

Hayo, Bernd

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Money-output Granger causality revisited: An empirical analysis of EU countries

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Zentrum für Europäische Integrationsforschung
Center for European Integration Studies
Rheinische Friedrich-Wilhelms-Universität Bonn



Bernd Hayo

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An Empirical Analysis of EU Countries

Bernd Hayo^{*}

ZEI

University of Bonn

Walter-Flex-Str. 3

53113 Bonn

Germany

Tel. +49 (0)228/73-1878

Fax +49 (0)228/73-1809

e-mail: hayo@sfb4.econ1.uni-bonn.de

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Money-Output Granger Causality Revisited:

An Empirical Analysis of EU Countries

Abstract

In this paper, the evidence collected in the large literature on testing for Granger-causality from money to output is revisited. Using a broad data base of 14 EU-countries plus Canada, the US and Japan, and quarterly data from the mid 60s to the mid 90s, a number of hypotheses from this literature is evaluated. It is found that very few general conclusions can be sustained. For instance, in most countries it is not the case that the use of data in levels creates a bias in favour of finding Granger-causality effects of money on output compared to using differences. Neither does the significance of money lags decline when increasing the number of variables included in the model. What appears to be robust, though, is that allowing for asymmetries clearly increases the likelihood of finding significant causality effects. Based on the Granger-causality test results, a number of country groups are obtained using cluster analysis, which are characterised by a similar behaviour with respect to the money-output relation.

Keywords: Money-Output Causality, Granger Causality, EU countries

JEL: E40, E50

1 . Introduction

The question whether money causes output appears to be important for many economists working in the area of macroeconomics. One often applied method to investigate the empirical relationship between money and real activity is Granger-causality analysis (Granger (1969)). Using this approach, the causality question can be sharply posed as whether past values of money help to predict current values of output. This concept, however, should be clearly distinguished from any richer philosophical notion of causality (cf. Holland (1986)).

There exists a voluminous literature on Granger-causality tests, selectively reviewed below. The first thing a student of this literature notices regarding the scope of most articles is that the Granger-causality tests were mainly applied to US data. While concentrating on the US, the studies vary with respect to the specification of the tests, the variables and the sample period. It should be clear that for testing a theory claiming to describe economic reality in industrialised market economies one ought to be more prudent than to rely on the experience from only one country (see also Pikkarainen and Virén (1989)).

This study seeks to fill the gap in the literature by attempting to systematically explore the question of Granger-causality using a much broader data base and a collection of different modelling specifications. In this paper data from 17 industrial countries are used. The core of this selection is made up of European countries, with Canada, Japan and the US representing non-European economies. Concentrating on these cases allows the use of quarterly data for a relatively long time span (mid 1960s to mid 1990s) and of a broad country data base at the same time.

While data availability and quality is one great advantage of employing data on Europe, there is an important additional issue which deserves mentioning. With great probability, most countries of the European Union will join together in 1999 to form a monetary union (EMU). For this reason, a new central bank will be shaped - the European Central Bank (ECB) - which will then conduct monetary policy for EMU. Although the prime responsibility of the ECB shall be to ensure price stability, there will be some leeway for setting the money supply reflecting other objectives, like output and employment, as well. But then it would be very helpful if the effect of money on output - if there is one at all - could be more precisely described. Even if it turned out that no clear Granger-causality effects can be found, it may be interesting to see whether there exist certain groups of national economies displaying a similar behaviour with respect to changes in the money stock or the money growth rate. A caveat of

this type of analysis is its vulnerability to the Lucas critique, as the formation of EMU may erase most of the informational content of historical data. On the other hand, many EU countries do not appear to show a very fast adjustment to structural changes and thus there are good grounds to believe that at least during the start-up phase of EMU old national patterns will continue to be important.

In the remaining part of this paper, I will select important studies from the literature on money-output Granger-causality, interpret their main findings as a general hypothesis and put these to the test. Along these lines, five stylised facts of the literature are extracted in section two, and section three gives an overview of the data base and the econometric approach. In the fourth section, new Granger-causality tests for 17 countries are reported and their outcomes are shown. With the help of these results, the five stylised facts from the literature are then evaluated. In section five, an attempt is made to group countries using a cluster analysis according to the results of the aforementioned tests. Finally, a short conclusion is put forward.

2 . Reviewing some Stylised Facts of Money-Income Granger-Causality Tests

The literature on money-income causality testing is far too voluminous to be reviewed here in any detail and I will refrain from doing so. Additional references can be obtained from the articles cited below. Instead, I will combine the results of a number of important studies to generate five hypotheses on the existence, strength and type of Granger-causality between money and output.

The seminal contribution to this topic is Sims (1972). Based on his early study we can formulate the following hypothesis:

H1: In a model with only two variables, money Granger-causes output.

In a later study, Sims (1980) analysed the question in a vector autoregression (VAR) employing additional variables (prices and interest rates). He found:

H2: The statistical significance of the effect of money on output will be lower when including other variables in a multivariate test.

King and Plosser (1984) argue that the strong influence of broader monetary aggregates is due to reverse causality, with the money supply reacting to an increase in output. They demonstrate that narrow money (especially central bank money) has a weaker effect on real activity. We can derive the following testable proposition:

H3: The use of narrow money is less likely to support Granger-causality from money to output than broad money.

In a paper by Christiano and Ljungquist (1988) it is shown that the results of Granger-causality tests are dependent upon the use of (log-) level variables or growth rates. However, they argue in favour of using level variables, since they find in a simulation study that the power of the tests on growth variables is very low, and thus there is the danger of making a false inference. Stock and Watson (1989) propose that the problem lies in the handling of the trend behaviour of the money variables. They show that by removing the trend from the monetary variable and including the residual in the Granger-causality framework, it is possible to restore the influence of money on output which seemed to have broken down when extending the sample to include the 1980s. Finally, in a recent study by Hafer and Kutan (1997), the trend removal suggested by Stock and Watson (1989) is rejected. Instead, they claim that the instability of results in Granger-causality test simply depends on the question whether the variables are modelled as trend- or difference stationary. If the modelling takes place assuming that the variables are trend stationary, money is typically found to be Granger-causing output in the US. The reverse result holds for the assumption that the variables are difference stationary. The main results of these studies can be synthesised into the following hypothesis:

H4: Assuming that variables are trend stationary and modelling them in (log-) levels with a deterministic trend is more likely to lead to significant test results than assuming difference stationarity and employing growth rates.

Thoma (1994) argues that there are reasons to believe that the effect of money on output is conditional on the direction of the impulse, i.e. an increase in money growth may affect output differently than a decrease. Moreover, he shows for monthly data on M1 that the state of the business cycle has considerable influence on the results. When real activity declines, the effect of money on output becomes stronger, while the opposite takes place during a recovery.

H5: Allowing for asymmetric effects of money on output growth and including the state of the business cycle greatly influences results and strengthens the causal effect of money.

In the next section, the approach employed for testing these hypotheses is explained in some more detail.

3 . Econometric Procedure and Data Base

The basic principle of Granger-causality analysis (see Granger (1969)) is to test whether past values of a monetary aggregate help to explain current values of output. There are different types of these tests:

Simple Granger-causality tests operate in a single equation with two variables and their lags (autoregressive-distributed lag models). It is tested whether the lags of the lagged money variables are equal to zero. If this hypothesis can be rejected, it is said that money causes output.

Multivariate causality tests include more variables beside money and output in the equation. The principle remains the same, except that now the influence of other variables can affect the test results. For instance, it may be that an effect on output does in fact run via the interest rate. In a two-variable test without an interest rate variable this effect might erroneously be allocated to money.

Finally, there are Granger-causality tests taking place in a vector autoregression (VAR). Here the multivariate model will be extended to allow for the simultaneity of all included variables. The test of the lags of the money variables takes place in the output equation only. The empirical results presented in this paper are all calculated within a VAR-model. However, the number of variables included in the model varies from two (money and output) to four (money, output, prices and interest rates).

The five hypotheses listed in the preceding section will be tested using a data base consisting of 14 EU-countries plus Canada, Japan and the US, with quarterly observations from the mid 1960s to mid 1990s (see the Appendix for more information on the data base). The choice of some of the variables is partially dictated by data availability over this time span.

The following variables are being used in this study (all in logarithms except interest rates):

- Real GDP (Y),
- Narrow Money (M),
- Broad Money (MQ),
- Interest Rate (R),
- Consumer Price Index (P).

The variable employed as a proxy for output is real GDP. This is seen as being superior to industrial production, since the share of the industrial sector in the overall value-added of the industrial economies is declining. The consumer price index over all goods has been chosen as a deflator. For most countries narrow money is defined as M1 and broad money as M3. As an interest rate, a long-term government bond rate is included where available. There are two main reasons for this choice: First, the data for long-term government bond yields are defined more consistently for different countries and are available over longer-time periods. Second,

long-term interest rates can be seen as reflecting future short-term rates. Thereby it is possible to include expectational effects as well.

Here the analysis of Granger-causality concentrates on testing the lagged coefficients of money variables in the output equation within a VAR-model. No evidence regarding impulse-response functions or variance decompositions is considered, as these approaches are not valid, except in the two-variable case, for assessing the existence of Granger-causality (see Dufour and Tessier (1993)).

In a first step, a two-variable VAR is estimated containing only money and output. In a second step, a three-variable system with the price level added is estimated. Finally, in a third step the interest rate is included too. The Granger-causality tests in all these models are calculated as F-type tests on the lags of the money variables in the real GDP equation. Clearly, these steps are necessary to assess the validity of **H1** and **H2**. To allow for an evaluation of **H3**, these procedures are alternatively computed for narrow and broad money variables.

H4 can be tested by comparing the results of the Granger-causality tests using variables in (log-) levels and growth rates. In the VAR in levels a deterministic trend is added to every one of the equations. As it turns out, in most cases the trend does not appear to make any difference to the test results, which supports the finding by Krol and Ohanian (1990) that the trend removing procedure suggested by Stock and Watson (1989) is not very helpful when applied to other countries. The deterministic trend variable has not been removed in the testing down process even if it was not significant. All estimated models contain seasonal dummy variables.

Before coming to the actual estimation, it is prudent to take a look at the time series characteristics of the variables. A model in levels with integrated variables can display serious distortions in the test statistics and the Granger-causality tests become even theoretically invalid. Applying unit root tests to the series (see Appendix Table A1) leads us to conclude that most of the variables are integrated of order one.

However, there are a number of exceptions to this result. Especially with respect to the price level there exists considerable evidence that it may be integrated of order two. Strictly following these tests would imply mixing growth rates and level variables in many models. But under these circumstances, using both level and growth variables in the models makes the economic interpretation extremely cumbersome. Moreover, the power of most statistical tests and estimation procedures dealing with difference-stationary variables is greatly reduced in small samples (see for instance Banerjee et al. (1993)). Therefore one should not put too much

emphasis on the results of these tests. This is an additional reason why no attempt has been made to estimate models containing both level and growth rate variables.

On the other hand, the estimate of models in levels is only acceptable from a statistical point of view if the variables are cointegrated. Table A2 in the Appendix summarises the cointegration tests on different combinations of the variables. While there do exist some cases where there is an indication of cointegration even in the case of only money and output, it is usually for the four-variable system that cointegration is found in almost all countries for both narrow and broad money variables. Consequently, special caution should be exercised in the interpretation of the two-variable and three-variable causality tests with variables in levels.

Another important issue is the lag length selection of the VAR. As shown for example by Thornton and Batten (1985), the choice of a specific lag length can have a significant influence on the test results. Unfortunately, there does not exist a generally best method for choosing the lag length. The approach taken here is the following: In a first step, a VAR with eight lags in levels or seven lags in differences is estimated. Then it is checked with an LM-test whether the residuals of the equations contain autocorrelation. If no trace of serial correlation can be found, the number of lags is reduced according to a Hendry-type testing down procedure (e.g. Hendry (1993)), with a nominal significance level of 5%. Within this reduced VAR system the Granger-causality tests then take place. If it should turn out that there is autocorrelation, the lag length is increased to twelve or eleven respectively, and then the testing down process starts. When there is still serial autocorrelation in the residuals, another four lags are added before testing down, and so forth.

Next, the outlined five hypotheses are put to the test employing data from Europe and the U.S., Canada and Japan as an external reference group.

4 . Testing the Hypothesis Using Data for 17 Countries

To avoid an overload of information in the tables, no numerical figures are given.¹ Starting with narrow money, the results of the Granger-causality tests are given in Table 1. In the left half of the table, the tests for causality running from money to output are summarised (marked as M→Y). The results for the bivariate framework are given in columns two and three. In column two, tests on the (log-) level VAR are presented, and in column three tests conducted within a system with differenced variables are reported.

¹ All the omitted information is available upon request.

Tab. 1: Granger-causality tests for *narrow* money

Country	M → Y						Y → M					
	M, Y		M, Y, P		M, Y, P, R		M, Y		M, Y, P		M, Y, P, R	
	Lev	Diff	Lev	Diff	Lev	Diff	Lev	Diff	Lev	Diff	Lev	Diff
Austria	(*) 12	* 11	** 12	* 7	** 8	** 10	**	**	**	**	**	**
Belgium	** 8	** 7	** 8	* 7	** 7	** 7			*		*	
Denmark	* 5	* 4	* 5	* 6	* 5	* 4						
Finland	9	8	13	6	9	* 11			**			
France	5	* 3	7	7	5	7			**		*	*
Germany	5	4	5	3	* 4	3						*
Greece	** 10	** 11	* 8	* 4	* 7	* 8						
Ireland	* 4	3	* 4	(*) 11	* 6	7	(*)	*		*		
Italy	** 3	* 2	** 3	** 3	** 7	** 3	(*)					
Nether	* 8	11	(*) 14	10	13	11			*	*	**	**
Portugal	5	4	5	4	5	4						
Spain	** 5	** 11	** 13	** 15	** 20	* 5		**	**	**	**	**
Swede	* 3	2	4	3	3	4						
UK	1	0	** 2	1	18	** 17						
Canada	** 10	** 5	** 10	** 9	** 10	** 8						
Japan	** 2	6	4	6	8	9	**				*	**
US	8	7	8	11	** 7	7	**	*	**	**	*	**

Notes: One (two) stars indicate statistical significance at a level of 5% (1%). Additionally, the star in brackets reflects a p-value between 5% and 10%. The numbers show the actual lag length of the VARs.

The main information given in the table is the statistical significance level and the lag length of the respective VAR. In the following discussion, only significance at a 1% (**) or 5% (*) level is considered as supporting Granger-causality. Test statistics which are significant at a level of 10% ((*)) are merely shown to give an impression of the robustness of the results. A corresponding structure is used in columns four and five for the three variable VAR, and columns six and seven for the four variable VAR. In the right half of the table (denoted by Y → M), a similar division is used to display the results for testing causality running from output to money. Table 2 summarises the Granger-causality test results for broad money in the same way.

The validity of **H1** can be checked in the light of the presented evidence. Regarding **H1** and narrow money (broad money), we find in Tables 1 and 2 evidence for Granger-causality in 10 out of 17 countries (7 out of 17) using the models in levels. For the VARs in differences the corresponding numbers are 8 cases for narrow and 6 for broad money.

At the same time, the direction of causality from output to money is supported by the tests using level variables and narrow (broad) money in 3 (6) countries. For growth rates, we find 3 (3) significant tests in the case of narrow (broad) money. I would not consider these results as

more than a modest success of **H1**. Obviously, there are countries where we observe the causality running from money to output, but one should be careful in generalising this finding. Even less widespread is the evidence for reverse causation from output to money in a two-variable framework.

Tab. 2: Granger-causality tests for *broad* money

Country	M → Y						Y → M					
	M, Y		M, Y, P		M, Y, P, R		M, Y		M, Y, P		M, Y, P, R	
	Lev	Diff	Lev	Diff	Lev	Diff	Lev	Diff	Lev	Diff	Lev	Diff
Austria	** 14	* 14	** 7	** 7	** 8	** 8	**	**	**	**	**	**
Belgium	* 8	** 7	** 8	* 7	** 7	** 7						
Denmark	* 6	* 7	** 6	* 7	** 7	* 7		(*)	*	**	*	**
Finland	(*) 9	12	** 4	(*) 3	* 10	8		(*)	**	*	**	
France	2	1	8	7	6	7			*		**	
Germany	(*) 4	3	4	3	4	3	**		(*)		(*)	
Greece	** 6	* 5	** 8	** 7	** 5	** 7	*					
Ireland	4	3	4	3	7	5						
Italy	* 3	* 3	** 8	** 2	** 6	** 5	**					
Nether	8	11	12	14	12	11						
Portugal	4	4	4	4	5	4			*			
Spain	* 12	* 11	** 12	* 15	** 12	* 11	**	**	**	**	**	**
Swede	5	4	9	4	13	4	(*)				*	
UK	1	4	** 2	1	18	** 17						
Canada	6	6	11	7	** 7	* 7	**	**	**	**	**	**
Japan	* 5	(*) 5	7	6	(*) 7	(*) 5			**			
US	3	2	** 4	** 6	** 4	** 6						

Notes: One (two) stars indicate statistical significance at a level of 5% (1%). Additionally, the star in brackets reflects a p-value between 5% and 10%. The numbers show the actual lag length of the VARs.

Coming to **H2**, which says that the significance of money will decline when adding additional variables to the VAR, we can compare the number of significant correlations for the two, three and four variable cases given in Tables 1 and 2. Starting with the models in levels and narrow (broad) money, we find 10 (7) significant test statistics using two, 9 (9) using three, and 9 (9) using four variables. For the VARs in growth rates the relevant numbers are 8 (6), 7 (7), and 9 (9). Thus there does not appear to be a reduction of the significance of lagged money connected with the increase in the number of included variables. Moreover, as has been noted above, for many countries there is evidence of cointegration among the time series in levels only in the four variable case.

H3 postulates that using a narrower money aggregate will produce less evidence of Granger-causality from money to output. Since the relevant numbers of significant cases are already

given in the preceding paragraphs, we can simply conclude that there is no such evidence present in the data analysed here. Although for some countries it makes a difference whether one uses narrow or broad money to test for money-output causality (e.g. Ireland, France, Germany or Sweden), in general we do not find a strong indication that using broad money implies a greater likelihood of finding a significant relationship.

Regarding **H4**, the question whether money-output causality can be more often found using (log-)level variables than growth rates, we find slight evidence in favour of this hypothesis only in the bivariate case. This can be easily confirmed by looking at Tables 1 and 2 or referring directly to the numbers given in the preceding discussion of **H1**. Still, I would not regard this as sufficient evidence for granting **H4** a high degree of generality, especially since the two-variable case is subject to nonstationarity problems when using level variables.

It might be interesting to add that one gets reverse causality results for Canada and the US using either narrow or broad money aggregates. While for Canada there is strong evidence of money-output causality for narrow money and weaker evidence for broad money, the opposite result holds for the US. However, the explanation of this finding is not straightforward. Serletis and King (1994) report a similar result and point towards the different size of the economies. While this explanation might be true, it is still not fully satisfactory, since it does not lay open the economic mechanisms leading to this observation.

Finally there is **H5** and its claim that asymmetric effects and the influence of the business cycle might be present. Thoma (1994) argues that it may well be the case that there exist asymmetries in the reaction of output to money. Before we come to the evaluation of his specific suggestion for modelling the asymmetries, we first attempt to capture reactions of output depending on the sign of money growth and the phase of the business cycle. In this framework, it only makes sense to look at variables in growth rates. The lag lengths chosen are those of Tables 1 and 2. Now the money growth series is decomposed into two variables containing respectively positive (ΔM_{Plus}) and negative growth values (ΔM_{Min}). A problem for some countries using this splitting rule is that the number of non-zero observations in ΔM_{Min} is very limited.²

In a second step, these variables are connected with the phase of the business cycle. A variable reflecting the business cycle is constructed as the residual of a regression of output growth on a constant and a deterministic trend term (see Thoma (1994)). This variable is multiplied with

² In the case of narrow money for Japan there is not a single negative money growth figure.

$\Delta MPlus$ and $\Delta MMin$ giving $\Delta MCyP$ and $\Delta MCyM$ respectively. These four variables are substituted for money growth in the output growth equation of the VAR.

Thus we have as new variables:

$\Delta MPlus = \Delta M$ for $\Delta M > 0$, and zero otherwise,

$\Delta MMin = \Delta M$ for $\Delta M < 0$, and zero otherwise,

$\Delta MCyP = \Delta MPlus$ multiplied by phase of business cycle,

$\Delta MCyM = \Delta MMin$ multiplied by phase of business cycle.

We would expect that there is a greater chance of rejecting the null hypothesis of no Granger-causality from money to output, since the model is now somewhat more general than before. However, there is evidence of collinearity between $\Delta MPlus$ and $\Delta MCyP$ as well as $\Delta MMin$ and $\Delta MCyM$, which will tend to increase the standard errors. It should also be noted that the regression models reported in Tables 1 and 2 are not fully nested in these models due to the variables capturing the phase of the business cycle. There are also differences because of variations in the degrees of freedom used in the computation of the F-test statistics.

The actual results of the regressions for narrow money are reported in Table 3.

Tab. 3: Asymmetric approach for *narrow* money

	$\Delta MMin = 0$	$\Delta MPlus = 0$	$\Delta MMin = \Delta MPlus = 0$	$\Delta MCyM = 0$	$\Delta MCyP = 0$	$\Delta MCyM = \Delta MCyP = 0$	All $\Delta M = 0$
Austria	**	**	**	**	**	**	**
Belgium		**	**	*	**	**	**
Denmark		**	**		**	**	**
Finland	*	(*)	**	**	*	**	**
France		*			*	*	*
Germany							
Greece	**	**	**				**
Ireland	*	*	**	**	**	**	**
Italy		*	*				*
Nether	**	**	**	**	**	**	**
Portugal				*	*	*	
Spain		**	**	*		*	**
Swede		*		*		**	*
UK	**		**	**		**	**
Canada		*					**
Japan		**	*	*	**	**	**
US				*		*	*

Notes: One (two) stars indicate statistical significance at a level of 5% (1%). Additionally, the star in brackets reflects a p-value between 5% and 10%.

In Table 4, the corresponding results for broad money are given:

Tab. 4: Asymmetric approach for *broad* money

	$\Delta M_{\text{Min}} = 0$	$\Delta M_{\text{Plus}} = 0$	$\Delta M_{\text{Min}} = \Delta M_{\text{Plus}} = 0$	$\Delta M_{\text{CyM}} = 0$	$\Delta M_{\text{CyP}} = 0$	$\Delta M_{\text{CyM}} = \Delta M_{\text{CyP}} = 0$	All $\Delta M = 0$
Austria		(*)	(*)		*	**	**
Belgium	*	**	**	**	**	**	**
Denmark		*			**	**	*
Finland		*	*			*	**
France	(*)	(*)	*		**	**	*
Germany							
Greece		**	**				*
Ireland				(*)			(*)
Italy	*		*		*	*	*
Nether	**	**	**	**	**	**	**
Portugal					*		
Spain	*		*	(*)	*	**	**
Swede					**	**	(*)
UK	**	(*)	**	**	(*)	**	**
Canada	**	**	**	**	*	**	**
Japan	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
US		*					

Notes: One (two) stars indicate statistical significance at a level of 5% (1%). Additionally, the star in brackets reflects a p-value between 5% and 10%.

First we look at differences between the results in Tables 1 and 2 and the findings in Tables 3 and 4. Comparing the results for the *narrow* money four-variable model in differences to the ones allowing for asymmetries, we observe more evidence for Granger-causality in the latter case. This assertion holds for France, Ireland, Netherlands, Portugal, Sweden, Japan and the US.

Next we look at traces indicating differences in the significance of effects through positive, respectively negative, money growth on output growth. In Belgium, Denmark, France, Italy, Spain, Sweden, Canada and Japan Granger-causality from narrow money to output is present when the money growth rate is positive, and in Finland and the UK when it is negative. For the other countries we observe either a two-way or no causal relationship.

It is also interesting to consider the influence of the business cycle on Granger-causality tests. Here statistically significant effects can be found for all countries except Germany, Greece, Italy and Canada. The result that Granger-causality is only present in a specific phase of the business cycle is found for Denmark, France, Spain, Sweden, UK and the US. In the case of

the first two countries, the business cycle affects the influence of negative money growth and for the other countries it alters the effect of positive money growth.

For *broad* money, the general picture stays the same except that the effects for specific countries can be very different compared to what was found for narrow money. Countries that have displayed no traces of money-output Granger-causality in the symmetric approach (four-variables VAR in differences) but show evidence now are Finland, France, Greece, Netherlands, Portugal and Spain. More precisely, asymmetric effects due to positive broad money growth are observed for Denmark, Finland, Greece, and the US, and asymmetric effects caused by negative money growth can be detected for Italy, Spain and the UK. Further, we find an influence of the state of the business cycle for broad money as well. The only countries not affected are Germany, Greece, Ireland and the US.

Tab. 5: Thoma approach for *narrow* money

	$\Delta\text{MTM} = 0$	$\Delta\text{MTP} = 0$	$\Delta\text{MTM} = \Delta\text{MTP} = 0$	$\Delta\text{MTCyM} = 0$	$\Delta\text{MTCyP} = 0$	$\Delta\text{MTCyM} = \Delta\text{MTCyP} = 0$	All $\Delta\text{MT} = 0$
Austria	**	**	**	*	**	**	**
Belgium	(*)	**	**	*	**	**	**
Denmark		*	*		**	**	**
Finland	**	*	**	**	**	**	**
France					*	*	
Germany							
Greece		**	**				*
Ireland	*		*	*	**	**	**
Italy	*	**	**				*
Nether	**	(*)	**	**	**	**	**
Portugal							
Spain	**		**	**		*	**
Swede		(*)		*	(*)	**	*
UK	**		**	**	**	**	**
Canada		**	**	*	**	**	**
Japan			**	**	**	**	**
US	*		*	*		(*)	*

Notes: One (two) stars indicate statistical significance at a level of 5% (1%). Additionally, the star in brackets reflects a p-value between 5% and 10%.

The concrete approach chosen by Thoma (1994) proceeds somewhat differently. Instead of splitting the information in the money growth variable into series containing positive and negative growth, he looks at whether money growth is increasing or decreasing. He bases the construction of variables used to capture asymmetries on the following transformations:

- ΔMTP = ΔM for $\Delta\Delta\text{M} > 0$, and zero otherwise,
 ΔMTM = ΔM for $\Delta\Delta\text{M} < 0$, and zero otherwise,
 ΔMTCyP = ΔMTP multiplied by phase of business cycle,
 ΔMTCyM = ΔMTM multiplied by phase of business cycle.

The results of using these variables in the output equation are given in Table 5 for narrow money. For broad money, the values calculated using the Thoma-procedure are recorded in Table 6.

Tab. 6: Thoma approach for *broad* money

	$\Delta\text{MTM} = 0$	$\Delta\text{MTP} = 0$	$\Delta\text{MTM} = \Delta\text{MTP} = 0$	$\Delta\text{MTCyM} = 0$	$\Delta\text{MTCyP} = 0$	$\Delta\text{MTCyM} = \Delta\text{MTCyP} = 0$	All $\Delta\text{MT} = 0$
Austria	**	*	**		**	**	**
Belgium	**	**	**	**	**	**	**
Denmark		*	(*)		**	**	**
Finland	*	**	**	**	*	**	**
France	**		**		**	*	*
Germany							
Greece	**	**	**				*
Ireland	(*)				*	(*)	(*)
Italy	*		*		*	(*)	*
Nether		**	**	**	**	**	**
Portugal					*		
Spain	(*)			**	*	**	**
Swede					**	**	*
UK	**		**	**		**	**
Canada		*	*		*	*	*
Japan		**	**	**	**	**	**
US						*	*

Notes: One (two) stars indicate statistical significance at a level of 5% (1%). Additionally, the star in brackets reflects a p-value between 5% and 10%.

Starting the interpretation of the results again with *narrow* money, the same list of countries, except Portugal, as in Table 3 display a statistically significant effect of lagged money on output. For *broad* money, differences to Table 4 occur only in the case of Ireland and Japan.

In general it can be said that the asymmetric effects are not similarly distributed over different countries. For instance, there is no evidence that periods of negative money growth have a larger impact than periods with positive growth or vice versa. Furthermore, opposite to what Thoma (1994) claims for the US, internationally, there is no evidence that allowing for

business cycle effects leads to statistically more significant effects of money on output than simply constructing variables according to the sign of the money growth rate.

Thus to evaluate **H5** based on the evidence presented in Tables 3-6, we can safely claim that asymmetric effects indeed matter. However, the results vary depending on the specification of asymmetry and no simple conclusion emerges with respect to the general behaviour of countries in the sample. Thus although we find evidence in favour of **H5**, it is not obvious whether this tells us much about economic structures, since the results appear to be strongly dependent on the specific country one is looking at.

5 . Clustering countries according to the Granger-causality tests

Even if it is not possible to deduce general conclusions about money-output Granger-causalities, maybe it is possible to isolate particular groups of countries displaying a very similar behaviour with respect to the variables of interest. For instance, one could imagine that the core EU countries show money-output test results which are very close to each other.

To investigate this question, a rather crude cluster analysis has been employed. Every column in the Table 1-6 was defined as a variable and the countries were defined as cases. The coding of the cases has been done in the following way:

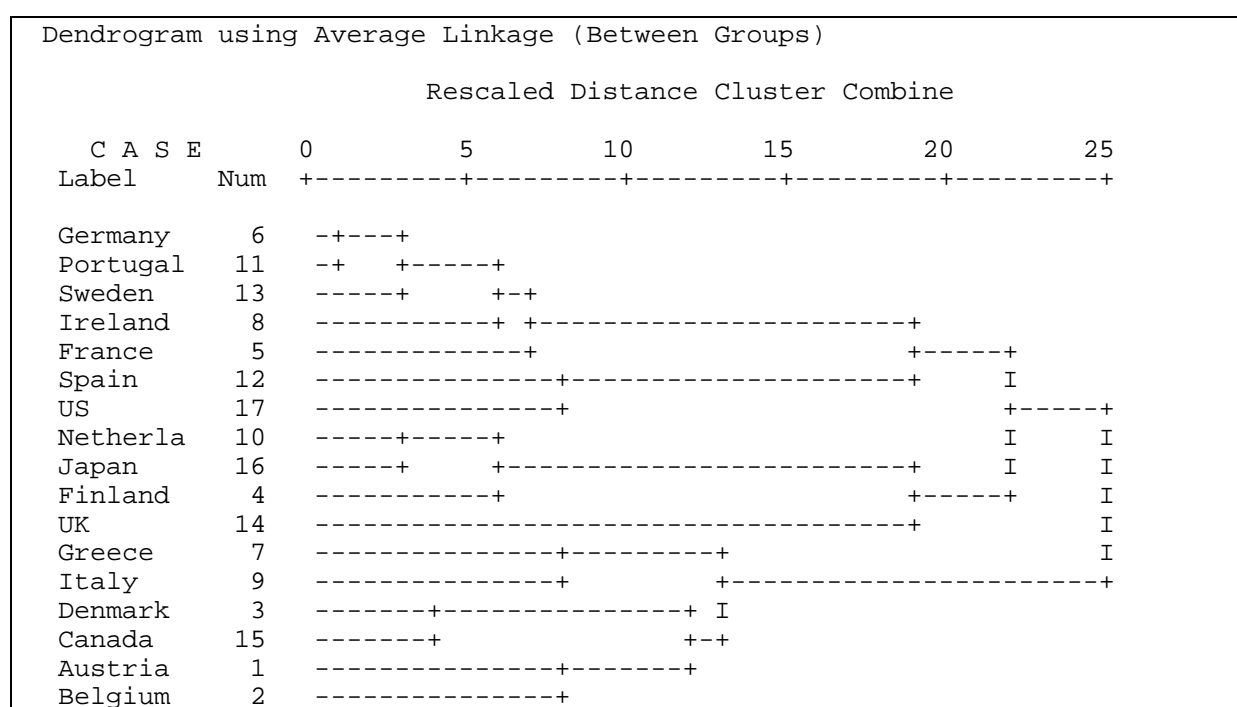
- Significant at a level of 1% → Coded as 10
- Significant at a level of 5% → Coded as 5
- Significant at a level of 10% → Coded as 1
- Not significant at a level of 10% → Coded as 0

This approach can be seen as a reasonable compromise between obtaining information reflecting the different strengths of the statistical relationships as well as not pretending to be very exact. Other specifications have been tried, for instance modelling the variable as a simple dummy variable with significant results at a level of 5% coded as unity, and the results do not appear to be very sensitive to the particular formulation of these variables. To assist us in finding a structure within the diverse group of countries of this sample, a cluster analysis based on the squared Euclidean distance is used. Here we concentrate on a graphical representation of the clusters called dendrogram, which features the relative similarity of the countries in an easy-to-survey way.

The question arises as to which Granger-causality test results should be included in the analysis. Instead of displaying all possible combinations of variables or even including all

variables, three possible selections of variables will be shown containing only the results of the money-output tests in the framework of symmetric and asymmetric four variable VARs. The potential problems associated with the lower dimensional VARs have already been mentioned. We concentrate on the formulation of asymmetry as put forward by Thoma (1994), with and without business cycle influence. This allows the inclusion of Japan as a separate case. It should be noted, however, that the results are relatively robust to the inclusion of variables and that the presented results can be regarded as fairly representative. Employing these 12 variables in the clustering gives the following dendrogram (see Figure 1):

Fig. 1: Cluster analysis for money-output causality



Depending on the specific cut-off point to distinguish between different country clusters, we can isolate the following three groups:

- Germany, Portugal, Sweden, Ireland, France, Spain, and the USA
- Netherlands, Japan, Finland, and the UK
- Greece, Italy, Denmark, Canada, Austria, Belgium

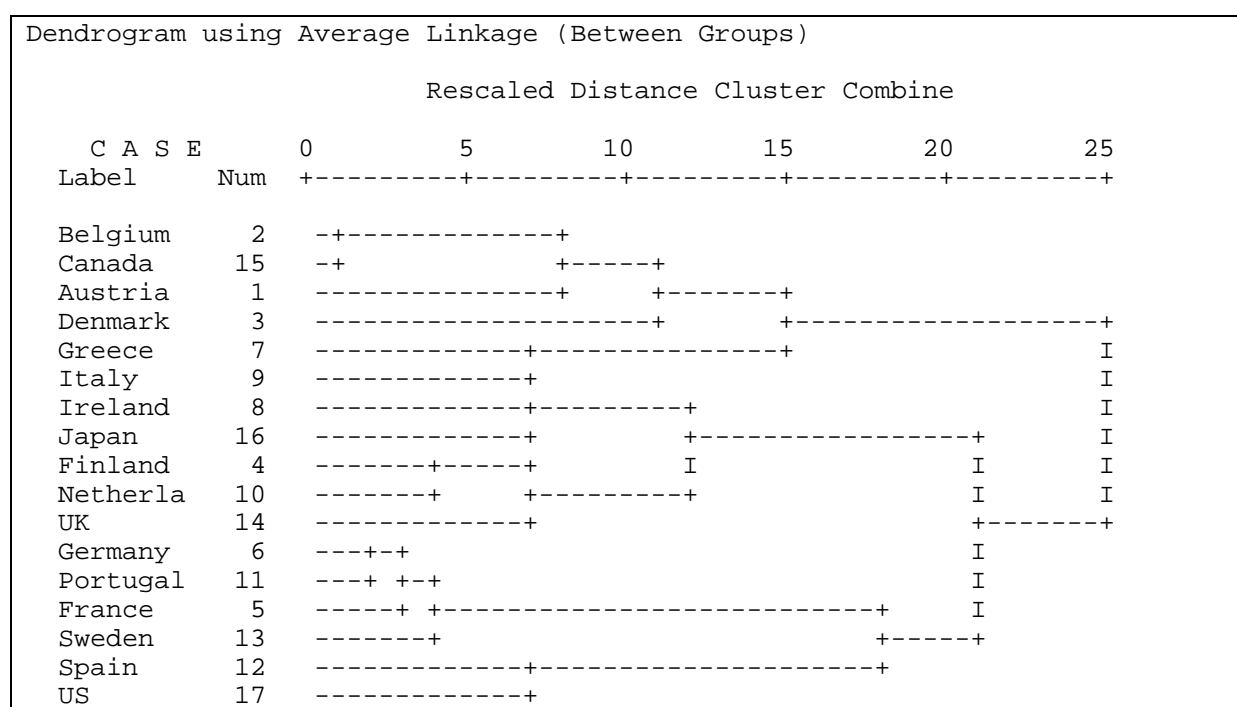
Allowing for more heterogeneity within groups and combining the first two clusters, the dimensionality of the cluster space could be reduced to two. Trying to get more homogeneous groups would result in an increase of the number of clusters. Pursuing this route, the only cluster left with a larger number of countries would include Germany, Portugal, Sweden, Ireland, and France.

Clearly, the three cluster identified above do not reflect any precise a priori expectations. But the groups do seem to contain countries which are characterised by economic similarities. Cluster 1 includes Germany and France, which one would expect to see in one cluster. Sweden is a country which was characterised over the sample period as a country with a high welfare state component. Up to a certain point this is also true for Germany and France. However, the cluster also includes Portugal and Spain, the economies of which are strongly interlinked but which do not have obvious similarities to the aforementioned countries.

In the second cluster, it is more difficult to synthesise plausible a priori candidates for similar behaviour. Here it is helpful to refer to the larger two-cluster interpretation of Figure 1, where one could at least put the Netherlands together in the group with Germany and France, and Finland together with Sweden, its neighbour and most important economic partner.

Within the third cluster, we notice a close similarity between Greece and Italy. Both countries are part of the Southern region of the EU. A different connection can be discovered when adding Belgium to this group. These three countries have the largest debt-to-GDP ratios of EU countries. Moreover, a large debt-to-GDP ratio can also be found in Japan. Finally, in accordance with Serletis and King (1994), the US and Canada are attributed to non-overlapping clusters, indicating their different economic behaviour based on money-output tests.

Fig. 2: Cluster analysis involving *narrow* money variables

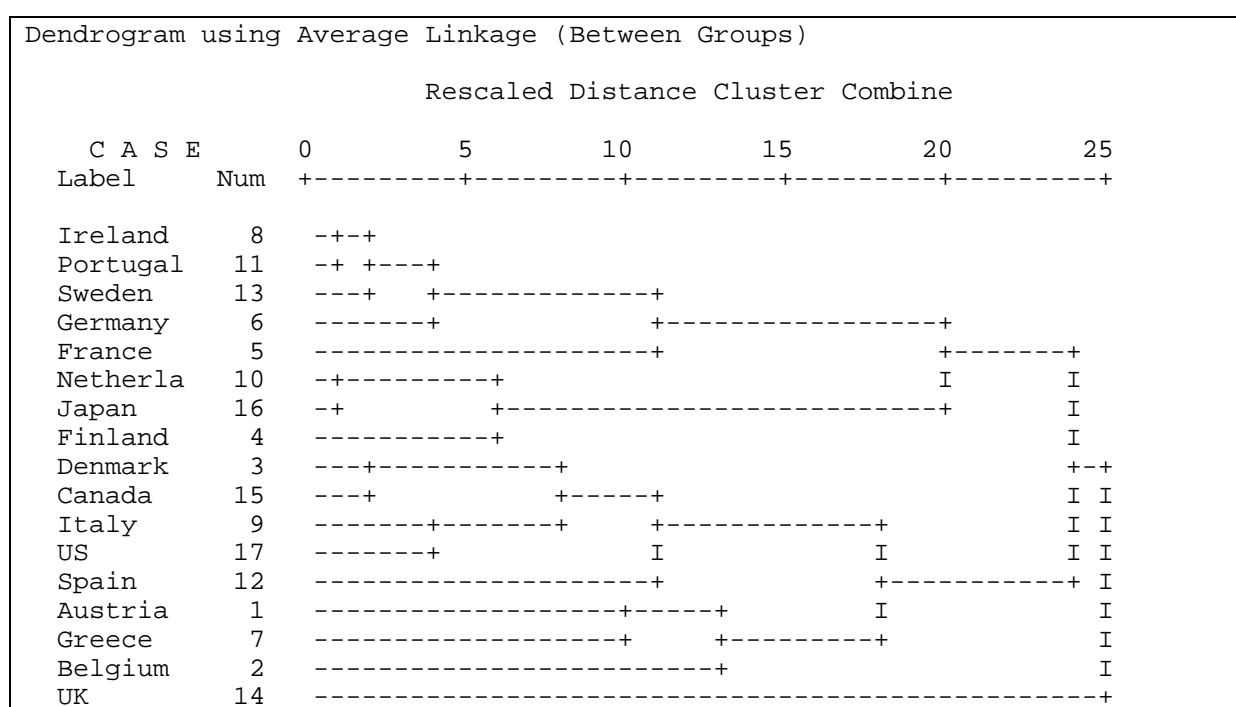


Next we can ask whether the identified country groupings vary with respect to the choice of the money aggregate. In Figure 2, only variables containing *narrow* money test results are included in the analysis (6 variables).

The core cluster just mentioned consists now of only Germany, Portugal, France and Sweden. Applying the three cluster scheme again would lead to similar groups as before, with Ireland being the only exception. For narrow money, Ireland becomes part of the second cluster listed above.

Finally, the analysis is applied to *broad* money and the results are shown in Figure 3:

Fig. 3: Cluster analysis involving *broad* money variables



Here the natural three-cluster grouping displayed above does not really hold. But we do find the core cluster again, this time including Ireland, but the rest is less homogeneous. Combining the countries into two clusters gives us the same results displayed in Figures 1 and 2. There is one big exception, though, and this is the behaviour of the UK, which is for broad money strikingly different to all other countries included in the sample.

Thus the use of specific monetary aggregates has only a limited influence on the results of the analysis. More generally, the extracted clusters do not conform easily to a simple division of EU countries into categories like North versus South, or richer versus poorer countries, or older versus newer members. However, by allowing for less clear divisions it is still possible to put economic meaning into the respective country groupings. With respect to the control

countries Canada, Japan and the US it needs to be said that the EU countries do not generally appear to be more similar than these over the underlying time period. If strong EU convergence has occurred, it cannot be discovered in a sample size as long as this one. Using a much shorter sample, though, leads to a strong decline in the power of the underlying causality tests.

6 . Conclusion

The preceding discussion in section three has made pretty clear that general hypotheses based upon Granger-causality tests are not very robust with respect to different variables, time periods or countries. However, there appears to be a Granger-causality effect present in many of the economies under investigation. This effect will be much more pronounced when allowing for a number of asymmetric influences. But more general statements about money-output causality cannot really be supported. All the other substantial findings are more or less connected with specific countries, like the reverse causality results for Canada and the US, the existence of significant two-way causalities in Austria and Spain, and the statistically insignificant effects for Germany. One important lesson to draw from this conclusion is that concentrating research on one country, here the US, does not help very much in assessing general questions connected with Granger-causality. For instance, the specific claim made by Davis and Tanner (1997) that money still causes economic activity when appropriately adjusting the time period is likely to be correct only in the context of the US economy.

Looking at the attempt of grouping countries according to the results of the causality tests presented in the preceding section does not improve the situation very much. Even though it is possible to extract a small number of country groups displaying similar behaviour, it is not always clear why they actually show that behaviour. Many of the countries in the grouping conform to a priori expectations, while others do not display obvious similarities. On the other hand, the main reason for employing exploratory data analysis is to uncover relationships which are not obvious. In any case, the result of the country clustering should make us careful with respect to simple generalisations, like North versus South, or core versus periphery.

Coming back to the question of EMU raised in the introduction, an ECB will find it hard to use monetary policy to influence output. There are at least two, if not three or more, groups of countries which are likely to react rather differently in economic activity to variations in money. This could be seen as supporting the view that the ECB ought not to attempt any stabilisation policy. However, at least three caveats should be borne in mind: First, the results

of the Granger-causality tests do not really capture monetary policy. Second, statistical significance does not say a lot about economic significance (see McCloskey and Ziliak (1996)). Third, it may be the case that the money-output relationship will be heavily influenced by forming EMU, thereby rendering the tests based on historical data obsolete.

Consequently, it would be premature to exclude the ECB from considerations of stabilisation policy. However, great care should be exercised when using it, as there might result asymmetric outcomes between different EMU member countries.

Appendix

Data:

Most series have been taken from the OECD Main Economic Indicators CD-Rom 1/1996. Some series were obtained from the IMF International Financial Statistics. Finally, some data had to be estimated since they were not available, like quarterly GDP for Belgium. Most estimations were done using ADL-models and the method of Chow and Lin (1971).

Nominal GDP and money aggregates are calculated in million units of the respective national currency, interest rates in per cent per annum, and the consumer price indices have 1990 as a base year. Real GDP was computed using the CPI. A complete listing of data sources and extrapolations is available upon request.

Unit root tests:

Tab. A1: Unit root tests (ADF-test)

Country	Variables				
	LM	LMQ	LGDP	LCPI	INT
Austria	I(1)	I(2)	I(1)	I(1)	I(0)
Belgium	I(1)	I(1)	I(1)	I(2)	I(1)
Denmark	I(1)	I(1)	I(1)	I(1)	I(1)
Finland	I(1)	I(2)	I(1)	I(1)	I(1)
France	I(1)	I(1)	I(0)	I(2)	I(1)
Germany	I(1)	I(1)	I(1)	I(1)	I(0)
Greece	I(1)	I(1)	I(0)	I(2)	I(1)
Ireland	I(1)	I(1)	I(1)	I(2)	I(1)
Italy	I(2)	I(2)	I(0)	I(2)	I(1)
Netherlands	I(1)	I(1)	I(1)	I(2)	I(1)
Portugal	I(1)	I(1)	I(1)	I(1)	I(1)
Spain	I(2)	I(2)	I(0)	I(2)	I(1)
Sweden	I(1)	I(1)	I(0)	I(1)	I(1)
UK	I(1)	I(1)	I(1)	I(1)	I(1)
Canada	I(1)	I(0)	I(0)	I(2)	I(1)
Japan	I(0)	I(0)	I(1)	I(2)	I(1)
USA	I(1)	I(1)	I(1)	I(2)	I(1)

Notes: Critical values are taken from MacKinnon (1991).

Cointegration:

Tab. A2: Cointegration Tests (Johansen-Method)

Länder	LY, LM	LY, LMQ	LY, LM, LP	LY, LMQ, LP	LY, LM, LP, R	LY, LMQ, LP, R
Austria	(*/*)	(**/**)	(**/**)	(**/**)	(**/**)	(**/**)
Belgium	(-/-)	(-/-)	(**/*)	(-/-)	(**/**)	(**/**)
Denmark	(-/-)	(-/-)	(**/**)	(**/**)	(**/**)	(*/*)
Finland	(-/-)	(*/*)	(*/*)	(*/*)	(-/-)	(**/**)
France	(-/-)	(-/-)	(-/*)	(-/-)	(-/-)	(-/-)
Germany	(-/*)	(**/**)	(-/-)	(**/**)	(**/*)	(**/**)
Greece	(-/**)	(-/-)	(-/-)	(-/-)	(-/*)	(**/**)
Ireland	(-/-)	(-/*)	(**/**)	(*/**)	(*/**)	(**/**)
Italy	(*/*)	(*/*)	(*/*)	(-/*)	(*/**)	(-/-)
Netherlands	(-/-)	(-/-)	(**/**)	(-/*)	(**/**)	(-/**)
Portugal	(-/-)	(-/-)	(-/-)	(-/-)	(-/*)	(-/-)
Spain	(**/**)	(*/*)	(**/**)	(**/**)	(**/**)	(**/**)
Sweden	(-/*)	(-/-)	(*/-)	(-/-)	(-/**)	(**/**)
UK	(-/-)	(-/-)	(-/-)	(-/-)	(**/**)	(**/**)
Canada	(-/-)	(-/-)	(-/-)	(*/*)	(-/-)	(**/**)
Japan	(**/**)	(-/-)	(**/**)	(-/*)	(-/**)	(**/**)
USA	(-/*)	(-/-)	(-/-)	(**/**)	(**/**)	(-/*)

Notes: One (two) stars indicate statistical significance at a level of 5% (1%). The first digit within the brackets reflects the results of the maximum eigenvalue test, the second of the trace test. Critical values are taken from Osterwald-Lenum (1992).

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Zentrum für Europäische Integrationsforschung
Center for European Integration Studies
Rheinische Friedrich-Wilhelms-Universität Bonn

Walter-Flex-Strasse 3
D-53113 Bonn
Germany

Tel.: +49-228-73-1732
Fax: +49-228-73-1809
www.zei.de