The Economic and Social Review, Vol. 21, No. 1, October, 1989, pp. 139-149

Determinants of Money Demand in Ireland 1971 to 1988: Rounding-up the Usual Suspects*

MARGARET HURLEY
CATHAL GUIOMARD
Central Bank of Ireland

I INTRODUCTION

Unless some form of stable relationship between money demand and economic activity exists, there is no possibility of the monetary authorities being able to affect economic activity by changing the money supply. This fact, coupled with the breakdown of conventionally estimated demand for money functions in the 1970s[1] has led to a plethora of research projects seeking to identify and estimate a stable demand for money relationship. The present note reports the work to date on one such project, which uses the recently developed cointegration methodology to attempt to identify a stable money demand function using Irish monthly data.

Paper presented to the Third Annual Conference of the Irish Economics Association.

*Thanks are due to our Bank colleagues, participants at the IEA conference and editors of this journal for helpful discussions and comments. We are particularly indebted to John Frain and Gabriel Fagan, who made their computer and statistical expertise available to us. The views expressed in this paper are not necessarily those held by the Bank and are the personal responsibility of the authors. Comments and criticisms are welcome.

1. See Judd and Scadding (1982).

The first question to be tackled when estimating such a function is to decide on the appropriate variables to be included. Conventional theory suggests that money demand should depend on some measure of economic activity, normally income, and some variable representing the opportunity cost of holding money, usually a short-term interest rate or an inflation rate. There is also the question of whether money should be defined broadly or narrowly. Here we take a pragmatic approach and state that the measures of money, economic activity and opportunity cost appropriate to a money demand function are those that result in the most stable relationship. This mirrors the approach followed in a paper by Kearney and MacDonald (1988), using American and British data. The unusual aspect of our specification is that we do not use income as a proxy for activity. Our monthly focus meant that the only candidate scale variables available to us were retail sales and industrial production. In any case, it has been argued (Mankiw and Summers (1986)) that the use of income as a scale variable in money demand functions may not be the most relevant proxy for economic activity and that the choice of scale variable has important theoretical implications.

The criterion used for selecting variables is the non-rejection of the null hypothesis of cointegration in the regression involving these variables. This implies the existence of a long-run equilibrium relationship which, by the Engle and Granger (1987) result, means that there is a corresponding error correction formulation which can be used to specify a short-run dynamic equation. The estimation of such a Hendry-type equation will be the next stage of this project. The part of the project reported here is the examination of individual data series to determine their order of integration and to proceed to testing whether the money and scale variables are in fact cointegrated.

II COINTEGRATION

Cointegration theory makes precise the idea in economic theory that, in equilibrium, variables "cannot drift too far apart". It means that deviations from equilibrium are stationary, with finite variances, even though the series themselves may be non-stationary with infinite variances.

To establish that certain variables are cointegrated, three things are required:

1. Testing the individual series to discover their order of integration;
2. Selecting a set of series with the same order of integration;
3. Testing for cointegration between the selected set of series.

We use Dickey Fuller and Augmented Dickey Fuller statistics to test for the presence of unit roots in levels and changes of our data series, and in the residuals generated by the cointegrating regressions. A stationary series, which by definition will not contain a unit root, is characterised by high values of

Dickey Fuller statistics. Very often economic time series are non-stationary in levels, but stationary in changes,[2] so that differencing once produces stationarity. In the terminology of the cointegration literature this means that they are I(1). If the residuals derived from the cointegrating regression of two I(1) variables are I(0), i.e., the null hypothesis of the presence of a unit root in the residuals is rejected using Dickey Fuller test, then the two I(1) series are said to be cointegrated. The ordinary Durbin-Watson statistic of the regression also gives some information as to the order of integration of the residuals: non-stationary residuals will be associated with a DW not significantly different from zero. A more rigorous and detailed discussion of cointegration theory and the associated statistical tests is given in Dolado and Jenkinson (1987) and Engle and Granger (1987). The above discussion is simply to aid in the interpretation of the tables of results given below.

III DATA

We collected a data base that eventually contained 11 basic variables. Two moneys (M1 and M3), two scale variables (retail sales and industrial production), three interest rates (Associated Bank deposit rates on small deposits (<£5,000) the Exchequer Bill rate, and long bond yields), two deflators (the retail price index for retail sales, and the wholesale price of manufacturing output for industrial production) and two inflation rates (using the retail price index and the wholesale price of manufacturing output index). Appendix 1 lists the basic variables and any transformations of them that we used. (The data are in logs and so prefixed by L.)

Not all of the data are available for the full period 1971:4 to 1988:8. Industrial production data only exists from 1975:7, while the wholesale price of manufactured output is available only from 1975:1. At each stage, we use as long a data period as possible.

IV ORDERS OF INTEGRATION OF POSSIBLE MONEY DEMAND VARIABLES

We began by testing for the order of integration of the series available for the full period 1971:4 to 1988:8. The money series were deflated by the RPI. The results are set out in Table 1(i). Two features stand out. One is the difference between the results for M1 and the other series. M1 appears to be I(0) on the basis of the ADF statistic. All the other series are I(1). Although M3 has an uncomfortably high value, the ADF statistic increases considerably between the levels and differences equations, and we have taken it to be I(1).

2. See Nelson and Plosser (1982).

The second notable feature is that to produce white noise residuals as part of the ADF test for M1, a much larger number of lags is required than the published results for M1 in other countries (e.g., Melnick (1988) using Argentinian data). 23 lags are needed for the first differences of the Irish M1 series.

Table 1(i): *Order of Integration Tests*
Retail Sales as Scale Variable

*Variable**	*DF*	*ADF*	*# of Lags*
	Levels 1971:4 to 1988:8		
LM1RPI	-2.9631	-3.7498	24
LM3RPI	-2.2687	-2.8911	12
LRSVO	-8.5039	-1.6556	17
RSINFL	-6.3452	-2.6499	15
RSMALL	-1.4667	-1.9079	4
EBILL	-2.5407	-2.2544	1
RLONG	-1.4165	-1.762	1
	First Differences 1971:5 to 1988:8		
ΔLM1RPI	-18.763	-1.9482	23
ΔLM3RPI	-14.888	-3.3345	11
ΔLRSVO	-22.592	-3.4066	16
ΔRSINFL	-19.244	-4.281	14
ΔRSMALL	-12.793	-7.1896	3
ΔEBILL	-15.990	-11.417	1
ΔRLONG	-12.184	-8.211	1

The critical values for the test statistics at, respectively, the 1, 5 and 10 per cent levels are -3.51, -2.89 and -2.58.
*Variables are as defined in Appendix 1.

On the basis of Table 1(i), there is no possibility of cointegration between M1 and the other variables, and so no equilibrium long-run relationship between narrow-money, retail sales and the interest or inflation rates. However, M3 looks more promising and we later proceeded to the stage (3) mentioned above with M3, retail sales and the various interest and inflation rates.

First, however, we turned to industrial production as another possible scale variable. The period for which these data were available was 1975:7 to 1988:8 (158 observations). The order of integration tests are given in Table 1(ii).

Table 1(ii): *Order of Integration Tests*
Industrial Production as Scale Variable

*Variable**	*DF*	*ADF*	*# of Lags*
	Levels 1975:7 to 1988:8		
LM1WPMO	-3.278	-2.937	20
LM3WPMO	-2.056	-2.166	12
LIPVOL	-2.781	-0.563	16
RSMALL	-1.467	-2.390	3
EBILL	-1.622	-2.401	1
RLONG	-1.737	-2.030	1
WPMOINFL	-9.596	-3.127	1
	First Differences 1975:8 to 1988:8		
ΔLM1WPMO	-15.638	-2.918	11
ΔLM3WPMO	-12.022	-3.071	11
ΔLIPVOL	-5.895	-1.852	15
ΔRSMALL	-11.035	-6.072	3
ΔEBILL	-9.212	-7.932	1
ΔRLONG	-10.711	-6.908	3
ΔWPMOINFL	-18.587	-7.137	5

Critical values are those quoted in Table 1(i).

This time the money variables have been deflated by the WPMO index. Real M3, and all three interest rates are unambiguously I(1). The wholesale price of manufacturing output inflation is I(0). The Dickey-Fuller and Augmented Dickey-Fuller tests give contradictory messages for real M1 and industrial production; we decided none the less to put them in the I(1) category on the basis of the Dickey-Fuller statistic so that we could see what results the next stage would yield. A summary of our tests of order of integration is given in Tanle 1(iii).

Table 1(iii): *Order of Integration Tests: Summary*

Variable \ *Period*	*1971:1988*	*1975:1988*
LM1RPI	I(0)?	
LM3RPI	I(1)	
LRSVO	I(1)	
RSINFL	I(1)	
LM1WPMO		I(1)?
LM3WPMO		I(1)
LIP		I(1)?
WPMOINFL		I(0)
RSMALL	I(1)	I(1)
EBILL	I(1)	I(1)
RLONG	I(1)	I(1)

V COINTEGRATION TESTS OF POSSIBLE MONEY DEMAND VARIABLES

Having obtained money series that were I(1) we tested for cointegration between the money and scale variables. The results are in Table 2. No equation meets all three tests at the 5 per cent level. These results suggest that there is not a long-run equilibrium relationship between money and either of our proxies for economic activity.

To see if the results could be strengthened by allowing for opportunity costs, we then tested for three-way cointegration between one money, one scale variable and *either* an interest rate or an inflation rate. The results of the nine cointegrating regressions are reported in Table 3.[3] The Augmented Dickey-Fuller statistic does not indicate the presence of stationary residuals in any of the nine regressions; cointegration is uniformly rejected using this statistic. The first regression, between M3, retail sales and inflation is the only one that satisfies the other two criteria for cointegration, though only just. The coefficient on the scale variable is significantly positive and statistically close to unity, and the inflation coefficient is significantly negative, corresponding to our prior expectations. Our results indicate, very tentatively,

3. The results reported here are only a subset of a longer cointegration search. We also looked at a larger selection of interest rates, different time periods (see our Technical Paper 2/RT/89) and "velocity" cointegrating regressions, which involve imposing a unit coefficient on the scale variable and testing for cointegration between this composite variable and combinations of interest rates. We decided not to present the complete results in order to avoid presenting over-long tables; in general the data in any of its forms did not unambiguously support the hypothesis of a stable long-run relationship.

Table 2: *Cointegrating Regressions*
Moneys and Scale Variables

Variables	*Time Period*	*Cointegrating Regressions*	*Test Statistics*			
			CRDW	*CRDF*	*CRADF*	*# of Lags*
Real M3, Retail Sales Volume	1971:1988	LM3RPI = 0.1216 + 0.80LRSVO (0.492) (0.11)	0.23	-3.48	-0.67	17
Real M1, Industrial Production Volume	1975:1988	LM1WPMO = 1.96 + 0.10LIPVOL (0.07) (0.01)	0.29	-3.40	-2.46	20
Real M3, Industrial Production Volume	1975:1988	LM1WPMO = 1.92 + 0.39 LIPVOL (0.05) (0.01)	0.14	-2.31	-3.06	12

	Statistics \ *Level*	*1%*	*5%*	*10%*
Critical Values Calculated for 100 observations, Engle and Granger (1987)	CRDW	0.511	0.368	0.322
	CRDF	-4.07	-3.37	-3.03
	CRADF	-3.77	-3.17	-2.84

Table 3: *Cointegrating Regressions*
Moneys, Scale Variables and Interest Rates

Variables	*Time Period*	*Cointegrating Regressions*	*Test Statistics*			
			CRDW	*CRDF*	*CRADF*	*#of Lags*
Real M3, Retail Sales Volume, Retail Sales Inflation	1971:1988	LM3RPI = −0.186 + 0.855 LRSVO − 8.34 RSINFL (0.463) (0.104) (1.4)	0.308	−4.3	−1.39	12
Real M3, Retail Sales Volume, Exchequer Bill Rate	1971:1988	LM3RPI = 1.339 + 0.4816 LRSVO + 1.795 EBILL (0.48) (0.11) (0.256)	0.152	−2.4	−0.02	12
Real M3, Retail Sales Volume, Yield on 15 year bonds	1971:1988	LM3RPI = 0.551 + 0.6704 LRSVO + 1.133 RLONG (0.51) (0.117) (0.376)	0.169	−2.77	0.3	20
Real M1, Industrial Production, Exchequer Bill Rate	1975:1988	LM1WPMO = 1.97 + 0.10 LIPVOL − 0.0013 EBILL (0.07) (0.01) (0.002)	0.27	−3.43	−2.56	20
Real M1, Industrial Production, Interest Rate on Small Deposits	1975:1988	LM1WPMO = 1.95 + 0.10 LIPVOL + 0.0008 RSMALL (0.07) (0.01) (0.003)	0.27	−3.40	−2.63	21
Real M1, Industrial Production, Yield on 15 year bonds	1975:1988	LM1WPMO = 2.01 + 0.10 LIPVOL − 0.0025 RLONG (0.09) (0.01) (0.0025)	0.27	−3.45	−2.56	20
Real M1, Industrial Production, Exchequer Bill Rate	1975:1988	LM3WPMO = 1.90 + 0.39 LIPVOL − 0.0027 EBILL (0.05) (0.01) (0.0011)	0.15	−2.30	−3.00	12
Real M3, Industrial Production, Interest Rate on Small Deposits	1975:1988	LM3WPMO = 1.87 + 0.39 LIPVOL − 0.0049 RSMALL (0.05) (0.01) (0.0017)	0.15	−2.33	−2.93	12
Real M3, Industrial Production, Yield on 15 year bonds	1975:1988	LM3WPMO = 1.87 + 0.39 LIPVOL − 0.0023 RLONG (0.06) (0.01) (0.0017)	0.14	−2.28	−3.10	12

Critical Values for test statistics (see Kearney and MacDonald (1988))

Statistics \ *Level*	*1%*	*5%*	*10%*
CRDW	0.488	0.367	0.308
CRDF	−4.45	−3.93	−3.59
CRADF	−4.22	−3.62	−3.32

that, in so far as the reported cointegration tests give any support to the idea of developing a dynamic error correction model of money demand, the variables to be included should be broad money, retail sales and an inflation rate. The inflation rate is significantly better at producing a plausible equation than any of the interest rates, many of which appear with a positive coefficient and none of which satisfy more than one of the cointegration tests.

V CONCLUSIONS

At the theoretical level, cointegration is a powerful test for the existence of a long-run equilibrium relationship. However, if the most "obvious" candidate variables do not turn out to be cointegrated (as in Table 2) the large number of possible alternatives can quickly give rise to a major "cointegration search". We have not found cointegration tests to provide overwhelming evidence of a long-run relationship between money, a scale variable and an opportunity cost variable, given the variables selected and the time periods they relate to. While we are proceeding to use the variables suggested here to build a dynamic demand equation, we do realise that one partially positive result in a large number of trials (many of which are not reported) is not a strong indication of the existence of an equilibrium relationship. This could be for one or more of many reasons:

(1) A stable money demand function does not exist for Ireland.
(2) Retail Sales and Industrial Production are not appropriate measures of activity for the Irish economy.
(3) The statistical tests we are using for cointegration are not sufficiently discriminating.

At this applied level humility is essential and we would be cautious about concluding that no equilibrium money demand relationship exists. As well as the estimation of the dynamic equation mentioned above, we are also going to look at other proxies for economic activity, which will probably mean using quarterly data. The results of these investigations will be reported in a later paper.

REFERENCES

DOLADO, JUAN J., and TIM JENKINSON, 1987. "Cointegration: A Survey of Recent Developments", *University of Oxford Applied Economics Discussion Paper No. 39.*

ENGLE, ROBERT F., and CLIVE W.J. GRANGER, 1987. "Cointegration and Error Correction: Representation, Estimation and Testing", *Econometrica*, Vol. 55, No. 2, pp. 251-276.

HURLEY, MARGARET and CATHAL GUIOMARD, 1989. "Determinants of money demand in Ireland, 1970 to 1988", Central Bank of Ireland Technical Paper 2/RT/89.

JUDD, JOHN P., and JOHN L. SCADDING, 1982. "The Search for a Stable Money Demand Function: A Survey of the Post-1973 Literature", *Journal of Economic Literature*, Vol. XX, No. 3, pp. 993-1023.

KEARNEY, COLM, and RONALD MacDONALD, 1988. "The Stability of Monetary Velocities in the UK and USA 1971-1975: A Cointegration Analysis", Central Bank of Ireland, Technical Paper 6/RT/88.

MANKIW, N. GREGORY and LAURENCE H. SUMMERS, 1986. "Money Demand and the Effect of Fiscal Policies", *Journal of Money Credit and Banking*, Vol. 18, No. 4, pp. 415-429.

MELNICK, RAFI, 1988. "The Demand for Money in Argentina 1978-1987: Before and After the Austral Program", Department of Economics, Boston University, mimeo.

NELSON, CHARLES R., and CHARLES I. PLOSSER, 1982. "Trends and Random Walks in Macroeconomic Time Series", *Journal of Monetary Economics*, Vol. 10, No. 2, pp. 139-162.

APPENDIX 1: DATA SERIES AND SOURCES

1. *Money*

M1 — Narrow definition of money, as reported in the *Central Bank Quarterly Bulletin* 1982:12 to 1988:8. The earlier data (prior to the new bank return) is calculated from the published data in a manner described in a note available in the Central Bank Research Division.

M3 — Broad definition of money, again from *Central Bank Quarterly Bulletins* post-1982:12 and from the Research Division note mentioned above.

2. *Activity Variables*

RSVO: — Retail Sales volume; the unadjusted series in the CSO data bank.

IP: — Industrial Production; the unadjusted output from the CSO data bank.

3. *Prices*

RPI: — The retail sales price index from the CSO data bank.

WPMO: — The wholesale price of manufacturing output from the CSO data bank.

4. *Interest Rates*

RSMALL:	Associated Bank deposit rates on deposits less than £5,000, as calculated from published data by the Monetary Policy Division.
RLONG:	The yield on fifteen year bonds, from the *Bulletin*,
EBILL:	The exchequer bill rate.

5. *Transformed Series*

LM1RPI:	The Log of M1 deflated by the Retail Sales Price Index.
LM3RPI:	The Log of M3 deflated by the Retail Sales Price Index.
LM1WPMO:	The Log of M1 deflated by the Wholesale Price of Manufacturing Output.
LM3WPMO:	The Log of M3 deflated by the Wholesale Price of Manufacturing Output.
RSINFL:	Retail Sales Price Index Inflation.
WPMOINFL:	Wholesale Price of Manufacturing Output Price Inflation.
LRSVO:	Log of Retail Sales Volume.
LIP:	Log of Industrial Production.