Why We Don't Know Whether Money Causes Output

by Charles T. Carlstrom
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Introduction

Macroeconomics has undergone a revolution in the past 20 years, in which significant challenges have been made to supposedly well-established theories and facts. Among the most important of these prevailing theories is the positive correlation between money and real output.

Traditionally, most economists and policymakers have interpreted this correlation to imply that Federal Reserve open market operations could affect real output. This interpretation has persisted in spite of weak and sometimes contradictory empirical evidence. Unfortunately, we cannot attempt to examine all of the existing evidence on the direction of causality between money and output. Instead, this paper examines whether Granger-causality is a valid test for causality and what can be inferred from existing tests of Granger-causality. The answers to these questions are of paramount importance, since most policymakers assume that money causes output in a consistent and reliable way. This correlation is illustrated in figures 1, 2, and 3 using three measures of money: base, M1, and M2.[1]

The usual method of distinguishing among competing economic theories involves econometric testing. However, as is well known (see, for example, Black [1982]), econometric models indicate correlation, but not causality. Even the econometric technique of Granger (1969) does not necessarily identify causality as the term is commonly understood. We will show in the following section that the concept of Granger-causality is not robust to changes in the underlying model of the economy.[2] In other words, it is impossible to interpret Granger-causality independent of theory. Given this, sections II through IV examine models that try to explain the correlation between money and output.

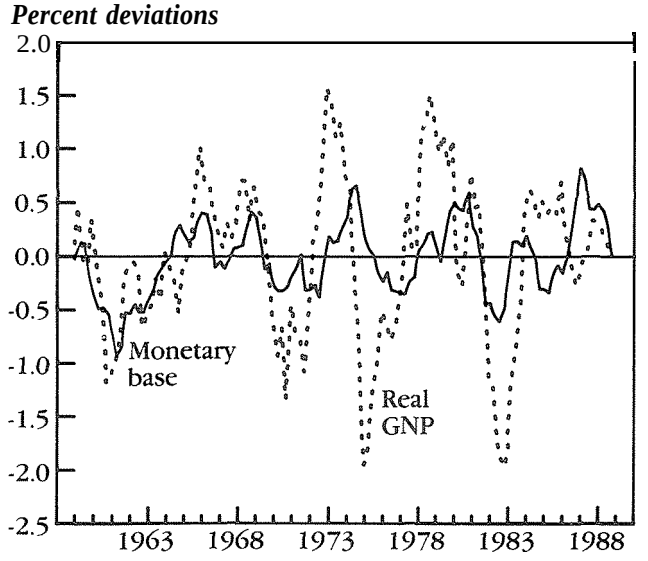
Traditionally, this correlation was explained by assuming some type of nominal rigidity (either prices or wages). Tobin (1970), however, showed that the correlation between money and output could be a result of the Federal Reserve's operating procedure and that it did not necessarily imply that changes in money caused output changes. Section III shows that if the Federal Reserve accommodates increases in output with a corresponding increase in the money supply,

1 The series is detrended using a Hodrick and Prescott (1980) filter Figure 4 illustrates this method as it is applied to real output (GNP).

2 See also Cooley and LeRoy (1985)

FIGURE 1

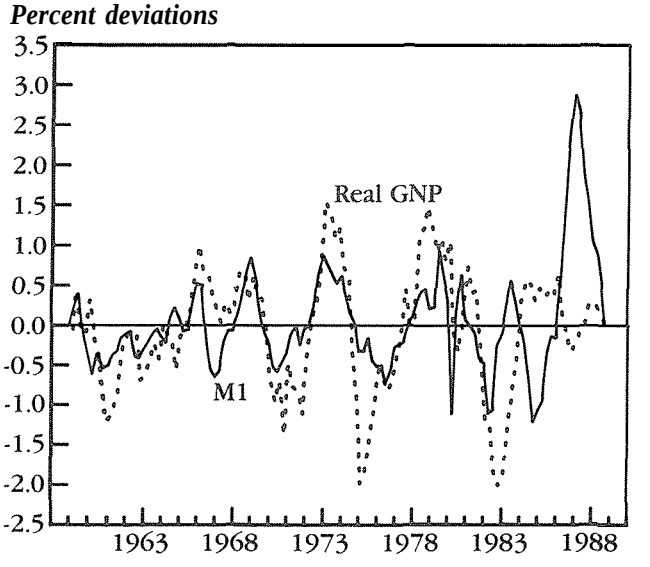
Real GNP and Monetary Base



NOTE: Sample period is from 1959:IQ to 1988:IVQ.
SOURCES: Data Resources, Inc., and Board of Governors of the Federal Reserve System.

FIGURE 2

Real GNP and M1



NOTE: Sample period is from 1959:IQ to 1988:IVQ.
SOURCES: Data Resources, Inc., and Board of Governors of the Federal Reserve System.

then one would expect to observe a positive correlation between output and money even though money is not causing output.

Real business cycle theorists have recently argued that the correlation between money and output could be due to reverse causality; that is, output can cause money independent of the Federal Reserve's reaction function. Section IV examines a model by King and Plosser (1784) showing that M1 and output are correlated because increases in real output cause increases in the demand for financial intermediation. This increased demand leads to the expansion of broader monetary measures, such as M1 and M2, even though changes in money have no influence on real output.

Section V reviews the empirical evidence uncovered in these theories to help ascertain the direction of causality in the money-output correlation. Section VI concludes with a discussion of policy implications.

I. Granger-Causality

Causality is a very elusive concept. In practice, most people define x causing y to mean that a change in x leads to a change in y. As an analogy, we would implicitly assume that if we could cause a low-pressure system to appear over a city (all else remaining constant), then there would be a high probability that rain would fall. This causality usually means that if low-pressure systems cause rain, then low-pressure systems must precede rain.

As can be seen in figure 3, M2 appears to lead GNP. Does this chronology imply that M2 causes GNP? The Granger definition of causality requires two assumptions. As stated by Granger and Newbold (1986, p. 220):

a) The future cannot cause the past. Causality can only occur with the past causing the present or future.

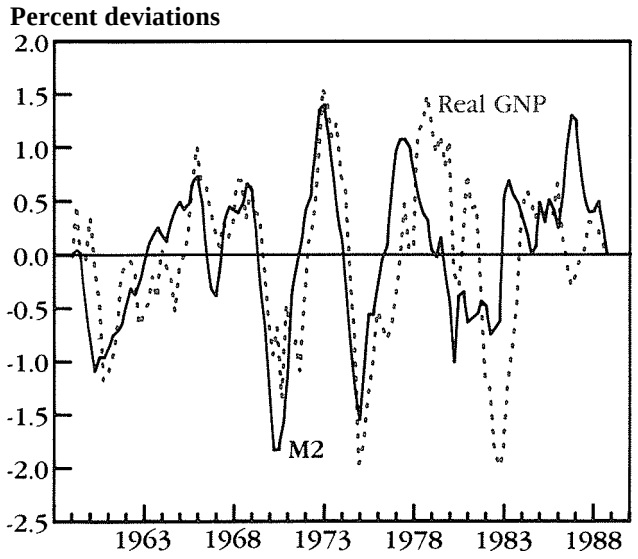
b) A cause contains unique information about an effect that is not available elsewhere.

According to the first assumption, then, if M2 always leads changes in GNP, we can logically infer that GNP does not cause M2. Does this mean that we can conclude the alternative, that M2 causes GNP? Consider the following example.

Suppose that a group of individuals always listens to weather forecasts and that these forecasts are always accurate. Further, suppose that these people decide to carry umbrellas on days that rain is forecasted. Clearly, carrying an umbrella and rain will be correlated, and carrying an umbrella will precede a rainstorm.

FIGURE 3

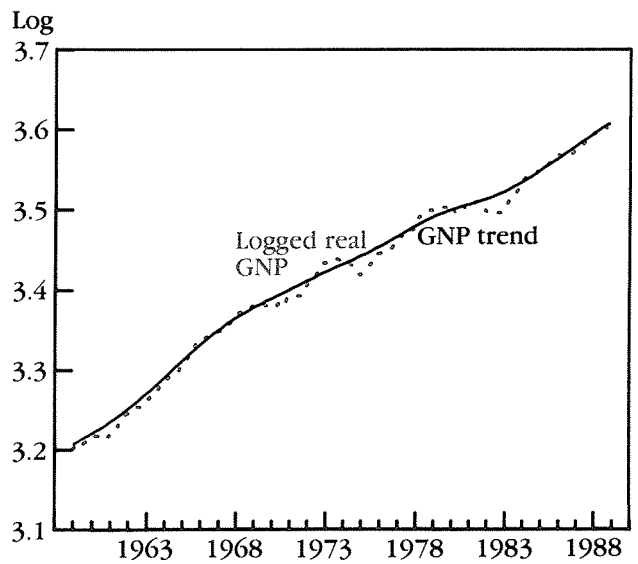
Real GNP and M2



NOTE: Sample period is from 1959:IQ to 1988:IVQ.
SOURCES: Data Resources, Inc., and Board of Governors of the Federal Reserve System.

FIGURE 4

Logged Real GNP and GNP Trend



NOTE: Sample period is from 1959:IQ to 1988:IVQ.
SOURCES: Data Resources, Inc., and Board of Governors of the Federal Reserve System.

According to the first assumption of Granger-causality, rain cannot cause umbrella-carrying. Yet, clearly, meteorologists would reject the conclusion that umbrellas cause rain.

The problem with our umbrella and rain example is that assumption a) is violated. This assumption is also frequently violated in many econometric tests. A third variable that uniquely causes people to carry umbrellas is omitted. Strictly speaking, rain does not cause umbrellas, but the *expectation* that rain may occur causes people to carry umbrellas. Ekpectations are not formed in a vacuum, however; low-pressure systems in this example could be shown to cause both umbrella-carrying and rain. Neglecting this third variable would cause one to conclude that carrying an umbrella Granger-causes rain.

Because of the importance of expectations in economics, a variable, X, that precedes another variable, y, will frequently not cause y. Variable X may depend on the expected value of y, causing X and y to be correlated. Since expectations depend on numerous variables that are, in principle, observable by the econometrician, one could conceivably conduct a Granger-causality test by including all relevant variables. The econometrician, however, would need to have a well-defined model of how expectations are formed. It is therefore extremely important that Granger-causality tests be interpreted in light of the theory that one is trying to test.

Consider the formal definition of Granger-causality. Let Ω_t be all the information available in the universe at time t. Let x_t and y_t be two random variables within this universe. Granger says that X causes (does not cause) y if

$$F(y_{t+k}|\Omega_t) \neq (=)\ F(y_{t+k}|\Omega_t - x_t)$$

for $k > 1$, where $F(.|.)$ is the conditional probability density function of y_{t+k}, given Ω_t or $\Omega_t - X_t$ and $\Omega_t - x_t$ is defined to be the universe less x_t.

Suppose that these conditional distribution functions are equal. If X and y are correlated, it follows that there must exist a third variable in Ω_t that causes both X and y. For example, let y denote the occurrence of rain and let X denote the occurrence of umbrella-carrying. Leaving umbrella-carrying out of the information set does not affect the conditional distribution of rain or, in other words, weathermen can accurately predict rain without seeing whether people are carrying umbrellas. Because the entire universe, including low-pressure systems, is assumed to be in the information set, this example correctly predicts that umbrella-carrying does not Granger-cause rain.

Sims (1972) showed that Granger-causality is identical to the concept of exogeneity. In other words, x Granger-causes y if x is exogenous to y and y is not exogenous to x. A variable x is exogenous to y if the occurrence of x is independent of the occurrence of y. Similarly, a variable y is not exogenous to x if the occurrence of y is dependent on x occurring. Thus, the occurrence of rain is exogenous to whether people carry umbrellas: rain will fall regardless of whether people carry umbrellas. The converse is not true, however; if it starts to rain, people will tend to carry umbrellas.

At first glance, Granger-causality or exogeneity seems to be a reasonable definition of causality. However, it ignores the case of bivariate causality, where two variables cause each other. For example, rain causes puddles, and the evaporation of puddles causes rain to fall at a later date. To make Granger-causality operational, the universe of information must be restricted and the moments of the conditional distribution functions must be tested for equality. The universe of information is restricted by theory. In practice, the distribution functions are saicl to be equal if their first moments (the means) are equal. Testing for Granger-causality usually involves the following: A variable x is said to Granger-cause (not Granger-cause) y with respect to the information set I_t if

$$E(y_{t+k}|I_t) \neq (=)\ E(y_{t+k}|I_t - x_t) \text{ for } k \geq 1.$$

Because we do not consider all moments of the distribution, and we do not use all of the information set, Granger-causality as practiced is neither a necessary nor a sufficient condition to determine the direction of causation between x and y.

Consider the case where all the relevant information in the universe is included in a Granger-causality test, but only the means are tested to see if they are equal. If the means were found to be unequal, then one could logically infer that x must cause y. If the means were found to be equal, however, then one could not infer that x did not cause y.

Now consider the second assumption in the case where all the moments can be tested, but the universe of information is restricted in an ad hoc manner and an important determinant of y is accidentally omitted. Equality between the conditional distribution functions necessarily implies that x does not cause y. However, if the conditional distributions are not equal, then we cannot infer that x causes y. This is the case in our example: umbrellas help to predict rain and thus Granger-cause rain if lomi-pressure systems are excluded from the information set.

Since any operational test of causality involves restricting both the moments of the distribution functions to be tested and the information set in the universe relevant to the problem, employing a Granger-causalit). test exposes one to the risk of incorrectly rejecting causality when it is present and incorrectly rejecting the assumption of no causality when causality is not present. The econometrician can seek the direction of causality using a Granger-causality test only by using theory to determine which variables are helpful in predicting y_{t+k}. However, even after choosing variables based on some theory, a specification test should be conducted to help ensure that important variables have not been omitted.

It should be clear from this discussion that Granger-causality is neither a necessary nor a sufficient test for the existence of true causality. First, if bidirectional causality exists, then Granger-causality cannot indicate the presence of causality. Second, even when bidirectional causality is not present, the Granger-causality test may fail to identify whether causality is present if the information set excludes relevant variables or if all moments of the conditional distributions are not tested for equality. In addition, Granger-causality is not a useful test for showing the presence of contemporaneous causality.

Sections II and III present representative theories that have been developed to explain the money-output correlation. Section IV then interprets the econometric evidence that has been uncovered in light of these theories and the problems discussecl above.

II. Money Causes Output

Most economists currently favor the interpretation that money causes output. They believe that some nominal rigidities, or price/wage sluggishness, allow changes in nominal variables, like money, to have real effects. These rigitlities can be motivated by nominal wage contracts (Fischer [1977], Gray [1976]), or by incomplete information (Lucas [1972, 1977]).

For expositional ease, we consider the nominal wage contracting model as exemplified by Fischer. In his moclel, agents in the economy have rational (model-consistent) expectations, but wages are "sticky" because of the existence of long-term nominal wage contracts. Further, Fischer assumes that employment is demand-determined; that is, employment is always chosen so that the real wage is equal to the marginal productivity of labor. Thus, changes in the

money supply that were unexpected at the time the contract was signed will have real effects. Unanticipated increases in the money supply will cause prices to be higher than expected and will cause the real wage to be lower than expected. The decline in the real wage lowers the marginal cost for firms to hire additional workers, leading to an expansion of employment and thus output.

Consider a scaled-down version of the model analyzed by Hoehn (1788). In this example, contracts will not be overlapping, and the only source of uncertainty will be from the money supply process. Assume that the aggregate production function is Cobb-Douglas, that is, $Y_t = N_t^{\gamma}$, where Y_t and N_t are real output and the labor supply, respectively. Because wages are assumed to be demand-determined, we set the real wage equal to the marginal productivity of capital. Taking logarithms gives

$$(1) \quad w_t - p_t = ln(\gamma) - (1 - \gamma)n_t,$$

where w_t, p_t, and n_t are the natural logarithms of wages, prices, and employment. Labor supply is assumed to be of the following form:

$$(2) \quad n^s_t = \beta_0 + \beta_1(w_t - p_t) \text{ for } \beta_0, \beta_1 > 0$$

Setting labor supply equal to labor demand, one can solve for the real wage rate that clears the market. From this equation, it is assumed that wages are chosen so that the labor market clears on average.[3] This gives the following equation for nominal wages:

$$(3) \quad w^*_t = E_{t-1}p_t + [ln(\gamma) - (1 - \gamma)\beta_0]J,$$

where $J = [1 + \beta_1(1 - \gamma)]^{-1}$.

To close the model, we must posit a form for money demand and money supply. Money demand is taken to be the simple quantity equation, that is, $M^d = KP_t Y_t$. In logarithmic form, it is

$$(4) \quad m^d_t = p_t + y_t + k.$$

For our purposes, this year's log of money supply is equal to last year's money supply plus a random shock. That is, $m^s_t = m_{t-1} + \epsilon_t$, where the shock ϵ_t is assumed to be an independently, identically distributed random variable over time. With these assumptions, output equals

$$(5) \quad y_t = A + \gamma\epsilon_t,$$

where $A = \gamma[\beta_0 + \beta_1 ln(\gamma)]J$.

For this simple case, in which contracts do not overlap and there are no shocks other than those to the money supply, changes in output depend only on the shock to this period's money, ϵ_t. If one were to randomly determine different realizations of ϵ_t, and were then to graph money supply and output against time (different realizations of ϵ_t), one would obtain a picture very similar to that given in figure 1. In this case, money causes changes in output. However, because changes in money and output occur contemporaneously, money does not Granger-cause output.

Equation (5) is also the output equation that results from a simple linearized version of the Lucas (1772, 1777) model. Here, workers confuse nominal and real shocks. Unanticipated increases in money result in higher nominal wages, which workers confuse with higher real wages. They do not know the extent to which higher wages reflect an increase in the relative price of their product or an increase in the general price level. Unanticipated changes in the money supply will cause increases in output as workers rationally mistake this nominal shock for a change in their real wage.

Models of the type discussed above were originally developed in response to the lack of empirical and theoretical support for traditional Keynesian and monetarist models. Both the Lucas and the Fischer models have recently come under attack. Barro (1777) shows that contracting models such as Fischer's are inconsistent with maximizing behavior. He argues that there is no a priori reason why labor should be demand-determined in these models.

In addition, economists question why firms have not indexed their wages, because sticky wages result in alleged output swings at both the firm and the macro level. Ahmed (1787) also presents empirical evidence showing that nominal wage contracting is not important for explaining output movements in Canadian data. Although Lucas' model is consistent with maximizing behavior, it also lacks empirical support. Mishkin (1983) and Boschen and Grossinan (1982), for example, find evidence against the equilibrium monetary explanation of the business cycle.

The following section shows why the Federal Reserve's operating procedure may cause money and output to be correlated.

3 Actually, this assumption is not quite true. Wages in Hoehn's model are chosen not so that $EN^d = N^S$, but so that $Eln(N^d) = En^d = hN^S = n^S$.

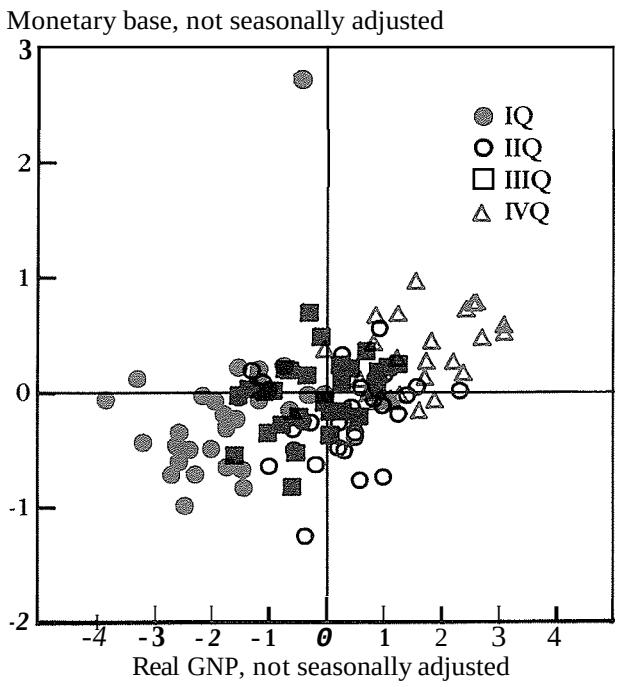
III. Post Hoc: Does The Federal Reserve Cause Christmas?

Figure 5 plots a scatter diagram of quarterly changes in the monetary base versus quarterly changes in output. Fourth-quarter points generally lie to the northeast of the first- through third-quarter points. Therefore, money and output are both higher on average in the fourth quarter, or around Christmastime. One could erroneously conclude that Federal Reserve policy causes holiday spending.

Clearly, causality in this case goes the other way. Output increases in the fourth quarter because of holiday spending, and the Federal Reserve, attempting to remove the seasonality from the interest-rate series, accommodates this higher output by increasing the money supply. This is an example of a point given by Tobin (1970) in his seminal article, "Money and Income: Post Hoc Ergo Propter Hoc?" meaning "after this therefore because of it." Tobin's argument was that a positive correlation between money and output may be the result of the Federal Reserve's operating procedure and not a reflection of the common belief that money causes output.

FIGURE 5

Real GNP and Monetary Base



NOTE: Sample period is from 1959:IQ to 1988:IVQ.
SOURCES: Data Resources, Inc., and Board of Governors of the Federal Reserve System.

Instead of presenting Tobin's model, we show how the operating procedure of the Federal Reserve can cause one to incorrectly conclude that the Federal Reserve causes, or at least influences, business cycles. Consider the following variation of the model presented in the previous section: Let output be Cobb-Douglas, so that the log of real wages will again be given by equation (1). Further, assume that the log of the labor supply is given by the following equation:

$$(6) \quad n^s_t = \beta_0 + \beta_1(w_t - p_t) + \beta_2 r_t$$

for $\beta_0, \beta_1, \beta_2 > 0$.

This equation differs from equation (2) because the labor supply is also assumed to be influenced by the real interest rate, r_t. Equation (6) assumes that the labor supply depends positively on the real interest rate, because of the intertemporal substitution effect. That is, when interest rates are high, workers transfer consumption from today until tomorrow to take advantage of the high real rate. Consumption is reduced, thus increasing the marginal utility of consumption in the current period. This, in turn, increases the incentive for agents in the economy to work additional hours in order to consume more today.

Instead of assuming that there are long-term nominal wage contracts, this model assumes that wages vary to clear the market continuously so that money does not influence output. By equating the real wage in equations (1) and (5), we solve for the equilibrium amount of labor supplied (demanded) in this economy:

$$(7) \quad n_t = [\beta_0 + \beta_1 ln(\gamma)]J + J\beta_2 r_t.$$

Real interest rates in the economy are assumed to fluctuate randomly around a constant mean r:

$$(8) \quad r_t = r + \eta_t.$$

Temporary changes in interest rates, η_t, can result because of either shifting tastes or temporary changes in government expenditures. Incorporating this variable into equation (7), we see that output depends positively on the innovation in real interest rates today.

$$(9) \quad y_t = \gamma[\beta_0 + \beta_1 ln(\gamma) + \beta_2 r]J + \gamma J \beta_2 \eta_t.$$

To close the model, we assume that money demand is given by equation (4) and that the Federal Reserve follows a nominal interest rate rule:

$$(10)\quad m^s_t = b + \lambda(R_t - r), \text{ and } A > 0,$$

where $R_t = r_t + E_t p_{t+1} - p_t$.

Nominal interest rates are assumed to be the sum of the real rate plus expected inflation over the next period. Using equations (4), (8), (9), and (10), the reduced form for the nominal interest rate is given by the following equation:

$$(11)\quad R_t = r + \eta_t [(1/(1 + \lambda)) + \gamma\beta_2 J/(1 + \lambda)]$$

Innovations in the real interest rate are assumed to be temporary. An increase in the real interest rate causes policymakers to expand the money supply in order to stabilize nominal interest rates. Prices are then temporarily high and deflation is expected over the next period, which will offset the increase in the real interest rate. When A approaches infinity, the nominal interest rate approaches the long-term real interest rate, r. That is, when A approaches infinity, the Federal Reserve is following an interest-rate peg.

From equation (11), the reduced form of the money-supply equation is given by

$$(12)\quad m^s_t = b + \lambda[(1/(1 + A)) + \gamma\beta_2 J/(1 + \lambda)]\eta_t.$$

If one were to randomly determine different realizations of η_t, and were then to graph money supply and output against time (different realizations of η_t), one would again obtain a picture very similar to that given in figure 1. A temporary increase in interest rates causes people to supply more labor today. This occurs since high real interest rates imply that, on the margin, individuals greatly value consumption today, causing them to work longer hours today. The increase in interest rates also causes the Federal Reserve to expand the money supply in order to smooth nominal interest rates, which causes a temporary rise in prices.

This example implies that, on average, prices will fall over the next period, leading to a decline in the nominal interest rate. Unlike the example given in the previous section, interest rates in this model cause changes in both output and money. Thus, money and output are positively correlated. Like the example given in section III, however, interest rates do not Granger-cause output, because interest rates and output occur contemporaneously.

The above model illustrates how an interest-rate target can produce a positive correlation between money and output. The example was extremely simple and predicted that money and output would move contemporaneously. One could likewise construct examples in which money leads changes in output and would thus appear to cause changes in output.

For example, consider an economy in which money has no real effects, but in which agents are able to predict future output. The prospect of higher future output will cause agents to borrow (or save less) in an attempt to smooth their consumption stream over time. This increased borrowing will boost interest rates. If the effect on output today from an increase in interest rates is negligible, then changes in money will occur before changes in output when the Federal Reserve pursues an interest-rate peg. In this economy, money leads, but does not cause, output.

The next section discusses another mechanism in which output can cause changes in money. Unlike the model presented in this section, the mechanism will not come from the Federal Reserve's operating procedure, but will result from the public's willingness to hold currency versus either demand or time deposits.

IV. Output Causes Money

Real business cycle theorists typically assume that the cause of business cycles is either a shock to consumer preferences or a shock to real productivity.[4] Because an indirect measure of these shocks can be obtained through the use of Solow residuals (see Solow [1956]), theorists have tended to concentrate on technology shocks as a source of business cycle fluctuations.

Real business cycle theory has been successful in explaining the quantitative aspects of business cycles. These include the standard deviations of—and comovements among—real variables such as output, investment, consumption, and hours worked. In contrast, monetary-driven business cycle models have concentrated on explaining the qualitative aspects of the correlation between money and output.[5]

Because real business cycle models do not include a role for money, they have been criticized for not explaining the comovements

4 For a thoughtful exposition of real business cycles, see Prescotl (1986) or Stockman (1988).

5 As noted by Stockman (1988. p. 35). "The large-scale econometric models do not qualify because they are not true structural models in the sense of the Lucas critique of econometric policy evaluation...."

TABLE 1

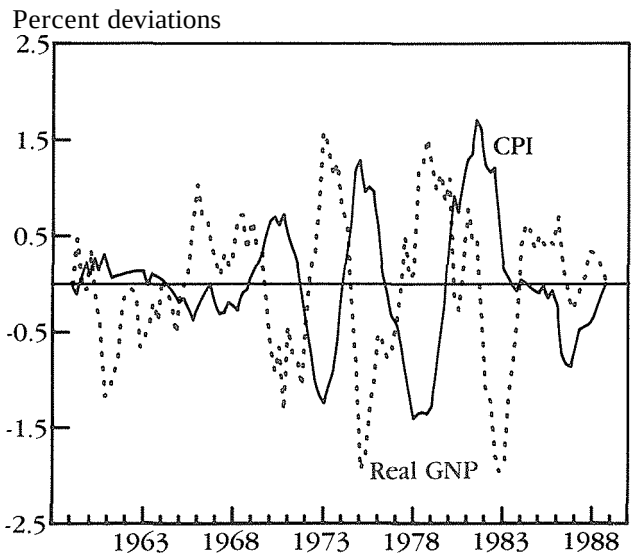
Cross-Correlations of Output

Variable x	$x(t-4)$	$x(t-3)$	$x(t-2)$	$x(t-1)$	$x(t)$	$x(t+1)$	$x(t+2)$	$x(t+3)$	$x(t+4)$
Real GNP	.25	.45	.68	.87	1.00	.87	.68	.46	.26
Monetary base	.08	.20	.29	.39	.44	.44	.42	.39	.37
M1	.12	.25	.35	.37	.34	.26	.21	.16	.15
M2	.62	.68	.69	.62	.48	.29	.10	-.08	-.25
Interest rates	-.55	-.36	-.15	.10	.34	.47	.51	.49	.45
Real interest rates	-.57	-.41	-.20	.07	.30	.40	.44	.43	.41
CPI	-.70	-.75	-.75	-.69	-.56	-.40	-.23	-.05	.13

NOTE: Sample period is from 1959:IQ to 1988:IVQ.
SOURCES: Data Resources, Inc., and Board of Governors of the Federal Reserve System.

FIGURE 6

Real GNP and Consumer Price Index



NOTE: Sample period is from 1959:IQ to 1988:IVQ.
SOURCES: Data Resources, Inc., and Board of Governors of the Federal Reserve System.

among nominal variables such as the price level, wages, and money (see Summers [1986]). However, as figure 6 and table 1 illustrate, the comovements among interest rates, prices, and real output are qualitatively consistent with real business cycle theory. In particular, interest rates have been contemporaneously procyclical and prices have been countercyclical since 1959.[6]

Procyclical interest rates arise in real business cycle models generated by temporary productivity shocks. A temporary increase in productivity today, which is expected to lead to higher output in the future, causes individuals to borrow money in order to smooth consumption. Countercyclical prices arise in these models because the demand for real money balances increases when output increases. Assuming that the Federal Reserve does not fully accommodate the increases in interest rates and output, it follows that prices must fall.

Table 1 provides further evidence that the Federal Reserve may accommodate increases in output. Note that the strongest correlations between the monetary base and output occur contemporaneously and with money lagging output by one quarter. Real business cycle theorists argue that the correlation between the monetary base and output is the result of the Federal Reserve's operating procedure. They point out that this correlation is small relative to the correlation between output and broader measures of money, such as M1 and M2.

Table 1 shows that while the contemporaneous correlation between the monetary base (percent deviations from trend) and real GNP is only .44, the correlation between M2 (percent deviations from trend) and real GNP two quarters later is .68. Although table 1 indicates that the correlation between M1 and real GNP is similar to the correlation between the monetary base and real GNP, the correlation between M1 (percent deviations from trend) and real GNP is .59 if one ignores the tremendous increase in M1 during 1986.

While the monetary base is determined solely by the Federal Reserve, components of M1 and M2, such as checking accounts, short-term time deposits, money market accounts, and mutual

□ 6 Prior to 1953, prices seem to be more procyclical.

funds, are determined by commercial banks and the public.[7] This suggests an important role for reverse causality. The public appears to respond endogenously to future output changes by shifting its portfolio from currency to demand and time deposits. Some mechanism must therefore serve to link output and deposits.

King and Plosser (1984) develop a model in which individuals demand both currency and financial services (demand deposits). In their model, demand deposits, like other goods, are producecl with capital and labor. They derive a demand curve for both inside money (financial services) and outside money (currency). They assume that the cost of making a transaction depends negatively on the real amount of inside ancl outside money that a person holds. The demand for both financial services and currency increases with real output in this model, explaining why empirically both real currency and real demand deposits are correlated with real output.

However, King and Plosser also show empirically that there is a positive correlation between nominal demand deposits and currency with real output. If one restricts their cost of transactions and assumes that with larger purchases (higher output) there is an extra cost associated with currency over demand deposits, one can also generate a positive correlation between nominal demand deposits and output. This assumption seems natural because the demand for high-ticket durable goods is much more procyclical than for less-expensive purchases such as services. A model like this can explain the positive correlation between nominal bank deposits and real GNP.

An example of reverse causality occurred during the Great Depression. The monetary base grew slightly through the period, while the money supply, defined by M1, declined substantially as depositors shifted out of demand deposits and into currency. The result was a decline in the currency/deposit ratio as output fell ancl banks failed. The ensuing bank failures were probably both a cause and an effect of the Great Depression. The decline in the money supply, therefore, was partly the effect of factors that caused the Great Depression, although it map also have been a contributing factor in causing the financial collapse.[8] Empirical work has not been able to distinguish this causation.

Real business cycle models have generated a resurgence in interest to test for the direction of causality between money and output. The next section reviews this literature in light of the theories presented in sections I through IV.

V. Bests of the Money-Output Relationship

To determine the direction of causality between money and output, economists since Sims (1972) have employed Granger-causality tests. The results of these tests are not robust to changes in the sample period, to changes in the variables included in the test, or to whether the data are in log-level or first-differenced form.

Sims finds that money Granger-causes output in a simple bivariate setting. In a later paper, Sims (1980) determines that money fails to Granger-cause output when the commercial paper rate is includecl in the test. Litterman and Weiss (1985) replicate this result and also show that the nominal commercial paper rate Granger-causes both money and output. They find that the real interest rate, however, does not Granger-cause either output or money.

Eichenbaum and Singleton (1986) replace the commercial paper rate with the real rate of return on stocks and the real rate of return on Treasury bills in their Granger-causality tests. They find that while the real rate of return on Treasury bills does not Granger-cause output, the real rate of return on stocks does. Their model allows no explanatory power for money once these variables are included.

Stock and Watson (1989) find that money Granger-causes output if the rate of return on stocks is omitted and the nominal rate of return on Treasury bills is included. Friedman and Kuttner (1989), however, find that this result is sensitive to the sample period chosen. They also determine that money fails to Granger-cause output (except for one subsample) when the nominal commercial paper rate is replaced by the spread between the commercial paper rate and the Treasury bill rate.

What do these results tell us about the direction of causality between money and output? First, the inclusion of interest sates seems to weaken the explanatory power of money. This seems to be inconsistent with a money-driven business cycle. McCallum (1983), however, argues (but does not show) that if the Federal Reserve attempts to peg the interest rate, then interest-rate innovations are a better indication of the influence of money on output than are monetary innovations. This result is obtained

7 The Federal Reserve currently can control the nonbonowed monetary base wilh a fair amount of precision. However, to control total monetary base, the Federal Reserve would need to alter the current administrative practices of the discount window and reserve accounting practices. See Laurent (1979).

8 See Friedman and Schwartz (1963)

because monetary innovations that affect output also cause interest rates to change. There are also nonmonetary shocks that cause interest rates to change, leading to changes in output.

Second, different measures of the rate of return yield drastically different results. The reason is probably that some rates of return are a better proxy for future changes in output than others. As Friedman and Kuttner indicate, the primary determinant of the spread between the Treasury bill rate and the commercial paper rate is the default risk on corporate securities. The primary determinant of the default risk of corporate securities is probably the anticipation of future business conditions, that is, future changes in output. The real rate of return on stocks in Eichenbaum and Singleton's study is probably also a proxy for future changes in output.

The issue of whether money is significant in its ability to predict future output when the spread or return on stocks is included in the causality test tells us little about the actual direction of causality between money and output. Money will Granger-cause output whether money actually causes output or whether future output causes money, whenever the spread (or the return on stocks) is a proxy, but an imperfect proxy for future output. Money would appear to be significant for both models because it helps to eliminate some of the noise present in the spread. Similarly, money will not Granger-cause output if the spread (or the return on stocks) is a perfect proxy for future output. The two models, money causing output and output causing money, are thus observationally equivalent in their predictions concerning whether money Granger-causes output.

This analysis indicates that inferences about the direction of causality between money and output cannot be made from the existing Granger-causality tests. One of the major problems with the existing empirical studies is that they use M1 as their measure of money. As indicated in the previous sections, broader measures of money respond to future business conditions more than narrow measures of money, such as the monetary base. It appears that it would be difficult to distinguish between money causing output or output causing money when measures of money containing endogenous components are used. The same caveat holds for narrow measures of money like the monetary base. These measures, however, do not seem to respond to future business conditions to the same degree as M1 or M2.

These results suggest that the use of causality tests should proceed along the lines indicated by Sims (1989). He urges that researchers should concentrate on combining the theoretical techniques developed by real business cycle theorists and the empirical technique of vector autoregressions. That is, researchers should proceed along the lines of Prescott (1986), but should compare more than simple correlations when matching simulated data to actual data. Sims recommends that they compare the results of Granger-causality tests run on both simulated data and actual data. This requires models to pass stricter empirical tests before being judged as either successful or unsuccessful. Applying this technique to help determine the direction of causality between money and output would require building a real business cycle model with money and then comparing the vector autoregressions run on simulated data from both models with actual data.

VI. Conclusion and Policy Implications

This paper has shown that Granger-causality tests alone cannot settle the debate about the direction of causality between money and output. One reason is the ever-present problem of a potentially missing third variable. In section I, we showed how umbrellas could Granger-cause rain when a variable proxying for the expectation of rain, low-pressure systems, is excluded from the tests. The above studies seem to affirm the notion that leaving out variables that proxy for the expectation of future output could leave money with explanatory power when no causality is actually present. It should be clear that this debate is not likely to be settled on the basis of Granger-causality tests alone. Unfortunately, the issue can probably never be completely settled without having the Federal Reserve conduct controlled experiments with monetary policy that would be infeasible.

Causality tests are not necessarily useless, however. They may provide some information about the direction of causality, as long as they are interpreted within the confines of a model. That is, we must start with the null hypothesis that a specific model is correct and attempt to test whether or not we can reject this hypothesis. This approach is in the spirit of Eichenbaum and Singleton (1986); however, the suggestions made by Sims (1989) seem more appropriate.

Many policymakers currently assume that money causes output in a consistent and reliable way. Economists have been unable to demonstrate this relationship, however. If money does *not* cause output, are policies predicated on such causation benign or harmful? At first glance,

it would seem that the effects of current policy would be benign if money does not cause output.

However, by not being able to pin down the direction of causality, we cannot rule out other possibilities. For instance, it may be possible that inflation or monetary growth decreases output. Support for this proposition comes from Kormendi and Meguire (1985). Using cross-country data, they find a negative correlation between inflation and the growth rate of real output. The possibility that inflation may lower output should not be too surprising, given that inflation is a tax on real cash balances. As is the case with any other tax, we would expect increases in this tax to depress output. For example, higher rates of inflation cause people to engage in wasteful activities in order to economize on money holdings, thus serving to lower output.

Because researchers cannot tell whether increases in money cause output to increase—and there is some evidence that increases in the growth rate of money actually depress output—how should policymakers proceed? Policy actions should be analyzed in light of their potential costs and benefits. Traditional Keynesian analysis assumes that all output fluctuations are inefficient and that policy could improve economic welfare by stabilizing output. However, as Lucas (1987) points out, the welfare gains associated with smoothing business-cycle fluctuations are small and are dwarfed by the potential gains associated with increasing long-run economic growth.

The costs associated with stabilizing output may not be small. If unanticipated money increases output as described by Lucas (1972, 1977), then the real output effects from money are welfare-reducing. The reason is that the output effects of money are generated by misperceptions on the part of the public. As Lucas points out, this analysis prescribes that the Federal Reserve should follow a rule when conducting monetary policy. In Lucas's model, any output changes induced by money are inefficient. Even if his reasons for why money affects output are incorrect, it still may be best for policymakers to follow a rule.

Stockman (1988) also makes the point that conducting policy as if output fluctuations are inefficient can be damaging. If the true explanation of business cycles turns out to require both Keynesian and real business cycle elements, then there may be substantial welfare losses associated with output stabilization. As argued by real business cycle theorists, some output changes are efficient. In aclclition, it is presently impossible to distinguish inefficient from efficient movements in output. Using monetary policy to offset these shocks could very well leave us worse off. Therefore, even if money has real effects, it is not clear how aggressively, if at all, monetary policy should try to stabilize output.

Policymakers should accept the possibility that money does not cause output. Instead of conducting policy as if money does cause output, they could base monetary policy on what we currently know about its costs and benefits. The preceding analysis leads us to believe that policymakers should be more reluctant to fine-tune the economy without understanding the inefficiencies present in the economy. Because the costs of economic stabilization are thought to be large, while the potential benefits have been shown to be fairly small, we recommend that monetary policy be predicated on a rule that is easy for policymakers to implement and even easier for the public to monitor.

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