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Working Paper

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Kiel Working Papers, No. 475

Provided in cooperation with:
Institut für Weltwirtschaft (IfW)

Suggested citation: Scheide, Joachim (1991) : On the causality between output, money and the terms of trade in Germany, Kiel Working Papers, No. 475, http://hdl.handle.net/10419/576

Kieler Arbeitspapiere
Kiel Working Papers

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ON THE CAUSALITY BETWEEN OUTPUT, MONEY AND THE TERMS OF TRADE IN GERMANY

by

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ISSN 0342-0787

The Kiel Institute of World Economics
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May 1991

On the Causality Between Output, Money and the Terms of Trade in Germany[1]

I. Introduction

The idea that monetary policy has a significant influence on economic activity had been accepted for a long time. In recent years, however, this view was challenged by the theory of real business cycles; most models of this class set out to explain output fluctuations without any important role for money.[2] On an empirical level, two lines of arguments can be described. The first states that changes in the money stock do not have any predictive power for output movements; Sims (1980), for example, arrives at this conclusion on the basis of an analysis with vector autoregressions.[3] The second argument runs as follows: Even if money appears to cause output in the Granger sense, it is only because of the endogenous response of money to changes in the production possibilities in the economy; however, actions by the central bank--i.e. changes in high-powered money--play no or only a minor role.[4] According to these findings, the money stock is not a true cause but only a leading indicator (though a good one, maybe) for economic activity.

While most of the influential empirical work focuses on U.S. data of various periods, the purpose of this paper is to shed light on the relevance of monetary policy for output in West Germany. In particular, it is investigated whether money in various definitions helps to

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[1]I want to thank Stephen Gordon and Andreas Hornstein for helpful comments on an earlier version of this paper.

[2]The benchmark model is Kydland, Prescott (1982), which is discussed by Lucas (1987). McCallum (1989) provides an overview of the models and the empirical implications of real business cycle theory.

[3]See McCallum (1986) for a criticism.

[4]See, for example, Rush (1985), Manchester (1989) and Plosser (1990). The theoretical background for this link between output and money is presented by King, Plosser (1984).

predict output movements. Additionally, the role of an important real factor, changes in the terms of trade, is analyzed for this open economy. It is of special interest to test whether this variable has a dominant impact on output in the sense that it not only reduces the significance of the money-output relationship substantially but also is contributing itself to changes in the "endogenous" components of money.

The structure of this paper is as follows. In the second section, the choice of the data and the method of investigation are briefly described. The analysis of vector autoregressions, including causality tests and variance decompositions, is generally regarded as helpful for testing competing hypotheses derived from various models. The results in tests like these, however, depend very much on the choice of the information set. The third section presents tests of Granger-causality and estimates for variance decomposition for the variables considered, starting with two-variable systems in the first part. In the second part, the information set is increased; it contains systems with three variables so that a judgment can be made concerning the relative importance of various measures related to money (e.g., high-powered money and endogenous money) and the terms of trade with respect to output. For the four-variable systems, some restrictions which refer to the hypothesis of real business cycle theory are tested in the third part. Finally, the results are summarized and I will draw a few conclusions from the tests presented.

II. On Data and Methods

The output variable (Y) is real domestic expenditures (real GNP minus real net exports). It has been shown that the link between monetary aggregates and this measure is closer than that between money and real GNP, possibly because exports are influenced more by policies abroad than by domestic policy. The real factor which is analyzed with respect to its impact on output is the measure of the terms of trade (TT).[5] The use of changes in the

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[5]Defined as the ratio between the export deflator and the import deflator (NIA-basis).

terms of trade or in other variables of the external sector as a proxy for a real shock has been suggested in the literature on real business cycle theory.[6] According to this, terms-of-trade shocks affect the production possibilities of the economy and the investment and consumption decisions of the private sector which will in turn lead to change in the demand for money. In the real business cycle interpretation, the recessions in the middle of the 1970s and the early 1980s were due to the sharp increase in import prices; also, another measure often used to define a supply shock, namely the Solow residual, shows large negative values for these periods [Plosser, 1989]. For Germany, a country with a large external sector, terms-of-trade movements have been sizable in the past two decades; furthermore, earlier work on the German economy found a significant impact of the terms of trade or related variables (e.g. import prices) on economic activity.[7]

The monetary variables include the money stock M1 as well as its components, i.e. currency (CU) and demand deposits (DD).[8] Two measures of the monetary base are available: One (BB) is published by the Deutsche Bundesbank in the monthly report, and it was the target variable for monetary policy for 14 years; the other (BS) is calculated by the Sachverständigenrat (German expert council). The latter is comparable to the extended monetary base [Neumann, 1986] since it takes account of effects due to changes in the required-reserve ratios[9], while the former is calculated for fixed reserve ratios and fixed

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[6]See, for example, Stockman (1988), Plosser (1989) and McCallum (1989). -Variables related to fiscal policy--such as government expenditures--are not considered in this paper since various studies have shown that the impact of government actions--at least, as far as broad aggregates such as expenditures, revenues or deficits are concerned--on economic activity is negligible.

[7]Cf. Dewald, Marchon (1979), Neumann (1981), Hansen (1986), Fratianni, Nabli (1985) and Scheide (1989).

[8]The Kiel Institute adjusts the series of the monetary aggregates for structural breaks which are due to changes in the number of reporting banks etc. I also tested the importance of the money stock M2 and related measures, e.g. the time-deposit currency ratio. However, in accordance with other studies on the German economy, M2 does not show any clear-cut relationship with economic activity.

[9]For a discussion of the difference in the concepts, cf. Sachverständigenrat (1986). The data were kindly provided by the Sachverständigenrat. Unfortunately, there is no reliable series on required reserves for the entire estimation period, so the role of this policy measure cannot be explicitly analyzed.

structure of deposits. Furthermore, the money measures include the multipliers for M1 in terms of the two definitions of the monetary base (MB, MS). Finally, an important component of the multipliers is considered, namely the demand deposit-currency ratio (DC).

Quarterly data for Germany are available from 1960 onwards. They are usually published in the unadjusted form.[10] For all ten series, I use the seasonal difference in the logs of the variables, so that any variable X_{it} is in all tests defined as

$$X_{it} = (1-L^4)\log x_{it} \qquad i=1,2,...,10$$

where x_{it} is the original series and L is the lag operator. Differencing seems appropriate since the time series are, as can generally be assumed, integrated of order one.[11]

Before estimates of the variance decomposition of all systems are analyzed, I also test separately for Granger-causality. These tests can be interpreted as a method to determine whether a particular variable should be included in a model.[12] Also, since the software of defining confidence intervals for the decomposition is not generally available, tests for Granger-causality may be of some help in determining the strength of the link. For these tests, the procedure proposed by Hsiao (1981) based on Akaike's final-prediction-error criterion is used. The measure FPE is defined as

$$FPE = \frac{1}{T} \cdot \frac{T+q}{T-q} \cdot SSR$$

where T is the number of observations, q is the number of estimated coefficients, and SSR is the sum of the squared residuals in the regression.

All estimations cover the period 1964:1 to 1989:4, i.e. there are 104 observations. For all variables (seasonal differences of the logs), univariate autoregressions are run as follows:

$$(1) \qquad X_t = c + bt + \sum_{j=1}^{N} a_j X_{t-j} + u_t; \qquad N=1,2,...,8$$

where c is a constant and t takes account of the fact that a trend may be present in some of the

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[10] The exception is the monetary base in the definition of the Bundesbank which is published only on a seasonally adjusted basis.

[11] For a test of various series, cf. Scheide (1990).

[12] There are, of course, many alternative ways to test that, e.g. by means of exclusion restrictions.

variables. With the optimal lag length of N1, i.e. the lag at which the FPE reaches the minimum,[13] it is then tested whether another variable Z causes X:

$$(2) \qquad X_t = c + bt + \sum_{j=1}^{N1} a_j X_{t-j} + \sum_{j=1}^{N} d_j Z_{t-j} + v_t; \qquad N=1,2,...,8$$

Causality is present (Z causes X) if the FPE for any of the equations (2) is lower than the minimum in the univariate case (i.e. equation (1)). Reversed causality (does X cause Z?) as well as the causality relationship with further variables is tested accordingly.[14]

As a first check of the data, the cross correlations of real domestic expenditures with all other 9 series -- with lags running from -6 to +6 -- are calculated (Table 1). Both measures of the monetary base (BS and BB) as well as currency (CU) have the maximum correlation with contemporaneous Y. M1 and related measures (DD, DC and the M1-multipliers) seem to have a lead of two or three quarters; the terms of trade also have the highest correlation with output at a lead of three quarters.

Correlation, however, does not say anything about causality. For that, more appropriate tests are necessary; they are reported in the next section.

III. Causality Tests and Variance Decomposition

1. Two-variable systems

Since the object is to find out what causes output, the analysis starts with two-variable systems in which one of the series is real domestic expenditures (Y). All of the 9 variables under consideration have an impact (Table A1). The size of the reduction of the FPE[15] varies

[13]Up to eight lags are tested for each equation. The following analysis reveals that the optimal lag for the added variable is often just one. Later on, however, this criterion has to be given up because the estimation of the variance decomposition is based on a fixed number of lags. Nevertheless, the causality tests are helpful in determining the lag length that should be used; in general, lags 1 to 4 seem to be appropriate in most cases and are therefore used in the tests with vector autoregressions that follow.

[14]In the system with three variables, the system with the optimal lag N2 for Z in equation (2) serves as the starting point; given the optimal lags N1 and N2, another variable (S) is added to this equation to test for causality (does S cause X?), and so on.

[15]Note that the figures given for the FPE in all the tables in the Appendix are multiplied by 10^6.

Table 1

Cross Correlation Between Output (Y) and 9 Other Variables[a] (1963.1-1988.2)

	-6	-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5	+6
TT	0.31	0.40	0.40	0.42	0.37	0.28	0.29	0.17	0.09	0.05	-0.04	-0.04	-0.03
BS	-0.17	-0.02	0.15	0.31	0.45	0.52	0.53	0.48	0.38	0.31	0.23	0.16	0.14
BB	-0.09	0.08	0.24	0.39	0.52	0.58	0.58	0.54	0.46	0.36	0.27	0.20	0.13
CU	-0.22	-0.07	0.08	0.20	0.30	0.35	0.36	0.32	0.27	0.20	0.13	0.09	0.02
M1	0.11	0.27	0.41	0.54	0.59	0.54	0.44	0.28	0.10	-0.02	-0.08	-0.11	-0.10
DD	0.21	0.36	0.48	0.60	0.64	0.56	0.43	0.24	0.03	-0.09	-0.14	-0.17	-0.13
MS	0.36	0.44	0.46	0.49	0.42	0.28	0.11	-0.09	-0.26	-0.37	-0.36	-0.34	-0.30
MB	0.26	0.34	0.40	0.45	0.41	0.28	0.13	-0.07	-0.27	-0.36	-0.36	-0.35	-0.28
DC	0.45	0.53	0.55	0.61	0.57	0.43	0.25	0.05	-0.18	-0.28	-0.27	-0.27	-0.18

[a] $X_{i,t+j}$ with j ranging from -6 to +6.

Variables (seasonal differences of the logs) are as defined in the text. Y: real domestic expenditure.
TT: terms of trade. BS: corrected monetary base. BB: monetary base.
CU: currency. M1: money stock M1. DD: demand deposits.
MB: M1-multiplier for BB. MS: M1-multiplier for BS. DC: ratio demand deposits-currency.

hinting at a difference in the strength of the causal link.[16] While the terms of trade (TT) do as well as the monetary base (BB), a more significant impact seems to come from the money stock M1 and related measures, namely demand deposits (DD), the two multipliers (MS and MB) and the deposit currency ratio (DC). While this result can certainly not suffice to convince proponents of real business cycle theory--after all, money may still be endogenous[17]--it does support the hypothesis that there is a causal relationship between money and output, and this applies--given the information sets--also to the monetary base.

Most of the 9 variables in the respective systems are not caused, however, by output (Table A2); the terms of trade, the variables of the monetary base, M1 and most related measures can be viewed as exogenous in the two-variable systems. Output has an impact only on the deposit currency ratio (DC). So only in this case there is an interdependence, whereas otherwise there is causality in just one direction.

The next preliminary test concerns the relationship between the terms of trade and the various money measures. The results for the causality tests (Table A3) reveal that all measures of money help to predict the terms of trade[18]. While the influence of money may not be surprising--it may just reveal that monetary policy affects the exchange rate--the tests for causality in the opposite direction, however, do not always show the expected relationship (Table A4). The hypothesis that the terms of trade have a significant impact on those monetary variables which are endogenous, thereby explaining, at least in part, the causal link between money and output does not find much support. The impact of the terms of trade on BS does not reflect an endogenous response of money to a real shock but suggest, if anything, a reaction function of the central bank in which the terms of trade play a role.[19] There is only a small influence on the multiplier (MS)--the reduction of the FPE is minimal. However, the terms of trade strongly influence the deposit currency ratio (DC) which may reflect the

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[16]The bigger the decline in the FPE, the more significant is the influence in terms of the t-statistic for a given number of estimated coefficients q.

[17]This hypothesis will be taken up below.

[18]The sign is negative in all cases.

[19]However, the impact is only on BS and not BB. So one would have to argue that changes of the terms of trade induce the Bundesbank to change reserve requirements.

response of the private sector to a real disturbance. Given this, it is surprising, though, that neither demand deposits nor the multiplier MB are affected. Nevertheless, this result will be taken into account for further tests.

For the two-variable systems described above, the results for the forecast error variance decomposition are also reported. On the one hand, given the causality tests, these estimates may not provide much new information, for if there is no causality, the contribution to explaining the forecast variance may also be minimal. But on the other hand, they provide an important additional information by estimating the effects of shocks (innovations) on the "dependent" variable. The percentage of the explanation in the forecast variance may vary substantially between the variables.

The results are based on estimates of the following type of equation[20]:

$$(3) \qquad X_t = c + bt + \sum_{i=1}^{4} a_i X_{t-i} + \sum_{i=1}^{4} d_i Z_{t-i} + \varepsilon_t$$

The (fixed) lag length is four in all cases; given the results for the causality tests, this choice can be justified since the optimal lag length in those systems is often smaller than or at least close to four. Therefore, the use of, e.g., eight lags might be inappropriate in many of the systems considered here and might unduly reduce the degrees of freedom.[21]

Table 2 summarizes the variance decomposition results for the 12-quarters-ahead forecast error in the systems analyzing the causal relationship with real domestic expenditures.[22] In general, these results support the conclusions based on the causality tests[23]: Those series which have a strong causal influence on real domestic expenditures--i.e. they lead to a large reduction in the FPE--also account for a large share when the impact of innovations

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[20]The equation for Z is equivalent.

[21]Manchester (1989) estimates systems with eight lags for each variable; Plosser (1990), however, also uses four lags.

[22]The results depend on the ordering of the variables (the information concerning the ordering is therefore always given in the tables). The numbers in the table refer to the part of the forecast error variance explained by the respective other variable. Each variable itself explains the difference between the values given and 100.

[23]Tables A1 and A2.

of these series (X) on the variance of Y are analyzed. In particular, M1, DD and DC (with values of 28.1, 30.4 and 26.9, respectively) perform better in this regard than TT (18.7). The effect of a different ordering can be seen in the right part of Table 2. In most cases, the innovations in the series X now account for a much larger share of the forecast variance of Y; equivalently, innovations in Y explain a smaller share of the variance in X. In general, the results in columns 3 and 5 accord with the causality tests, i.e. real domestic expenditures seem to affect only the deposit currency ratio.

The variance decomposition results for the systems including the terms of trade (TT) are also in accordance with the results of the causality tests[24]: Several of the monetary aggregates and other money measures explain a large part of the forecast variance in TT (up to 29.1 percent in the case of currency), while the multiplier MS shows the smallest impact which is--if the causality results are considered--not significant (Table 3). In the opposite direction, the terms of trade explain only a small fraction of the forecast variance of the series under consideration. As before, the impact on the deposit currency ratio is high; contrary to the results of the causality tests, there is a comparable influence on demand deposits (DD).

To summarize, the analysis so far contradicts the view that monetary impulses play no or only a minor role in explaining output movements. The money stock M1 and most related measures seem to have a bigger impact than the terms of trade; the latter variable does not explain more than the two measures of the monetary base and performs only slightly better than currency. Furthermore, money causes the real variable terms of trade. In contrast, most monetary variables are exogenous with respect to output and the terms of trade in the respective two-variable systems; a notable exception is the deposit currency ratio (DC).

However, the tests are not yet complete. Analyzing whether the impact of money on real variables is due to the overriding importance of the public's response to real shocks rather than actions by the central bank and whether the terms of trade play a dominating role in explaining output--directly or via measures of money--requires larger systems to which I will turn next.

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[24]Tables A3 and A4.

Table 2

Variance Decomposition in Two-variable Systems with Output (Y) and 9 Other Variables (X) - 12 steps ahead[a]

	[Y X]		[X Y]	
Series X	Innovation in X, effect on Y	Innovation in Y, effect on X	Innovation on X, effect on Y	Innovation in Y, effect on X
TT	18.7	11.4	30.5	1.1
BS	19.7	5.0	28.8	3.1
BB	25.1	2.8	31.9	1.0
CU	14.7	1.3	21.1	0.5
M1	28.1	3.6	44.4	3.9
DD	30.4	6.0	50.0	4.6
MS	24.5	6.0	35.5	6.1
MB	20.9	8.0	37.6	8.2
DC	26.9	20.1	45.5	16.8

[a]Ordering in brackets.

Table 3

Variance Decomposition in Two-variable Systems with Terms of Trade (TT) and 8 Money Measures (X) - 12 steps ahead[a]

	[TT X]		[X TT]	
Series X	Innovation in X, effect on TT	Innovation in TT, effect on X	Innovation in X, effect on TT	Innovation in TT, effect on X
BS	28.9	8.1	30.7	8.5
BB	16.6	9.9	20.6	7.4
CU	29.1	4.2	34.1	5.1
M1	25.7	8.6	31.2	7.1
DD	20.2	11.0	25.2	9.8
MS	9.3	4.3	13.9	2.4
MB	16.7	4.5	20.2	4.6
DC	13.8	11.7	18.9	9.3

[a]Ordering in brackets.

2. Systems with three variables

Based on the results of the causality tests reported in Table A1 and A2, it is now analyzed whether the addition of a third variable improves the forecast derived from the optimal two-variable systems, i.e. whether the respective third variable also causes output in the Granger sense (Table A5). It is obvious from the first three systems that the influence of demand deposits (DD) dominates when the monetary base (both BS and BB) or currency (CU) is added; neither of these three variables can improve the forecast of output (Y) based on the knowledge of Y and DD. If the influence of the monetary base is compared to that of the respective multipliers (systems (4) and (5)), the stronger impact comes in both cases from the multipliers; only the base BS is causal in the system (reducing the FPE slightly) while the addition of BB leaves the FPE unchanged. However, both measures of the base--as well as currency--are causal in the systems with one component of the multiplier, namely the deposit currency ratio (DC), although the impact from DC seems to be stronger in all cases, i.e. the FPE declines much more when this variable is added.

Testing the relative performance of the terms of trade (TT) reveals that this real variable causes output in all of the three-variable systems. Its impact appears to be strong--i.e. the reduction of the FPE large--when high-powered money and currency are included (systems (10) to (12)), while the effect is small when M1, DD and DC are included in the systems ((9), (13), (14)). This result seems plausible from a real-business-cycle point of view; however, the fact is that the monetary base in either definition also causes output even when the series terms of trade is included.

For all the 14 systems described the analysis is extended to the estimation of the forecast error variance decomposition (Table 4).[25] These tests not only reveal the impact of shocks in the variables on output but also give a clue as to the interaction of all variables in a system. The comparison between effects of demand deposits (DD) on the one hand and the monetary base (BS and BB) and currency (CU) on the other shows--again--a dominance of

[25]The estimates are based on equations like (3), the systems now include three (and later four) variables. Note that in the tables of the variance decomposition the numbers in each row add up to 100.

DD. This is obvious for both orderings chosen; the contribution varies substantially only in the case of BB (system (3)): Innovations in the monetary base seem to have a significant impact on output (14.6) in the first but only a negligible effect in the second ordering (1.9). The relative importance of the measures of the monetary base and the respective multipliers or the multiplier component DC changes with the ordering; nevertheless, there is no clearcut evidence that would reject the hypothesis of an influence of the monetary base in addition to that of the respective other variables. Currency, however, seems to be unimportant in connection with DC (system (8)).

While it might be expected that innovations in the money shock M1 dominate the impact on output that comes from the terms of trade (system (9)), it is somewhat surprising that the innovations in the monetary base contribute more to the reduction in the forecast variance of output than the real variable. This is even the case for currency (system (12)). The reason may be that the terms of trade are not exogenous with respect to the various money measures[26]; in the variance decomposition results, therefore, innovations in the monetary base or in currency explain up to 36.5 percent of the forecast error variance of the terms of trade. Finally, in connection with DD and DC (systems (13) and (14)), the impact of the terms of trade seems to be somewhat stronger.

In general, these results indicate that only a small role can be attributed to the terms of trade for explaining output fluctuations. The question that will be analyzed next is what the indirect role of the terms of trade may be; i.e. does this variable have a substantial impact on the multipliers and the deposit currency ratio?

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[26]See also Table A3.

Table 4

Variance Decomposition in Three-variable Systems with

Output (Y) and 9 Other Variables - 12 steps ahead[a]

		Innovation in:					
Effect on:	(1)	[Y	BS	DD]	[Y	DD	BS]
Y		68.4	6.0	25.6	68.4	26.8	4.8
BS		2.6	51.1	46.3	2.6	68.6	28.8
DD		4.6	21.5	73.9	4.6	84.4	11.0
	(2)	[Y	BB	DD]	[Y	DD	BB]
Y		67.8	14.6	17.7	67.8	30.4	1.9
BB		2.0	68.7	29.3	2.0	73.5	24.5
DD		4.9	34.3	60.8	4.9	92.2	3.0
	(3)	[Y	CU	DD]	[Y	DD	CU]
Y		69.9	5.4	24.7	69.9	28.4	1.6
CU		1.1	86.9	12.0	1.1	36.8	61.1
DD		7.2	40.9	51.9	7.2	72.5	20.3
	(4)	[Y	BS	MS]	[Y	MS	BS]
Y		70.9	4.7	24.5	70.9	20.3	8.8
BS		2.9	39.9	57.1	2.9	51.9	45.2
MS		3.7	15.3	81.1	3.7	82.3	12.3
	(5)	[Y	BB	MB]	[Y	MB	BB]
Y		68.7	14.4	16.9	68.7	20.7	10.6
BB		2.9	65.2	31.9	2.9	42.2	54.9
MB		5.7	8.4	85.8	5.7	89.1	5.2
	(6)	[Y	BS	DC]	[Y	DC	BS]
Y		73.6	13.9	12.5	73.6	17.5	8.9
BS		4.8	89.9	5.3	4.8	17.2	78.0
DC		11.6	41.8	46.5	11.6	53.3	31.0
	(7)	[Y	BB	DC]	[Y	DC	BB]
Y		70.8	17.6	11.7	70.8	18.0	11.3
BB		1.8	88.9	9.3	1.8	22.7	25.5
DC		10.5	40.8	48.7	10.5	60.5	29.0
	(8)	[Y	CU	DC]	[Y	DC	CU]
Y		69.9	5.4	24.7	69.9	18.8	11.2
CU		1.1	86.9	12.0	1.1	3.8	95.2
DC		12.1	21.3	66.5	12.1	63.0	25.0

Table 4 (cont'd.)

Effect on:		Innovation in:					
	(9)	[Y	M1	TT]	[Y	TT	M1]
Y		66.3	22.5	11.2	66.3	11.5	22.2
M1		5.1	88.3	6.6	5.1	9.3	85.6
TT		16.4	33.2	50.4	16.4	55.0	28.6
	(10)	[Y	BS	TT]	[Y	TT	BS]
Y		69.8	20.4	9.7	69.8	9.3	20.9
BS		3.4	90.9	5.6	3.4	5.4	91.2
TT		9.9	36.5	53.6	9.9	54.2	35.9
	(11)	[Y	BB	TT]	[Y	TT	BB]
Y		67.7	21.8	10.5	67.7	10.3	22.0
BB		2.0	92.4	5.5	2.0	7.5	90.4
TT		11.1	24.0	64.9	11.1	68.1	20.8
	(12)	[Y	CU	TT]	[Y	TT	CU]
Y		74.2	16.1	9.7	74.2	10.2	15.6
CU		0.7	95.0	4.3	0.7	4.2	95.1
TT		9.1	34.5	56.4	9.1	59.2	31.6
	(13)	[Y	DD	TT]	[Y	TT	DD]
Y		65.6	22.2	12.2	65.6	12.7	21.7
DD		6.3	83.4	10.3	6.3	12.9	80.8
TT		18.2	26.6	55.2	18.2	60.1	21.8
	(14)	[Y	DC	TT]	[Y	TT	DC]
Y		67.8	17.6	14.6	67.8	16.6	15.6
DC		15.1	68.0	16.9	15.1	20.3	64.6
TT		7.5	24.7	67.7	7.5	75.9	16.6

[a]Ordering in brackets.

Table A6 summarizes the tests for the causal link between measures of "endogenous money" (DD, MS, MB, DC) on the one hand and "high-powered" money (BS, BB, CU) or the terms of trade (TT) on the other. Since demand deposits, the multipliers and the deposit currency ratio (as an important component of the multipliers) show a strong link with real domestic expenditures, the question is whether they are themselves influenced by a real variable rather than by changes in monetary policy. The series DD is not affected by TT whereas BS, BB and CU cause DD in the respective two-variable systems. Only in one case does TT help to improve the forecast based on the two-variable system (DD, BB), while both measures of the monetary base cause DD in the system with TT.

The multiplier MB is exogenous with respect to all variables under consideration. In the case of MS, however, there is a reduction of the FPE if the terms of trade and the monetary base (BS) are included in that system; the impact from BS is greater. The deposit currency ratio is caused by all variables under consideration; in general, it can be said that the real variable TT does not perform better than the monetary base (BS or BB) or currency (CU) in explaining DC.

The variance decomposition results for the three-variable systems mentioned in Table A6 conform, in general, with the conclusions mentioned above (Table 5). However, the variable of the terms of trade, though not reducing the forecast variance of DD by a large amount, is more important than the monetary base (BS and BB). The most striking change can be observed in the case of currency: CU has a very strong impact on DD while the terms

Table 5

Variance Decomposition in Three-variable Systems with Exogenous and Endogenous Money-12 steps ahead[a]

		Innovation in:					
Effect on:	(1)	[DD	BS	TT]	[DD	TT	BS]
DD		90.0	2.5	7.5	90.0	6.8	3.3
BS		66.4	25.6	8.0	66.4	7.6	26.0
TT		29.1	6.0	64.8	29.1	66.9	3.9
	(2)	[DD	BB	TT]	[DD	TT	BB]
DD		90.7	0.2	9.1	90.7	9.0	0.2
BB		66.3	27.2	6.6	66.3	6.9	26.8
TT		25.4	2.6	72.1	25.4	73.8	0.8
	(3)	[DD	CU	TT]	[DD	TT	CU]
DD		72.7	22.9	4.4	72.7	4.9	22.4
CU		29.7	66.8	3.5	22.1	65.7	12.2
TT		22.1	15.6	62.3	29.7	2.4	67.9
	(4)	[DC	BS	TT]	[DC	TT	BS]
DC		56.4	31.9	11.7	56.4	9.3	34.4
BS		8.9	82.9	8.2	8.9	8.8	82.3
TT		4.9	27.0	68.1	4.9	71.3	23.8
	(5)	[DC	BB	TT]	[DC	TT	BB]
DC		65.8	24.5	9.7	65.8	7.4	26.8
BB		18.2	77.3	4.6	18.2	8.0	73.8
TT		8.8	13.9	77.3	8.8	82.0	9.1
	(6)	[DC	CU	TT]	[DC	TT	CU]
DC		70.1	27.8	7.2	70.1	5.4	24.6
CU		2.3	94.1	3.5	2.3	3.7	93.9
TT		4.8	32.9	62.3	4.8	70.0	25.6
	(7)	[MB	BB	TT]	[MB	TT	BB]
MB		92.7	2.5	4.9	92.7	4.0	3.3
BB		34.7	58.1	7.3	34.7	8.4	56.9
TT		23.7	8.0	68.3	23.7	71.3	5.0
	(8)	[MB	CU	TT]	[MB	TT	CU]
MB		95.6	1.0	3.4	95.6	3.2	1.1
CU		30.7	64.4	4.9	30.7	4.8	64.5
TT		22.1	13.6	64.2	22.1	67.5	10.4
	(9)	[MS	BS	TT]	[MS	TT	BS]
MS		85.9	10.4	3.7	85.9	2.3	11.7
BS		32.5	58.7	8.8	32.5	9.5	58.0
TT		14.3	22.8	62.8	14.3	69.0	16.6
	(10)	[MS	CU	TT]	[MS	TT	CU]
MS		96.0	2.3	1.7	96.0	1.2	2.8
CU		34.9	58.8	63.3	34.9	6.4	58.6
TT		14.5	18.8	66.7	14.5	70.8	14.7

[a]Ordering in brackets.

of trade do not explain a substantial part of the forecast error variance.

3. Tests of restricted and unrestricted four-variable systems

Finally, a strong version of the real business cycle theory is tested in systems which include four variables: output, the money multiplier or other measures of endogenous money, the terms of trade and the monetary base. The hypothesis is that the monetary base plays no role in explaining any of the other three variables under consideration. For that purpose, the four equations which contain four lags of each variable (plus constant and time trend) are estimated simultaneously[27] with and without the restriction that the coefficients of the monetary base are zero (i.e. there are 12 restrictions). For the estimates of the unrestricted and restricted systems the likelihood ratio is calculated which follows a chi-square distribution.[28]

Table 6 summarizes the results for the six systems. The null-hypothesis (i.e. the coefficients of the monetary base are zero) can be rejected in three cases. As could be expected from the results in the previous tests, in those systems which include demand deposits (DD) the null-hypothesis (H_0) cannot be rejected which again suggests a strong role for this variable in explaining output.

While these results seem somewhat inconclusive, it has to be remembered that in those systems the monetary base had to "compete" against two other measures which are supposedly much more important for explaining output. The ambiguity of the results is also revealed in the results for the forecast error variance decomposition for the same systems (Table 7). Here, the output variable of domestic expenditures (Y) always appears first in the ordering of variables. The motive behind changing the ordering for the remaining variables is to give the monetary base a "chance" equal to that of the terms of trade so TT appears either in fourth or in second place (the multipliers, the deposit currency ratio and demand deposits are always

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[27]Contrary to the common practice in vector autoregressions and estimates of variance decompositions which are based on estimates equation by equation, the equations in the systems mentioned above are estimated simultaneously to take account of the fact that the residuals of the equations may be correlated (method of "seemingly unrelated equations").

[28]The critical values for the chi-square distribution (for 12 degrees of freedom) are 18.55, 21.03 and 26.22 for the 10%, 5% and 1% level of significance, respectively.

Table 6

Likelihood-ratio Tests for Unrestricted and Restricted Four-variable Systems

System	Calculated value of likelihood-ratio	Conclusion for H_0
(1) [Y MS BS TT]	41.66	rejected
(2) [Y MB BB TT]	16.70	not rejected
(3) [Y DC BS TT]	31.22	rejected
(4) [Y DC BB TT]	24.36	rejected
(5) [Y DD BS TT]	12.14	not rejected
(6) [Y DD BB TT]	4.48	not rejected

ordered in third place).

Given that the variable of real domestic expenditures explains 65 to 70 percent of its own forecast variance and that the other variables have to account for the rest, a value of well above 10 percent would indicate a substantial impact, while a value of well below 10 percent would mean that the innovations in that respective variable are of minor importance. By this definition, the multipliers (MB and MS) and demand deposits (DD) are the most important variables for explaining output fluctuations. The deposit currency ratio (DC), however, plays only a small role in systems including any measure of the monetary base. In most systems, innovations in the monetary base explain at least as much of the forecast error variance of Y as the terms of trade, the exceptions being systems (1) and (5). In general, BB seems to perform better than BS indicating that changes in reserve requirements do not play a major role in explaining output.

Also in these systems, the impact of the terms of trade on measures which represent endogenous money is small; TT explains more than 10 percent only in the case of the forecast error variance in DC. However, it is important to note that the measures of the monetary base

Table 7

Variance Decomposition in Four-variable Systems with Output (Y), the Terms of Trade and Various Money Measures--

12 steps ahead[a]

Innovation in:

Effect on:									
	(1)	[Y	BS	MS	TT]	[Y	TT	MS	BS]
Y		66.6	2.3	20.5	10.6	66.6	10.2	16.3	7.0
BS		4.8	37.6	51.0	6.6	4.8	8.9	37.5	48.8
MS		2.9	11.8	79.7	5.7	2.9	6.2	80.7	10.3
TT		15.4	13.0	24.9	46.7	15.4	52.5	15.2	16.9
	(2)	[Y	BB	MB	TT]	[Y	TT	MB	BB]
Y		64.4	11.2	13.9	10.6	64.4	10.4	16.6	8.6
BB		3.7	63.4	28.1	4.8	3.7	7.2	35.5	53.6
MB		5.7	6.0	81.4	6.8	5.7	6.9	82.6	4.8
TT		15.7	10.7	23.1	50.5	15.7	55.0	23.9	5.4
	(3)	[Y	BS	DC	TT]	[Y	TT	DC	BS]
Y		70.0	14.0	5.8	10.1	70.0	9.1	9.5	11.4
BS		4.8	88.5	1.9	4.8	4.8	4.5	9.3	81.4
DC		8.1	39.9	38.2	13.7	8.1	11.8	46.5	33.6
TT		12.7	34.0	1.5	51.8	12.7	53.4	5.1	28.7
	(4)	[Y	BB	DC	TT]	[Y	TT	DC	BB]
Y		68.3	15.4	6.2	10.1	68.3	10.4	10.2	11.1
BB		2.2	88.0	7.1	2.8	2.2	6.7	17.7	73.5
DC		8.5	37.3	42.4	11.8	8.5	10.8	51.7	29.0
TT		14.4	19.9	7.0	58.7	14.4	64.2	9.2	12.1
	(5)	[Y	BS	DD	TT]	[Y	TT	DD	BS]
Y		66.3	4.4	19.2	10.1	66.3	9.1	22.3	2.3
BS		4.7	50.8	39.2	5.3	4.7	6.3	62.8	26.2
DD		5.7	18.6	67.9	7.8	5.7	8.2	79.0	7.1
TT		16.6	18.2	17.5	47.8	16.6	52.3	27.1	4.0
	(6)	[Y	BB	DD	TT]	[Y	TT	DD	BB]
Y		65.0	12.0	12.4	10.6	65.0	10.5	23.1	1.4
BB		3.3	68.5	24.1	4.2	3.3	7.1	65.7	23.9
DD		6.0	30.8	54.5	8.8	6.0	10.5	81.9	1.7
TT		17.4	13.8	16.4	52.5	17.4	57.4	24.7	0.5

[a]Ordering in brackets.

explain not only a large share of the variance in the terms of trade but also have a substantial impact on demand deposits and the deposit currency ratio with values between 18.6 (system (5)) and 39.9 percent (system (3)), when the first ordering is considered.

IV. Conclusions

The causality tests and the estimates of forecast error variance decomposition have the purpose to find sources of output fluctuations. The variables under consideration reflect actions of the central bank, a real disturbance and responses of the public. One object is to test the relative importance of the different variables. Many regressions were run for the period 1964-1989 in order to take account of the fact that results and interpretations very much depend on the information set chosen. It would be possible to pick results in such a way as to either support the real business cycle view or to subscribe to conventional theories.

Although the evidence is not always clearcut it seems safe to conclude that the strong hypothesis of real business cycle theory finds no or only limited support. For this theory to be correct it would have to be shown that first, the monetary base has no impact on output and second, that measures of endogenous money are not only the dominant explanatory variables for output but are also influenced exclusively by supply shocks.[29] As to the first hypothesis, the results of the empirical tests do not allow a rejection of the view that actions of the central bank matter. Both measures of the monetary base - and even currency - explain some of the movements of output. Furthermore, the monetary base BB seems to perform better in many cases than BS; a real business cycle interpretation would imply the opposite because BS takes account of changes in reserve requirements. As far as the second hypothesis is concerned, it is indeed obvious that the stronger impact on output stems from the multipliers or demand deposits. But these measures of endogenous money are themselves not dominantly explained by movements of the terms of trade; in fact, they are at least as much influenced by monetary policy. In the tests presented here, the response of the public does not necessarily

[29]"It seems inadequate to conclude that whatever is not monetary ... must be real in the sense of real disturbances that appear in RBC theories" [Barro, 1986, p. 136].

mean a response to supply shocks.

The tests reveal that real disturbances, measured as changes in the terms of trade, are not the dominant source of output fluctuations although there is certainly a causal role. In principle, the variable of the terms of trade could be an important measure of real shocks. It is observable, it also has fluctuated substantially and could therefore account for major ups and downs in economic activity.[30] It would, of course, be ideal to use a real disturbance which is truly exogenous. The variable of the terms of trade is not since - as the tests also show - it is influenced by domestic monetary policy and - one may assume - by foreign monetary policy as well. Even changes in, say, raw material prices which may have a dominant impact on the terms of trade cannot be viewed as exogenous since they are also affected by monetary policy in industrial countries [Langfeldt, Scheide, Trapp 1989].

To summarize, the German experience does not support the real business cycle interpretation in its strong version which denies any importance of central bank actions. There is a role for the monetary base in explaining output movements although the effects stemming from reactions of the public seem to be stronger. But a satisfactory interpretation along the lines of real business cycle theory would require more empirical research to test what the possible causes of these responses by the public are. In this regard, the variable of the terms of trade is obviously not the suitable choice.

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[30] If measured in relation to output, it accounted for a 2.5 percent decline before the 1974/75 recession; before the 1980/82 downturn, the respective value was 2 percent. However, prior to the recession in 1966/67 (which was about as severe as the other two) no major change could be observed.

Appendix

Table A1

Causality Tests for Output (Y) and 9 Other Variables[a]

Added Variable	Optimal lag	FPE	Causality (yes/no)
TT	2	286	yes
BS	1	294	yes
BB	3	286	yes
CU	1	296	yes
M1	1	272	yes
DD	1	264	yes
MS	1	277	yes
MB	1	277	yes
DC	1	268	yes

[a]Based on the optimal univariate model for Y with AR(4) and FPE = 297.

Table A2

Causality Tests for 9 Variables and Output (Y)

Variable	Optimal lag for univariate case (FPE)	Optimal lag for added variable Y (FPE)	Causality (yes/no)
TT	7 (336)	1 (341)	no
BS	7 (147)	1 (150)	no
BB	6 (60)	1 (61)	no
CU	5 (125)	1 (127)	no
M1	2 (213)	1 (224)	no
DD	2 (391)	2 (392)	no
MS	4 (197)	1 (199)	no
MB	4 (138)	1 (139)	no
DC	8 (351)	2 (347)	yes

Table A3

Causality Tests for Terms of Trade (TT) and 8 Money Measures[a]

Added Variable	Optimal lag	FPE	Causality (yes/no)
BS	2	309	yes
BB	3	334	yes
CU	3	326	yes
M1	5	302	yes
DD	5	297	yes
MS	4	336	no
MB	5	309	yes
DC	5	309	yes

[a]Based on the optimal univariate model for TT with AR(7) and FPE = 336.

Table A4

Causality Tests for 8 Money Measures and Terms of Trade (TT)

Variable	Optimal lag for univariate case (FPE)	Optimal lag for added variable TT (FPE)	Causality (yes/no)
BS	7 (147)	3 (142)	yes
BB	6 (60)	1 (60)	no
CU	5 (125)	4 (125)	no
M1	2 (213)	1 (219)	no
DD	2 (391)	1 (392)	no
MS	4 (197)	8 (193)	yes
MB	4 (138)	1 (140)	no
DC	8 (351)	1 (335)	yes

Table A5

Causality Tests for Output(Y)
and 9 Other Variables in Three-variable Systems

	Two-variable system[a] (optimal lags)	FPE	Added variable	Optimal lag for the added variable (FPE)	Causality (yes/no)
(1)	Y,BS(4,1)	294	DD	1 (267)	yes
	Y,DD(4,1)	264	BS	1 (267)	no
(2)	Y,BB(4,3)	286	DD	1 (276)	yes
	Y,DD(4,1)	264	BB	1 (269)	no
(3)	Y,CU(4,1)	296	DD	1 (264)	yes
	Y,DD(4,1)	264	CU	1 (264)	no
(4)	Y,BS(4,1)	294	MS	1 (275)	yes
	Y,MS(4,1)	277	BS	1 (275)	yes
(5)	Y,BB(4,3)	286	MB	1 (282)	yes
	Y,MB(4,1)	277	BB	1 (277)	no
(6)	Y,BS(4,1)	294	DC	5 (264)	yes
	Y,DC(4,1)	268	BS	1 (267)	yes
(7)	Y,BB(4,3)	286	DC	5 (267)	yes
	Y,DC(4,1)	268	BB	1 (265)	yes
(8)	Y,CU(4,1)	296	DC	5 (261)	yes
	Y,DC(4,1)	268	CU	1 (264)	yes
(9)	Y,M1(4,1)	272	TT	2 (269)	yes
	Y,TT(4,2)	286	M1	2 (267)	yes
(10)	Y,BS(4,1)	294	TT	2 (286)	yes
	Y,TT(4,2)	286	BS	3 (283)	yes
(11)	Y,BB(4,3)	286	TT	2 (280)	yes
	Y,TT(4,2)	286	BB	3 (280)	yes
(12)	Y,CU(4,1)	296	TT	2 (286)	yes
	Y,TT(4,2)	286	CU	1 (286)	no
(13)	Y,DD(4,1)	264	TT	2 (262)	yes
	Y,TT(4,2)	286	DD	1 (262)	yes
(14)	Y,DC(4,1)	268	TT	2 (264)	yes
	Y,TT(4,2)	286	DC	1 (264)	yes

[a]Based on the causality tests reported in Table A1.

Table A6

Causality Tests for Demand Deposits and Money Multipliers

Optimal System (Lags)	FPE	Added Variable	Optimal lag for added variable	Causality (yes/no)
DD(2)	391	BS	2(380)	yes
DD(2)	391	BB	6(386)	yes
DD(2)	391	CU	4(387)	yes
DD(2)	391	TT	1(392)	no
DD,BS(2,2)	380	TT	1(384)	no
DD,BB(2,6)	386	TT	1(385)	yes
DD,CU(2,4)	387	TT	1(393)	no
DD,TT(2,1)	392	BS	5(380)	yes
DD,TT(2,1)	392	BB	6(385)	yes
DD,TT(2,1)	392	CU	3(393)	no
MS(4)	197	BS	3(170)	yes
MS(4)	197	CU	1(198)	no
MS(4)	197	TT	8(193)	yes
MS,BS(4,3)	170	TT	8(171)	no
MS,CU(4,1)	198	TT	8(196)	no
MS,TT(4,8)	193	BS	3(171)	yes
MS,TT(4,8)	193	CU	1(201)	no
MB(4)	138	BB	1(140)	no
MB(4)	138	CU	1(141)	no
MB(4)	138	TT	1(141)	no
MB,BB(4,1)	140	TT	1(142)	no
MB,CU(4,1)	141	TT	1(143)	no
MB,TT(4,1)	140	BB	1(142)	no
MB,TT(4,1)	140	CU	1(143)	no
DC(8)	351	BS	4(327)	yes
DC(8)	351	BB	3(337)	yes
DC(8)	351	CU	4(337)	yes
DC(8)	351	TT	1(335)	yes
DC,BS(8,4)	327	TT	3(318)	yes
DC,BB(8,3)	337	TT	1(326)	yes
DC,CU(8,4)	337	TT	1(332)	yes
DC,TT(8,1)	335	BS	2(317)	yes
DC,TT(8,1)	335	BB	3(326)	yes
DC,TT(8,1)	335	CU	2(331)	yes

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