Utah State University

DigitalCommons@USU

8-1-1987

An Empirical Investigation of the Effects of Monetary Changes on the U.K. Economy

Peter J. Saunders
Utah State University

Follow this and additional works at: https://digitalcommons.usu.edu/eri

Utah State University
MERRILL-CAZIER LIBRARY

August 1987   Study Paper #87-07

AN EMPIRICAL INVESTIGATION OF THE EFFECTS OF
MONETARY CHANGES ON THE U.K. ECONOMY

By

Peter J. Saunders

AN EMPIRICAL INVESTIGATION OF THE EFFECTS OF MONETARY CHANGES ON THE U.K. ECONOMY

by

Peter J. Saunders, Ph.D.*

*Assistant Professor, Department of Economics, Utah State University.

I. Introduction

Theoretical discussions involving the relationship between the money supply and an economy's output has dominated the field of monetary economics for many years. Theoretically, the resolution of two separate issues is crucial - (1) the question of causality in the money-income relationship and (2) the effects of monetary changes on the two components of nominal output; i.e., the price level and real output. Two major opposing views can readily be identified: the monetarist view and the keynesian view.[1] The monetarists' view is based on the postulates of the Quantity Theory of Money.[2] In their view, the money supply is exogenously determined. Furthermore, according to the monetarists, there exists a direct causal flow from money to nominal output.[3] Consequently, changes in the money supply dominate movements in nominal output. Some monetarists allow for a feedback from nominal output to the money supply, but even then, monetary changes are considered the major factors determining nominal output.[4]

Keynesians, on the other hand, assert that the money supply is endogenously determined. Proponents of the endogeneity theory claim that since the money supply is endogenously determined, the causal flow from money to nominal output cannot be established. According to their view, fluctuations in monetary growth result primarily from the behavior of the public and commercial banks and not from the actions of the monetary authority.[5] Consequently, the stock of money is demand determined, and nominal output is determined independently of it.

Theoretically, two closely related issues exist. The first deals with the question of causality in the money - income relationship. Once the causality issue is resolved, then there remains the crucial question of the

effects of monetary changes on the two components of nominal income, namely the price level and real output. Essentially, the key theoretical issue is whether changes in the money supply lead only to changes in the price level (the monetarist long-run position) or whether real output is permanently affected by changes in the money supply (keynesian position).[6]

Resolving these theoretical issues involves econometric testing of the causal flow in the money - income relationship. It also involves causality tests of the two components of nominal income. In this sense, the U.S. data has been thoroughly analyzed by many writers, most importantly by Granger (1969) and Sims (1972). More recent studies in this area have been carried out by Guilkey and Salemi (1982), Geweke, Meese, and Dent (1983), and Hsiao (1981, 1982), among others. Both the earlier work by Sims and the recent contributions of Guilkey and Salemi rely on an arbitrary choice of the lag structure in causality tests. Hsiao (1981) charges that the arbitrary lag selection method in causality testing may lead to unreliable test results because the distribution of test statistics may be sensitive to lag length.[7] This problem can be eliminated by using the minimum final prediction error (FPE) procedure in causality testing.

The United Kingdom data have been subjected to empirical examination by numerous writers. Initial causality tests of these data were conducted by Williams, Goodhart, and Gowland (1976). The authors find empirical evidence of causality running from nominal income to money as well as some evidence of a unidirectional causality from money to prices. Their results indicate the possibility of a simultaneous determination of money and income in the United Kingdom. Mills and Wood (1978) suggest that even though Williams' et al. results are inconsistent with the results reported by Sims (1972) for the U.S. economy, these results can be explained by the

fixed exchange rate policy followed by the U.K. authorities during the period under investigation.

A similar agrument to explain the different test results of the U.S. and the U.K. data is also used by Putnam and Wilford (1978). The authors attempt to tie together the findings of Sims (1972) for the United States and those of Williams et al. (1976). They claim that different causality results can be explained by the different roles played by the two countries under the Bretton Woods fixed exchange rate system. In particular, the ability of the reserve currency country to create international reserve assets can explain this result.

The above hypothesis, i.e., the hypothesis that the U.S. money supply affects U.K. income under the fixed exchange rate system is empirically tested by Mixon, Pratt, and Wallace (1979). Mixon et al. find little support for the hypothesis that the U.S. monetary policy had a direct impact on U.K. nominal income under the fixed exchange rate regime. This finding is in direct contrast to the results reported by Putnam and Wilford (1978) and those of Willims et al (1976). When testing for causality during the period of flexible exchange rates, Mixon et al. report a significant impact of the U.S. monetary policy on U.K. income.

Cuddington (1981) empirically examines the question of causality on the money - nominal income relationship in the United Kingdom. When testing for causality in this relationship, Cuddington relies on a four lag specification in the tests. Using this particular lag selection Cuddington finds statistically significant unidirectional causality running from the United Kingdom income to money. His results are in direct contrast to the results reported by Sims (1972) for the United States. At the same time they reinforce the results reported by Williams et al (1976).

Cuddington's (1981) results are supported by empirical evidence

presented by Sheehan (1983). When using M_1 as the measure of money, Sheehan finds a unidirectional causation from U.K. income to this measure of money. When the money supply is approximated by M_2, then a feedback relationship is established between U.K. money and income. Sheehan's results additionally indicate that the U.S. money causes both U.K. money and U.K. income.

Holly and Longbottom (1982) examine the causal empirical relationship between the price level and sterling M_3. The authors suggest that even though in some test cases empirical evidence of feedback from price to money exists, causality runs from past values of the money stock to prices. Furthermore, a proportional relationship is found to exist between the price level and the stock of money.

An interesting attempt to analyze the effects of monetary changes on prices and real output in the United Kingdom is undertaken by Mills (1980). The entire analysis is conducted within a bivariate system. Relying on an arbitrary lag selection in causality testing and choosing the four and the eight lag specifications, Mills tests the null hypotheses that money does not cause changes in nominal income, prices, or real output. These bivariate causality tests are, therefore, undertaken for several variables, such as the money supply and nominal income, the money supply and the price series, and the money supply and the real gross domestic product series.

Mills (1980) reports evidence of the causal relationship between M_1 and nominal gross domestic product (GDP). In fact, nominal GDP causes nominal M_1 while nominal M_3 and nominal GDP are found to be statistically independent. Regarding the causality of real gross domestic product (RGDP) and prices, nominal M_1 causes real GDP, and a feedback exists between nominal M_1 and the price component. Additionally, nominal M_3 causes real

GDP, and the price component causes nominal M_3. When real output is approximated by total final expenditures (TFE), nominal M_1 does not cause the TFE series while nominal M_3 does cause the TFE series.

On the whole, empirical testing of the U.K. data provides mixed and inconclusive evidence with respect to the money - income relationship. Consequently, further examination of this relationship can provide important information on this unresolved issue. The purpose of this study is to analyze the United Kingdom data for further empirical support of either the monetarist or keynesian position. The present study is designed to provide meaningful empirical evidence not only about causality in the money - income relationship, but also on the issue of the effects of monetary changes on the United Kingdom's price level and real output. Empirical evidence of this type can make a significant contribution towards resolving the above mentioned key economic theory issues, especially since many comparisons with the results obtained for the U.S. data are readily available. This evidence can also have important implications to economic policy issues.

This paper is divided into three major sections. Initially, the bivariate analysis is undertaken to gather further empirical evidence on the money - income relationship. For this purpose, both the arbitrary lag selection Granger causality method and the minimum FPE test procedure are used. An obvious advantage of using both of these test procedures lies in the fact that the causality test results so obtained can be readily compared. Consequently, the FPE test procedure can further strengthen the results obtained through the arbitrary lag selection method. The FPE causality test method is expanded to the trivariate analysis thereafter. The main purpose of this extension is to ascertain the impact of changes in the money supply on the two components of nominal income: the price level

and real output. Finally, overall conclusions of this study are reached in the last section of this paper.

II. The bivariate test procedures and the data

Many procedures exist for testing the direction of causality in bivariate contexts. Most of these procedures rely on the concept of causality outlined by Granger (1969).[8] Guilkey and Salemi (1982) compare the performance of various causality test procedures. In particular, they present their versions of three causality tests: the Granger test, the Sims test, and the modified Sims test.[9] The main objective of their study is to identify which test is best for the causal ordering of time-series in the Granger sense. The authors find the Granger and the modified Sims test [as developed by Geweke et al. (1983)] superior to the Sims test. However, the Granger test is recommended because of its computational simplicity and a lesser loss of degrees of freedom. Therefore, initially Granger's arbitrary lag selection causality testing method is adopted in the present study for investigating bivariate causal ordering between changes in the money supply and nominal income in the United Kingdom.

The test itself involves an OLS estimation of the following equation:

$$X_{1(t)} = \sum_{j=1}^{J} a_j X_{1(t-j)} + \sum_{j=1}^{J} b_j X_{2(t-j)} + \alpha + \beta \cdot t + U_t \quad (1)$$

Here X1 and X2 represent nominal income and the money stock respectively; t is a time-trend variable which purges X1 of trend-based nonstationarity. U_t is a stochastic term, and j indicates the lag length. The test of the null hypothesis that X2 does not cause X1 is the test that $b_j = 0$ for j = 1, 2, 3, ... , J. Potential problems of serial correlation in estimation of equation (1) are eliminated because of the inclusion of lagged dependent variables.

Equation (1) is estimated in both constrained and unconstrained forms. The test of no causality is based on the following statistics:

$$F = \frac{(SEE_c - SEE_u)/J}{SEE_u/[T - (2J + 2)]} \cdot$$

(2)

Here SEE_u and SEE_c are the residual sums of squares from the unconstrained and constrained regressions, T is the number of observations, and J indicates the number of lags. To test the hypothesis that X1 does not cause X2, the F-statistic is estimated while the roles of X1 and X2 are reversed. Within this test procedure the choice of J is arbitrary. In this study J is selected with 8 and 10 periods.

In the following calculations, X1 represents nominal gross domestic product (NGDP) with X2 representing the money supply. Three different measures of the money supply are used, namely the monetary base (the M0 series) and money stock sterling M1 and M3.[10] Quarterly data are used throughout all estimations. Quarterly data are more appropriate than any other shorter term data because changes in the money supply usually affect the economy with a lag of several quarters. The sample period under consideration is 1970-I to 1984-IV. All equations are estimated in the first differences of logarithms form.[11]

The causality test results are presented in Table 1. This table contains F-statistics for tests of the hypothesis of "no causality" from the money supply to nominal gross domestic product. It also includes critical F-statistics for both the five and the ten percent levels of significance. An insignificant F value implies that that the null hypothesis cannot be rejected. A large value of the F-statistic implies that the null hypothesis cannot be sustained.

Using M1 and M3 as the measures of money, it is clear that in no case

Table 1

Granger Causality Test Results for

Nominal GDP (NGDP), M_1, M_3, and the Monetary Base (BASE)

Levels of Significance:	Eight-Quarter F^a:	Lag: F^b:	Implications:	Ten-Quarter F^a:	Lag: F^b:	Implications
M_1 and NGDP at the 5% level of significance:	0.578	2.18	$M_1 \not\Rightarrow$ NGDP	0.555	2.16	$M_1 \not\Rightarrow$ NGDP
	1.577	2.18	NGDP $\not\Rightarrow M_1$	1.225	2.16	NGDP $\not\Rightarrow M_1$
M_1 and NGDP at the 1% level of significance:	0.578	2.99	$M_1 \not\Rightarrow$ NGDP	0.555	2.98	$M_1 \not\Rightarrow$ NGDP
	1.577	2.99	NGDP $\not\Rightarrow M_1$	1.225	2.98	NGDP $\not\Rightarrow M_1$
M_3 and NGDP at the 5% level of significance:	1.573	2.18	$M_3 \not\Rightarrow$ NGDP	1.33	2.16	$M_3 \not\Rightarrow$ NGDP
	0.664	2.18	NGDP $\not\Rightarrow M_3$	0.747	2.16	NGDP $\not\Rightarrow M_3$
M_3 and NGDP at the 1% level of significance:	1.573	2.99	$M_3 \not\Rightarrow$ NGDP	1.33	2.98	$M_3 \not\Rightarrow$ NGDP
	0.664	2.99	NGDP $\not\Rightarrow M_3$	0.747	2.98	NGDP $\not\Rightarrow M_3$
BASE and NGDP at the 5% level of significance:	2.75	2.18	BASE $\Rightarrow$ NGDP	2.17	2.16	BASE $\Rightarrow$ NGDP
	0.788	2.18	NGDP $\not\Rightarrow$ BASE	1.26	2.16	NGDP $\not\Rightarrow$ BASE
BASE and NGDP at the 1% level of significance:	2.75	2.99	BASE $\not\Rightarrow$ NGDP	2.17	2.98	BASE $\not\Rightarrow$ NGDP
	0.788	2.99	NGDP $\not\Rightarrow$ BASE	1.26	2.98	NGDP $\not\Rightarrow$ BASE

F^a is the F statistic for testing the null hypothesis that past values of the causal variable significantly do not affect current values of the affected variable.

F^b is the critical F statistic for the null hypothesis test.

can the hypothesis that there exists no causal flow from the money supply to nominal output be rejected at any reasonable level of significance. Similarly, there appears to be no empirical evidence of a causal flow from nominal GDP to the money supply. Consequently, these monetary variables and the nominal GDP are found to be statistically independent. This result holds for J = 8 as well as J = 10. Therefore, it appears that the keynesian position of endogeneity with respect to determining the money supply is sustained when either M1 or M3 is used as the measure of the money supply. In other words, the causality tests suggest that there are other factors determining both the money supply (as approximated by M1 and M3) and the nominal GDP, and that consequently these two variables are determined independently of one another.

However, when the money supply is approximated by the monetary base, it appears that a direct causal relationship between the monetary base and nominal GDP can be established. It is clear from Table 1 that the hypothesis of no causal flow from the monetary base to nominal GDP cannot be sustained at the conventional five percent level of significance, with J = 8 and J =10. At the same time, the null hypothesis of no causal flow from the nominal GDP to the monetary base cannot be rejected at the five percent level of significance. These results clearly indicate that a unidirectional causality exists between the monetary base and nominal GDP. Consequently, using the monetary base as the measure of the money supply, the monetarists' position with respect to causality in the money - income relationship is supported.

These results may be explained by considering the changes that took place in the British economy since the early 1970s. These changes include the widespread adoption of flexible exchange rates in the United Kingdom

and the change in the Bank of England's direction of the control of the money supply. This change of economic circumstances may explain the causality results involving the monetary base and nominal gross domestic product which are reported in the bivariate analysis above and the subsequent trivariate analysis.

Having established a causal relationship between the monetary base and nominal GDP, it may be of interest to make a judgement regarding the size of the impact of money (as approximated by the monetary base) on nominal GDP. Since there seems to exist a unidirectional causal flow from the monetary base to the nominal GDP with no significant feedback, an indication of the magnitude of the effect of the monetary base on nominal GDP can be obtained from the sum of the lagged monetary term coefficients in equations (1) and (1a), where $X1$ stands for nominal GDP and $X2$ is the monetary base.[12]

Empirical results of estimating equations (1) and (1a) are presented in Table 2. The sum of the eight lagged monetary base term coefficients in equation (1) is 1.412; the sum of the same terms in equation (1a) equals 1.841. Although these numbers should be interpreted with caution, they imply that changes in the monetary base have a large positive impact on nominal GDP. Examining the size of individual lagged coefficients of the monetary base variable can indicate the magnitude of the impact of the monetary variable on the nominal GDP in each quarter. Although this impact appears negligible in the first quarter, it becomes significant from the second quarter onwards. It is strongest in the eighth quarter in both equations (1) and (1a). From a policy point of view, these results imply an approximately two-year lag to the fullest impact of monetary policy on

TABLE 2

Autoregressive Estimates of Equations (1) and (1a)*

Equation 1				Equation 1a			
Statistics		Lags	Coefficients (t-statistics)	Statistics		Lags	Coefficients (t-statistics)
R^2	0.541	GNP (-1)	-0.060 (-0.407)	R^2	0.589	GNP (-1)	-0.066 (-0.372)
S.E. of regression	0.018	(-2)	-0.022 (-0.147)	S.E. of regression	0.018	(-2)	-0.129 (-0.735)
DW	2.005	(-3)	0.017 (0.121)	DW	1.992	(-3)	-0.016 (-0.101)
F	2.494	(-4)	-0.194 (-1.358)	F	2.049	(-4)	-0.209 (-1.336)
		(-5)	-0.156 (-1.076)			(-5)	-0.213 (-1.383)
		(-6)	0.157 (1.070)			(-6)	0.188 (1.154)
		(-7)	-0.156 (-1.050)			(-7)	-0.232 (-1.414)
		(-8)	-0.182 (-1.251)			(-8)	-0.218 (-1.338)
		BASE (-1)	0.001 (0.003)			(-9)	-0.111 (-0.685)
		(-2)	0.345 (1.477)			(-10)	-0.067 (-0.418)
		(-3)	0.215 (0.911)			BASE (-1)	0.119 (0.392)
		(-4)	-0.263 (-1.118)			(-2)	0.165 (0.533)
		(-5)	0.127 (0.536)			(-3)	0.257 (0.879)
		(-6)	0.285 (1.201)			(-4)	-0.238 (-0.945)
		(-7)	0.013 (0.056)			(-5)	0.121 (0.478)
		(-8)	0.689 (2.926)			(-6)	0.285 (1.126)
						(-7)	0.081 (0.314)
						(-8)	0.693 (2.616)
						(-9)	-0.043 (-0.154)
						(-10)	0.401 (1.459)

* Single & double digit numbers in parentheses indicate number of lags of manipulated variables, other numbers in parentheses are t-statistics

nominal output. As such, these results are consistent with the results of other empirical studies conducted with the U.K. data.[13]

The Granger method for testing causal ordering in finite samples relying on an arbirtary lag selection in causality test procedures can provide important empirical information about the causal relationships under investigation. However, test results so obtained may be influenced by the arbitrary lag selection method, as the distribution of the test statistics may be sensitive to the lag selection itself. As previously mentioned, Hsiao (1981, 1982) outlines a method of causality testing in which the problem of lag length selection is alleviated considerably. Hsiao's causality test procedure is used to supplement the arbitrary lag selection test results reported in Table 1.

Hsiao's (1981) procedure combines the minimum final prediction error (FPE) criterion developed by Akaike (1969a, b) with Granger's definition of causality. The minimum final prediction error (FPE) can be computed 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. The procedure involves several statistical steps in the estimation process. Using the Granger causality concept, Hsiao outlines three possible outcomes in causality testing. Given two variables X1 and X2, X1 is said to cause X2 if the prediction of X2 using past values of X1 is more accurate than without using past values of X1. Feedback occurs if X1 causes X2 and X2 causes X1. Finally, X1 and X2 can be statistically independent. This happens if X1 does not cause X2, and X2 does not cause X1.[14]

Hsiao's (1981) causality test procedure is implemented by searching for the optimal lag over the past ten quarters in each test equation. The minimum final prediction error (FPE) criterion is used in each case to

determine the optimum lag. Using the first definition of causality (later referred to as step 1), the nominal GDP (NGDP) is treated as a one-dimensional autoregressive process. The minimum FPE is then computed by varying the maximum order of lags from one to ten. Once the lag operator for the NGDP is set, it is assumed that the monetary base (BASE) is the manipulated variable controlling the outcome of the NGDP. The minimum FPE criterion is then used to determine the lag order of BASE (step 2), holding the order of the lag operator on the NGDP constant. The next stage involves comparing the smallest FPEs of steps 1 and 2. If the FPE obtained from step 1 exceeds the FPE resulting from step 2, then the BASE causes the NGDP. If the opposite is true, then the BASE does not cause the NGDP. This entire procedure is repeated using the BASE as the initial variable. Overall causality inferences are made on the basis of the causality results for both of the above described processes.[15]

The bivariate FPE method causality test results are reported in section I of Table 3. These results support the conclusions suggested by Table 1. There is no evidence of any significant causal flow from the NGDP to the BASE. At the same time, it is obvious that the BASE has a significant causal impact on the NGDP. Consequently, using the minimum FPE causality testing procedure and thus avoiding statistical problems associated with an arbitrary lag selection, a unidirectional causal flow is established from the BASE to the NGDP with no feedback. Furthermore, this result is consistent with the findings of the arbitrary lag selection procedure reported previously. Using the BASE as the measure of money, the FPE causality test method results seem to support the monetarist position regarding the causality issue in the money - income relationship.

III. The trivariate analysis

The bivariate test results provide important information about the

Table 3

Causality Testing by Computing Final Prediction Error (FPE)
of the Controlled Variables:
U.K. Data from 1970I - 1984IV*

Equation	Controlled Variable	First Manipulated Variable	Second Manipulated Variable	FPE x 10^{-3}
	I. Bivariate Results			
3	NGDP (3)			0.4221
4	BASE (8)			0.1331
5	NGDP (3)	BASE (2)		0.4151
6	BASE (8)	NGDP (1)		0.1358
	II. Trivariate Results			
7	RGDP (1)			0.2392
8	CPI (1)			0.1260
9	RGDP (1)	CPI (1)		0.2403
10	CPI (1)	RGDP (9)		0.1118
11	RGDP (1)	CPI (1)	BASE (1)	0.2471
12	CPI (1)	RGDP (9)	BASE (2)	0.1086

* Numbers in parentheses are lags for minimum FPE

causality issue in the money - income relationship in the United Kingdom. When the money supply is approximated by the monetary base, empirical evidence points to a unidirectional causal flow from the BASE to the NGDP. However, this causality test gives no indication to what extent the monetary changes affect the two components of the NGDP: the price level and real output. Resolving this issue is crucial, not only from a theoretical standpoint, but also from the policy point of view. This issue can be resolved by empirically identifying the existence and strength of the causal flow from the monetary base to the price level and real output. Such evidence can be obtained by employing a trivariate analysis of the data.

Although extending the arbitrary lag selection causality testing method to multivariate formulations is possible, this method suffers two serious problems. The first concerns the difficulty involving the arbitrary lag selection. In addition, the degrees of freedom tend to get exhausted very quickly as the lag length is increased. This presents a formidable problem, especially in cases where the sample size is relatively small. Both of the above mentioned shortcomings are alleviated when the minimum FPE causality method is used in the trivariate context. Consequently, this method is used for the subsequent trivariate analysis.

The trivariate analysis is essentially an expansion of the minimum FPE bivariate tests to a trivariate format. This format requires the inclusion of additional test variables. The purpose of the trivariate analysis is to identify the causal flow from the BASE to the price level and real output. Therefore, it is necessary to include two additional test variables, one approximating real output, the other measuring the price level changes. The choice of the real output variable is readily available, as real output can be measured by the real gross domestic product (RGDP). This choice is

consistent with existing economic theory and with the bivariate causality analysis previously outlined. Consequently, the RGDP is used throughout the trivariate analysis.

Several possible measures of inflation exist. The two most commonly used measures of inflation are undoubtedly the percentage change in the consumer price index (CPI) and the percentage change in the GDP deflator. Even though it is an obvious measure of inflation, the percentage change in the GDP deflator may not be appropriate because it is also used in computing the RGDP. Therefore, in this case it may be more appropriate to use a measure of inflation constructed independently of the calculations of real output. Since the CPI provides a reasonable alternative to the GDP deflator, it is used within the trivariate analysis as the measure of inflation.

Section II in Table 3 contains the main trivariate results. The format of reporting these results is adopted from Hsiao (1981). The last two rows of this table provide information on which inferences about the causal flow from the BASE to the RGDP and the CPI can be made. There appears no empirical evidence of a causal flow from the monetary base to the real gross domestic product. An addition of the lagged monetary base to the real output equation (11) does not reduce the FPE. In fact, the FPE is increased from 0.2403 to 0.2471. However, an addition of the lagged monetary base term to the inflation equation (12), an equation with lagged CPI and RGDP terms, reduces the FPE from 0.1118 to 0.1086. These results imply that the major impact of monetary changes on nominal output operates through an increase in inflation and not through an increase in real output. Empirically, the results support the monetarists' long-run position with respect to the effects of monetary changes on the price level and real output.

An indication of the magnitude of the effects of monetary changes on both components of nominal output is given by the values of the lagged coefficients of the monetary base terms in equation (12), as reported in Table 4. The sum of the coefficients of the lagged monetary term in equation (12) is + 0.287. This number suggests that the impact of the monetary base on inflation is positive and substantial. This result is consistent with current economic theory.

IV. Overall conclusions

This study investigates Granger-causal ordering with respect to two important variables, namely the money supply and nominal output. For this purpose, two different causality test procedures are used, the Guilkey and Salemi (1982) test method and Hsiao's (1981) minimum FPE causality test method. Both procedures seem to have a greater appeal than most other causality test methods. The analysis is confined to the United Kingdom quarterly data, ranging from the first quarter of 1970 to the fourth quarter of 1984. The basic motivation is to gather empirical evidence on two closely related issues: (1) testing causality in the money - income relationship, and (2) analyzing the effects of monetary changes on the two components of nominal income: the price level and real output.

The bivariate test results indicate a causal flow from money (as approximated by the monetary base) to nominal output (measured by nominal GDP). At the same time no empirical evidence of a causal flow from nominal income to any of the three measures of money is discovered. These results are in direct contrast to the results reported by Willims et al. (1976), Mills (1980), Cuddington (1981), and Sheehan (1983). However, they are consistent with Sim's (1972) findings for the U.S. economy. As such the present study's results support the monetarists' position on the causality

Table 4

Trivariate Results of Autoregressive Estimates

of Equation (12)*

Statistics		Lags		Coefficients (t-statistics)
R^2	0.732	CPI	(-1)	0.639 (5.623)
S.E. of regression	0.009	RGDP	(-1)	0.104 (1.035)
			(-2)	-0.292 (-3.336)
DW	1.987		(-3)	0.185 (1.877)
F	9.118		(-4)	-0.045 (-0.523)
			(-5)	0.104 (1.192)
			(-6)	-0.216 (-2.570)
			(-7)	0.152 (1.703)
			(-8)	0.130 (1.397)
			(-9)	0.122 (1.230)
		BASE	(-1)	0.035 (0.249)
			(-2)	0.252 (1.884)

* Single digit numbers in parentheses indicate number of lags of manipulated variables.

issue in the money - income relationship in the United Kingdom. However, when the money supply is approximated by either M1 or M3, these two measures of money and nominal GDP are statistically independent. Consequently, using these two measures of money, the keynesian position cannot be rejected. Therefore, both theoretically and empirically, the resolution of the causality issue in the money - income relationship in the United Kingdom may well hinge on which definition of the money stock is chosen.

An important contribution of this study is contained within its trivariate analysis. The novelty of it lies not only in the FPE causality testing method, but also in its emphasis on establishing a causal flow from the monetary variable to both the price level and real output. Although numerous empirical studies provide useful information about the role of money as a causal force in determining nominal output, the resolution of the issue of the effects of monetary changes on the two components of nominal income is perhaps of even greater importance. The essential issue is whether changes in the money supply, undertaken in less-than-full employment conditions (such as was the case of the United Kingdom economy between 1970 and 1984), can lead to real output changes (keynesian position), or whether these changes lead only to price-level changes (monetarists' long-run position).

The results of the trivariate analysis are crucially important. They indicate that contrary to conventional economic wisdom, monetary changes appear to have no impact on the real output of the United Kingdom economy, even though unemployment conditions prevailed throughout the period under investigation. The trivariate analysis based upon Hsiao's (1981) causality testing procedure indicates that the main causal impact of money on nominal income operates through an acceleration of inflation, and not through

increases in the United Kingdom economy's real output. Furthermore, this impact is positive and substantial.

As in the bivariate case, the trivariate results are in variance with the results presented by Mills (1980). Mills reports a causal impact of nominal M_1 on real GDP as well as an impact of M_3 on the total final expenditures. The present study indicates that changes in the nominal stock of money (as approximated by the monetary base) have no measurable impact on real economic variables (as approximated by real GDP). The impact is only on the price level. One possible explanation of these differing results may lie in the causality testing method used for analyzing the data. As previously explained, the arbitrary lag selection method may yield inconsistent results.

The results of this study may have important implications for economic policy decisions. If these causal relations are accepted, then they throw considerable doubt on the conventional wisdom concerning the objectives of monetary policy. One obvious interpretation of these results is that the United Kingdom economy's real output cannot be positively affected by increasing the money supply. Therefore, an expansionary monetary policy is ineffective in increasing real output and/or reducing unemployment. On the other hand, an expansionary monetary policy will lead to substantial inflation.

Notes

1. The origins of the exogeneity of money debate date to the 18th century Bullionist controversy and the Currency-Banking School debate of the 19th century. These issues are discussed in greater detail in Humphrey (1974), Makinen (1977), Becker and Baumol (1952), and others.

2. For an excellent discussion of the postulates of the Quantity Theory of Money, see Humphrey (1974).

3. For a thorough discussion of these views, see Friedman (1970, and 1972), Patinkin (1972), and Tobin (1972).

4. A detailed discussion of this view is outlined in Friedman and Schwartz's (1963) work.

5. Earlier writings on this subject can be found in the Radcliffe Report (1959) and in Gurley's (1960) paper. Further explanation of this view is outlined by Gramley and Chase (1965), Kareken (1967), Davis (1968), and many others.

6. For a detailed discussion of this point, see Friedman (1970, 1971, and 1972), and many others.

7. For a further discussion of this point, see Hsiao (1981, pp. 85 - 87).

8. There exist three possible outcomes in causality testing. X2 is said to cause X1 if the predictions of X1 using past values of X2 are more accurate than without using past values of X2. Feedback occurs if X1 causes X2, and X2 causes X1. Finally, X2 and X1 can be statistically independent.

9. For exact specification of these tests, see Guilkey and Salemi (1982, pp. 669 - 670).

10. All the above data are seasonally adjusted. However, the lag distributions used in this study are long enough to prevent any bias from the source to seriously affect the test results. For a further discussion of this point, see Sims (1972, p. 546). The monetary base series, unlike other U.K. monetary series, has not been subject to frequent revisions. The M3 series does not include public sector deposits and, therefore, it conforms with the present definition of the targeted aggregate.

11. The first differences of logarithms form of estimation should be helpful with respect to the stationarity of the time-series variables used in the test procedures. Furthermore, the trend variable should also help to alleviate this problem.

12. In equation (1) j = 8, and in equation (1a) j = 10.

13. Holly and Longbottom (1982) report a two and half to four year

impact lag of monetary policy on prices.

14. For a further discussion of definitions of causality, see Hsiao
    (1981, pp. 90 - 91).

15. More detailed explanation of Hsiao's test method is omitted to
    save space. The intrested reader is referred to Hsiao (1981, pp.
    88 - 93).

References

Akaike, H. 1969a. Statistical predicator identification. **Annals of the Institute of Statistical Mathematics** 21.

--------. 1969b. Fitting autoregressions for prediction. **Annals of the Institute of Statistical Mathematics** 21.

Becker, G. S., and Baumol, W.J. 1952. The classical monetary policy: The outcome of the discussion. **Economica** (November).

Committee on the Working of the Monetary System. 1959. **Report.** (Chairman: The Rt. Hon. Lord Radcliffe, G.B.E.). London.

Cuddington, J. T. 1981. Money, income, and causality in the United Kingdom. **Journal of Money, Credit, and Banking** 13.

Davis, R.G. 1968. The role of the money supply in business cycles. **Monthly Review** (April). Federal Reserve Bank of New York.

Friedman, M. 1970. A theoretical framework for monetary analysis. **Journal of Political Economy** 78(2, March/April).

--------. 1971. A monetary theory of nominal income. **Journal of Political Economy** 79(2, March/April).

--------. 1972. Comments on critics. **Journal of Political Economy** 80(5, September/October).

Friedman, M., and Schwartz, A. 1963. Money and business cycles. **Review of Economics and Statistics** 45(Supplement).

Geweke, J.; Meese, J.; and Dent, W.T. 1983. Comparing alternative tests of causality in temporal systems: Analytical results and experimental evidence. **Journal of Econometrics** 21(February).

Gramley, L., and Chase, S. 1965. Time deposits in monetary analysis. **Federal Reserve Bulletin** (October).

Granger, C.W.J. 1969. Investigating causal relationships by econometric models and cross-spectral methods. **Econometrica** 37(3, July).

Guilkey, D.K., and Salemi, M.K. 1982. Small sample properties of three tests for Granger-causal ordering in a bivariate stochastic system. **Review of Economics and Statistics** 64(November).

Gurley, J.G. 1960. The Radcliffe report and evidence: A review article. **American Economic Review** 50(4, September).

Holly, S., and Longbottom, J. A. 1982. The empirical relationship between the money stock and the price level in the UK: A test of causality. **Bulletin of Economic Research** 34.

Hsiao, C. 1981. Autoregressive modeling and money-income causality detection. **Journal of Monetary Economics** 7.

———. 1982. Autoregressive modeling and causal ordering of economic variables. **Journal of Economic Dynamics and Control** 4.

Humphrey, T.M. 1974. The quantity theory of money: Its historical evolution and role in policy debates. **Economic Review** (May/June). Federal Reserve Bank of Richmond.

Kareken, H. 1967. Commercial banks and the supply of money: A market determined demand deposit rate. **Federal Reserve Bulletin** (October).

Makinen, G.E. 1977. **Money, the price level, and interest rates: An introduction to monetary theory.** New Jersey: Prentice-Hall, Inc.

Mills, T.C. 1980. Money, income and causality in the U.K. - A look at the recent evidence. **Bulletin of Economic Research** 32.

Mills, T.C., and Wood, G.E. 1978. Money-income relationship and the exchange rate regime. **Bulletin of the Federal Reserve Bank of St. Louis** 60.

Mixon, J., Pratt, L.J., and Wallace, M.S. 1979. Cross-national money to income causality. **Journal of Money, Credit, and Banking** 11.

Patinkin, D. 1972. Friedman on quantity theory of money. **Journal of Political Economy** 80(5, September/October).

Putnam, B.H., and Wilford, D.S. 1978. Money, income, and causality in the United States and the United Kingdom: A theoretical explanation of different findings. **American Economic Review** 68.

Sheehan, R.G. 1983. Money-income causality: Results for six countries. **Journal of Macroeconomics** 5.

Sims, C.A. 1972. Money, income, and causality. **American Economic Review** 62.

Tobin, J. 1972. Friedman's theoretical framework. **Journal of Political Economy** 80(5, September/October).

Williams, D., Goodhart, C.A.E., and Gowland, D.H. 1976. Money, income, and causality: The U.K. experience. **American Economic Review** 66.