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# An Empirical Note on the Effects of Monetary Changes on the Price Level and Real Output

Basudeb Biswas
*Utah State University*

Peter J. Saunders
*Utah State University*

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## I. Introduction

One of the key controversies in economic theory involves the effects of changes in the money supply on the price level and the economy's output. In this respect, two major opposing views can readily be identified: the monetarist view and the income expenditure view.[1] Monetarists regard money as an independent source of economic disturbance. In their view, the money supply is exogenously determined and changes in it exert no lasting influence on any real economic variables.[2] Keynesians, on the other hand, assert that under the conditions of unemployment, changes in the money supply may lead to permanent changes in real variables.[3]

The above theoretical dispute can be formulated within the confines of the Quantity Theory of Money postulates. It involves two separate issues. The first deals with the question of causality in the money-income relationship; the second involves the effects of the monetary changes on the two components of nominal income, namely the price level and the real output. In terms of the Quantity Theory of Money's equation of exchange where $MV = PY$, it is essential to initially establish the direction of the causality.[4] Once the causality issue is resolved, it becomes crucial to determine which component of the nominal income ($PY$) is affected by monetary changes. Essentially, the key theoretical issue is whether changes in the money supply lead only to changes in the price level (monetarist long-run position) or whether the real income is permanently affected (keynesian position)[5].

Resolving this theoretical dispute can most satisfactorily be accomplished through empirical research. The purpose of this paper is

to search for empirical evidence supporting the two above stated theoretical positions. This study is divided into two parts. Initially, the bivariate causality test procedures are used to gather further empirical evidence on the money-income causality issue. For this purpose, the FPE causality test method outlined by Hsiao (1981, 1982) is used. This method is extended to the trivariate analysis in the following section. The main purpose of the trivariate analysis is to ascertain the impact of the monetary variable on the two components of nominal income: the price level and the real output.

## II. Theoretical Considerations

Most causality test procedures are based on the concept of causality suggested by Granger (1969). In this respect, the original work of Sims (1972) is of crucial importance. Recent contributions to the Granger-type of causality testing include the studies of Geweke, Meese, and Dent (1983); Guilkey and Salemi (1982); and Ram (1983). All these studies rely on the arbitrary selection of the lag structure in causality tests. Biswas and Saunders (1985) indicate that the causality test results obtained through the arbitrary lag selection may be unreliable because the distribution of test statistics can be sensitive to lag length.[6] The FPE procedure developed by Hsiao (1981) not only solves the problem of arbitrary lag selection but also provides a powerful causality test method.[7] Consequently, this method is adopted for both the bivariate and the trivariate test procedures.

## III. Bivariate Test Results

Hsiao's (1981) procedure involves using five statistical steps

for correct system identification.[8] We implement this method by searching for the optimal lag structure over the previous fifteen quarters. In each case, the criterion of minimum final prediction error (FPE) is used. Minimum FPE can be calculated as $(SEE)^2 \cdot (T + K)/T$, where SEE is the standard error of the regression, T is the number of observations, and K is the number of parameters. Hsiao's definitions of causality are applied to the test results.[9] Seasonally adjusted data for the real GNP(GNPR), nominal GNP, $M_1$, $M_2$, consumer price index (CPI), and monetary base are used.[10] The sample test period is 1959-I to 1984-II. All equations are estimated in the natural logarithmic form.

The test results are presented in Tables 1 and 2. Causality implications are outlined in Table 3. As reported in Table 1, the smallest FPEs for $M_1$, $M_2$, monetary base (B), and nominal GNP are 8, 2, 11, and 3. In order to obtain the results reported in Table 2, it is assumed that each variable is a controlled variable. The other variable is then treated as the manipulated variable. Selecting the lag structure specified in Table 1, the FPE of the controlled variable is computed by varying the order of lags of the manipulated variable from 1 to 15. The specification yielding the smallest FPE is reported in Table 2.[11]

The summary of the causality implication is given in Table 3. The test results indicate that feedback exists between $M_1$ and GNP as well as between $M_2$ and GNP. However, when the monetary base is used as the measure of money, then a direct causal relationship between the monetary base and the nominal GNP exists. Consequently, using the monetary base as a measure of the money stock, empirical support is

TABLE 1

The FPE of Fitting a One-Dimensional Autoregressive Process for GNP, $M_1$, $M_2$, the Monetary Base (B), Real GNP (GNPR), and Consumer Price Index (CPI)

| The Order of Lags | FPE of $M_1 \times 10^{-4}$ | FPE of $M_2 \times 10^{-4}$ | FPE of $Bx^{10-4}$ | FPE of GNP $\times 10^{-4}$ | FPE of GNPR $\times 10^{-4}$ | FPE of CPI $\times 10^{-4}$ |
|---|---|---|---|---|---|---|
| 1 | 0.5249 | 0.5835 | 0.2344 | 1.0486 | 1.0625 | 0.5867 |
| 2 | 0.5225 | 0.4216 | 0.1805 | 1.0097 | 0.9655 | 0.2488 |
| 3 | 0.5386 | 0.4338 | 0.1818 | 0.9879 | 0.9407 | 0.2550 |
| 4 | 0.5245 | 0.4373 | 0.1727 | 1.0181 | 0.9696 | 0.2203 |
| 5 | 0.5196 | 0.4409 | 0.1738 | 1.0340 | 0.9878 | 0.2210 |
| 6 | 0.5159 | 0.4546 | 0.1694 | 1.1022 | 0.9738 | 0.2216 |
| 7 | 0.5287 | 0.4610 | 0.1747 | 1.0455 | 0.9971 | 0.2075 |
| 8 | 0.5028 | 0.4614 | 0.1807 | 1.0193 | 0.9924 | 0.2047 |
| 9 | 0.5189 | 0.4701 | 0.1825 | 1.0305 | 0.9713 | 0.1965 |
| 10 | 0.5309 | 0.4772 | 0.1794 | 1.0510 | 0.9847 | 0.2003 |
| 11 | 0.5414 | 0.4259 | 0.1689 | 1.0514 | 0.9978 | 0.2072 |
| 12 | 0.5555 | 0.4612 | 0.1746 | 1.0470 | 1.0281 | 0.2132 |
| 13 | 0.5622 | 0.4773 | 0.1781 | 1.0396 | 0.9808 | 0.2206 |
| 14 | 0.5839 | 0.4946 | 0.1847 | 1.0798 | 1.0139 | 0.2291 |
| 15 | 0.5803 | 0.4996 | 0.1880 | 1.1011 | 1.0308 | 0.2298 |

TABLE 2

The Optimum Lags of the Manipulated Variable and the FPE of the Controlled Variable

| Controlled Variable | Manipulated Variable | The Optimum Lag of Manipulated Variable | FPE x $10^{-4}$ |
|---|---|---|---|
| $M_1$ (8) | GNP | 7 | 0.4649 |
| GNP (3) | $M_1$ | 3 | 0.8945 |
| $M_2$ (2) | GNP | 2 | 0.4205 |
| GNP (3) | $M_2$ | 1 | 0.8074 |
| B (11) | GNP | 1 | 0.1695 |
| GNP (3) | Base | 4 | 0.8185 |

TABLE 3

Causality Implications of the FPE Procedure for GNP, $M_1$, $M_2$, and Monetary Base

| $M_1$ | | | $M_2$ | | | Monetary Base (B) | | |
|---|---|---|---|---|---|---|---|---|
| Process | | Implications | Process | | Implications | Process | | Implications |
| GNP Process: | | | GNP Process: | | | GNP Process: | | |
| FPE (Step 1) | 0.9879 | 0.9879 > 0.8947 | FPE (Step 1) | 0.9879 | 0.9879 > 0.8074 | FPE (Step 1) | 0.9879 | 0.9879 > 0.8183 |
| FPE (Step 2) | 0.8947 | $M_1$ ==> GNP | FPE (Step 2) | 0.8074 | $M_2$ ==> GNP | FPE (Step 2) | 0.8183 | B ==> GNP |
| $M_1$ Process: | | | $M_2$ Process: | | | Base Process: | | |
| FPE (Step 1) | 0.5028 | 0.5028 > 0.4649 | FPE (Step 1) | 0.4216 | 0.4216 > 0.4205 | FPE (Step 1) | 0.1689 | 0.1689 < 0.1695 |
| FPE (Step 2) | 0.4649 | GNP ==> $M_1$ | FPE (Step 2) | 0.4205 | GNP ==> $M_2$ | FPE (Step 2) | 0.1695 | B ==> GNP |

found for the monetarist position concerning the causality in the money-income relationship. When the stock of money is approximated by either $M_1$ or $M_2$, the Keynesian position cannot be rejected. Both measures of money, $M_1$ and $M_2$ appear to be more endogenous.

One possible explanation of the above results can be found in economic theory itself. The theory suggests that because of its definition, monetary base or high-powered money is exogenously determined. Both components of the monetary base, currency and reserves, are under control of the Fed.[12] $M_1$, on the other hand, is defined as m . B, where B is the monetary base and m is the money multiplier. Several components of the money multiplier can be considered endogenous.[13] The same argument applies for $M_2$ and for $M_3$. Consequently, both theoretically and empirically, the resolution of the causality issue may hinge on which definition of the money stock is chosen.

## IV. Trivariate Analysis

The bivariate results reported provide useful information about the causality issue in the money-income relationship. In the case of monetary base, empirical evidence suggests a unidirectional causal flow from money to nominal income. However, the causality test procedures give no indication to what extent the monetary changes affect the two components of nominal income: price level and real income. Resolution of this issue necessitates empirically identifying the existence and strength of the causal flow from the monetary base to the price level and real output. This evidence can be obtained by employing a trivariate analysis of a simple kind.

The Granger method for testing causal relationships in bivariate contexts can be extended to multivariate formulations.[14] However, employing this method has two serious drawbacks. In the first place, the choice of the appropriate lag length presents a difficult problem, and, as previously explained, may seriously influence the test results. Second, degrees of freedom diminish rapidly as the lag length is increased. Both of these problems are overcome when the FPE procedure is used.

The trivariate results are reported in Table 4. The optimal specification of the real output equation (1) and the price level equation (2) are reported in Table 5. The format of the trivariate results reported in Table 4 is adopted from Hsiao (1981). The last two rows of this table enable us to draw inferences about the causal flow from the monetary base to the price level and the real output. There appears to be no evidence of a causal flow from the monetary base to the price level. Adding the lagged monetary base variable to the inflation equation does not reduce the FPE. In fact, the FPE increases from 0.1544 to 0.1569. On the other hand, adding the lagged monetary base variable to the real output equation decreases the FPE from 0.8329 to 0.7395. Interpreting these results is straightforward. The major impact of monetary changes on nominal income operates through an increase in real output and not through an increase in the price level.

Further statistical inferences can be made by analyzing the coefficients in equations (1) and (2) as reported in Table 5. The coefficient of the first lagged monetary base term in the real output equation is 0.52. One interpretation of this result is that the positive effect of the monetary base on real output is large and quite fast.

TABLE 4

Trivariate Results. Causality Testing by Computing Final Prediction Error of the Controlled Variable. Numbers in Parentheses are Lags for Minimum FPE

| Controlled Variable | First Manipulated Variable | Second Manipulated Variable | FPE x $10^{-4}$ |
|---|---|---|---|
| GNPR (3) | | | 0.9407 |
| B (11) | | | 0.1689 |
| CPI (9) | | | 0.1965 |
| GNPR (3) | CPI (3) | | 0.8329 |
| CPI (9) | GNPR (2) | | 0.1544 |
| GNPR (3) | CIP (3) | B (8) | 0.7395 |
| CPI (9) | GNPR (2) | B (1) | 0.1569 |

TABLE 5

Autoregressive Estimates of Equations (1) and (2)

| Equation 1 | | | | Equation 2 | | | |
|---|---|---|---|---|---|---|---|
| Statistics | | Lags | Coefficients (t-statistics) | Statistics | | Lags | Coefficients (t-statistics) |
| $R^2$ | 0.998867 | ln GNP (-1) | 1.021 | $R^2$ | 0.999929 | ln CPI (-1) | 1.529 |
| | | | (9.529) | | | | (14.675) |
| S.E. of | | (-2) | -0.095 | S.E. of | | (-2) | -0.770 |
| regression | 0.007986 | | (0.609) | regression | 0.00371 | | (-3.9591) |
| | | (-3) | -0.065 | | | (-3) | 0.905 |
| DW | 2.0263 | | (-0.6611) | DW | 1.868 | | (4.499) |
| | | | | | | (-4) | -0.660 |
| F | 4973 | | | F | 94142 | | (-3.121) |
| | | ln CPI (-1) | -0.419 | | | (-5) | 0.148 |
| | | | (-2.215) | | | | (0.699) |
| | | (-2) | 0.124 | | | (-6) | -0.358 |
| | | | (0.346) | | | | (-1.7691) |
| | | (-3) | 0.194 | | | (-7) | 0.010 |
| | | | (0.935) | | | | (0.0531) |
| | | | | | | (-8) | 0.030 |
| | | ln B (-1) | 0.521 | | | | (0.1361) |
| | | | (2.260) | | | (-9) | 0.152 |
| | | (-2) | -0.665 | | | | (1.442) |
| | | | (-1.722) | | | | |

TABLE 5. Continued

| Equation 1 | | | Equation 2 | | |
|---|---|---|---|---|---|
| Statistics | Lags | Coefficients (t-statistics) | Statistics | Lags | Coefficients (t-statistics) |
| | ln B (-3) | 0.704 | | ln GNPR (-1) | 0.172 |
| | | (1.728) | | | (3.328) |
| | (-4) | -0.651 | | (-2) | -0.166 |
| | | (-1.662) | | | (-3.444) |
| | (-5) | 0.634 | | | |
| | | (1.5791) | | ln B (-1) | 0.014 |
| | (-6) | -0.479 | | | (0.686) |
| | | (1.208) | | | |
| | (-7) | 0.186 | | | |
| | | (0.489) | | | |
| | (-8) | -0.099 | | | |
| | | (-0.424) | | | |

By the same token, the coefficient of the lagged monetary base term in the price level equation is negligibly small, approximately equalling to 0.01. Consequently, it appears that the effect of the monetary variable on the price level is also negligible.

## V. Concluding Remarks

The present study finds clear evidence of a causal flow from money (as approximated by the monetary base) to nominal income (measured by the nominal GNP). Utilizing the FPE causality test procedure, the monetary base is found to be supperior to either $M_1$ or $M_2$ as the measure of the money stock because of its unambiguous causal flow. This result supports the monetarist position on the causality in the money-income relationship. However, contrary to the monetarist position, changes in the monetary variable appear to affect the real output and not the price level. This evidence is consistent with the prevailing Keynesian view concerning the influence of money on the economy's real output.

The results of this study may have important implications for the economic policy decisions. One obvious interpretation of these results is that the economy's real output can be positively affected by increasing the money supply. Furthermore, this increase does not appear to lead to any substantial inflation. Instead, it appears to lead to a rapid increase in the economy's real output.

However, at this stage a word of caution is needed. The key qualification is the distinction between short-run versus long-run effects of monetary changes on the real output and the price level. The statistical methods used in this study do not allow any inferences to be

made about the short run versus the long run. Therefore, it conceivably could be argued that the empirical evidence presented in this study concerns the short-run situation only. In that sense the results would be consistent with both the monetarist and the Keynesian positions.[15] In this respect, further research into the short-run versus the long-run effects of monetary changes on the two components of nominal income would be desirable.

## Notes

1. The monetarist view is based, to a large extent, on the postulates of the Quantity Theory of Money. According to this theory, money has no lasting influence on any real variables in an economy. For a further explanation of this view, see Humphrey (1974) and others.

2. For a further theoretical discussion of this view and the distinction between the short-run and the long-run effects of monetary changes on an economy, see Makinen (1977, pp. 53-93).

3. Within the Keynesian framework changes in the stock of money affect the real sector of an economy via their effect on interest rates and investment. For a further discussion of this point, see Keynes (1936, p. 298).

4. The variables in the equation of exchange are: M--stock of money, V--velocity of money, P--price level, and Y--economy's output.

5. For a detailed discussion of this point, see Friedman (1970, 1971, and 1972), Tobin (1972), Patinkin (1972), and others.

6. Biswas and Saunders (1985) use the Granger causality test procedure to test the exogeneity of $M_1$, $M_2$, and the monetary base. The causality test results are directly dependent upon the arbitrary selection of the lag structure.

7. Hsiao (1981, pp. 90-91) outlines the causality implications of the FPE procedure.

8. This procedure is outlined in detail by Hsiao (1981, pp. 92-93).

9. Hsiao (1981, pp. 90-91) gives his three definitions of causality.

10. All the data used are seasonally adjusted at the source. However, the lag distributions used in this study are long enough to prevent any bias from the source to seriously affect the test results. Sims (1972, p. 546) offers a further explanation of this point.

11. For a further description of this procedure, see Hsiao (1981, pp. 92-93).

12. For a further discussion of the exogeneity issue and some empirical evidence, see Cagan (1965), Brunner and Meltzer (1964), and Fand (1970).

13. Siegel (1982, pp. 134-144) outlines in detail the money multiplier components.

14. For this type of a trivariate analysis, see Jarrett and Selody (1982, pp. 363-366).

15. According to monetarists, changes in the money supply can have a temporary effect on real output so long as the market participants do not correctly anticipate inflation. Consequently, in the short run, the Phillip's curve type of relationship is possible. See Friedman (1977).

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