Bank of England

Discussion Paper No.7

The direction of causality between the exchange rate, prices and money

by

C.A.Enoch

November 1979

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ISBN 0 903312 20 4

ISSN 0142-6753

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Introduction [1]

1 This paper reports the results of an attempt to determine the direction of causality between changes in various economic indices in the United Kingdom relative to overseas. There have been several studies of the direction of causality between money and domestic prices;[2] this study extends the approach by including also the exchange rate, import prices, and export prices.

2 Two 'triangular' sets of variables were tested in pairs for causality. The first test examined causality between retail prices in the United Kingdom relative to overseas and the effective exchange rate for the pound since sterling floated in 1972. Because of arguments that both prices and the exchange rate are in fact determined by relative rates of money growth, causality tests were also made between money and retail prices, and between money and the exchange rate. The second test focused more directly on the exchange rate/inflation transmission mechanism: thus it examined the direction of causality between the exchange rate, relative import prices and relative retail prices. In addition, largely because of mistrust of the method of weighting of other countries (especially for the money variables), similar tests were performed for the first 'triangle' on a bilateral basis - i.e. movement in the variables in the United Kingdom relative to the United States. Finally, alternative theories suggest the use of export rather than import prices as the means of transmission of changes between the exchange rate and domestic prices.[3] They were, therefore, included as an alternative in the second 'triangle'.

3 In the study, bidirectional causality was found between most of the pairs of variables under examination. However, since the results of many of the tests were unsatisfactory, these findings must be considered tentative. The study suggests that, in most cases,

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[1] I am grateful to W.A.Allen, R.N.Brown, L.A.Dicks-Mireaux, B.C.Hilliard, Ms.M.V.Lowther, M.Panić, I.D.Saville and J.C.Townend for advice and comments on an earlier draft. The responsibility for all remaining errors is, of course, my own.

[2] For instance, Sims (1972) and Williams, Goodhart and Gowland (1976).

[3] See paragraph 12 for a discussion of the Scandinavian theory of inflation, which embodies this approach.

testing only two variables can give little indication of the actual relationship between them. Only in a very limited number of instances, where a particular theory specifically excludes bidirectional causality, may this approach add to the understanding of the relationships involved. In this context, the results presented here appear to contradict the predictions of the Scandinavian theory of inflation.[1]

4 Section 2 explains the purpose of the study. Section 3 describes the methodology of the study and Section 4 the data. The two following sections report the results. Section 7 gives a brief summary of the results.

[1] This theory of the causes of inflation was first put forward by Aukrust (1970) and Edgren, Faxen and Odhner (1969).

Implications of the study

Prices, money and the exchange rate

5 Let us consider the three variables: 'prices', 'money' and 'the exchange rate'. These variables are tested in pairs for causality between them.[1] For each pair there are four possible outcomes: neither variable causes the other; A causes B, B causes A, and bidirectional causality (i.e. A causes B and B causes A). Since there are three sets of pairs to be tested, there are sixty-four (i.e. 4^3) possible outcomes in total. If we exclude the possibility that a test may reveal no evidence of causality in either direction, there are still twenty-seven (3^3) possible outcomes. Fourteen of these outcomes are not internally consistent;[2] of the remaining thirteen, some outcomes are from the viewpoint of economic theory more plausible than others. Table A (overleaf) shows the economic implications of the thirteen internally-consistent outcomes.

6 Alternative theories can be found to support causality between prices or money and the exchange rate running in either direction. A crude purchasing power parity theory asserts that prices are determined domestically in each country, and the exchange rate then serves to equilibrate the price levels, expressed in a common currency, of each country. Crude monetarism asserts that the money supply measured in domestic currency is determined exogenously in each country by the authorities and that the exchange rate then serves to change the price level so as to make the nominal money supply just satisfy the demand for real money balances. Thus, for instance, economic journalists and stockbrokers' analysts sometimes publish charts which show the price level or growth of the money supply in the United Kingdom relative to overseas over a period of time, and use this chart to determine whether the exchange rate is 'too high' or 'too low' and, by implication, to forecast its future path. On the other hand, it is sometimes argued that in the short run the exchange rate is determined by short-run capital flows which are independent of underlying economic factors[3] and that prices and the money supply adjust so as to validate any change in the exchange rate.

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[1] See next section for details of the method used.

[2] For instance, if a change in A causes a change in B and a change in B causes a change in C, then a change in A must cause a change in C.

[3] See, for instance, Allen and Enoch (1978).

Table A

Economic implications of alternative outcomes

'Excessive' means 'greater than overseas'.
→ means that causality runs from the first to the second variable.
← means that causality runs from the second to the first variable.

	Prices and the exchange rate	Money and the exchange rate	Prices and money	
1	→	→	→	Exchange rate counters excessive inflation in the United Kingdom; money supply validates excessive price increases.
2	→	→	←	Excessive money supply causes price increases and causes exchange rate depreciation.
3	→	→	→ ←	Excessive prices and money together cause exchange rate depreciation.
4	→	←	→	Excessive prices feed through to the exchange rate, later to money.
5	→	→ ←	→	Exchange rate and money supply both react to excessive inflation.
6	←	→	←	Money affects the exchange rate first, then the price level; no independent role for the exchange rate.
7	←	←	→	Exchange rate fall leads to price increase validated by money increase.
8	←	←	←	Exchange rate fall leads to money increase in anticipation of price increase.
9	←	←	→ ←	Exchange rate fall leads to price and money increases.
10	←	→ ←	←	Money changes the exchange rate first then the price level: and/or the exchange rate changes money then the price level.
11	→ ←	→	←	Excessive money leads both to price increases and to exchange rate depreciation.
12	→ ←	←	→	Money is influenced by prices and the exchange rate but has no influence on anything.
13	→ ←	→ ←	→ ←	Everything causes everything else.

7 It is clearly important for policy purposes to be able to distinguish between the alternative theories. If causality were found to run unidirectionally from prices to the exchange rate and from prices to money, one could regard the exchange rate as a mechanism for correcting the tendency for excess inflation in the United Kingdom to lead to lower UK competitiveness. In the absence of any confidence that the faster rate of inflation could be corrected by some other policy instrument (fiscal or monetary policy, or an incomes policy) or that the faster inflation was itself caused by changes in the exchange rate, it would appear dangerous for the authorities to consider making the exchange rate constant in the long term. If causality were found to run unidirectionally from money to prices and from money to the exchange rate, this would be consistent with crude monetarism and the exchange rate would be redundant as an instrument of policy. On the other hand, if causality were found to run unidirectionally from the exchange rate to prices and to money, this would imply that private speculators (or the authorities) are able to determine the domestic (sterling) price level through operations in the foreign exchange market. If private speculators determine the rate, and if they behave in a destabilising manner, this would present a case for the authorities preventing a free float of the exchange rate, so as to avoid the costs involved in excessive exchange rate volatility. In addition, it would imply that the exchange rate could be a useful policy instrument since it would indicate that official intervention in the exchange market could change the rate.[1]

8 The arguments for each direction of causality are not necessarily mutually exclusive, and one may well expect to discover bidirectional causality for some or all of the tests. Such a finding between the exchange rate and prices and/or money would tend to contradict the crude version of purchasing power parity which asserts that the exchange rate path can be predicted solely from knowledge of prices or of money in the United Kingdom and overseas; it would also contradict those who argue that movements in the exchange rate are without any economic foundation.

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[1] If the 'law of one price' holds, any attempt to manipulate the exchange rate will lead to offsetting domestic price movements, but the exchange rate manipulation will still have been useful if relative prices are not the correct measure of competitiveness and if the wage/price link is not strong.

9 It is important to distinguish between bidirectional causality, as defined above, and the conventional 'feedback mechanism' of exchange rate changes and inflation. For example, if the United Kingdom suffers from excess inflation, the pound may depreciate; the depreciation will then, via higher import prices, raw materials costs and wage demands, feed through to higher consumer prices. It would, however, be wrong to attribute bidirectional causality to this process. If the inflation/depreciation/inflation spiral proceeds in a well-determined and constant manner, it should be possible to predict the later rounds of inflation from the earlier rounds; the exchange rate only 'causes' inflation if part of the United Kingdom's inflation is left unexplained when past inflation has been taken into account.

10 In the tests which follow, statistical manipulations are performed on each series so that each observation is purged of information provided by past observations of that series. The objective is that when two series are run together the residual movements of each series can be explained solely in terms of the other series' residual movements. If, for instance, changes in the exchange rate 'cause' price changes, this is regarded as implying that the price changes result from exogenous movements in the exchange rate. One important, and generally recognised, defect of this approach is that movements in both variables in a test might be caused by some third variable. This study aims to take explicit account of this possibility by studying a triangular set of regression tests in pairs, so that money is an additional explanatory variable for changes in prices and the exchange rate.[1]

Retail prices, the exchange rate and import or export prices

11 A further combination of variables was also tested for 'triangular causality': retail prices, the exchange rate, and export and import prices. The set of possible outcomes of these tests can be presented in the same way as in Table A with money replaced by export or import prices. The problems of identifying an exogenous shift in one of the variables, especially where evidence of bidirectional causality is found, are identical to those discussed in the previous paragraph.

12 This set of variables may be used to shed light on the Scandinavian theory of imported inflation, according to which the crucial division in an economy is between its tradeable and its non-tradeable sector.

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[1] Of course, this assumes that money is the third variable. There still remains the possibility of an omitted common determinant in the triangle - see paragraph 16.

Tradeable prices adjust to world prices, i.e. the law of one price holds. Wages rise in the tradeable sector, because of tradeable firms' higher profitability, but wages are equalised domestically across sectors. Thus prices in the non-tradeable sector follow prices in the tradeable sector. The assumptions that the law of one price holds, and that prices in the non-tradeable sector follow prices in the tradeable sector, underlie much recent argument on the ineffectiveness of currency depreciation, and similarly underlie many of the arguments of proponents of a European Monetary System.[1] If, however, causality runs (additionally) from retail prices to export/import prices (i.e. from the non-tradeable sector to the tradeable sector), this suggests that price changes can be generated internally and that the exchange rate then serves to equilibrate each country's price level (Purchasing Power Parity). If this is so, it would seem dangerous for the authorities to try to keep the exchange rate constant in the long run. If export/import prices are used as proxies for prices in the tradeable sector and retail prices proxy prices in the non-tradeable sector, causality in this 'triangle' can be seen as a test of the Scandinavian theory.

[1] See, for instance, Thyssen (1978).

Technique of estimation

13 In this study, causality will be defined as in Granger and several more recent studies.[1] A variable X is said to cause a variable Y if, after all the information incorporated in past values of Y has been allowed for, the value of remaining information in Y can be explained better when the information contained in past and present X is included than when it is excluded. A more formal definition derives from Pierce and Haugh:[2]

X causes Y if

$$\sigma^2(Y/\bar{A}) < \sigma^2(Y/\overline{A-X})$$

where:

A = all information available in time t,

A-X = all information excluding X available in time t,

$-$ = all values for periods prior to period t,

$\sigma^2(Y/\bar{A})$, $\sigma^2(Y/\overline{A-X})$ = the mean square errors of $P_t(Y/\bar{A})$, $P_t(Y/\overline{A-X})$,

$P_t(Y/\bar{A})$, $P_t(Y/\overline{A-X})$ = the minimum mean square errors one step ahead predictors of Y_t given $\bar{A}$, or given $\overline{A-X}$.[3]

14 There are two approaches to testing for causality in this respect. The 'regression test' involves regressing variable Y against leads of variable X, against lags of variable X, and against leads and lags of X. If X causes Y unidirectionally, then the lags of X should help explain Y; if Y causes X unidirectionally, then the leads of X should explain Y. If causality is bidirectional, both leads and lags should help explain Y. The process is repeated, regressing X against Y. It is generally regarded to be important first to transform the series so that it becomes covariance-stationary, i.e. each series should have zero mean and constant variance. The regression programme must also take account of any autocorrelation in the residuals of the equations.

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[1] Granger (1969). Also, for instance, Hilliard (1979).

[2] Pierce and Haugh (1977).

[3] This definition of causality has recently been criticised in Zellner (1979) and Schwert (1979). Schwert indeed suggests (page 82) that the term 'causality' should in this context be replaced by 'incremental predictability'. Many of their criticisms are also recognised in this paper. Sims (1979) strongly disputes that they are sufficient to invalidate the methodology; however, they do serve to make some of the conclusions rather tentative.

15 The Box-Jenkins approach involves 'filtering' each series separately, by selecting an appropriate order of autocorrelation (parameter P), differencing (parameter D) and moving average (parameter Q) for each series, in order to reduce it to a series of random residuals (white noise). The method of selecting the appropriate model is explained fully in Box and Jenkins (1970). Parsimonious parameterisation is obtained by studying the autocorrelation function and partial autocorrelation function of the series, estimating the resulting model, and performing certain diagnostic checks. It is also possible to take account of seasonal influences on each series (select parameters BP, BD, BQ). Finally, an appropriate number of lags of each series of random residuals are created, and the cross-correlation coefficients between the various lags of the two 'whitened' series are calculated. If any of the lags of the 'whitened' exchange rate series are significantly correlated with the current value of 'whitened' relative prices, for instance, then movements in the exchange rate may be regarded as causing movements in relative prices; if, on the other hand, any of the leads are significant, then movements in relative prices may be regarded as causing movements in the exchange rate. The Box-Jenkins approach appears more general than the regression approach. However, the ARIMA (auto-regressive integrated moving average) models selected by the Box-Jenkins approach are usually not the only models that would satisfy the choice criteria, so the results of the study may be dependent on the model selected. Moreover, as mentioned below, far fewer observations are available than are considered by Box and Jenkins to be the 'safe' minimum number. Hence both sets of results are reported below.

16 At least four limitations to these approaches should be mentioned. First, these approaches rely on heuristic justification, i.e. 'post hoc ergo propter hoc'. Thus, they give the wrong result if an event occurs before the event which causes it: for instance, if it is announced that wage increases over the next pay round will be very high so that the market expects large future price increases, the exchange rate may depreciate immediately. These tests would suggest that the exchange rate change caused the subsequent prices changes.[1]

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[1] This is equivalent to the 'Christmas card' and 'travel agent' examples - see Goodhart and Crockett (1970), page 177. People go to travel agents and book their holidays; subsequently they take their holidays. This does not mean that the act of booking actually <u>causes</u> the holiday.

Secondly, instantaneous causality (i.e. where one variable has an effect on the other variable within the same period) may not be discovered by the tests. Moreover, when these tests are extended to form 'triangular' causality, they may give misleading results. If A causes B and B causes C within the same period, it is possible that the effect of A on C may appear within the next period. Thus it will appear that the only causality between the variables is from A to C. Thirdly, the tests cannot distinguish the actions of the authorities from those of other market participants: for instance, if it is found that exchange rate movements, unexplained by past relative price movements, lead to relative price movements, the implications for policy will be different, depending on whether the autonomous exchange rate movements are caused by the authorities or by private speculators. Finally, as discussed in the previous section, 'causality' may be a misleading term in these tests since both variables may in fact respond to another variable.

Data

17 All data were taken from International Financial Statistics. The analysis covers the period from July 1972 to December 1977. The start of the period was chosen to coincide with the floating of sterling. Monthly data were used to increase the number of observations in the sample period and to reduce the problem of instantaneous causality discussed above. The consumer price index (CPI, line 64), export price index (XPI, line 74), import price index (MPI, line 75),[1] and money index (MO, line 32) were chosen largely because of the availability of internationally-comparable data.[2] All these indices were calculated for the United Kingdom relative to nine other countries, with the choice of other countries being restricted by the availability of data for all indices.[3] Average market rates for the various currencies against the dollar were used as the exchange rate variable.

18 Other countries were weighted with weights derived from the IMF's Multilateral Exchange Rate Model.[4] It is questionable whether these are the correct weights to be used here, particularly for the money index; the Monetary Approach to the Balance of Payments might suggest as an alternative the total money stock in each country at some particular date, but this index too would be open to question and it would be inconsistent to use different theoretical justifications for the weighting of different indices in the study. Some of the analysis was repeated on a bilateral basis, comparing the United Kingdom only with the United States.

[1] It should be noted that the relative import price series here represents import prices in the United Kingdom relative to import prices elsewhere. This differs from other work where relative import price series represent import prices in the United Kingdom relative to some domestic price index in the United Kingdom.

[2] Attempts were made also to construct a relative domestic credit index but no monthly series is available for the United Kingdom (or Belgium). For similar reasons it was impossible to extend the analysis to cover cost indices.

[3] Other countries in this study were: the United States, Canada, France, Western Germany, Italy, Japan, the Netherlands, Belgium and Sweden.

[4] See Rhomberg (1976).

Regression test results

19 All five series involved in the multilateral analysis (EX, RPI, XPI, MPI, MO) and all three series involved in the bilateral analysis (BEX, BRPI, BMO) were transformed into logarithms and estimated as first differences.[1] A major problem with the regression approach is that creating leads and lags of a series serves to reduce the degrees of freedom when estimating the equations, thus limiting the number of leads and lags that can be created. Each variable was regressed against eighteen lags and six leads of the other variable in each combination of pairs and then against the six leads alone of the other variable in order to find the incremental explanatory power of the lags. The first variable was then regressed against eighteen leads and six lags of the other variable and then against the six lags alone so as to find the incremental explanatory power of the leads. The procedure was then reversed, running the leads and lags of the first variable against the second variable. To make the estimation period consistent, all equations were run over the period from March 1974 to December 1977.

20 The equations were all tested for up to fourth order autocorrelation (the maximum order that can be dealt with on the Bank's computer) and the maximum order that was found significant was chosen for both series in each comparison of two series.[2] For evaluating the significance of extra explanatory variables, in the presence of autocorrelation, the result that

$$N \log \frac{RSS_1}{RSS_2}$$

is asymptotically distributed as χ^2 with r degrees of freedom, was used where RSS_1 is the residual sum of squares from the equation without the additional explanatory variables, RSS_2 is the residual sum of squares from the equation with the additional explanatory variables, N is the number of observations and r is the number of

[1] All series were very highly trended. Also when an AR(1) model was fitted to each series, the coefficients on the resultant lag operations were insignificantly different from unity.

[2] The fact that only fourth order autocorrelation was tested in these runs may be thought to reduce the acceptability of these results since a filter incorporating sixth and twelfth order autocorrelation were selected for some of the series in the Box-Jenkins approach described in the next section.

additional explanatory variables.[1] The results are summarised in Table B below.

21 There is evidence (at the 99% probability level) of causality running from relative prices to the exchange rate both from the equation regressing the exchange rate against lags of relative prices and from the equation regressing relative prices against leads of the exchange rate. There is also evidence (at the 99% probability level) from the equation regressing relative prices against lags of the exchange rate that causality runs in the reverse direction, i.e. from the exchange rate on to prices. In the light of this second result, it is perhaps surprising that leads of relative prices added nothing to the explanatory power of the equation explaining current values of the exchange rate; it is not immediately obvious how to explain this asymmetry. Nevertheless, the results here do provide evidence for the existence of bidirectional causality. In the bilateral regressions there is evidence (at the 99% level) from both the leads and lags tests that causality between EX and RPI is bidirectional.

22 Both the multilateral and bilateral regressions show bidirectional causality at the 95% level between the exchange rate and money; all the regressions except the multilateral ones showing the effect of money changes on exchange rate changes are significant at the 99% level.

23 The multilateral tests on money and relative prices indicate (at the 99% level) the existence of bidirectional causality. The bilateral lag tests indicate (at the 95% level) bidirectional causality, whilst the leads tests indicate only that price changes cause money changes. This last result again is surprising, but overall the tests suggest bidirectional causality.

24 The remaining tests all show strong evidence of bidirectional causality. The finding of bidirectional causality between export prices and the exchange rate and between export prices and retail prices serve to confirm the finding of bidirectional causality between the exchange rate and retail prices; moreover, the findings that causality runs from the exchange rate both to export prices and to import prices imply a refutation of the crude assertion of

[1] See Hendry (1974), page 563.

Purchasing Power Parity that exchange rates always adjust to equalise each country's export prices. The existence of a causal relationship from retail prices to import prices is interesting: one explanation is that retail prices (as a proxy for domestic prices) reflect other countries' export prices, so that an increase in A's relative retail price index will be reflected in B's relative import price index. An alternative explanation is that import prices reflect international transfer prices; firms set the price of imported goods according to some oligopolistic rule whereby their prices bear some fixed relationship to the prices of the domestic goods against which they are competing.

Table B

Results of regression test

$\chi^2(18)$ = 28.87 at 95% level; 34.81 at 99% level.

1 Exchange rate and retail prices

Multilateral analysis

	Dep. var.	Indep. var.	No.of leads	No.of lags	Order of autocorrelation	RSS
(1)	EX	RPI	18	6	4	.000835
	RPI	EX	18	6	4	.000375
(2)	EX	RPI	-	6	4	.004777
	RPI	EX	-	6	4	.001619
(3)	EX	RPI	6	18	4	.000934
	RPI	EX	6	18	1	.000978
(4)	EX	RPI	6	-	4	.005194
	RPI	EX	6	-	1	.001741

Bilateral analysis

(1)	BEX	BRP	18	6	4	.000865
	BRP	BEX	18	6	4	.000224
(2)	BEX	BRP	-	6	4	.006643
	BRP	BEX	-	6	4	.000224
(3)	BEX	BRP	6	18	4	.001784
	BRP	BEX	6	18	4	.000102
(4)	BEX	BRP	6	-	4	.007850
	BRP	BEX	6	-	4	.001893

Significance of leads and lags

[Distributed as $\chi^2(18)$]

Multilateral

Dependent variable EX

(2) - (1)	64.53
(4) - (3)	54.11

Dependent variable RPI

(2) - (1)	63.48
(4) - (3)	21.34

Bilateral

Dependent variable BEX

(2) - (1)	36.69
(4) - (3)	44.22

Dependent variable BRP

(2) - (1)	54.82
(4) - (3)	108.07

Conclusions

Multilateral

Leads test: bidirectional causality

Lags test : from prices to the exchange rate

Bilateral

Bidirectional causality

Table B (continued)

Results of regression test

2 Exchange rate and money

Multilateral analysis

	Dep. var.	Indep. var.	No.of leads	No.of lags	Order of autocorrelation	RSS
(1)	EX	MO	18	6	4	.000860
	MO	EX	18	6	4	.001611
(2)	EX	MO	-	6	4	.004399
	MO	EX	-	6	4	.014363
(3)	EX	MO	6	18	4	.000608
	MO	EX	6	18	4	.001999
(4)	EX	MO	6	-	4	.005012
	MO	EX	6	-	4	.011798

Bilateral analysis

	Dep. var.	Indep. var.	No.of leads	No.of lags	Order of autocorrelation	RSS
(1)	BEX	BMO	18	6	2	.004107
	BMO	BEX	18	6	4	.001014
(2)	BEX	BMO	-	6	2	.007694
	BMO	BEX	-	6	4	.027673
(3)	BEX	BMO	6	18	2	.001661
	BMO	BEX	6	18	3	.002995
(4)	BEX	BMO	6	-	2	.007082
	BMO	BEX	6	-	3	.021000

Significance of leads and lags

[Distributed as $\chi^2(18)$]

Multilateral

Dependent variable EX

(2) - (1) 29.38

(4) - (3) 39.38

Dependent variable MO

(2) - (1) 37.97

(4) - (3) 31.96

Bilateral

Dependent variable BEX

(2) - (1) 69.32

(4) - (3) 122.34

Dependent variable BMO

(2) - (1) 53.66

(4) - (3) 72.06

Conclusions

Multilateral

Bidirectional causality

Bilateral

Bidirectional causality

Table B (continued)

Results of regression test

3 Retail prices and money

Multilateral analysis

	Dep. var.	Indep. var.	No.of leads	No.of lags.	Order of autocorrelation	RSS
(1)	RPI	MO	18	6	4	.000216
	MO	RPI	18	6	3	.004433
(2)	RPI	MO	-	6	4	.001095
	MO	RPI	-	6	3	.011575
(3)	RPI	MO	6	18	4	.000229
	MO	RPI	6	18	3	.001438
(4)	RPI	MO	6	-	4	.001190
	MO	RPI	6	-	3	.016833

Bilateral analysis

(1)	BRP	BMO	18	6	4	.000285
	BMO	BRP	18	6	3	.006597
(2)	BRP	BMO	-	6	4	.001812
	BMO	BRP	-	6	3	.015189
(3)	BRP	BMO	6	18	1	.000810
	BMO	BRP	6	18	4	.002427
(4)	BRP	BMO	6	-	1	.001517
	BMO	BRP	6	-	4	.022995

Significance of leads and lags

[Distributed as $\chi^2(18)$]

Multilateral

Dependent variable RPI

(2) - (1) 59.03

(4) - (3) 60.98

Dependent variable MO

(2) - (1) 35.51

(4) - (3) 91.02

Bilateral

Dependent variable BRP

(2) - (1) 68.43

(4) - (3) 23.17

Dependent variable BMO

(2) - (1) 30.85

(4) - (3) 83.20

Conclusions

Multilateral

Bidirectional causality

Bilateral

Leads test: price changes cause money changes

Lags test : bidirectional causality

Table B (continued)

Results of regression test

Export prices and the exchange rate

	Dep. var.	Indep. var.	No.of leads	No.of lags	Order of autocorrelation	RSS
(1)	EX	XPI	18	6	4	.000231
	XPI	EX	18	6	3	.000833
(2)	EX	XPI	-	6	4	.004814
	XPI	EX	-	6	3	.004393
(3)	EX	XPI	6	18	4	.002015
	XPI	EX	6	18	-	.001547
(4)	EX	XPI	6	-	4	.004808
	XPI	EX	6	-	-	.004284

Import prices and the exchange rate

	Dep. var.	Indep. var.	No.of leads	No.of lags	Order of autocorrelation	RSS
(1)	EX	MPI	18	6	4	.001002
	MPI	EX	18	6	-	.001874
(2)	EX	MPI	-	6	4	.003829
	MPI	EX	-	6	-	.004555
(3)	EX	MPI	6	18	3	.000911
	MPI	EX	6	18	4	.000577
(4)	EX	MPI	6	-	3	.003913
	MPI	EX	6	-	4	.003755

Significance of leads and lags

[Distributed as $\chi^2(18)$]

Export prices

Dependent variable EX

(2) - (1)	112.36
(4) - (3)	32.18

Dependent variable XPI

(2) - (1)	61.52
(4) - (3)	37.69

Import prices

Dependent variable EX

(2) - (1)	49.60
(4) - (3)	53.93

Dependent variable MPI

(2) - (1)	32.87
(4) - (3)	69.30

Conclusions

Bidirectional causality

Table B (concluded)

Results of regression test

Retail prices and export prices

	Dep. var.	Indep. var.	No.of leads	No.of lags	Order of autocorrelation	RSS
(1)	RPI	XPI	18	6	4	.000089
	XPI	RPI	18	6	3	.000651
(2)	RPI	XPI	-	6	4	.001116
	XPI	RPI	-	6	3	.004338
(3)	RPI	XPI	6	18	3	.000469
	XPI	RPI	6	18	-	.000898
(4)	RPI	XPI	6	-	3	.001430
	XPI	RPI	6	-	-	.003162

Retail prices and import prices

	Dep. var.	Indep. var.	No.of leads	No.of lags	Order of autocorrelation	RSS
(1)	RPI	MPI	18	6	3	.000239
	MPI	RPI	18	6	4	.000518
(2)	RPI	MPI	-	6	3	.001606
	MPI	RPI	-	6	4	.005341
(3)	RPI	MPI	6	18	4	.000299
	MPI	RPI	6	18	-	.000865
(4)	RPI	MPI	6	-	4	.001622
	MPI	RPI	6	-	-	.005117

Significance of leads and lags

[Distributed as $\chi^2(18)$]

Export prices

Dependent variable RPI

(2) - (1)	93.57
(4) - (3)	41.24

Dependent variable XPI

(2) - (1)	70.17
(4) - (3)	46.58

Import prices

Dependent variable RPI

(2) - (1)	93.57
(4) - (3)	41.24

Dependent variable MPI

(2) - (1)	70.17
(4) - (3)	46.58

Conclusions

Bidirectional causality

ARIMA model results

25 As explained above, the ARIMA approach provides greater flexibility in dealing with the individual series. Nevertheless, the results obtained were disappointing. This may have been due, as mentioned above, to the small number of observations available (sixty-six) compared with the minimum number (about 100) suggested by Box and Jenkins as satisfactory; alternatively, the tests may have been influenced by outside variables.[1][2]

26 The eight series were all transformed into logarithms, and the parameters P, D, Q, BP, BQ, as defined in paragraph 15, selected for each series. Within-sample estimates of the resultant models were found in order to obtain the required series of residuals. The usual diagnostic checks of overfitting and 'Q' tests were made to confirm that the residuals were random. The models chosen are shown in Table C opposite. A cross-correlogram was then estimated by obtaining twenty-four leads and lags of the residuals from the ARIMA models and running them individually against the residuals of the ARIMA model of other variables, to test the same pairs as in the regression tests. The results are shown in Table D.

27 The choice of the number of leads and lags is rather arbitrary: if too few are chosen, the full effect of one variable on another may not be captured, whilst if too many are chosen, spurious results may be obtained in the independence test (see next paragraph) and it is more likely that the influence of third variables on the two currently being tested will be captured. It is highly probable that different lag lengths should be applied to each test; however, to choose the maximum lag length ex post by examination of the data may lead to a spurious rejection of the independence test.

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[1] It is, of course, possible that better results would have been obtained if there had been experimentation with alternative satisfactory ARIMA models. This might have been feasible when testing the relationship between only two variables but would have involved very considerable effort in this case (in addition to being econometrically highly questionable), given the large number of models that had to be fitted.

[2] Results may have been poor because of defects in the methodology as illustrated by Schwert (1979).

Table C

The preferred ARIMA models

EX: $(1 - L)(1 - .11L) Z_t = (1 + 41L) U_t$

$Q(27) = 28.52$

BEX: $(1 - L)(1 - .55L + .31L^2) Z_t = U_t$

$Q(27) = 22.99$

RPI: $(1 - L)(1 - .16L^6) Z_t = (1 - .42L) U_t$

$Q(27) = 32.03$

BRPI: $(1 - L) Z_t = (1 + .34L)(1 + .37L^6 + .34L^{12}) U_t$

$Q(27) = 32.98$

MO: $(1 - L) Z_t = (1 - .87L)(1 - .75L^6 - .50L^{12}) U_t$

$Q(27) = 34.45$

BMO: $(1 - L)(1 - .77L)(1 - .61L^{12}) Z_t = (1 - .81L + .36L^2) U_t$

$Q(25) = 34.18$

XPI: $(1 - L)(1 - .85L + .29L^2) Z_t = (1 - .75L) U_t$

$Q(26) = 31.27$

MPI: $(1 - L)(1 + .50L + .81L^2) Z_t = (1 + .19L + .91L^2) U_t$

$Q(25) = 30.61$

$\chi^2(25) = 34.38$ at 90% level, 37.65 at 95% level

$\chi^2(26) = 35.56$ at 90% level, 38.89 at 95% level

$\chi^2(27) = 36.74$ at 90% level, 40.11 at 95% level

---

28 The first test is for independence between each pair of series. This is made by calculating the test statistic S_m^*, where:

$$S_m^* = N^2 \sum_{k=-m}^{m} (N - |K|)^{-1} r_{12}(K)^2 \sim \chi^2_{2m+1}$$

where:

m = maximum lead and lag,

N = sample size,

$r_{12}(K)$ = cross-correlation coefficient between series 1 lagged K periods and series 2.

The results are shown in Table D. The hypothesis that the two series are independent of each other can be rejected at the 99% level for all pairs except for the multilateral series relating money to the exchange rate and to relative prices, where independence cannot be rejected even at the 95% level. However, in the bilateral series both these tests of independence could be rejected; this suggests that the method of weighting of competitor countries for testing the money variable may be wrong.[1]

Table D

Tests of independence between pairs of residuals

	S_m^*
EX/RPI	90.25
BEX/RPI	84.17
EX/MO	66.75*
BEX/BMO	80.45
RPI/MO	55.54*
BRPI/BMO	108.39
EX/XP	77.94
EX/MP	79.49
RPI/XP	101.46
RPI/XP	80.79
RPI/MP	83.34

χ^2_{49} = 70.21 at 95% level
= 74.90 at 99% level

* Independence of two series cannot be rejected at 95% level.

29 The results shown in Table E (pages 29-33), however, are not very satisfactory. The significant coefficients appear to occur at fairly random intervals in most of the tests, so it is generally not possible

[1] Zellner (1979) has shown that this test may be biased in the direction of finding spurious independence.

to place a time dimension on the causality between two series; even worse, most of the cross-correlograms display significant wrong-signed coefficients. It is not always easy to interpret these: they may arise by chance (since one in twenty of all random coefficients would appear to be significant at the 95% level). Alternatively, they may arise through the influence of omitted variables: for instance, if a fall in the exchange rate causes the authorities to contract the money supply, then this may lead to a fall in the rate of inflation. Some evidence for this second possibility arises from the fact that most of the wrong-signed coefficients represent long lags between the two variables being studied, perhaps longer lags than might be expected from their direct interaction.

30 Table E(1) indicates bidirectional causality betweeen retail prices and the exchange rate. There are significant negative coefficients when the exchange rate is run against prices lagged by sixteen and seventeen months, also when the exchange rate is lagged twenty months behind prices (and at the 90% level when it is lagged four and seven months); there are, however, three wrong-signed coefficients (two of which arise with lags of over twenty months). The bilateral test also suggests bidirectional causality. There are significant negative coefficients when the exchange rate is run against prices lagged by two and seventeen months and when the exchange rate is lagged sixteen and eighteen months behind prices. Again, there are several wrong-signed coefficients.

31 Table E(2) shows the cross-correlogram of the residuals of EX and MO; there are significant correct-signed coefficients in both directions, but, as explained above, the hypothesis that the series are independent cannot be rejected (at the 95% level).[1] The bilateral test provides evidence of bidirectional causality. When the exchange rate is run against money lagged by seven, fifteen, seventeen and twenty-three months and when the exchange rate leads money by eighteen months, there are significant negative coefficients. There are two significant wrong-signed coefficients when the exchange rate is lagged.

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[1] This does not appear to be solely a function of the length of lag chosen for the test. More significant results might be expected, from inspecting Table E(2), from taking only one or three lags of the series. In neither case, however, can the hypothesis of independence be rejected at the 95% level.

32 The independence of retail prices and money [Table E(3)] in the multilateral test cannot be rejected (at the 95% level). The bilateral test again indicates bidirectional causality; there are, however, more wrong-signed than correct-signed coefficients on the runs where retail prices lag behind money. This might be explained in terms of the authorities' reaction function, especially since all these coefficients have rather long lags. An alternative explanation may lie with defects in the choice of money variable in this study.

33 Bidirectional causality was found between the exchange rate and both export and import prices [Table E(4)]. There are significant negative coefficients when export prices lag the exchange rate by twenty-one and six months, and when they lead by four, seventeen and twenty-one months. Each series has one significant wrong-signed coefficient. When import prices lag the exchange rate four and twenty-three months, there are significant negative-coefficients. There are also significant negative coefficients when the exchange rate is lagged four months (and at 90% level one month). It seems highly likely for this series that the maximum lag length should, however, be restricted to zero or possibly four months. As we might expect, there is very high zero-lag causality between the two series, which is therefore of uncertain direction. Almost all the coefficients with less than seven months lags in each direction are correct-signed and many are significant at the 90% level.

34 Finally, the test between retail prices and export prices indicates bidirectional causality [Table E(5)]. Export prices are significantly positive with lags of three and seven months, and with leads of nine and fifteen months; there are also three significantly wrong-signed coefficients (with relatively long lags). Most importantly, there is a very strong zero-lag relationship between them. The tests between retail prices and import prices, were, however, unsatisfactory because no significant correct-signed coefficients on low lags were found. Significant correct-signed coefficients were found in both directions (when import prices were lagged twenty-one months, and led fifteen, seventeen and eighteen months) and there was only one (barely) significant wrong-signed coefficient, but these lags seem implausibly long.

Table E(1)

Number of months lead and lag on the exchange rate relative to consumer prices (+ = lead, - = lag). Standard errors in brackets.

Cross-correlogram of EX and RPI			Cross correlogram of BEX and BRPI		
RPI→EX			BRPI→BEX		
+ 24	.0290	(.098)	+ 24	.0574	(.097)
23	.0068	(.100)	23	.0146	(.098)
22	.2269	(.101) *	22	.1142	(.100)
21	.0632	(.102)	21	.0472	(.107)
20	.1642	(.103)	20	.1088	(.102)
19	.1432	(.105)	19	.0596	(.103)
18	-.1238	(.106)	18	-.0237	(.104)
17	-.4121	(.107) *	17	-.4508	(.105) *
16	-.2494	(.108) *	16	-.1380	(.106)
15	-.0921	(.109)	15	-.1586	(.107)
14	-.0687	(.111)	14	-.0450	(.109)
13	-.1912	(.112)	13	-.0647	(.110)
12	-.0353	(.113)	12	-.0536	(.111)
11	-.1825	(.114)	11	-.1127	(.112)
10	-.0321	(.115)	10	.0120	(.113)
9	.1078	(.116)	9	.0232	(.114)
8	-.0900	(.118)	8	-.0231	(.115)
7	.1413	(.119)	7	-.0369	(.116)
6	-.1632	(.120)	6	-.1768	(.117)
5	-.0923	(.121)	5	.0811	(.118)
4	-.0045	(.122)	4	-.1018	(.119)
3	-.0737	(.123)	3	.0171	(.120)
2	-.1092	(.124)	2	-.2677	(.121) *
1	-.0466	(.126)	1	.0810	(.122)
0	-.0264	(.127)	0	-.0442	(.123)
EX→RPI			BEX→BRPI		
- 1	-.0183	(.126)	- 1	-.0334	(.122)
2	-.0188	(.124)	2	.1328	(.121)
3	.0676	(.123)	3	-.0955	(.120)
4	-.2348	(.122)	4	.0225	(.119)
5	.1422	(.121)	5	-.0757	(.118)
6	-.1007	(.120)	6	-.1437	(.117)
7	-.2337	(.119)	7	-.0913	(.116)
8	.1079	(.118)	8	.0711	(.115)
9	-.0555	(.116)	9	-.0644	(.114)
10	.0142	(.115)	10	.0695	(.113)
11	.2852	(.114) *	11	.2858	(.112) *
12	.1521	(.113)	12	-.0367	(.111)
13	.1820	(.112)	13	.1013	(.110)
14	.1936	(.111)	14	.1744	(.109)
15	.0756	(.109)	15	.0186	(.107)
16	-.0658	(.108)	16	-.2280	(.106) *
17	-.0267	(.107)	17	-.1759	(.105)
18	-.0378	(.106)	18	-.2167	(.104) *
19	.0615	(.105)	19	.2184	(.103) *
20	-.2643	(.103) *	20	.0067	(.102)
21	.0702	(.102)	21	-.0779	(.101)
22	-.1835	(.101)	22	.1674	(.100)
23	-.0244	(.100)	23	.2565	(.098) *
24	.3118	(.098) *	24	.2459	(.097) *

* Coefficient significant at 95% level.

$var_{12}(k) = (1 - |K/N|)/N$.

Table E(2)

Number of months lead and lag on the exchange rate relative to money (+ = lead, - = lag). Standard errors in brackets.

Cross-correlogram of EX and MO		Cross-correlogram of BEX and BMO	
MO→EX		BMO→BEX	
+ 24	.1194 (.098)	+ 24	.0167 (.100)
23	.0220 (.100)	23	-.2183 (.101) *
22	.1972 (.101)	22	.1692 (.102)
21	-.0196 (.102)	21	.1276 (.104)
20	.0959 (.103)	20	-.1053 (.106)
19	.0227 (.105)	19	-.0376 (.107)
18	.0596 (.106)	18	-.0115 (.109)
17	-.3129 (.107) *	17	-.3863 (.110) *
16	-.0538 (.108)	16	.1649 (.112)
15	-.0875 (.109)	15	-.2352 (.113) *
14	.0743 (.111)	14	-.1422 (.115)
13	-.1509 (.112)	13	-.0838 (.116)
12	-.1287 (.113)	12	-.1544 (.117)
11	.0288 (.114)	11	-.0483 (.119)
10	-.2426 (.115) *	10	-.1397 (.120)
9	.1097 (.116)	9	-.0458 (.122)
8	-.0818 (.118)	8	-.0547 (.123)
7	-.2598 (.119) *	7	-.2632 (.124) *
6	-.1922 (.120)	6	-.1215 (.125)
5	.1234 (.121)	5	.0837 (.127)
4	.0159 (.122)	4	.0229 (.128)
3	.0034 (.123)	3	.2109 (.130)
2	-.1067 (.124)	2	-.1159 (.131)
1	-.3079 (.125) *	1	-.0231 (.132)
0	.0268 (.126)	0	.0292 (.133)
EX→MO		BEX→BMO	
- 1	.1019 (.125)	- 1	-.0762 (.132)
2	-.0146 (.124)	2	.0832 (.131)
3	.2497 (.123) *	3	.2439 (.130)
4	-.0748 (.122)	4	.1062 (.128)
5	-.0145 (.121)	5	.0320 (.127)
6	-.0000 (.120)	6	.2563 (.125) *
7	.1909 (.119)	7	.1206 (.124)
8	-.0167 (.118)	8	.0787 (.123)
9	.2019 (.116)	9	-.1442 (.122)
10	.2327 (.115) *	10	.2562 (.120) *
11	.0583 (.114)	11	.1614 (.119)
12	-.0463 (.113)	12	-.0679 (.117)
13	-.1383 (.112)	13	-.2273 (.116)
14	.0924 (.111)	14	.0155 (.115)
15	-.0300 (.109)	15	.2061 (.113)
16	.0458 (.108)	16	-.0128 (.112)
17	.0267 (.107)	17	.0819 (.110)
18	-.1723 (.106)	18	-.2190 (.109) *
19	-.0620 (.105)	19	-.1121 (.107)
20	-.1023 (.103)	20	-.2043 (.106)
21	.1608 (.102)	21	-.0798 (.104)
22	-.2288 (.101) *	22	-.1732 (.102)
23	.0877 (.100)	23	.0110 (.101)
24	-.1587 (.098)	24	.1149 (.100)

* Coefficient significant at 95% level.

$var_{12}(k) = (1 - |K/N|)/N$.

Table E(3)

Number of months lead and lag on retail prices relative to money (+ = lead, - = lag). Standard errors in brackets.

Cross-correlogram of RPI and MO			Cross-correlogram of BRPI and BMO		
MO→RPI			BMO → RPI		
+ 24	-.0052	(.098)	+ 24	.2671	(.100) *
23	.1081	(.100)	23	.3846	(.101) *
22	.1161	(.101)	22	-.0046	(.102)
21	-.0447	(.102)	21	.1193	(.104)
20	.0293	(.103)	20	.0947	(.105)
19	-.1916	(.105)	19	-.1475	(.107)
18	.1095	(.106)	18	.0110	(.109)
17	-.1658	(.107)	17	-.1509	(.110) *
16	.0475	(.108)	16	.1213	(.112)
15	-.0621	(.109)	15	-.0169	(.113)
14	-.1722	(.111)	14	.0317	(.115)
13	-.1310	(.112)	13	-.1009	(.116)
12	-.2083	(.113)	12	-.1576	(.117)
11	-.0170	(.112)	11	-.0350	(.119)
10	-.1250	(.115)	10	-.2737	(.120) *
9	.0430	(.116)	9	.0549	(.122)
8	.0049	(.118)	8	.1900	(.123)
7	.0791	(.119)	7	.1849	(.124)
6	-.0531	(.120)	6	-.1092	(.125)
5	.1136	(.121)	5	.1861	(.127)
4	.1938	(.122)	4	.0699	(.128)
3	.0041	(.123)	3	.0407	(.130)
2	.2093	(.124)	2	.1257	(.131)
1	.0062	(.125)	1	-.0764	(.132)
0	.1559	(.126)	0	.1744	(.133)
RPI→MO			BRPI→BMO		
- 1	.0680	(.125)	- 1	.0173	(.132)
2	.0443	(.124)	2	.0214	(.131)
3	.0014	(.123)	3	-.0328	(.130)
4	.2003	(.122)	4	.1866	(.128)
5	-.0058	(.121)	5	-.0542	(.127)
6	-.0097	(.120)	6	.0678	(.125)
7	.0404	(.119)	7	-.1139	(.124)
8	-.0713	(.118)	8	-.2152	(.123)
9	.1191	(.116)	9	.1878	(.122)
10	.0707	(.115)	10	-.0695	(.120)
11	.1112	(.114)	11	.0846	(.119)
12	-.0785	(.113)	12	-.1645	(.117)
13	.0777	(.112)	13	.0207	(.116)
14	-.1415	(.111)	14	-.3284	(.115) *
15	.0742	(.109)	15	.2387	(.113) *
16	.1131	(.108)	16	.0889	(.112)
17	-.1228	(.107)	17	-.2444	(.110) *
18	-.1146	(.106)	18	-.1316	(.109)
19	-.1775	(.105)	19	-.2358	(.107) *
20	-.0365	(.103)	20	-.1097	(.106)
21	-.3516	(.102) *	21	-.3669	(.104) *
22	.1022	(.101)	22	.1955	(.102)
23	.0263	(.100)	23	-.2356	(.101) *
24	-.1560	(.098)	24	.1417	(.100)

* Coefficient significant at 95% level.

$var_{12}(k) = (1 - |K/N|)/N$.

Table E(4)

Number of months lead and lag on the exchange rate relative to export/import prices (+ = lead, - = lag). Standard errors in brackets.

Cross-correlogram of EX and XPI

XPI→EX		
+ 24	.0977	(.097)
23	-.0302	(.098)
22	.2996	(.099)*
21	-.2668	(.100)*
20	-.0720	(.101)
19	.1021	(.102)
18	.1056	(.104)
17	-.1767	(.105)
16	.0513	(.106)
15	-.1798	(.107)
14	-.0932	(.108)
13	.0292	(.109)
12	-.0965	(.110)
11	.0313	(.111)
10	.0235	(.112)
9	-.0027	(.113)
8	-.0586	(.114)
7	-.0652	(.115)
6	-.2805	(.116)*
5	.0647	(.117)
4	-.0899	(.118)
3	-.0688	(.119)
2	.0557	(.120)
1	-.0077	(.121)
0	-.0539	(.122)
EX→XPI		
- 1	-.1496	(.121)
2	-.1419	(.120)
3	.1135	(.119)
4	-.2517	(.118)*
5	.1687	(.117)
6	-.0157	(.116)
7	-.0349	(.115)
8	.0541	(.114)
9	-.0231	(.113)
10	-.0012	(.112)
11	.1735	(.111)
12	.0336	(.110)
13	-.0644	(.109)
14	.2036	(.108)
15	.1021	(.107)
16	-.1694	(.106)
17	.2568	(.105)*
18	-.2387	(.104)*
19	.0326	(.102)
20	.1720	(.101)
21	-.2096	(.100)*
22	-.1191	(.099)
23	-.1646	(.098)
24	.0664	(.097)

Cross-correlogram of EX and MPI

MPI→EX		
+ 24	.2661	(.097)*
23	-.2066	(.098)*
22	.3024	(.099)*
21	.0107	(.100)
20	.2183	(.101)*
19	.1850	(.102)
18	.2996	(.104)*
17	.0389	(.105)
16	.1836	(.106)
15	-.1303	(.107)
14	.0618	(.108)
13	.0943	(.109)
12	-.0691	(.110)
11	.0743	(.111)
10	.1714	(.112)
9	.1412	(.113)
8	.1199	(.114)
7	-.0446	(.115)
6	-.1011	(.116)
5	-.0288	(.117)
4	-.2590	(.118)*
3	.0603	(.119)
2	-.0338	(.120)
1	-.1835	(.121)
0	-.3997	(.122)*
EX→MPI		
- 1	-.2259	(.121)
2	-.1316	(.120)
3	.1491	(.119)
4	-.2186	(.118)*
5	-.1053	(.117)
6	-.0815	(.116)
7	-.2062	(.115)
8	.0989	(.114)
9	-.1567	(.113)
10	-.1947	(.112)
11	.0912	(.111)
12	-.0498	(.110)
13	.1581	(.109)
14	.1328	(.108)
15	.0633	(.107)
16	.0676	(.106)
17	.1004	(.105)
18	-.0701	(.104)
19	.1031	(.102)
20	.1409	(.101)
21	.2086	(.100)*
22	.1545	(.099)
23	.1023	(.098)
24	.1211	(.097)

* Coefficient significant at 95% level.

$var_{12}(k) = (1 - |K/N|)/N$.

Table E(5)

Number of months lead and lag on retail prices relative to export/import prices (+ = lead, - = lag). Standard errors in brackets.

Cross-correlogram of RPI and XPI			Cross-correlogram of RPI and MPI		
XPI→RPI			**MPI→RPI**		
+ 24	.0639	(.098)	+ 24	-.0663	(.098)
23	.0313	(.100)	23	.0421	(.100)
22	.0032	(.101)	22	.1979	(.101)
21	-.0399	(.102)	21	.3271	(.102) *
20	-.1823	(.103)	20	.1339	(.103)
19	.1027	(.105)	19	.0015	(.105)
18	-.1622	(.106)	18	.0391	(.106)
17	-.3554	(.107) *	17	-.1721	(.107)
16	-.0528	(.108)	16	-.1446	(.108)
15	-.0223	(.109)	15	-.0972	(.109)
14	-.0329	(.111)	14	-.2249	(.111) *
13	.1125	(.112)	13	-.0046	(.112)
12	-.0664	(.113)	12	-.1870	(.113)
11	-.0799	(.114)	11	-.1032	(.114)
10	-.0222	(.115)	10	-.0549	(.115)
9	-.2226	(.116)	9	-.1124	(.116)
8	-.1131	(.118)	8	-.0340	(.118)
7	.2662	(.119) *	7	-.0754	(.119) *
6	-.0313	(.120)	6	-.0276	(.120)
5	-.0339	(.121)	5	-.2178	(.121)
4	.1990	(.122)	4	-.1389	(.122)
3	.2376	(.123) *	3	.0540	(.123)
2	.0285	(.124)	2	.0450	(.124)
1	.0608	(.125)	1	-.0352	(.125)
0	.3646	(.126) *	0	.1508	(.126)
RPI→XPI			**RPI→MPI**		
- 1	-.0124	(.125)	- 1	.0518	(.125)
2	.1294	(.124)	2	.1239	(.124)
3	.1452	(.123)	3	.2013	(.123)
4	.0180	(.122)	4	.0696	(.122)
5	.1305	(.121)	5	.0773	(.121)
6	-.0019	(.120)	6	.1143	(.120)
7	-.0062	(.119)	7	.0232	(.119)
8	-.2502	(.118) *	8	-.1960	(.118)
9	.2668	(.116) *	9	.2112	(.116)
10	-.2904	(.115) *	10	.0119	(.115)
11	-.1150	(.114)	11	.0806	(.114)
12	.1454	(.113)	12	.1087	(.113)
13	-.1511	(.112)	13	.2164	(.112)
14	-.0457	(.111)	14	-.0180	(.111)
15	.2239	(.109) *	15	.2530	(.109) *
16	.0539	(.108)	16	.1365	(.108)
17	.0796	(.107)	17	.4465	(.107) *
18	.0793	(.106)	18	.2122	(.106) *
19	-.1077	(.105)	19	-.1411	(.105)
20	-.1126	(.103)	20	-.0075	(.103)
21	-.0212	(.102)	21	-.0676	(.102)
22	-.1663	(.101)	22	-.0031	(.101)
23	-.1218	(.100)	23	-.0464	(.100)
24	.1199	(.098)	24	-.0953	(.098)

* Coefficient significant at 95% level.

$var_{12}(k) = (1 - |K/N|)/N$.

Conclusions

35 The poor quality of the ARIMA results and the criticisms of the approach that were mentioned earlier mean that the conclusions presented here must be regarded as merely suggestive. Nevertheless, it is interesting to consider the implications of the results both from the regression approach and from the ARIMA approach that causality between each of the pairs tested runs in both directions. This result may seem unsurprising, but it does serve to contradict some of the crude theories described in Section 2. Table A showed what each set of possible outcomes would imply about how the world works: the general bidirectional finding tells us less than could most of the other possible outcomes. For instance, an exchange rate change causes a change in relative retail prices; however, we cannot tell whether this initial exchange rate change was truly exogenous (i.e. outside our three-variable model) or whether it is responding to money supply changes which will themselves cause the relative price changes.

36 The Scandinavian theory, as described in Section 2, ruled out bidirectional causality between domestic and export/import prices. The results from the exchange rate/retail price/export and import price 'triangles' contradict this theory and therefore an important argument for the ineffectiveness of exchange rate changes. As stated above, in the absence of any confidence in the (superior) ability of monetary and fiscal policy to correct the effects of excess inflation in the United Kingdom, use of the exchange rate as a policy instrument may not be ruled out.

37 Overall, this study suggests that use of bivariate causality tests conceals, rather than overcomes, the problem of omitted variables. In most cases, testing only two variables can give little indication of the actual relationship between them: only in a very limited number of cases, such as, for instance, the Scandinavian model which was examined in this paper, could omitted variables be irrelevant and bidirectional causality be inconsistent with the theory being studied.

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