Money, Income and Prices in Switzerland: An Empirical Test*

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The main purpose of this note is to present empirical evidence which is consistent with the proposition that money growth accommodates to variations in income and prices. Our tests of exogeneity correspond to those proposed by *Sims* (1972).

1. Introduction

In a recent paper, *Sims* (1972) developed a statistical technique, based on earlier work by *Granger* (1969), for testing the causal relationship within a two-variable system. The purpose of this note is to examine the relationship between movements in income, money and prices for the small and extremely open economy of Switzerland.

The money-income-price interdependences has occupied an enormous amount of space in the learned journals. But still the debate has not stopped. Indeed, it has intensified since economic analysis has begun to embrace the problems of small open economies in more depth and generality. We do not intend to trace the theory behind the diversity of opinions on the causes and cures of excessive growth of money, income and prices. All we need to emphasize is that different views on causation have led to a multitude of different policy prescriptions. Any piece of evidence which contributes to ascertaining causal relationships is therefore noteworthy.

Moreover, causality tests as part of an extensive empirical investigation preliminary to model building may give some insights into the causal structure of an economy and thus help avoid specification errors. Unfortunately, the econometric work aimed at exploring the causal structure between money, income and prices has remained notoriously inconclusive. This may be due to some inherent difficulties and

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weaknesses of the test, which shall be discussed below. In Table 1 we present some very general information on previous studies of the money-income-price relationship utilizing *Sims*' technique. The reader should note that it is not our intention to offer a critical review of the merits of these contributions.

Thus Table 1 substantiates the above proposition as to the inconclusive nature of the 'empirical econometrics of causality'. All the same we believe that this summary provides a basis for the null hypothesis that money growth determines nominal income and prices in relatively closed economies whereas the direction of causation is reversed in small open economies. It is the second half of this hypothesis we set out to test.

Two of the above authors had the same conjecture. *Barth* and *Bennett* (1974), p. 286) provide the following explanation of their result: "The role of money in an open economy with inflexible exchange rates is likely to be substantially different because the use of monetary policy for domestic purposes is circumvented by interest-sensitive international capital flows". *Williams, Goodhart* and *Gowland* (1976, p. 417) pick up the thread: Under "a regime of fixed exchange rates ... the private sector can easily adjust their money holdings to their incomes by transfers of funds over the exchanges ...". The institutional characteristics of the Swiss economy in general and the Swiss banking sector in particular fit these descriptions extremely well. Of relevance in this respect is the absence of exchange controls during the period of analysis (1953 - 1976) and the excess of Swiss foreign assets over foreign liabilities (1976: 164 billion Swiss francs, estimate Union Bank of Switzerland). The banking sector alone had foreign assets of approximately 100 billion francs in 1976, which enabled it to counteract tight monetary conditions by transferring foreign funds into the country.

The next section describes the test applied in this paper and discusses some limitations. In section 3, the test is applied to postwar data.

2. The Test

The rational for *Sims*' statistical technique for testing whether there is evidence of unidirectional causality between two variables X and Y was partly anticipated by *Wold* (1954), who argued convincingly that economic relationships were recursive, i. e. that they show unidirectional causation rather than simultaneous interdependence, due to the many lags in agents responses to economic and other stimuli. The reason why traditional economic modelling is directed towards simultaneous systems is inherently a problem of time aggregation. Even if the 'true' model is recursive we have, in general, no way of generating the data

Table 1

Comparison of the Conclusions of Earlier Studies

Author(s) Country Period(s)	Conclusions of the author(s)
Sims (1972) USA 1947 - 69 quarterly	"... the hypothesis that causality is unidirectional from money to income agrees with the postwar USA data, whereas the hypothesis that causality is unidirectional from income to money is rejected" (p. 540).
Barth, Bennett (1974) Canada 1959 - 1972 quarterly	"... all the findings are inconsistent with a unidirectional causal link running from money supply to GNP without feedback" (p. 285).
Sharpe, Miller (1974) Canada 1959 - 72 quarterly	"... unidirectional causality is shown to exist between M 1 and GNP, and it runs in the direction suggested by modern quantity theorists" (p. 290).
Sargent, Wallace (1973) 7 European countries subperiods between 1920 - 46 monthly	"The results indicate that inflation strongly influences subsequent rates of money creation, but that an influence of money creation on subsequent rates of inflation is harder to detect" (p. 339/40).
Barth, Bennett (1975) USA 1947 - 70 quarterly	"... there is unidirectional causality that runs from the money supply to wholesale and consumer prices" (p. 393).
Williams, Goodhart, Gowland (1976) UK 1958 - 71 quarterly	There is "some evidence of unidirectional causality running from nominal incomes to money but also some evidence of unidirectional causality running from money to prices. Taken together, this evidence suggests, perhaps, a more complicated causal relationship between money and incomes in which both are determined simultaneously" (p. 423).
Ciccolo (1978) USA 1919 - 39 quarterly	The "results indicate that it is reasonable to treat money as exogenous vis-à-vis consumer prices" However "the hypothesis of exogeneity (of money vis-à-vis industrial production) can be rejected at the 15 percent level" (p. 53/54).
Mills, Wood (1978) UK 1870 - 1914 yearly	The "results imply that there is unidirectional causality between Y and *M* ... There is no evidence to suggest that there is any causality running from *M* to Y" (p. 25).

available by the true model, for these are published too infrequently. Current economic models must therefore be understood as approximations to recursive systems.

What *Sims* set out to do was to test the following hypothesis: Does X (money supply) cause Y (nominal *GNP*)? To this end he derived the following proposition (p. 541): "If and only if causality runs one way from current and past values of some list of exogenous variables to a given endogenous variable, then in a regression of the endogenous variable on past, current, and future values of the exogenous variables, the future values of the exogenous variables should have zero coefficients." It is, perhaps, intuitively clear that sizeable and/or significant coefficients on future values of X in a regression

$$Y_t = \sum_{i=-m}^{n} c_i X_{t-i} \tag{1a}$$

imply feedback or causality running from Y to X.

On the other hand, insignificant future values of X will reinforce the unidirectional interpretation. By symmetry, if X causes Y, the future values of Y in the regression

$$X_t = \sum_{j=-m}^{u} d_j Y_{t-j} \tag{2a}$$

should be significantly positive. However, an affirmative answer to this question requires that the future variables of X as a group do not contribute to reducing the sum squares of errors in equation (1a), but that the future values of Y, as a group, do lower the sum of squared residuals in equation (2a). A conventional analysis-of-variance provides all necessary information needed to assess the significance of the future variables. We therefore repeat the above regressions excluding the leads, i. e.

$$Y_t = \sum_{i=1}^{n} c_i' X_{t-i} \tag{1b}$$

$$X_t = \sum_{j=1}^{n} d_j' Y_{t-j} \tag{2b}$$

and compute the appropriate F-values. Each test for causality then requires the above two sets of regressions, comprising in total four regressions.

Before proceeding in this manner, one has to take account of two limitations affecting the possibility of detecting the underlying causal relationship in a bivariate system. The first is of a methodological, the second of a statistical nature.

As to the *methodological* aspects, we shall confine ourselves to three short remarks on the test-performance. All are concerned with circumstances, in which the test fails to detect the true causal relations.

First, and most important, *Sims'* procedure will give a wrong answer in the case of an unspecified third variable entering one of the equations of the model. If a variable Z determines both X and Y, then the test will come up with any answer, depending on the particular lag structure between Z, X and Y, respectively.

Second, if there is a systematic relationship, albeit incomplete, between the predictions of the model and the public's expectations (an extreme form thereof are 'rational' expectations), the test will fail. Future values of X would significantly explain the dependent variable Y, and unidirectional causality from Y to X would be deduced. In such a case it is not the causal structure but the expectations formation process that is responsible for the result.

Third, there will always be bidirectional causality if one variable is subject to optimal control. It is immediately clear that this institutionalized feedback prevents the underlying ralationship from manifesting itself.

Let us now turn to the *statistical* problems which have proven quite weighty in practice. They arise because all economic interlinkages are blurred by 'noise' in the data, i. e. by nonstationary sources of variation, such as trends, seasonal variations and autocorrelation of residuals. These have to be removed by means of filters in order to achieve stationary processes and, hopefully, an uncorrelated error structure. It is clear that trends, seasons and serial correlation mask the simple causal linkages.

Sims (1972) found that prefiltering with natural logs and $(1 - \frac{3}{4}L)^2$ flattened the spectral density of most economic time series, i. e. transformed them to stationarity. It was his hope that the regression residuals would be very nearly white noise. Applying the same filter to our data and looking at the plots and spectral densities of the filtered series, we recognized that they did not meet the above requirements. In particular the residuals were not serially uncorrelated. After some experimenting we therefore chose the following three-phase filter.

The first multiplicative term of the filter $(1 - L)$ allows for a stochastic trend, the second $(1 - L^4)$ for seasonal variations, as we worked with quarterly data (see section 3). The last term of the filter was to achieve an uncorrelated error structure in each of the regressions. In order to asses the magnitudes of the coefficients in the autoregressive error process, an *OLS* regression was run on the specifications using the filter $(1 - L)$ $(1 - L^4)$. Subsequently, the residuals were regressed on four past values, determining the four autocorrelation coefficients. These were utilized to form the third multiplicative term of the filter: $(1 - \hat{p}_1 L - \hat{p}_2 L^2 - \hat{p}_3 L^3 - \hat{p}_4 L^4)$.

Assuming that the relationship, if any, between money and income, money and prices, respectively, were linear on the logarithmic scale, the regressions themselves are on logs of variables, prefiltered as just explained. In addition to the past and future values of the independent variable a constant term, a linear trend and three seasonal dummies are included. Having found an optimal filter, these additional variables would, of course, all be insignificant. Thus, we can assess the filter by checking the values and standard errors of these terms.

3. Empirical Results

In this section we will attempt to falsify the null hypothesis put forward subsequent to Table 1. To this end we shall make use of four time series, namely the monetary base (*MB*), the stock of money narrowly defined (*M*1), gross national product in nominal terms (*GNP*) and the wholesale price index (*PIW*).

Since there is no published data of *GNP* on a quarterly basis, this variable had to be interpolated. One of the most successful approximating functions for this purpose have proved to be spline functions (see e. g. *Prenter* (1975)). We therefore chose a cubic spline function, which has continous derivations of the first and second order[1].

Tables 2 and 3 report the results of performing causality tests along the lines proposed by *Sims* and elaborated in section 2. Beginning with R^2 the successive columns of regression statistics are the coefficient of determination, the F-statistic for the independent variables, the Durbin-Watson statistic, the standard error of the regression, the degrees of freedom and, the cornerstone of the tables, the F-statistic on the future coefficients of the independent variable. Lastly, "*" represents the 5 percent significance level. The analysis spans the period 1953 I - 1976 IV. Yet, nine observations were lost in the transformation of the variables, and an additional eight observations were dropped in order to accommodate the eight past lags (where four future variables were added, this means an additional loss of twelve observations). Taking into account the number of parameters estimated (14, 18), there were 60 and

[1] We wish to thank *W. Inderbitzin* and the Institute for Empirical Research in Economics of Zurich University for the provision and interpolation of the data. The interpolation programm INTSMO was developed by *C. Vital*.

56 degrees of freedom respectively. Following *Sims* we opted for 8 lags and 4 leads of the independent variable, i. e. $n = 8$, $m = 4$ in equations (1) and (2).

First we shall focus on the relationship between money and *GNP*. Table 2 summarizes the statistics from the regressions pertinent for testing the null hypothesis that *GNP* determines the money variables in the small and open Swiss economy.

Table 2

Money and GNP

Nr.	Regression	R^2	F	DW	s	df	$F_{4,56}$
2.1	MB = f (GNP)						
	8 lags	.055	.266	1.920	.077	60	.9522
	8 lags, 4 leads	.115	.427	2.018	.077	56	
2.2	GNP = f (MB)						
	8 lags	.053	.258	.756	.003	60	3.0159*
	8 lags, 4 leads	.222	.938	.565	.003	56	
2.3	M 1 = f (GNP)						
	8 lags	.079	.399	1.416	.023	60	.9317
	8 lags, 4 leads	.136	.519	1.533	.023	56	
2.4	GNP = f (M 1)						
	8 lags	.104	.537	.539	.005	60	2.2634
	8 lags, 4 leads	.229	.978	.595	.005	56	

Trends and seasonal dummies were in all cases insignificant, confirming that there is no problem of remaining nonstationarity.

While the future values of the two money variables are significant or nearly significant in explaining *GNP*, the four future *GNP* variables are highly insignificant in explaining *MB* and *M*1 respectively. This supports the null hypothesis of a one-way causal chain running from nominal income to money.

Let us now look at some statistical caveats which may weaken the case for unidirectional causality. Firstly, there is some indication of first-order serial correlation, particularly in the *GNP* on *M*1 regressions.

Since the assumption of white noise residuals is an important prerequisite for the test, this caveat should not be dismissed lightly. Secondly, there remains a sizeable proportion of unexplained variation. And none of the R^2 is significantly different from zero. Considering the heavy differencing preceding the regressions, this is not too suprising.

The size of the (unrestricted) coefficients of the distributed lag can hardly be interpreted; the estimate of the lag profile is not efficient. Therefore we will abstain from making any inferences based on the relative size of coefficients of future variables (not reported here).

With some caution, we can conclude that the results allow firm rejection of the assertion that *GNP* is purely passive, responding to money without influencing it. On the contrary, there is some weighty evidence of unidirectional causation from *GNP* to money. Still, there remains the possibility of simultaneous causality. One way to check the results of Table 1 is to analyse the causal relationship between money and prices. If money is dominated by a consistent pattern of influence from prices, this will support the above conclusion.

Table 3 summarizes the statistics pertinent for testing this hypothesis.

Table 3

Money and Prices

Nr.	Regression	R^2	F	DW	s	df	$F_{4,56}$
3.1	MB = f (PIW)						
	8 lags	.152	.828	2.118	.071	60	.9017
	8 lags, 4 leads	.204	.842	2.196	.071	56	
3.2	PIW = f (MB)						
	8 lags	.126	.665	1.813	.015	60	3.4446*
	8 lags, 4 leads	.299	1.402	1.909	.014	56	
3.3	M 1 = f (PIW)						
	8 lags	.238	1.441	1.288	.020	60	.2754
	8 lags, 4 leads	.253	1.113	1.255	.021	56	
3.4	PIW = f (M 1)						
	8 lags	.245	1.493	1.644	.013	60	.9411
	8 lags, 4 leads	.292	1.359	1.797	.013	56	

Looking at the significance of the four leads, we find strong evidence in favour of a unidirectional causal pattern from prices to the monetary base. However, the results of the F-test on the future values are conclusive that there is feedback from $M1$ to prices: The coefficients of the future variables are insignificant not only for regression 3.3 but also for the reversed relation 3.4.

Comparing the other test-statistics to those of Table 2, we find a general improvement of the picture. The fit is slightly better and, more important, the Durbin-Watson statistics are closer to 2. The prefiltering turns out to be more appropriate for the regressions of Table 3.

Of course the causal pattern may change over time. After splitting the sample period into various subsamples, we applied the Chow-test to check whether a structural shift has taken place between two time periods. According to this test no significant differences between subsamples appeared in the regressions.

4. Conclusions

The regressions analysed in this paper lead to the conclusion that the monetary base is purely passive. Flows of foreign exchange reserves ensure that the monetary base accommodates to variations in nominal income and wholesale prices, rather than causing them. This result does not unambiguously apply to the money supply, leaving the possibility of bidirectional causality between $M1$ and GNP, $M1$ and prices respectively. In short, our null hypothesis could not be falsified, thus strengthening the case for the importance of institutional characteristics in economies with a highly developed financial sector.

Summary

It is shown that the distributed lag estimation of nominal GNP, money and prices does not yield empirical results consistent with the well known monetarist propositions. Specifically we find evidence of unidirectional causation from income to money, as well as from the monetary base to prices. However, feedback from money to prices cannot be excluded. We believe that these results are characteristic for small, open in contrast to closed economies.

Zuammenfassung

In diesem Aufsatz geht es um die Identifikation der Kausalitätsrichtung zwischen Geldmenge bzw. monetärer Basis und Bruttosozialprodukt und Preisniveau in einer kleinen, offenen Volkswirtschaft. Die Schätzresultate widerlegen die bekannten monetaristischen Postulate. Die empirische Evidenz weist vielmehr darauf hin, daß das Einkommenswachstum das Geldmengen-

wachstum, und die Entwicklung der monetären Basis die Inflationsrate, bestimmt. Indessen kann eine Rückkoppelung von der Geldmenge zum Preisniveau nicht ausgeschlossen werden.

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