CAUSALITY BETWEEN MONEY AND THE INDEX OF INDUSTRIAL PRODUCTION IN THE GREEK ECONOMY

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1. INTRODUCTION

The purpose of this study is to examine and report the results of an empirical test for determining the direction of causality between the stock of money and the Index of Industrial Production (IP) for the Greek economy.

Monetary economists emphasize the importance of disturbances arising from autonomous shifts in the supply of money function. They believe that the money supply plays a central role in determining the level of economic activity. Milton Friedman «has stated that the direction of causality runs from money to IP and not the other way around [1]».

Given the fact that IP is a main economic indicator, testing the hypothesis that unidirectional pattern of causation runs from the money stock to IP, it can provide empirical evidence for the monetarist view which could have important implications for the conduct of monetary policy. The test is based upon the notion of causality suggested by Granger and applied by Sims to the money-income relationship. Using this test, the direction of regression can also be found by testing the assumption that the right hand side variable is exogenous in a time-series regression.

1. Milton, Friedman (1969) «The Monetary Studies of the National Bureau», The Optimum Quantity of Money and other Essays (Chicago) pg. 280 - 3.

2. TESTING OF THE DIRECTION OF CAUSALITY

C. W. J. Granger defined causality in terms of predictability : «A time series Xt causes another time series Yt, with respect to a given universe of information set that includes Xt and Yt, if present Y_t can be better predicted by using past values of X than by not doing so, all other information contained in the past of the universe being used in either case»[2]. Christopher A. Sims gave content to Granger's definitions by assuming all time series to be jointly covariance stationary, by considering only linear predictors and by taking expected squared forcast error as the criterion for predictive accuracy. He developed and proved two theorems showing that even one can always estimate a regression of Yt on current and past Xt, only in the special case in which causality runs from Xt to Yt can one expect that no future values of Xt would enter the regression which are allowed. Hence one has a practical statistical test for unidirectional causality : Regress Yt on past and future values of Xt, taking account by generalized least squares or prefiltering of the serial correlation in the error term. Then if causality runs from Xt to Yt only, future values of Xt, in the regression should have coefficients insignificantly different from zero as a group.

Sims estimates a regression of the form :

$$Y_t = K + \sum_{i=-n_1}^{n_2} a_i X_{t-i} + n_t$$

Where K is a constant and Xt is serially unocorrelated with nt. Sim's choice of ni and n_2 is 4 and 8 respectively. If the future coefficients, $a_{i}; -n_1 < i < -1$, are not significant as a group, then Yt is said not to cfuse Xt. Reversing dependent and independent variables indicates if Xt is a causal factor of Yt.

Two conditions are necessary for this test to be valid. The first is the normal regression requirement that nt be white noise, serially uncorrelated, which is the condition that E (nt n_t-j) = 0 for all j 0. The second condition is that Y_t and Xt be covariance - stationary, which is the condition that, for example, cov (Xt Xt-j) be a function of the time interval j and not a function of time itself.[3].

2. C.W.J. Granger, «Investigating Causal Relations by Econometric Models and Cross-Spectral Methods», Econometrics, 1969, 37, 424-38.

3. Auerbach, Robert D. and Ruther Jack L. (1978) «A causality test of Canadian Money and Income : a comment on Berth and Bennett». Canadian Journal of Economics 11, pg. 584.

In this kind of analysis in which the fairly precise use of F-tests is required on groups of coefficients, it is important that the assumption of serially uncorrelated residuals be approximately accurate. Therefore, all variables used in regressions are measured as the natural logarithms and the data are transformed by a common filter, the purpose of which is to remove serial correlation in the residuals of a two - sided regression of Yt on Xt.

Sim's filter has the following form : Define Yt as the unfiltered analogue of the time series of Y_t then Y_t = (1 - 0.75L)2 ln Y_t = (1 - 1.5L + 0.5625L2) In Y_t

where L = Zt-j, or equivalently, each logged variable Y (t) was replaced

by Y(t)-1.5Y(t- 1)+ .5625Y (t-2). This filter is a particular case of a class of polynomial filters which employs non - negative powers of the log operator L,

where the polynomial has the form $B(L) = \sum_{i=0}^{s} \beta_i L^i$ with the value of s being either

predetermined or determined from the data, of course, $\beta_0 = 1$. One may choose to filter either the original data or, if they are growing expotentially, their logarithmic transformation as Sims did. The hope is that the regression residuals would be very nearly white noise with this prefiltering.

If the filter fails to produce white noise residuals, it is unlikely to fail by leaving substantial positive first - order serial correlation. Durbin - Watson statistics are therefore of little use in testing for the lack of serial correlation and are close to two because of the prefiltering.

A chi - square test can be used from Box and Pierce (1971) for testing jointly 1 to m order autocorrelations of the residuals of the form :

$$X^2 \ (m) = P\,(P+2) \sum_{j=1}^{m} r_j^2 \,/\, (P-j)$$

where P is the number of observations of the regression, rj is the jth autocorre-

lation of the residuals $r_j = \dfrac{Cov(n_t\ n_{t-j})}{V(n)}$ and m is an arbitrary truncation point.

X^2 (m) is a chi- square statistic with m degrees of freedom. The hypothesis in

this test is that the n_t are not autocorrelated, and it is rejected if X^2 (m) > X^2 (m), where a = 0.95. The lower X^2 (m), the more certain is it that the h_t are random. Sims says that in applying the F-tests for causal direction, the absolute size of the coefficients is important regardless of the F value. It is a truism often ingnored that coefficients are «large,» from the economic point of view, they should not be causally set to zero no matter how statistically «insignificant» they are. Thus the fact that future values of the independent variable have coefficients insignificantly different from zero only shows that unidirectional causality is possible. If the estimated coefficients on future values are as large as or larger than those on past values, bidirectional causality may be very important in practice, despite insignificant Fs. Moreover, small coefficients on future values of the independent variable may sometimes be safely ignored even they are statistically significant[4].

3. APPLICATION OF THE TEST

To apply the test, quarterly data were obtained from the International Monetary Fund for both money and the index of Industrial Production for the Greek economy.

The data used in the regressions cover the period 1971 : Q_1 through 1981 : Q_4.

Two measures of the money stock a) a narrow measure Ml (currency plus demand deposits) and b) a broader measure M2 (Ml plus personal savings deposits at the chartered banks) and the 1975 Base index of industrial production were used.

To test for causality between Ml (M2) and IP, four regressions were required :

1) Ml (M2) was regressed on current and eight past or lagged values of IP ;
2) Ml (M2) was regressed on current IP, eight lagged values of IP and four future values of IP ;
3) IP was regressed on current and eight past values of M1(M2) and ;
4) IP was regressed on current Ml (M2) and four future values of Ml (M2).

4. Christopher A. Sims : «Money, Income and Causality». American Economic Review, pg. 540-52.

It should be noted that two observations were lost in the transformation of the variables using the filter as it was described above. Eight more transormed observations were also dropped in order to accommodate the eight past lags.

Therefore the above four regressions begin in 1973 third quarter. In order also to allow for the four future values, the regression runs on the past only equations 1 and 3 ended in 1980 fourth quarter, but the other two regressions 2 and 4, which included the future, ended in 1981 fourth quarter.

Taking into account the number of parameters estimated there were 20 degrees of freedom for the regressions that contained the current and eight past variables and 16 degrees of freedom for the regressions which also included the four fu-four future variables as regressors.

Table 1 contains a summary of the eight regressions. With the exception of regressions 5 and 6 which are significatnt at both 1 % and 5 % levels, all other regressions are not statistically significant. The regressions also using M2 yield somewhat higher R_s^2 than those for M1.

TABLE 1

SUMMARY OF THE EIGHT OLS REGRESSIONS

	F–Test for Independent Variables	R^2	Standard Error of Estimate	Degrees of Freedom
M1 = f (IP, 8 past lags)	2.02024	0.476195	0.00584	20
M1 = f (IP, 4 future, 8 past lags)	1.90029	0.606917	0.00548	16
IP = f (M1, 8 past lags)	1.09202	0.3295	0.00165	20
IP = f (M1, 4 future, 8 past lags)	1.07353	0.4659	0.00147	16
M2 = f (IP, 8 past lags)	6.44728*	0.743674	0.00154	20
M2 = f (IP, 4 future, 8 past lags)	7.00333*	0.850528	0.00112	16
IP = f (M2, 8 past lags)	1.7346	0.438382	0.00138	20
IP = f (M2, 4 future, 8 past lags)	1.0977	0.471425	0.01629	16

* Significant at 1 % and 5 % levels.

The F – tests are for the H_0 : all right – hand side variables have zero coefficients.

The results of the F-tests for the significance of the coefficients of the four future variables for each of the regressions are shown in Table 2. It is apparent from the first two lines of the table that future values of IP are insignificantly different from zero in explaining movements in Ml and similarly, future values u of Ml are insignificant in the explanation of IP.

TABLE 2

F — TESTS ON FOUR FUTURE VARIABLES COEFFICIENTS

Regression Equation	F (4,16)	Causal Pattern
M1 on Industrial Production	1.33	IP → M1
Industrial Production on M1	1.02	M1 → IP
M2 on Industrial Production	2.86	IP → M2
Industrial Production on M2	.250	M2 → IP

5 Percent significance level 3.01

The assumption also that coefficients on future lags are small and coefficients on past lags are non zero and fairly smooth is not verified as Table 3 indicates.

These findings are inconsistent with a unidirectional causal link running from Ml to IP without feedback.

However, the future lags for M2 on IP are almost significant at the 5 percent level as a group in explaining the variation in M2 whereas those for IP on M2 are definitely non-significant. This suggests at least the possibility of unidirectional causality from M2 to IP. The coefficients of the regressions for M2 on IP and IP on M2 are given in Table 4. All X^2 statistics are acceptable indicating that the Sims filter was successful in producing «white noise» residuals in all cases. This means that all the F-statistics can be accepted as reliable.

TABLE 3

LAG DISTRIBUTION FROM THE REGRESSION

Coefficient on Lag of :	M1 on IP Past only	M1 on IP with future	IP on M1 Past only	IP in M1 with future
–4	–	0.762	–	–0.027
–3	–	0.099	–	0.229
–2	–	0.961	–	0.488
–1	–	0.593	–	0.155
0	–0.051	0.397	0.093	0.081
1	–0.439	–0.415	0.293	0.302
2	0.748	0.598	0.107	–0.044
3	0.229	0.154	–0.113	–0.312
4	0.613	0.299	0.054	0.007
5	–0.039	0.075	–0.152	–0.373
6	1.155	0.839	0.011	–0.293
7	0.900	0.785	0.009	0.023
8	0.549	0.464	–0.069	0.001
Standard Errors of Coefficients :				
Largest s.e.	0.508	0.539	0.205	0.405
Smallest s.e.	0.428	0.425	0.171	0.245
Sum of Coefficients	3.665	5.611	0.233	0.237
DW	2.764	2.663	2.517	2.627
X^2	5.41	3.70	3.83	7.89

TABLE 4

LAG DISTRIBUTION FROM THE REGRESSION

Coefficient on Lag of :	M2 on IP Past only	M2 on IP with future	IP on M2 Past only	IP on M2 with future
4	–	0.307	–	0.182
–3	–	–0.028	–	0.201
–2	–	0.700	–	0.024
–1	–	0.167	–	0.169
0	0.444	0.714	–0.236	–0.098
1	0.052	–0.015	–0.323	–0.238
2	0.742	0.675	–0.087	–0.063
3	0.151	0.099	–0.370	–0.497
4	0.865	0.714	0.232	–0.005
5	–0.323	–0.239	0.613	0.359
6	1.133	0.884	0.182	0.113
7	0.179	0.228	0.069	0.008
8	0.360	0.272	0.111	0.055
Standard Errors of Coefficients :				
Largest s.e.	0.297	0.294	0.465	0.574
Smallest s.e.	0.219	0.192	0.297	0.339
Sum of Coefficient	3.603	4.478	0.192	0.21
DW	2.538	2.322	2.419	2.263
X^2	2.74	1.04	2.89	1.58

4. CONCLUSION

The evidence indicating the direction of causality between money stock and Industrial production in the Greek economy is not quite clear. The results of this test indicated that there is some evidence of unidirectional causality running from M2 to IP. Hence Industrial production (an index of real output of the Greek economy) is determined by M2. This supports partly Friedman's belief as previously mentioned. Since there is no evidence of unidirectional causality running from Ml to IP still feedback exists.

This evidence suggests, perhaps, a more complicated causal relationship between money and industrial production in which both are determined simultaneusly.

Also the direction of regression is not clearly determined. It means that one can estimate a demand for money relation from these data, treating IP as exogenous with money Ml on the lefthand side and vice-versa. This may not be the case for the broader definition of money M2 as the results suggest.

With respect to the monetarist position, the main point is that the stock of money could be the prime causal agent in explaining movements in real output.

The role of money in the open Greek economy with flexible exchange rates is likely to be different because the use of monetary policy for domestic purposes is limited by interest sensitive international capital flows. Therefore, the domestic objectives of monetary policy, such as the control of employment, growth and stable prices, may be in conflict with the requirement of balance-of-payments adjustment.

Further investigation using alternative definitions of the stock of money and other economic variables is needed.

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