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GRANGER CAUSALITY BETWEEN MONEY, OUTPUT, PRICES AND INTEREST RATES: SOME CROSS-COUNTRY EVIDENCE FROM THE PERIOD 1875 - 1984*

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ABSTRACT

This paper studies the Granger causality between money, output, prices and nominal interest rates by making use of long time series from 11 countries. Empirical analyses, both in the time and frequency domain, suggest that money does not help in predicting movements in output over time. In fact, only in the cases of Canada, Italy and Norway there seems to exist a unidirectional causation from money to real output. A quite different result emerges with money and prices. Thus, typically causation runs from money to prices during the sample period.

CONTENTS

1 INTRODUCTION

Business cycle theories can be distinguished according to the impulses that induce fluctuations, propagation mechanisms that transform impulses into cyclical movements in (aggregate) time series and according to the equilibrium or disequilibrium nature of the model. During the last 15 years or so, equilibrium business cycle models have clearly dominated professional discussion. During recent years, in equilibrium business models the emphasis has been on real impulses, like exogenous shifts in the production technology and preferences, rather than on monetary shocks as the initial cause of fluctuations.[1] Although propagation mechanisms can vary widely in real business cycle models, monetary policy is not considered as the major reason for cyclical fluctuations as in the monetary business cycle approach.

On the other hand, there have been numerous empirical studies which have tried to clarify the causality structure between money, income, prices and interest rates by using so-called nonstructural models. There is no possibility of going through all these studies here, hence only a reference is made to Sims (1972), Friedman (1983), Litterman and Weiss (1985), Eichenbaum and Singleton (1986), and Stock and Watson (1987). In the early 1970s there was a considerable amount of optimism on the possibilities of producing important results with this kind of approach (cf. e.g. Sims (1972)). However, if the results of the studies produced so far are scrutinized, one can no longer be so optimistic. Perhaps the main reason for this disappointment is the sensitiviness of results in various studies, particularly in terms of the conditionalization of variables (i.e. whether to use a bivariate or a trivariate system, or an even more complicated system, see e.g. Sims (1980)). Also, such things as the prefiltering of data and the selection of lag structure have produced surprisingly large differences in results.

In this paper, we focus on the choice of data problem. A typical choice has been data from the United States covering the postwar

period only. Very little work has been carried out with other sample periods and with data from other countries (a notable exception is the study by Dwyer (1985)). Partly for this reason, our intention is to make use of data from most of the Western industrialized countries and to cover as long time periods as possible. In practical terms, this means that the data sample includes 11 countries and the time series cover a period of about one hundred years. The advantages of having more data are obvious. For instance, we can try to examine the relationships between different time series in the time domain, Section 3, and in the frequency domain, Section 4, as well (see Klotz and Neal (1973) as an example of such analysis).

2 DATA

The following four variables are examined: money, output, price level and nominal interest rate. A narrow definition of money (M) is applied here, output (Q) is measured by the volume of the Gross Domestic Product, the price level (P) is measured by the Consumer Price Index, and the yield on long-term government bonds is used as the interest rate (R). The main data sources are Maddison (1982), Mitchell (1980, 1983), the Statistical Year-Book of the League of Nations and the (IMF) International Financial Statistics. In addition, some national sources are also used. In the case of the Nordic countries, both the growth studies (covering the post-1860 period) and the monetary histories and/or the histories of the central banks provide the main part of the data. As far as other countries are concerned, the following special studies could be referred to: Friedman and Schwartz (1971), Sheppard (1971), Mattia (1978) and Butlin, Hall and White (1971). See also Bloomfield (1959) for a list of additional data sources as well as for discussion about the pre-WWI monetary policy. The data for Q and P could be derived fairly easily from these sources but the construction of the interest rate and the money series created some problems. In particular, the money series for the pre-WWI period caused some

difficulties because for some countries data were available only for the central bank money. As far as interest rates are concerned, there were obvious problems in getting continous and uniform time series for bond yields. In those cases the official discount rate was used as a point of reference. A detailed definition of the data and a data printout are available from the authors upon request. The data are annual and come from 11 countries. These countries and the exact sample periods are given in Table 1. The average number of observations per country is 94. All empirical analyses make use of data which are expressed as first log differences (the interest rates are, however, expressed as first differences).

3 EMPIRICAL ANALYSIS IN THE TIME DOMAIN

We begin the empirical analysis by carrying out an analysis of Granger causality. The analysis is done by applying the standard Granger procedure, with four lags in terms of the (log) differences of the respective variables, thus X = {ΔM, ΔP, ΔQ, ΔR} which, except for differencing all variables, is similar to Sims' (1980) model. There is at least one problem with this specification: that is, the identification of real interest rate effects is somewhat tedious. In order to overcome this problem X was defined as {ΔM, ΔP, ΔQ, R}, or, alternatively, as {ΔM, $\Delta\Delta$P, ΔQ, r}, where r is the (ex post) real rate of interest. The latter speficiation is analogous to that of Eichenbaum and Singleton (1986). These alternatives did not, however, produce any substantial difference in results. In fact, they treated further problems, so that we concentrate here on the results obtained with the first model.[2] Table 1 contains the marginal significance levels of the F-test statistics for the lagged terms in each equation. In addition, forecast variance decompositions, standard errors of the estimate, Durbin-Watson statistics and Box-Pierce autocorrelation test statistics are displayed.

The results presented in Table 1 provide no basis for arguing strongly in favour of some particular causality structure.[3] It seems

that money and prices are significantly interrelated in some cases and that causation runs typically from money to prices. See particularly Austria, Canada, Italy, Norway, Sweden and the United Kingdom. Finland in turn, represents a notable exception. What is interesting in the results is, however, the fact that there is very little evidence of significant causation from money to real output. Only in the cases of Canada, Italy and Norway does money help in predicting movements in output over time. The same is true for the Netherlands, although the corresponding relationship seems to be bidirectional. Hence, the results provide no basis for arguing that money is the most important causal element in explaining movements in real activity. Thus, in accordance with, for instance, Eichenbaum and Singleton (1986), it is hard to reconcile these results with the (equilibrium) business cycle view with monetary impulses as the major cause of real fluctuations. Instead, the results seem to fit the real business cycle view much better. As far as the relationship between output and prices is concerned, one can see that in most cases these variables seem to be closely related and, moreover, in such a way that causation runs from output to prices. Thus, there is some evidence for the existence of a standard Phillips curve type relationship (France, the Netherlands and the United States represent notable exceptions to this rule). Finally, it can be pointed out that interest rates do not help in explaining the movements of money, prices and real activity. Nominal rates seem to have a life of their own, largely independent of the other variables. Even though there are differences across countries in terms of some results, there seems to be no simple way of rationalizing these differences e.g. in terms of the size of country and the exchange rate regime.

Given the data, an obvious question is how robust the results are. When this issue is examined it turns out that the results are, in fact, strikingly robust. Thus, when the following additional analyses were carried out the results remained practically unchanged:[4] a) The nature of causality was examined by using trivariate models for M, P and Q[5], and, in addition, bivariate models for (M, Q), (M, P) and (M, PQ), b) the trivariate models were estimated with dummy variables for the World War years 1914 - 1918 and 1939 - 1945, c) alternative lag

TABLE 1

Country (estimation period)		Marginal significance levels of F-statistics				Variance decompositions						
		M	P	Q	R	M	P	Q	R	SEE	D-W	Q(30)
Australia	M	.020	.414	.131	.120	83.8	3.5	6.3	6.4	.057	1.96	20.9
(1875 - 1984)	P	.040	.000	.021	.372	25.5	64.8	6.6	3.1	.039	1.98	48.1
	Q	.175	.037	.023	.190	4.5	5.8	84.8	4.9	.041	1.83	23.4
	R	.120	.104	.671	.083	27.3	6.3	3.9	62.5	.695	2.02	19.9
Canada	M	.188	.920	.919	.580	91.8	2.3	0.7	5.3	.076	1.98	30.4
(1903 - 1984)	P	.001	.054	.023	.342	44.0	45.6	6.8	4.6	.042	1.95	29.5
	Q	.012	.121	.374	.165	36.9	5.5	48.3	9.3	.044	1.81	39.1
	R	.566	.009	.756	.002	4.7	7.6	2.2	85.4	.602	2.04	15.8
Denmark	M	.142	.195	.616	.041	60.6	17.1	4.0	18.3	.052	2.09	18.8
(1875 - 1984)	P	.079	.000	.009	.931	8.4	75.0	10.2	6.4	.046	2.07	35.2
	Q	.851	.021	.457	.901	2.3	14.1	80.3	3.3	.039	2.01	27.2
	R	.939	.097	.077	.013	1.3	6.8	3.6	88.3	1.007	2.09	16.6
Finland	M	.364	.000	.274	.326	74.3	19.6	4.1	2.1	.091	1.99	25.4
(1892 - 1984)	P	.072	.000	.000	.379	35.6	49.6	13.2	1.6	.089	1.98	22.1
	Q	.796	.615	.004	.129	5.8	18.6	66.8	8.8	.042	1.99	37.7
	R	.086	.321	.317	.324	14.0	8.9	5.3	71.9	.692	1.90	20.4
France	M	.847	.098	.871	.905	81.9	11.3	5.4	1.4	.106	2.01	12.6
(1918 - 1984)	P	.830	.000	.057	.923	5.7	72.5	20.5	1.2	.094	2.05	20.8
	Q	.075	.205	.007	.951	7.6	15.3	75.2	2.0	.075	2.14	28.4
	R	.999	.781	.857	.001	3.1	8.5	3.3	85.2	.763	1.99	11.9
Italy	M	.000	.071	.074	.865	80.3	6.8	11.2	1.8	.052	2.02	22.2
(1881 - 1984)	P	.000	.053	.061	.673	66.1	24.8	6.6	2.5	.082	1.98	31.5
	Q	.001	.071	.038	.056	19.1	11.7	61.3	7.8	.054	1.97	36.1
	R	.591	.685	.742	.000	11.0	2.8	15.1	71.0	.752	2.04	9.8
Netherlands	M	.230	.153	.000	.722	58.9	11.4	26.2	3.4	.081	2.05	16.8
(1918 - 1984)	P	.483	.003	.621	.687	9.4	87.0	1.6	2.0	.048	1.79	22.3
	Q	.000	.260	.801	.456	35.3	8.0	54.5	2.3	.078	2.20	26.7
	R	.696	.786	.468	.033	1.2	5.7	4.0	89.1	.610	2.10	11.5
Norway	M	.000	.213	.585	.580	86.8	6.7	4.8	1.7	.054	1.98	21.4
(1880 - 1984)	P	.013	.000	.030	.547	40.6	45.9	10.9	2.6	.047	2.24	39.2
	Q	.000	.056	.087	.950	16.6	9.9	72.0	1.6	.033	1.95	31.4
	R	.954	.882	.019	.049	5.7	5.0	7.6	81.7	.627	1.99	12.9
Sweden	M	.000	.574	.043	.375	81.0	8.1	6.5	4.4	.041	1.83	25.9
(1889 - 1984)	P	.004	.000	.037	.698	49.3	39.7	5.7	5.3	.040	1.99	12.3
	Q	.531	.864	.338	.259	6.1	12.4	74.5	7.1	.029	1.96	26.7
	R	.199	.319	.301	.008	17.4	6.6	2.7	73.3	.566	2.08	16.4
U.K.	M	.000	.784	.063	.025	74.2	6.1	7.8	11.9	.048	1.97	21.3
(1882 - 1984)	P	.051	.027	.084	.020	40.6	41.6	6.9	11.0	.042	1.97	30.8
	Q	.104	.868	.027	.348	25.6	2.8	57.7	13.8	.029	1.94	22.6
	R	.339	.595	.276	.000	2.4	5.7	4.6	87.2	.571	2.04	30.0
U.S.A.	M	.759	.104	.009	.193	76.8	8.4	10.4	4.3	.067	1.95	25.7
(1875 - 1984)	P	.933	.000	.944	.842	12.9	85.3	0.3	1.5	.037	2.05	18.5
	Q	.967	.841	.174	.114	6.7	5.4	79.3	8.5	.053	2.01	26.7
	R	.886	.028	.835	.000	2.2	14.3	1.4	82.1	.413	1.98	27.8

SEE is the standard error of the estimate, D-W the Durbin-Watson test statistic, and Q(30) the Box-Pierce autocorrelation test statistics for 30 lags (because of lagged dependent variables the values of D-W and Q(30) should be considered with due care). The variance decompositions have been computed over 10-years horizon.

lengths and differences were tried and d, finally, the Bayesian specification procedure, suggested by Litterman (1984), was applied.

Even then we should refer to at least two caveats in terms of these results. First, the fact that we use annual data does not allow investigation of the role of very short-term effects. Second, even though there are no obvious diagnostic problems e.g. in terms of autocorrelation and parameter stability, the models may be misspecified in terms of omitted error correction terms. It may well be true that the vector autoregressions in the differences of the data are not the correct specification because the variables are co-integrated in the sense of Engle and Granger (1987). Thus, also the lagged levels of the data should be introduced into the estimated specifications. Our preliminary results - not reported here - suggest that there is some evidence of co-integration.

4 EMPIRICAL ANALYSIS IN THE FREQUENCY DOMAIN

Given the fact that the data samples include nearly 100 observations for each country, the possibility of examining the relationships between these three variables in the frequency domain is not entirely irrelevant. When carrying out these analyses we tried to find out whether the relationships are of a short-term or long-term nature, whether there are clear lead-lag relationships and, finally, whether these relationships are similar over all frequencies.

The analyses discussed here were carried out using the Parzen window with a lag length of 25. We report here only the unweighted cross-country averages of the (squared) coherence and the phase, see Figures 1 and 2.[6] On the basis of all these results one can make the following assessments:

1) The coherences between money and output turn out to be rather weak. In general, there are no substantial differences in terms of low and high frequencies, even though coherences are slightly higher at low frequencies.[7]

2) The relationship between money and prices turns out to be much closer than the relationship between money and output. Moreover, low frequencies are clearly characterized by high coherences and vice versa. Thus, one could argue that the relationship between money and prices is of a long-term nature.

3) When the phases between money and output, on the one hand, and money and prices, on the other, are examined no systematic lead-lag relationship can be found over countries and frequencies. Thus, the unweighted cross-country averages presented in Figure 2 suggest that there is no lead-lag relationship between these two pairs of variables. It is indeed somewhat surprising to find that, without exception, the estimated phases vary enormously with respect to different frequencies. Given this result one is inclined to argue that the observed sensitiveness of the results with the Granger-Sims type causality tests may also reflect this variability in lead-lag relationships over frequencies.

5 CONCLUDING REMARKS

The previous analyses have clearly indicated that the Granger-Sims type analyses cannot provide affirmative results in terms of the choice between endogenous and exogenous variables. It seems that, even if long time series are available, the determination of the lead-lag relationships using a completely unrestricted model specification cannot be done so easily. It is also clear that the results which have been obtained using only one data sample, say, for instance, the U.S. postwar data, and a trivariate system with money, output and prices do not necessarily hold in other data samples and in a fourvariate system with the nominal interest rate. If our results are interpreted in the light of the discussion on the ultimate reasons for business cycles they do not support the (equilibrium) monetary business cycle view with monetary impulses as the major cause for real fluctuations but rather the real business cycle view.[8]

FOOTNOTES

1 On equilibrium real business cycle models, see Eichenbaum and Singleton (1986) and the studies cited therein. Lucas (1987) presents some criticism on equilibrium real business cycle models and advocates equilibrium monetary business cycle approach.

2 If the nominal interest rate series are not differenced, they are clearly nonstationary. Thus, for instance, the coefficient of first-order autocorrelation is in all cases above .89. As Eichenbaum and Singleton (1986) also point out, the problem becomes a slightly less acute when R is replaced by r but even then the respective time series are pronouncedly nonstationary. Moreover, in both cases the explanatory power of the VAR-model decreases. The standard errors of the estimate are systematically higher than in Table 1. The difference is generally not very large (the interest rate equations represent a clearer deterioration of performance) but it can still be clearly discerned. As far as the main causality results are concerned, these alternative specifications do not produce any difference. Thus, first of all, money does not help in predicting output over time and, moreover, interest rates (nominal or real) do not help in explaining the other three variables. A set of results is available upon request from the authors.

3 No precise definition of exogeneity or causality is adopted here, nor are various difficulties in testing for causation analyzed or discussed. We here refer only to Jacobs, Leamer and Ward (1979), and Stock and Watson (1987).

4 See Pikkarainen and Virén (1986).

5 In the case of the United States, our results are in line with the previous findings by Sims (1972, 1980): in the trivariate system (M, P, Q) there seems to be a unidirectional relationship from money to real output, but when nominal interest rates are added to the model this relationship disappears.

6 Country-by-country results are presented in Pikkarainen and Virén (1986).

7 Accordingly, the computed coherences to typically not exceed the 5 per cent critical value (of randomly related records) which would here be about .63. See Grovers and Hannan (1968) and Koopmans (1974) for the test procedure and the tabulated confidence intervals.

8 In this connection we should perhaps point out that the equilibrium monetary business cycle view has not performed very well in other empirical tests, either. This is particularly true

in terms of such things as 1) the relationship between various (broad and narrow) monetary aggregates and output, 2) the observed cyclical behavior of consumption and labor supply (and, in addition, real wages) and 3) the order of causation between money, prices and output. See e.g. Barro (1988) for further discussion.

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Figure 1.

———— average coherence: Money and Output
- - - - - - average coherence: Money and Prices

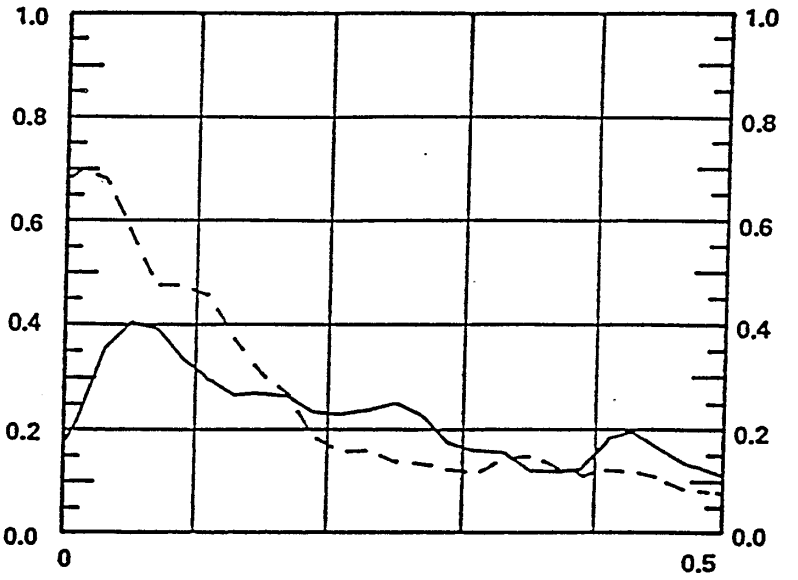
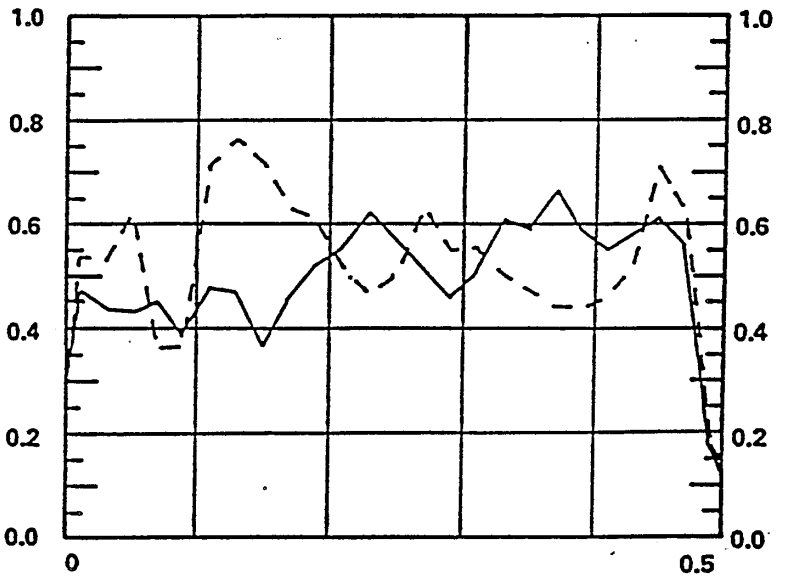


Figure 2.

———— average phase: Money and Output
- - - - - - average phase: Money and Prices



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