

*Testing the Causal Relationship between the Domestic Credit and Reserve Components of a Country's Monetary Base**

An important factor that helps distinguish between alternative balance of payments theories is the assumed causal relationship between the domestic credit and reserve components of a country's monetary base. This paper reports test results of this causal relationship in Australia, Belgium, France, Germany, Norway, and Sweden. Three causal detection methods are used: the Haugh test, the Granger test, and the Sims test. Two conclusions are drawn. First, the causal relationship does not run unidirectionally from domestic credit to reserves as the Monetary Approach to the Balance of Payments and many tests of that approach assume. Second, the results are quite robust across alternative causality tests.

1. Introduction

The exact nature of the causal relationship between the domestic credit and international reserve components of a country's monetary base is important because it is one of the key factors that distinguishes one balance of payments theory from another. One of these theories, the Monetary Approach to the Balance of Payments (MBOP), which assumes "the direction of causality . . . is clearly from domestic credit to foreign reserves" [Blejer (1979), p. 290], is particularly interesting for it not only forms the basis of a popular explanation of the worldwide inflationary epidemic of the late 60's [Johnson (1972b)], but it is also used by the IMF for policy recommendations to its member countries [Rhomberg and Heller (1977)] even though it poses "a direct challenge to the current orthodoxy and [has] revolutionary implications for

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balance-of-payments policy and even for balance-of-payments accounting" [Whitman (1975), p. 495]. If the causal relationship between domestic credit and reserves is not that posited by the MBOP, then not only might the theory and its numerous empirical tests (that explicitly or implicitly assume domestic credit exogeneity) be questioned [see Kreinin and Officer (1978) for a detailed summary of these studies], but so too might the revolutionary policy implications of that theory. Consequently, it is imperative that the causal relationship between domestic credit and reserves be tested formally, rather than remain a mere assertion now that empirical causal detection procedures have been proposed. This formal testing is one of the purposes of this paper.

Indeed, Phaup and Kusinitz (1977) and Blejer (1979) have tested for the causal relationship between these variables using alternative causal detection methods. Phaup and Kusinitz (1977) used a variation of the Haugh (1976) test of independence and found mixed results. There are two potential problems with their tests, however. First, the Haugh test is strictly appropriate only as a test of independence and cannot be used to draw formal statistical inferences regarding causal ordering. Second, the authors attach significant value to the sign, pattern, and magnitude of the cross-correlation coefficients used in their test which is problematic given that both series were prewhitened by different filters [Schwert (1977)]. Blejer (1979) employs the Sims (1972) procedure and concludes that the evidence "is indeed consistent with the direction of causality as proposed by the monetary approach to the balance of payments . . ." (p. 296). There are, however, a few potential problems with his tests as well. First, no explicit account has been taken of the possibility that serial correlation exists in the residuals. This omission does not appear to be a serious problem because most Durbin-Watson statistics do not indicate first-order serial correlation. Higher order serial correlation may exist, however, which can bias reported F statistics [see Granger and Newbold (1974)]. Second, Blejer pays little attention to the issue of instantaneous causality, a problem that is quite transparent given that all the contemporaneous coefficients in his regressions are highly significant. There is one problem, with potentially severe consequences, common to both the Phaup-Kusinitz study and the Blejer study, and it is that each study employs only one causal detection procedure when there are three to choose from—the Granger (1969) test, the Haugh (1976) test and the Sims (1972) test. Recently, Feige and Pearce (1979) have concluded, after a detailed examination

of money-income causality, that the "alternative methods for detecting causal relationships do not necessarily yield unambiguously compatible economic conclusions, even when the data base is uniform across test procedures" (p. 531). Consequently, one cannot put too much faith in the conclusions drawn by Phaup-Kusnitz (1977) and Blejer (1979) because their reported results may be technique sensitive.

The purpose of this paper is twofold. First, we test alternative hypotheses regarding the important causal relationship between domestic credit and reserves using a common data base and the Haugh (1976), Granger (1969), and Sims (1972) tests. Second, we examine whether the substantive conclusions regarding causal ordering are robust with respect to the different empirical testing procedures. The issue of robustness is not only important in the present context of uncovering the true relationship between domestic credit and reserves, but is important in general because of the ever increasing interest in individual causality tests as a means of distinguishing between alternative economic hypotheses.

The balance of the paper breaks down as follows. Section 2 briefly discusses several possible relationships between domestic credit and reserves that have appeared in the literature to show that the causal relationship between these variables assumed in the MBOP is only one of several alternatives. Section 3 summarizes three causality tests employed in this paper to test the domestic credit-reserve relationship. Section 4 reports the results of the tests and Section 5 highlights our conclusions.

2. Domestic Credit-Reserve Relationships

A popular reduced-form expression of the MBOP [see e.g., Johnson (1972a), Kreinin and Officer (1978), and Magee (1976)] is

$$(R/R + D) \Delta \log R = \Delta \log P + a_1 \Delta \log y - a_2 \cdot \Delta \log i - \Delta \log h - (D/R + D) \Delta \log D, \quad (1)$$

where the R is the international reserve component of a country's monetary base; D is the domestic credit component; P is the domestic price level; y is domestic real income; i is the domestic interest rate; and h is the domestic money multiplier. The coefficients a_1 and a_2 are the elasticities of money demand with respect to real

income and the interest rate, respectively. The fact that proponents of the approach consider (1) a reduced-form expression for reserve flows, and estimate it with ordinary least squares [e.g., Bean (1976), Genberg (1976), Guitian (1976), and Zecher (1976)], clearly highlights the fact that the MBOP takes domestic credit to be exogenous with respect to reserves, and moreover indicates "the direction of causality postulated by the monetary approach is therefore clearly from domestic credit to foreign reserves" [Blejer (1979), p. 290].

The direction of causality may, however, be exactly the opposite for at least two reasons. The first, and most frequently cited [e.g., Blejer (1979), and Magee (1976)] reason is that central banks may sterilize the impact of exogenous changes in international reserves on the domestic money supply by offsetting changes in domestic credit. Second, commercial banks may borrow domestic credit from central banks to offset exogenous outflows of international reserves that would otherwise have forced them to reduce outstanding loans or lines of credit. As Blejer [(1979), p. 291] explains

A fall in the country's foreign reserves leads to a similar loss of reserves by the commercial banking system. In order not to curtail their lending, the commercial banks tend to restore their reserves by borrowing from the central bank, thus increasing the domestic assets of the latter by the amount borrowed.

More synthetic balance of payments models suggest elements of both the MBOP and the central bank sterilization/commercial bank behavior just described characterize the real world implying that causality runs not only from domestic credit to reserves, but vice-versa. For example, Herring and Marston [(1977), p. 38] write of their model

The model which we have specified allows for imperfect substitution between assets and for sterilization of foreign exchange flows, but it is also general enough to incorporate the perfect substitution and complete offset behavior associated with the so-called Monetary Approach to the balance of payments.

3. Causality Tests

The Granger (1969), Haugh (1976), and Sims (1972) causality tests employed in this paper to test the causal relationship between

domestic credit and reserves derive from the analytically useful, but nevertheless controversial [Zellner (1979)] temporal definition of causality proposed by Granger (1969). According to Granger, a time series X_t causes another time series Y_t if current Y_t can be predicted better using past values of X_t than by not doing so, all other relevant information like past Y_t taken into consideration in both cases. If X_t does not cause Y_t in this sense, Y_t is said to be exogenous with respect to X_t . If the prediction of Y_t is improved by considering the current value of X_t , as well, then X_t is said to also cause Y_t , "instantaneously."

The tests themselves are based on the bivariate autoregressive and moving average representations of the (X_t, Y_t) process of interest. Informative discussions of how the actual tests are related to the Granger definition and the autoregressive/moving average representation of the process of interest can be found in Pierce and Haugh (1977) and Feige and Pearce (1979). Because the tests are bivariate ones, there is indeed the possibility of specification error. The effect of the omission of potentially relevant variables, in this case for example P , y , and i in equation (1), on the type of results reported here is discussed in Skoog (1976). The bivariate tests are, nevertheless, useful, especially in the current context, for two reasons. First, besides being suggestive of the true nature of the relationship between domestic credit and reserves, the empirical bivariate results can be used to assess the validity of the conclusions reached by authors who have 1) employed individual bivariate methods to test for domestic credit exogeneity [e.g., Phaup and Kusnitz (1977) and Blejer (1979)], or 2) simply assumed a particular causal relationship between domestic credit and reserves in their own bivariate work with these variables [e.g., Bisignano (1975), and Guitian (1976)]. Second, the bivariate tests focus attention, albeit in a bold fashion, on the primary variables of interest thereby facilitating a clear, formal presentation of each of the alternative hypotheses of interest.

The Haugh Test

The Haugh (1976) test is based on the sample cross-correlation function,

$$r_{\hat{A}_x \hat{A}_y} \quad (2)$$

of the univariate innovations \hat{A}_x and \hat{A}_y derived from the prewhitening ARIMA representations of the original series X and Y . The

use of ARIMA filters to prewhiten the data is justified on the grounds that these filters eliminate nonstationarity in the original series by use of differencing operations and, further, help avoid problems of spurious correlation of the type discussed in Granger and Newbold (1974). Filtering is, however, controversial [Sims (1977)]. The formal test of the hypothesis that X and Y are independent is based either on the statistic

$$S = N \sum_{k=-m}^m r_{\hat{\lambda}_x, \hat{\lambda}_y}^2(k), \quad (3)$$

where N is the number of observations, and k is the number of time units $\hat{\lambda}_x$ is lagged or on the statistic for the case where $|k|$ is large relative to N

$$S^* = N^2 \sum_{k=-m}^m (N - |k|)^{-1} r_{\hat{\lambda}_x, \hat{\lambda}_y}^2(k). \quad (4)$$

Under the null hypotheses of independence, the cross-correlation function has zero values at all positive, zero, and negative lags and both S and S^* are distributed asymptotically as $\chi^2(2m + 1)$. The test is strictly appropriate as a test of independence since the distributional properties of a causality test based on the one-sided cross-correlation function have not been established. One-sided cross-correlation tests have been used, however, by Phaup and Kusnitz (1977) to suggest the relationship between domestic credit and reserves.

The Granger Test

The Granger (1969) test, which derives from the autoregressive representation of the bivariate (X_t, Y_t) process of interest, involves estimating the regression

$$X_t = \sum_{i=1}^m f_i X_{t-i} + \sum_{i=0}^n g_i Y_{t-i} + e_t. \quad (5)$$

Under the null hypotheses that Y does not cause X , the standard procedure is to test if $g_i = 0$, $i = 1, n$. To test the hypothesis that Y does not cause X "at all" (i.e., including instantaneously), one

tests the contemporaneous coefficient as well; $g_i = 0$, $i = 0, n$.¹ X_t and Y_t are then reversed and a second regression is run to see if X causes Y .

The Sims Test

The Sims (1972) test of the hypothesis that Y does not cause X , which derives from the moving-average representation of the bivariate (X_t, Y_t) process of interest, involves testing whether $h_i = 0$, $-n \leq i < 0$ (i.e. the future coefficients on X) in the regression

$$Y_t = \sum_{i=-n}^m h_i X_{t-i} + u_t. \quad (6)$$

To test the hypothesis that Y does not cause X "at all" involves testing whether $h_i = 0$, $-n \leq i \leq 0$ [see Pierce and Haugh (1977)].

Before presenting the results of these different tests, it is important to note parenthetically that important issues must be addressed before the tests are actually implemented. These include the selection of an ARIMA filter in the case of the Haugh test (and sometimes the Sims test), and the choice of m and n in (5) and (6). Both of these issues are discussed in Feige and Pearce (1979) as well as in Pierce and Haugh (1977).

4. Results

The data used in this study consists of monthly seasonally unadjusted changes in the domestic credit and reserve components of the monetary base in Australia, Belgium, France, Germany, Norway, and Sweden over the period January, 1964 to July, 1971.² These countries were chosen for several reasons. First, the data

¹The test for instantaneous causality also involves testing the contemporaneous coefficient in the reversed regression [see Pierce and Haugh (1977)].

²The data were taken from the IMF's *International Financial Statistics* (IFS) data tape and can also be found in the various issues of *International Financial Statistics*. The German data ends in April, 1971 since Germany floated the mark in May, 1971. Reserves are taken to be official international reserves (line 1, IFS) converted at par to domestic currency units. The only exception is Australia for which reserves are taken to equal the sum of gold and foreign exchange (lines 1a and 1d). Domestic credit is defined as the monetary base (line 14, IFS) minus reserves. First differences are used because they are the natural implication of (1) when all other variables are ignored.

were available for these countries for a longer time period than for other countries. Second, these countries represent a cross section of countries with varying degrees of openness as defined by Salant [(1977), p. 220]. The most open is Norway, followed by (in decreasing order of openness) Belgium, Sweden, Germany, Australia, and France. Openness may be critical because the MBOP assumes that countries are open. Finally, these countries are some of the countries frequently examined in the balance of payments literature. We chose this particular time period for it fulfills, albeit imperfectly, the MBOP assumptions of fixed exchange rates and full employment.

We begin by reporting the results of the Haugh (1976) test. An examination of the autocorrelation function of the original series, ΔD and ΔR , and various differences of the original series indicated that the original series were already stationary, hence there was no reason to difference further. This is not too surprising because the original series are already first differences. The Box-Jenkins (1970) ARIMA models used to filter the original series to generate the residuals \hat{A}_D and \hat{A}_R used in the Haugh test are displayed in Table 1 along with the appropriate diagnostic check. The S and S^* statistics for the different countries and various lead-lags k are displayed in Table 2 and indicate that the hypothesis that ΔD and ΔR are independent can be rejected for each country in the sample at either the 0.10 or 0.05 significance level for most or all leads and lags k . Moreover, in each case, there is a significant negative contemporaneous correlation in the residuals, but it does not always indicate true contemporaneous causality [Price (1979)]. Phaup and Kusnitz's results also indicate this strong contemporaneous correlation. These results suggest, therefore, that there is indeed some relationship between changes in domestic credit and changes in reserves.

To test for the exact nature of this relationship, we employed both the Granger and Sims tests. To implement the Granger procedure, we estimated regressions (7) and (8) for each country.

$$\Delta D_t = \sum_{k=1}^m \alpha_k \Delta D_{t-k} + \sum_{j=0}^n \beta_j \Delta R_{t-j} + u_t, \quad (7)$$

$$\Delta R_t = \sum_{k=1}^m \delta_k \Delta R_{t-k} + \sum_{j=0}^n \gamma_j \Delta D_{t-j} + v_t. \quad (8)$$

Domestic Credit and Reserve Components

TABLE 1. *Box-Jenkins Filters for Domestic Component and Reserve Component Changes*

Country	Series	Diagnostic Check	
Australia	Dom. Comp.	$(1 - 0.27B - 0.57B^{12}) / (\Delta D - \mu)^* = A_D$ (0.10) (0.11)	$\chi^2 = 21.4$ $df = 27$
	Res. Comp.	$(1 - 0.57B)(1 - 0.59B^{12}) / (\Delta R - \mu) = A_R$ (0.10) (0.12)	$\chi^2 = 26.9$ $df = 27$
Belgium	Dom. Comp.	$(1 - B^{12}) \Delta D = (1 + 0.19B^3 + 0.67B^6) A_D$ (0.09) (0.10)	$\chi^2 = 36.2$ $df = 28$
	Res. Comp.	$(\Delta R - \mu) = (1 + 0.33B^4) A_R$ (0.11)	$\chi^2 = 25.1$ $df = 28$
France	Dom. Comp.	$(1 - 0.29B^{12}) / (\Delta D - \mu) = A_D$ (0.13)	$\chi^2 = 16.0$ $df = 28$
	Res. Comp.	$(1 - 0.51B) / (\Delta R - \mu) = A_R$ (0.10)	$\chi^2 = 17.5$ $df = 28$
Germany	Dom. Comp.	$(\Delta D - \mu) = A_D$	$\chi^2 = 26.0$ $df = 40$
	Res. Comp.	$(\Delta R - \mu) = (1 - 0.30B^7) A_R$ (0.12)	$\chi^2 = 16.1$ $df = 28$
Norway	Dom. Comp.	$(1 + 0.31B + 0.33B^3) / (\Delta D - \mu) = A_D$ (0.10) (0.10)	$\chi^2 = 17.6$ $df = 27$
	Res. Comp.	$(1 - 0.82B^{12}) / (\Delta R - \mu) = A_R$ (0.10)	$\chi^2 = 13.9$ $df = 28$
Sweden	Dom. Comp.	$(1 - 0.23B^2) / (1 - 0.78B^{12}) / (\Delta D - \mu) = A_D$ (0.12) (0.08)	$\chi^2 = 17.3$ $df = 27$
	Res. Comp.	$(1 - 0.36B) / (\Delta R - \mu) = A_R$ (0.10)	$\chi^2 = 20.5$ $df = 28$

* μ is the mean of the series. Number in parentheses under coefficient is the standard error.

TABLE 2. *Haugh Test Results*

Country	<i>S</i> Statistics			
	$ k = 1$	$ k = 6$	$ k = 12$	$ k = 24$
Australia				
<i>S</i>	46.54*	61.47*	75.80*	97.39*
<i>S</i> *	46.59*	62.22*	78.40*	106.89*
Belgium				
<i>S</i>	32.05*	57.38*	75.77*	90.67*
<i>S</i> *	32.07*	59.19*	80.37*	99.70*
France				
<i>S</i>	9.16*	22.40*	34.71†	53.12
<i>S</i> *	9.17*	23.28*	37.29†	61.25
Germany				
<i>S</i>	44.00*	49.07*	63.27*	82.32*
<i>S</i> *	44.07*	49.37*	65.36*	89.59*
Norway				
<i>S</i>	22.99*	29.44*	36.90†	52.47
<i>S</i> *	23.00*	29.76*	38.31*	58.68
Sweden				
<i>S</i>	24.50*	29.25*	46.76*	59.83
<i>S</i> *	24.56*	29.52*	49.78*	66.54†

†Significant at 0.10 level.

*Significant at 0.05 level.

The results presented later are for m and n equal twelve which are the values corresponding to a lag length of one year, the same lag length examined by Blejer (1979). In addition to the variables included in (7) and (8), each regression also includes a constant, trend, and monthly dummies.³

³Since the data used in these tests are not seasonally adjusted, the monthly dummies were included to remove seasonal patterns. Many of these dummies were significant in the cases of Australia, Belgium, and Norway while few, with the exception of December, were significant in the cases of France, Germany, and Sweden. The trend term was included as an added precaution to help eliminate problems that might arise because of nonstationarity in the data. As described in the text, the autocorrelation functions suggested that the data are stationary, but there is no formal test of this proposition. In only one of the twelve regressions (the Australian domestic credit regression) was the trend significant. This is not surprising given the presence of lagged dependent variables in the Granger test. The regressions for Germany also contain a dummy for the German revaluation in 1969, and the regressions for France a dummy for the devaluation in 1969 and riots in 1968.

Domestic Credit and Reserve Components

Detailed regression results are displayed in Table 3. The coefficients displayed in the ΔD column are the estimated coefficients in (7), and the coefficients under the ΔR column are the estimated coefficients in (8). For ΔR not to cause ΔD all the non-contemporaneous β_j (i.e. $j > 0$) must be zero, while for ΔR not to cause ΔD "at all" [see Pierce and Haugh (1977)], all β_j must equal zero as must γ_0 . For ΔD not to cause ΔR , γ_j ($j > 0$) must be zero, while for ΔD not to cause ΔR "at all," all γ_j ($j \geq 0$) must be zero as must β_0 . The F statistics for β_j ($j \geq 0$) and γ_j ($j \geq 0$) are displayed in Table 4. The F statistics for β_j ($j > 0$) and γ_j ($j > 0$) are displayed in Table 5.

The results displayed in Table 4 indicate that we can reject the hypothesis that there is no causality "at all" running from ΔR to ΔD , and the hypothesis that there is no causality at all from ΔD to ΔR , for each country in the sample, at least at the 0.10 significance level. These results indicate, therefore, that causality runs bidirectionally between domestic credit and reserves, implying both variables are endogenous as synthetic balance of payments models typically assume. Since these tests include the contemporaneous coefficients in (7) and (8) (and since these contemporaneous coefficients are significant with the exception of the French regressions and negative as both the MBOP and the other theories hold), the question naturally arises whether the relationship between ΔD and ΔR is purely contemporaneous. If it is, the nature of the causal ordering cannot be ascertained from the data as Pierce and Haugh [(1977), p. 273] point out. Consequently, one could not be sure if the relationship is one of feedback, unidirectional causality from ΔD to ΔR , or unidirectional causality from ΔR to ΔD .

The results of the causality test displayed in Table 5 shed some light on this matter. These results indicate that when the noncontemporaneous coefficients alone are considered, causality still appears to run bidirectionally between domestic credit and reserves in the cases of Belgium, France, and Germany. In the cases of Australia and Norway, however, causality runs unidirectionally from domestic credit to reserves just as the MBOP contends, while in the case of Sweden causality runs unidirectionally from reserves to domestic credit which is consistent with sterilization or Blejer's commercial bank credit scenario. If these same relation-

Reestimating the equations without these dummy variables did not change the results.

TABLE 3. Detailed Granger Test Regression Results

		Australia		Belgium		France	
		ΔD	ΔR	ΔD	ΔR	ΔD	ΔR
Lags on Independent Variable	1	0.3122*	0.4361*	0.0515	-0.0114	-0.1069	0.2028
	2	-0.1910	-0.1255	0.0164	-0.0061	0.4651*	0.1402
	3	-0.0367	-0.0568	0.1126	0.1752	0.2641	-0.0119
	4	0.0326	-0.1089	-0.1779	-0.1704	-0.0558	-0.2594
	5	-0.0012	-0.1106	0.0938	0.1609	-0.2917	0.3533*
	6	-0.1600	-0.1995	0.3537*	0.2867*	0.0094	0.0415
	7	0.1369	-0.0204	-0.1404	-0.1703	0.2102	-0.0207
	8	0.1170	-0.0820	-0.0436	0.0684	0.0031	0.2477
	9	-0.1526	-0.1310	0.0550	0.0204	0.1253	0.0218
	10	0.0044	-0.0481	0.0174	0.1180	0.0966	-0.2431
	11	0.1566	0.0525	0.2192*	0.3806*	0.4039*	-0.0573
	12	-0.3111*	-0.0295	0.2560*	0.1569	0.4141*	-0.0419
Lags on Dependent Variable	0	-1.0463*†	-0.6100*	-0.9896*†	-0.9222*†	0.4815	0.0819
	1	0.2401	0.3029*	-0.0004	0.0410	0.2227	-0.1013
	2	-0.0364	0.2719*	-0.0219	0.0204	0.3336	-0.1389
	3	-0.0473	0.0372	0.1976	0.0864	-0.1191	0.0455
	4	-0.0335	-0.1324	-0.1793	-0.2065	-0.2709	0.0170
	5	-0.1655	0.0048	0.2117	0.0773	-0.9272*	-0.0273
	6	-0.2350	-0.1556	0.2829*	0.3402*	0.8646*	-0.0321
	7	0.2324	-0.0255	-0.2128	-0.1239	-0.0588	0.2157*
	8	0.3360	0.0870	0.0607	-0.0348	-0.2451	0.0074
	9	-0.2477	0.1440	0.0309	0.0519	0.2705	0.0011
	10	-0.0424	-0.0104	0.1327	0.0087	0.0486	-0.1339
	11	0.2546	0.0508	0.4122*	0.2127*	0.1653	-0.0551
	12	-0.1331	-0.2017*	0.1706	0.2405*	1.1455*	-0.1668*
R^2	0.92	0.92	0.98	0.95	0.81	0.82	
df	41	41	41	41	39	39	

* Significant at the 0.05 level.

† Significant at the 0.10 level.

‡ Not significantly different from minus one at the 0.05 level.

ships hold instantaneously, then we could conclude that the evidence from three countries (Belgium, Germany, and France) is consistent with the synthetic models, two countries (Australia and Norway) the MBOP, and one (Sweden) the sterilization/bank credit scenario. The strong contemporaneous effects might also mean, however (we cannot tell), that Australia and Norway are sterilizing instantaneously, and that the MBOP effect that ΔD causes ΔR occurs instantaneously in Sweden. Given this possibility, the conservative conclusion, therefore, is that causality may run bidirectionally in all the countries.

Domestic Credit and Reserve Components

<i>Germany</i>		<i>Norway</i>		<i>Sweden</i>	
ΔD	ΔR	ΔD	ΔR	ΔD	ΔR
-0.7786*	-0.4493*	-0.5829*	-0.4394*	-0.4643*	-0.1179
-0.0891	-0.1220	-0.3064*	0.1769	-0.2830	-0.3003
0.3058	0.1450	-0.2884	0.2233	-0.1891	-0.0247
0.3423	-0.0098	-0.0888	0.2642	-0.3080*	-0.2934
0.2664	0.1376	0.0135	0.0389	-0.1430	-0.1567
0.3563*	0.4630*	-0.1311	0.0653	-0.0988	-0.3969*
0.3976*	0.0157	-0.1499	-0.1378	-0.2524	-0.1619
0.1594	-0.0581	-0.0808	0.1656	-0.3699*	-0.3934*
-0.2926	-0.2999	-0.0497	0.1127	-0.1215	-0.1762
-0.3961*	-0.0848	-0.1608	0.0009	-0.2674	-0.2225
-0.1024	0.3501	-0.2839	-0.0462	0.0139	-0.0384
-0.0535	0.0739	-0.3810*	-0.2375	0.0690	0.0134
-0.5342*	-0.8820*†	-0.6417*	-0.4285*	-0.7611*†	-0.6650*
-0.5549*	-0.7763*†	-0.4407*	-0.3479*	-0.5364*	-0.2675*
-0.1925	0.0679	-0.3903*	0.1705	-0.5752*	-0.0734
0.1612	0.1686	-0.3409	0.1278	-0.1087	-0.1852
0.2375	0.0199	-0.2294	0.1818	-0.2829	-0.2724
0.0927	0.0755	-0.0280	0.1233	-0.0614	-0.2222
0.2889*	0.5840*	-0.0865	-0.0236	-0.3141	-0.2475
0.2304	0.3573	-0.2206	0.1914	-0.0008	-0.3555*
0.0611	-0.1359	-0.4359*	0.0055	-0.4998*	-0.2485
-0.2424	-0.2645	0.1207	0.0127	-0.1599	-0.1217
-0.3501*	-0.0699	-0.0756	-0.1278	-0.5352**	-0.1174
-0.0138	0.2946	-0.0705	-0.1525	0.1881	-0.0362
0.0489	0.1402	-0.2637	-0.1631	-0.1336	-0.0726
0.88	0.85	0.83	0.88	0.95	0.73
37	37	41	41	41	41

Finally, we present the results of the Sims (1972) test which are based on the regressions

$$\Delta D_t = \sum_{i=-n}^m \rho_i \Delta R_{t-i} + z_t, \quad (9)$$

$$\Delta R_t = \sum_{i=-n}^m \lambda_i \Delta D_{t-i} + a_t, \quad (10)$$

where m and n are again equal to twelve. The regressions were estimated using a GLS procedure recently advocated by Sims (1974a) that helps overcome any potential problems of serial correlation.

TABLE 4. Granger *F* Test Results

Country	Hypothesis/Restriction	
	$\beta_j = 0, j \geq 0$	$\gamma_j = 0, j \geq 0$
Australia	9.42* (13, 41)	9.22* (13, 41)
Belgium	39.79* (13, 41)	35.89* (13, 41)
France	1.95+ (13, 39)	2.02* (13, 39)
Germany	6.34* (13, 37)	5.00* (13, 37)
Norway	4.15* (13, 41)	3.09* (13, 41)
Sweden	9.13* (13, 41)	5.03* (13, 41)

* Significant at the 0.05 level. Degrees of freedom in parentheses.

+ Significant at the 0.10 level. Degrees of freedom in parentheses.

This procedure is analogous to the Hannan (1963) efficient estimation procedure. The technique is somewhat computationally burdensome, but very inexpensive as far as serial correlation correction methods go, and is described in great detail in Geweke (1978).⁴ ΔD does not cause ΔR if the $\rho_i, i < 0$ are all equal to zero. ΔD does not cause ΔR "at all" if the $\rho_i, i \leq 0$ are all equal to zero. Similarly, ΔR does not cause ΔD if the $\lambda_i, i < 0$ are all zero and ΔR does not cause ΔD "at all" if the $\lambda_i, i \leq 0$ are all zero [see Pierce and Haugh (1977)]. Detailed regression results are presented in Table 6. The estimated coefficients under the ΔD and ΔR columns are those in equations (9) and (10), respectively.

The results displayed in Table 7 pertain to the "no causality at all" test. These results indicate that we can reject the hypothesis that there is no causality at all running from ΔR to ΔD and the hypothesis that there is no causality at all running from ΔD to ΔR in all cases. In other words, just as in the analogous Granger test, the conclusion to be drawn from this test is that causality

⁴Briefly, this procedure estimates the GLS weighting matrix by applying frequency domain techniques to the first pass OLS regression residuals. To obtain consistent estimates for the spectral density function of the residuals, the estimated periodogram was smoothed by a double moving average window. The spectral density at frequency λ was estimated by averaging 31 equally weighted periodogram ordinates centered around λ . All data were deseasonalized and detrended using similar methods before the first pass regressions were run. Each regression includes a constant and trend. The trend was included for the reasons described in footnote 3. With the exception of Germany, most trend terms were significant, but very small. The German and French regressions include the same dummy variables described in footnote 3. Excluding the dummies did not affect the results.

runs bidirectionally between domestic credit and reserves in each country. The contemporaneous coefficients (see Table 6) are highly significant as in the case of the Granger test, however, so once again the question naturally arises whether the domestic credit-reserve relationship is solely contemporaneous. The results of the Sims test based solely on the noncontemporaneous coefficients shed light on this matter. These results are displayed in Table 8 and indicate bidirectional causality in the cases of Australia, France, and Germany, unidirectional causality from reserves to domestic credit in the case of Sweden, unidirectional causality from domestic credit to reserves in the case of Norway, and independence in the case of Belgium. These results are subject to the same caveats described earlier for the analogous Granger test. Consequently, while it is possible to make the case that the evidence from these Sims tests favors the synthetic model in three cases (Australia, France, and Germany), the MBOP in one case (Norway), the sterilization/bank credit model in one case (Sweden), and none of the models in one case (Belgium), the conservative conclusion is that bidirectional causality may exist in all countries. The reason for this conclusion, of course, is the presence of the strong contemporaneous effect that makes it impossible to ascertain the direction of the instantaneous effects.

The interesting question that remains is: Are the substantive conclusions to be drawn from these three different tests robust across the tests? Table 9 provides the answer to this question. In this table, the column labeled Haugh refers to the results of the Haugh test, the column labeled Granger 1 refers to the Granger test that includes the contemporaneous coefficient, the column labeled Granger 2 refers to the Granger test without the con-

TABLE 5. *Granger F Test Results*

<i>Country</i>	$\beta_i = 0, j > 0$	$\gamma_i = 0, j > 0$
Australia	0.85 (12, 41)	1.82 ⁺ (12, 41)
Belgium	4.97* (12, 41)	4.06* (12, 41)
France	2.02* (12, 39)	1.92 ⁺ (12, 39)
Germany	3.11* (12, 37)	2.65* (12, 37)
Norway	1.25 (12, 41)	2.04* (12, 41)
Sweden	2.10* (12, 41)	0.78 (12, 41)

⁺ Significant at the 0.10 level. Degrees of freedom in parentheses.

* Significant at the 0.05 level. Degrees of freedom in parentheses.

TABLE 6. *Sims Test Regression Results*

		Australia		Belgium		France	
		ΔD	ΔR	ΔD	ΔR	ΔD	ΔR
Past Coefficients	12	0.0332	-0.0338	0.1011 [*]	-0.0697	0.1271	0.0039
	11	-0.1786 [†]	0.1027 [*]	0.0498	0.0614	0.0022	0.0332
	10	-0.0783	-0.0167	-0.0804	-0.0707	-0.1712	-0.0608 [*]
	9	-0.0839	0.0151	0.0022	0.0698	0.0747	0.0329
	8	0.1307	0.0793	-0.0080	0.0669	-0.5082 [*]	0.0258
	7	-0.2193 [†]	0.0850	-0.0791	-0.1407 [*]	0.7095 [*]	0.0089
	6	-0.0073	-0.0429	0.0814	0.0911	-0.4545 [†]	0.0421
	5	0.1250	-0.0469	-0.0322	0.0071	0.1276	-0.0960 [*]
	4	-0.1122	-0.0418	-0.1635 [*]	-0.0684	0.1566	-0.0798 [*]
	3	0.1305	-0.0583	0.1356	0.1205 [†]	0.4856	-0.0420
	2	-0.0594	-0.0338	0.0089	-0.1253 [†]	-0.5812 [†]	-0.0837 [*]
	1	0.1787	-0.1072 [†]	-0.1606 [*]	-0.0078	-0.5753 [†]	-0.0452
Future Coefficients	0	-1.017 [†]	-0.5695 [*]	-0.8120 [*]	-0.7790 [*]	-0.0536	-0.1834 [*]
	1	-0.3263 [*]	0.1259 [*]	-0.0135	-0.1188 [†]	-0.2638	-0.2285 [*]
	2	0.2360 [†]	-0.1767 [*]	-0.0933	-0.0122	0.0827	-0.1893 [*]
	3	0.1391	0.0649	0.1618 [*]	0.0784	0.1267	0.0011
	4	-0.1660	-0.0317	-0.0674	-0.1092	-0.1860	0.0966 [*]
	5	-0.1951	0.1126 [†]	-0.0498	0.0405	-0.6740 [*]	0.0226
	6	-0.0458	0.0131	0.1172 [†]	0.0519	0.2571	-0.0069
	7	0.2469 [†]	-0.1125 [†]	-0.0967	-0.0486	0.2907	0.1378 [*]
	8	0.1673	0.0109	-0.0219	-0.0415	-0.3797	-0.1338 [*]
	9	-0.1198	-0.0528	0.0725	0.0583	0.5084 [†]	-0.0245
	10	0.0551	-0.0093	0.0502	-0.1316 [†]	-0.3234	-0.1774 [*]
	11	0.0512	0.0570	0.1096	-0.0607	-0.0101	-0.0492 [†]
12	0.1187	-0.1042 [†]	-0.0245	0.0495	0.4379 [*]	-0.0467	
	R ²	0.91	0.92	0.96	0.97	0.97	0.98
	df	28	28	28	28	26	26

* Significant at the 0.05 level.

† Significant at the 0.10 level.

† Not significantly different from minus one at the 0.05 level.

temporaneous coefficient (the standard Granger test), the column labeled Sims 1 refers to the Sims test that includes the contemporaneous coefficient, and the column labeled Sims 2 refers to the Sims test without the contemporaneous coefficient (the standard Sims test). The arrow stands for unidirectional causality in the direction which it points, the double-headed arrow stands for bidirectional causality, and the dash stands for independence, i.e., no causality in either direction.

Three points are worth noting. First, the Haugh, Granger 1

Germany		Norway		Sweden	
ΔD	ΔR	ΔD	ΔR	ΔD	ΔR
-0.0170	0.0935	0.3331*	-0.0400	0.0488	-0.0337
0.0384	0.1286	0.1463	-0.0336	-0.1736	0.1330*
-0.1482*	-0.1333 ⁺	-0.3394*	-0.0370	0.1800	-0.1474*
0.1465*	-0.0697	0.2170	0.0367	-0.1041	-0.0428
-0.0778	0.0799	-0.1735	-0.1230 ⁺	0.2344 ⁺	0.0209
-0.1303 ⁺	0.0568	0.4032*	-0.0303	-0.2062	0.0840
0.2453*	0.0236	-0.2984	-0.0378	-0.0066	0.0028
-0.2744*	0.2096*	-0.1577	0.0322	0.0052	-0.0537
0.0668	-0.1034	0.5604*	-0.0835	-0.0487	0.0609
-0.1283*	0.0749	-0.3449 ⁺	-0.0693	-0.0519	0.0416
-0.0481	0.1029	0.7372*	-0.1865*	0.2025	-0.1705*
0.0834	-0.3461*	-0.5513*	-0.1670*	-0.0374	-0.1934*
-0.7076*	-0.9063* [†]	-0.5358*	-0.4483*	-0.8726* [†]	-0.5464*
0.0066	-0.1143	0.1587	-0.1518 ⁺	-0.2082	-0.0639
-0.2342*	-0.0635	-0.5082*	-0.1124	-0.3657*	0.1018
0.0091	0.1352	0.3284	-0.0214	0.2926*	-0.0786
-0.1186	0.0848	-0.3622	-0.0105	0.0311	-0.0003
-0.2143 ⁺	0.0348	-0.1297	0.1503 ⁺	-0.0837	0.1043 ⁺
0.1678*	0.2206*	0.3577	-0.0004	-0.2760*	0.1270*
-0.2823*	0.1865	-0.5632*	0.0006	0.2260 ⁺	-0.1102 ⁺
-0.0074	-0.0572	-0.0474	0.0359	-0.2852*	0.0571
-0.1723 ⁺	0.2213 ⁺	0.3434	-0.1323	0.2109	0.0558
-0.1755 ⁺	0.0459	0.0266	-0.1644 ⁺	-0.2472 ⁺	0.0232
0.8949	-0.0400	0.1020	-0.0688	0.1665 ⁺	0.0545
-0.1299	0.1324	0.5400*	-0.0399	-0.2739*	0.0868
0.95	0.95	0.85	0.81	0.91	0.94
24	24	28	28	28	28

TABLE 7. *Sims F Test Results*^a

	$\lambda_i = 0, i \leq 0$	$\rho_i = 0, i \leq 0$
Australia	12.77* (13, 28)	7.24* (13, 28)
Belgium	16.27* (13, 28)	18.68* (13, 28)
France	5.97* (13, 26)	5.22* (13, 26)
Germany	9.60* (13, 24)	6.31* (13, 24)
Norway	3.55* (13, 28)	4.17* (13, 28)
Sweden	15.50* (13, 28)	5.52* (13, 28)

^aThere are fewer degrees of freedom with this test because the sample size must be adjusted to reflect the fact that degrees of freedom are used up eliminating seasonal bands in the frequency domain deseasonalizing and detrending [see Sims (1974b)].

*Significant at the 0.05 level.

TABLE 8. *Sims F Test Results*^a

	$\lambda_i = 0, i < 0$	$\rho_i = 0, i < 0$
Australia	2.19* (12, 28)	1.83* (12, 28)
Belgium	0.76 (12, 28)	0.89 (12, 28)
France	4.22* (12, 26)	3.08* (12, 26)
Germany	3.07* (12, 24)	3.66* (12, 24)
Norway	1.50 (12, 28)	2.66* (12, 28)
Sweden	3.28* (12, 28)	1.23 (12, 28)

^aThere are fewer degrees of freedom with this test because the sample size must be adjusted to reflect the fact that degrees of freedom are used up eliminating seasonal bands in the frequency domain deseasonalizing and detrending [see Sims (1974b)].

* Significant at the 0.05 level.

[†] Significant at the 0.10 level.

and Sims 1 test yield identical conclusions for all countries.⁵ Second, the Granger 2 test does not consistently indicate the same relationship between domestic credit and reserves that the Granger 1 test does, nor does the Sims 2 test consistently indicate the same relationship that the Sims 1 test does. This is undoubtedly explained by the strong contemporaneous relationship that the Granger 2 and Sims 2 tests ignore. Finally, and most importantly, the Granger 2 and Sims 2 tests yield the same substantive conclusions in the cases of France, Germany, Norway, and Sweden, but not in the cases of Australia and Belgium.

What then are the substantive conclusions to be drawn from this battery of tests? First, there is a strong contemporaneous relationship between changes in domestic credit and changes in reserves. Since it is impossible to ascertain empirically the direction of causality embodied in this contemporaneous relationship, the most conservative conclusion is that domestic credit-reserve causality may be bidirectional. If we assume that the instantaneous relationship between these two variables is identical to the noninstantaneous relationship, then the results indicate that causality runs bidirectionally in the case of France and Germany, unidirectionally from domestic credit to reserves in the case of Norway, and unidirectionally from reserves to domestic credit in the case of Sweden. The reason this conclusion is safe given the assumption

⁵This assumes, of course, that the Haugh test indicates bidirectional causality. Statistically speaking, it indicates only that the series are not independent.

TABLE 9. *Comparison of the Tests*

Country	Haugh	Granger 1	Granger 2	Sims 1	Sims 2
Australia	$\Delta D \leftrightarrow \Delta R$	$\Delta D \leftrightarrow \Delta R$	$\Delta D \rightarrow \Delta R$	$\Delta D \leftrightarrow \Delta R$	$\Delta R \leftrightarrow \Delta D$
Belgium	$\Delta D \leftrightarrow \Delta R$	$\Delta D \leftrightarrow \Delta R$	$\Delta D \leftrightarrow \Delta R$	$\Delta D \leftrightarrow \Delta R$	$\Delta R - \Delta D$
France	$\Delta D \leftrightarrow \Delta R$	$\Delta D \leftrightarrow \Delta R$	$\Delta D \leftrightarrow \Delta R$	$\Delta D \leftrightarrow \Delta R$	$\Delta R \leftrightarrow \Delta D$
Germany	$\Delta D \leftrightarrow \Delta R$	$\Delta D \leftrightarrow \Delta R$	$\Delta D \leftrightarrow \Delta R$	$\Delta D \leftrightarrow \Delta R$	$\Delta R \leftrightarrow \Delta D$
Norway	$\Delta D \leftrightarrow \Delta R$	$\Delta D \leftrightarrow \Delta R$	$\Delta D \rightarrow \Delta R$	$\Delta D \leftrightarrow \Delta R$	$\Delta D \rightarrow \Delta R$
Sweden	$\Delta D \leftrightarrow \Delta R$	$\Delta D \leftrightarrow \Delta R$	$\Delta R \rightarrow \Delta D$	$\Delta D \leftrightarrow \Delta R$	$\Delta R \rightarrow \Delta D$

about the nature of the instantaneous relationship, is that these relationships are robust across all three empirical testing procedures. This is not the case for Australia and Belgium. For these countries, the Granger 2 and Sims 2 tests yield dramatically different conclusions regarding the domestic credit-reserve relationship. In the case of Australia, the Granger test indicates unidirectional causality from domestic credit to reserves while the Sims test indicates bidirectional causality. For Belgium, the Granger test indicates bidirectional causality, the Sims test independence. For these two countries, therefore, the results of the empirical causality tests fail to clarify the domestic credit-reserve relationship.

5. Conclusion

There are two conclusions to be drawn from the results presented in this paper. The first concerns the substantive issue of the nature of the domestic credit-reserve relationship. While it is difficult to compare our results with those of Phaup and Kusnitz (1977) whose results are purely suggestive, our results conflict with Blejer's (1979) conclusion that in France, Germany, and Sweden the evidence "is indeed consistent with the direction of causality as proposed by the monetary approach to the balance of payments . . ." (p. 296). Based on the results which are robust with respect to empirical testing procedure, our results indicate that the relationship between domestic credit and reserves is either bidirectional in all countries, or, if instantaneous and noninstantaneous relationships are the same, it is bidirectional in the cases of France and Germany, unidirectional from reserves to domestic credit in the case of Sweden, and unidirectional from domestic credit to reserves in the case of Norway. While it is true that Norway is the most open country in our sample, and therefore the results might be construed to favor the MBOP, it should be pointed out that the

MBOP has been taken to hold heretofore in the other countries as well. Moreover, by Salant's (1977) measure, Sweden is more open than either France or Germany; hence, if the MBOP is correct, Sweden should tend to favor the MBOP more so than France or Germany which is clearly not the case. Since the direction of causality does not appear to be that posited by the MBOP, the results of several empirical studies on the approach which assume the MBOP relationship must be viewed cautiously [e.g., Bean (1976), Bisignano (1975), Guitian (1975), and Zecher (1976)].

The second conclusion is a methodological one. The evidence presented here confirms Feige and Pearce's (1979) conclusion that "alternative methods for detecting causal relationships do not necessarily yield unambiguously compatible economic conclusions, even when the data set is uniform across test procedure" (p. 531). The results are, however, a little more promising than Feige and Pearce's as far as the potential usefulness of causality tests is concerned because the results of the individual tests are clearly inconsistent in only two of the six cases. This suggests that causality tests may still make important contributions to our understanding of fundamental economic relationships if used with caution. The implication for practitioners is that the full battery of tests should be employed whenever possible to check the robustness of the substantive conclusions, at least until that time when further research establishes the superiority of one of the causality tests.

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