that the series are trend- or difference-stationary.

III. DATA AND CAUSALITY TESTS RESULTS

Data

Two data sets are used in the analysis. One consists of annual observations for M1, M2, real GDP (1987$), the GDP deflator (1987=100) and the commercial paper

2. In addition to these papers, a number of recent papers suggest that too much emphasis is put on unit-root models (e.g., Sims [1988] and Christiano and Eichenbaum [1990]). For example, Sims notes that "The best known example of a behavioral theory implying unit roots is the efficient markets hypothesis, which in its most straightforward form implies that asset prices are random walks. But it has been understood since Lucas [1978] that the competitive market mechanism does not produce random walk asset price behavior, and my own paper [1984] shows that the intuition behind the efficient markets hypothesis actually applies only as an approximation at small time intervals. The theory actually implies only models with roots close to one, and the degree of their closeness will tend to vary across applications in which data are collected at different intervals" (p. 464).

3. The reason for the low power is because first-differencing the series seems to cause a specification error.

rate. The annual sample period runs from 1915 through 1993.[4] We use the commercial paper rate because using the three-month Treasury bill rate would require that the sample begin in 1934. Since the paper rate is available consistently before this date and given the recent theoretical arguments and empirical findings of Friedman and Kuttner [1992a; 1992b; 1993], this interest rate seems acceptable for our purpose. The other data set is seasonally adjusted, quarterly observations for the above series, running from 1960.I through 1993.IV. This is the more commonly investigated period in assessing the relative roles of money and interest rates in affecting real output. Except for the interest rate, all data, both annual and quarterly, are measured in logarithms.

Causality Test Results

Given the recent debate discussed in the preceding section, two VAR systems are estimated. One system uses all variables in levels and includes a time trend. This system represents the trend-stationary specification. Under this specification, series are assumed to have no stochastic trends in the sense that the fluctuations around a trend are transitory. In other words, the impact of a shock is only temporary. The other system uses first differences of the data and excludes the time trend. This system represents the difference-stationary specification. Under this specification, series possess stochastic trends in the sense that the fluctuations are not mean-reverting over time. Put another way, the impact of a shock is permanent. Each system includes a constant term in the estimations.

We should note that the standard causality tests based on the level (i.e., trend-stationary) specification are valid only if the series are trend-stationary, or if they are difference-stationary *and* cointegrated; that is, there exists a stable long-run money demand function. In other words, if the series are nonstationary but they are not cointegrated, then standard *F*-statistics are not valid since they do not have the correct distribution.[5,6]

Annual Data

Table I reports the causality test results for the VAR systems that include M1 and M2. To conserve on degrees of freedom, all estimations use one lag for each variable.[7] Because the focus is on the relationship with real output, the tables report only results for this variable.[8] Comparing across the trend-stationary and difference-stationary panels in Table I, the commercial paper rate (*CPR*) but not M1 is found to significantly influence the behavior of real output (*RGDP*) over the period 1915–1993. When M2 replaces M1 and the as-

4. The annual data used are taken from Balke and Gordon [1986] updated by Gordon [1993] and the authors. The quarterly data are from Gordon [1993] and updated by the authors.

5. For a further discussion of this issue, see Sims, Stock and Watson [1990]. They demonstrate that the usefulness of Granger-type causality tests are dependent on the order of integration for each variable and whether the system is cointegrated. If the series are nonstationary and system is not cointegrated, standard *F*-statistics are not valid for the level specification. To address this issue, we used the Dickey-Fuller tests and found that both annual and quarterly series are nonstationary. Evidence from Johansen tests indicated that the series are cointegrated for both annual and quarterly samples. It is interesting to note that evidence of cointegration was stronger for the case in which the level of the series is assumed to have no linear deterministic trends than linear trends. This result further shows the fragility of cointegration tests to different specifications (see also footnote 6). However, our results suggest that our level-specification is statistically valid.

6. Given the recent challenges to the classical integration inference, an important question is the fragility of subsequent inferences based on cointegration tests. DeJong [1992] studies this critical inference issue using a Bayesian approach and obtains similar results as DeJong and Whiteman [1991a; 1991b]. When the trend-stationarity hypothesis is assigned zero-prior probability, he finds that the data support cointegration. When this prior is relaxed, however, a trend-stationary representation is supported.

7. It is well-known that VARs are sensitive to a number of modifications, such as lag length. For a discussion, see Hafer and Sheenan [1991] and the articles cited therein. Since there is no one procedure to select the optimal lag length, we adopt the one-lag approach. Moreover, using a single-lag structure allows us to focus on the issue at hand.

8. A full set of results are available from the authors.

TABLE I
Causality Test Results: F-statistics Annual Data: 1915–93

Stationarity Assumption[a]	Dependent Variable	Independent Variables[b,c]			
		CPR	*M1*	*P*	*RGDP*
TS	*RGDP*	2.85***	1.89	0.96	131.41*
DS	*RGDP*	5.11*	0.40	0.23	14.30*
		CPR	*M2*	*P*	*RGDP*
TS	*RGDP*	3.70***	7.31*	6.00**	159.33*
DS	*RGDP*	5.94**	1.67	0.94	18.48*

[a]TS represents trend-stationary, DS is difference-stationary

[b]The mnemonics are: *CPR* is the commercial paper rate, *M1* is the narrow definition of money, *M2* is the broad measure of money, *P* is the GDP price deflator (1987 = 100), and *RGDP* is real GDP (1987$). All variables except the interest rate are expressed in logarithms.

[c]Significance at the 1, 5 and 10 percent levels is denoted by *, ** and ***, respectively.

sumption of trend-stationarity is used, however, *both* M2 and the interest rate significantly influence the behavior of real output. When the difference-stationary assumption is imposed, again only the interest rate achieves its statistical significance. The evidence in Table I shows that the choice of monetary measure along with the assumption concerning the stationarity of the data influences the outcome of the tests. If one assumes that the data are trend-stationary, M2 and the interest rate Granger cause output. This finding is undone if one assumes that the data are difference-stationary: under that constraint, only the interest rate is statistically significant in explaining output for the 1915–1993 sample period. The results indicate that only under a trend-stationary model of output does money (M2) have a significant impact on output and that this impact is best described as being transitory.

Quarterly Data

The causality test results based on quarterly observations for 1960–1993 are reported in Table II.[9] The results for M1 provide a different interpretation than that found in Table I. Imposing the trend-stationary assumption, we find that both M1 and the commercial paper rate significantly influence output in the short-run. This result contradicts that reported for this time period in previous research. If the difference-stationary assumption is used, however, this result reverts to the more common finding: the commercial paper rate Granger causes output while the effects of M1 are statistically insignificant. These results indicate that the relative importance of M1 or interest rates in explaining output is due in large part to the stationarity specification imposed by the researcher.

The results for M2 in Table II also are different than those found by many studies focusing on the post-1960 period and using M1. By substituting M2 for M1, the finding that M2 Granger causes output is again shown to be sensitive to the assumption about stationarity. Whether one assumes that the data are trend-stationary or difference-stationary affects the outcome that M2 Granger causes output. Equally interesting, under the assumption of trend-stationarity, the interest rate loses much of its statistical influence on output when combined with M2.

The results in Tables I and II suggest that the money-output link does not, con-

9. All systems include four lags of each variable.

TABLE II
Causality Test Results: F-statistics Quarterly Data: 1960–93

Stationarity Assumption	Dependent Variable	Independent Variables			
		CPR	*M1*	*P*	*RGDP*
TS	*RGDP*	4.72*	2.49**	0.96	141.60*
DS	*RGDP*	4.66*	0.16	0.50	3.22**
		CPR	*M2*	*P*	*RGDP*
TS	*RGDP*	2.34***	5.25*	1.77	36.46*
DS	*RGDP*	2.94**	1.82	1.89	2.82**

Notes: See Table I.

trary to some findings, collapse with the use of recent data. This finding is especially true for M2. Our findings highlight the sensitivity of recent conclusions to the assumptions concerning the stationarity of the data. If one assumes that the data are trend-stationary, M2 and the interest rate Granger cause output in every instance. On the other hand, assuming that the data are difference-stationary results in money being significant in none of the four estimated systems in Tables I and II. The upshot of the results in Tables I and II is that if money has any significant impact on output, it is only transitory; that is, money has no significant, long-run affect on real output.

IV. VARIANCE DECOMPOSITIONS

The previous tests determine whether money or the interest rate are *statistically* significant in explaining the behavior of output. A natural question to ask is whether a change in these variables is *quantitatively* important in affecting output. Does a shock to money or the interest rate generate an economically significant change in output, ceteris paribus? To address this question, variance decompositions from the different VAR models are calculated. Two orderings are used. Following Sims [1980], one ordering is interest rate, money (M1 or M2), prices, and real output. As discussed by Todd [1990], this ordering reflects an a priori belief that there is little contemporaneous feedback from output to money. As a check on the results, the alternative ordering of real output, prices, interest rate and money also is used.[10]

Annual Data

Table III reports the variance decompositions at a four-year horizon for the 1915–1993 data.[11] Results are reported for systems that use M1 or M2, for each of the two possible orderings, and whether the data are assumed to be trend- or difference-stationary. Looking first at the results for M1 in the upper half of the table, the variance decompositions generated by the "Sims" ordering (*CPR, M1, P, RGDP*) indicate that shocks to M1 account for about 22 to 28 percent of the variation in output regardless of the stationary assumption. Contrast this to the negligible impact from shocks to the interest rate, which account for only about 2 to 5 percent of the variation in output. These results indicate that simply including the interest rate in a system with M1 does not impair money's affect on output.

The inclusion of the interest rate does not affect the role of M1. The ordering of the variables clearly does, however. As

10. We would like to thank a referee for this suggestion and discussion.

11. Although under a trend-stationary model of output the impact of shocks is only transitory, it is still of great interest to policymakers. On the other hand, a difference-stationary model of output requires infinite horizons to completely study the dynamic response of output to shocks. Since we prefer to study shorter horizons with more practical significance, a four-year horizon is used.

TABLE III
Variance Decompositions for Output Annual Data: 1915–93
Four-Year Horizon: Trend-Stationary/Difference-Stationary

	Explained by Innovations in:			
Ordering	***CPR***	***M1***	***P***	***RGDP***
CPR, M1, P, RGDP	1.9/5.3	27.6/21.8	8.8/8.9	61.7/63.9
RGDP, P, CPR, M1	4.2/5.9	0.6/0.1	0.4/0.2	94.8/93.0
	CPR	*M2*	*P*	*RGDP*
CPR, M2, P, RGDP	1.8/4.8	25.3/18.9	4.3/9.7	68.6/66.5
RGDP, P, CPR, M2	4.6/4.9	5.9/3.1	0.5/0.1	89.0/91.9

Notes: See Table I.

shown in Table III, changing the ordering of the variables significantly reduces the impact of innovations in M1 on output. While the effects of M1 are reduced essentially to zero, note that the role of the interest rate is only marginally enhanced by the re-ordering. At best the interest rate accounts for only about 4 to 6 percent of the variation in output.

The outcome using M2 is reported in the lower half of Table III. When the Sims ordering is used, M2 shocks account for about 19 to 25 percent of the variation in output, depending on whether the trend-stationary or difference-stationary assumption is used. The effect of the interest rate is as weak as before, picking up 5 percent or less of the variation in output for the 1915–1993 sample. When the ordering is changed, M2, like M1, loses much of its impact. Even though the effect of a shock to M2 on output falls sharply, it remains larger than that for M1. For all intents, however, the effects of a shock to M2 and the interest rate are basically the same: both account for less than 10 percent of the variation in output under the alternative ordering.

Quarterly Data

Table IV presents the variance decompositions based on quarterly data for the 1960–1993 period. The annual data results were found to be sensitive to the ordering of the variables in determining whether money or interest rates account for more of the variation in output. Switching to quarterly data from the more recent period reveals that any change in relative importance largely stems from the stationary assumption. For example, if one assumes that the data are trend-stationary, the impact of an M1 shock on output is close to 27 percent for the Sims ordering and about 30 percent for the *RGDP, P, CPR, M1* ordering. The effect from a shock to the interest rate is about 8 percent and 10 percent, respectively. If one assumes the data are difference-stationary, however, the variance decompositions are dramatically affected: for M1 it drops to 8.7 percent and 3.9 percent for the two orderings. For the interest rate, it increases to 13.4 percent and 11.9 percent. These results again illustrate that popular conclusions regarding the effects on output from shocks to M1 or interest rates are very sensitive to the assumptions regarding the stationarity of the data.

The lower half of Table IV tells a similar story when M2 is substituted for M1. Regardless of ordering, the effect of an M2 shock on output is diminished when the data are assumed to be difference-stationary. Using the Sims ordering, the effect of a shock to M2 on output falls from 28.2 percent to 8.8 percent simply by imposing the difference-stationary assumption. Using the alternative ordering, the effects of an M2 shock decline from explaining 25.5 percent to 3.3 percent of output vari-

TABLE IV
Variance Decompositions for Output Quarterly Data: 1960–93
Four-Year Horizon: Trend-Stationary/Difference-Stationary

Ordering	Explained by Innovations in: CPR	M1	P	RGDP
CPR, M1, P, RGDP	7.9/13.4	26.9/8.7	5.3/2.9	59.9/75.0
RGDP, P, CPR, M1	10.1/11.9	29.7/3.9	12.2/2.7	48.0/81.6
	CPR	***M2***	***P***	***RGDP***
CPR, M2, P, RGDP	22.1/16.8	28.2/8.8	23.8/6.2	25.9/68.2
RGDP, P, CPR, M2	20.9/14.8	25.5/3.3	23.2/6.6	30.4/75.3

Notes: See Table I

ation. Even though there is some decrease in the amount of variation in output explained by a shock to the interest rate, the effects of changing the stationarity assumption are less dramatic. For the Sims ordering, the effect of a shock to the interest rate falls from 22.1 percent when the trend-stationarity specification is used to 16.8 percent of the variation in output under difference-stationarity. The decline of the interest-rate effect due to the change in stationarity assumptions is from 20.9 percent to 14.8 percent when the alternative ordering is used.

The variance decomposition results indicate that the relative effects of money and the interest rate on output are affected significantly by the stationarity assumption employed. If one assumes trend-stationarity, shocks to money, whether measured by M1 or M2, have a larger impact on output than do shocks to the interest rate. In other words, if both money and the interest rate have a significant transitory impact on output, this impact is larger for money than for the interest rate. This result is robust with respect to the ordering of the variables in the estimated VAR system. When one imposes difference-stationarity on the data, however, the impact of shocks to money are reduced relatively more than are those on the interest rates. An interesting result that emerges from our comparison is that the effect of interest rate shocks on output are reduced by combining it with M2 and changing the stationarity assumption. Given the difficulty in distinguishing between trend- and difference-stationary specifications, the variance decompositions reveal that conclusions reached in other studies regarding the reduced importance of money in explaining the behavior of real output have been greatly exaggerated.

V. A CLOSER LOOK AT THE 1980s

It has been argued that the apparent breakdown in the link between money and output stems from the myriad of economic events that occurred during the 1980s. The Federal Reserve's switch to an aggregates-based policy in 1979 and back to a de-facto interest rate policy in 1982, the recessions of 1980 and 1981–82, the special credit control fiasco of 1980, and the changing financial regulations are all implicated as reasons not to use monetary aggregates for monetary policy. Indeed, Friedman and Kuttner [1992b] find that beginning the sample in the 1960s and including data for the decade of the 1980s obviates the empirical support for any statistical relationship between money (M1) and real output.

Is there a chronology to the purported deterioration in money's effect on output? Also, is there a chronology to the apparent increase in the importance of interest rates? To address such questions, the quarterly VARs are re-estimated using M1 and M2 for the sample beginning in 1960 but

TABLE V
Variance Decompositions for Output: Quarterly Data Four-Year Horizon

	M1							
	Ordering: *CPR, M1, P, RGDP*				Ordering: *RGDP, P, CPR, M1*			
	Trend-Stationary		Difference-Stationary		Trend-Stationary		Difference-Stationary	
Endpoint	*CPR*	*M1*	*CPR*	*M1*	*CPR*	*M1*	*CPR*	*M1*
1979	35.6	31.0	13.6	21.8	32.7	21.7	14.1	11.6
1986	11.1	34.8	12.5	12.6	9.2	23.6	12.2	6.8
1993	7.9	26.9	13.4	8.7	10.1	29.7	11.9	3.9

	M2							
	Ordering: *CPR, M2, P, RGDP*				Ordering: *RGDP, P, CPR, M2*			
	Trend-Stationary		Difference-Stationary		Trend-Stationary		Difference-Stationary	
Endpoint	*CPR*	*M2*	*CPR*	*M2*	*CPR*	*M1*	*CPR*	*M1*
1979	42.5	21.8	16.7	13.4	42.5	15.7	17.3	8.9
1986	14.9	29.3	18.1	9.2	10.8	14.9	16.6	3.4
1993	22.1	28.2	16.8	8.8	20.9	25.5	14.8	3.3

Notes: See Table I.

now ending in 1979. The sample then is updated annually and the system re-estimated until the final estimate is for the full 1960.I–1993.IV sample. In the interest of space, variance decomposition results from this sequential estimation are reported in Table V for the 1979, 1986 and 1993 endpoints.[12]

The results for M1, found in the upper half of Table V, show that the full-sample results mask the temporal changes in the variables' relative impacts on output. What appears from the full-period estimates as a dominance of one variable over another now is revealed to be the result of one variable's effects declining less sharply than the other. For example, consider the results for the interest rate and M1 using the difference-stationary assumption and the Sims ordering. The full-period results show that shocks to the interest rate and M1 explain the variation in output on the order of 13.4 percent and 8.7 percent, respectively. But notice that the decade of the 1980s produced a dramatic decline in the effects of shocks to M1, declining from 21.8 percent for the period ending in 1979 and from 12.6 percent in 1986. The effects of shocks to the interest rate, however, simply remained at about the same level: 13.6 percent for the sample ending in 1979 and 12.5 percent for the sample ending in 1986. Under the assumption of difference-stationary data, it is not that shocks to interest rates increased in absolute importance, but they became relatively more important than shocks to M1 in explaining the behavior of output.

It is clear from Table V that the assumption of stationarity is crucial in determining the relative importance of either the interest rate or M1. Using the Sims ordering, switching from trend- to difference-stationary leads to either a dramatic reduction in the effects of a shock in the interest rate on output (35.6 percent to 7.9 percent) or almost no change (13.6 percent to 13.4 percent). For M1, using the Sims ordering, the impact on how big the decline in effect is, is about a 13 percent reduction when trend-stationarity is used versus 60 percent using difference-stationarity. While the quantitative results change using the alternative ordering, the

12. A full set of results are available on request.

qualitative results are basically unaffected under the difference-stationary assumption. The finding that shocks to the interest rate dominate those to M1 by the end of the sample period is largely a consequence of the stationarity assumption used. Indeed, imposing trend-stationarity reverses the importance of M1 and the interest rate. The dominance of M1 over the interest rate shown in the full-sample result (29.7 vs. 10.1 percent) is the result of an increase in M1's impact on output during the 1980s. Between 1979 and 1993, the effect on output from an interest rate shock fell almost 75 percent, compared to a 37 percent *increase* in the impact from M1.[13]

The results for M2, reported in the lower tier of Table V, tell a similar story. Regardless of the ordering used, assuming difference-stationarity results in a relatively larger reduction in the effects of M2 shocks on output relative to interest rate shocks. If one assumes trend-stationarity, however, the results for the 1980s show that the impact of M2 shocks on output actually *increase* and that for the interest rate declines as the decade progresses. One possible explanation for this result is the number of innovations that began in 1980 and the subsequent evolution of the new components in both M1 and M2. The portfolio decisions that are being captured by M2 may reflect a closer relation with respect to movements in output.

VI. CONCLUSIONS

This paper re-examines the relationship between output, money and interest rates. A number of recent studies conclude that, with the addition of the 1980s, money has little or no explanatory power over the behavior of real output. Instead, interest rates were found to be more closely related to output behavior and, hence, a better measure upon which policy decisions should be based. Many of these claims are based on VAR systems estimated under the assumption that the data are difference-stationary. Given the literature that questions the imposition of such an assumption against that of trend-stationarity and the robust evidence for trend-stationarity (i.e., Dejong and Whiteman [1991b]), our empirical tests use both specifications to see how this affects earlier conclusions.

For the broad 1915–1993 sample period, the significance of money (M1 and M2) depends whether one assumes that the data are trend- or difference-stationary. When the difference-specification is used, money has no apparent explanatory power over output. This indicates that, under a difference-stationary model of output, money shocks have no permanent, long-run impact on the output path. The historical evidence here is consistent with the recent findings of Boschen and Mills [1995] who investigate the post–World War II data for the U.S. economy. They conclude that "Permanent innovations in monetary aggregates play no role in explaining permanent movements in GNP" (p. 43). The trend-stationary specification also provides evidence for the transitory impact of M2 on output. Put another way, M2 has a significant transitory impact on output despite its neutrality in the long run.

The commercial paper rate is statistically significant for both specifications; that is, it may have both permanent and transitory impacts on the output path. One finding that is invariant with respect to the ordering of the variables in variance decompositions is that the interest rate plays a minor quantitative role in explaining the output variability. The quantitative effect of money shocks on output is more heavily influenced by the ordering of the VAR system than by the stationarity assumption imposed. While the quantitative impact of money on output is sensitive to the specification, this is not true for the interest rate. Shocks to the commercial paper rate simply do not explain much of

13. Indeed, Bernanke [1990] shows that as the decade of the 1980s concluded, the strength of the interest rate-output link was much weaker than previously thought.

the variation in output across this long period.

Lastly, the apparent empirical breakdown of money's effect on output during the 1980s is due largely to the stationarity assumption imposed on the data. Switching from trend- to difference-stationarity reverses the Granger causality test results for M1 and M2 from significance to no significance for the post-1960 quarterly data. During this period, money has a significant transitory impact on output under the trend-stationary model of output.

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