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The Demand for Money and the Term Structure of Interest Rates in Ireland, 1971-1981

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Abstract: This paper investigates the extent to which the demand for various measures of money in Ireland depends upon the term structure of interest rates. The yield to maturity curve is first estimated using refinements of the approximation specification employed by Heller and Khan (1979). The estimated parameters are then entered as parameters into the money demand equations which are estimated using autoregressive least squares. Amongst other findings is a considerably greater response of money demand to a uniform shift in the yield curve than is obtained using conventional estimates which are based on only a single interest rate.

I INTRODUCTION

he extent to which the demands for financial assets are responsive to changes in interest rates constitutes a fundamental link in the monetary transmission mechanism. The interest elasticity of the demand for money has been the focus of much attention in this regard. Empirical research has been virtually unanimous in finding a significant negative interest rate elasticity in money demand equations. Until recently, however, the existence of strong collinearity between interest rates has hampered research into the relationship between asset demands and the term structure of interest rates.

This paper investigates the relationship between the demand for money and the term structure of interest rates in Ireland over the 1970s. The method employed is to estimate the entire yield to maturity curve using various approximation specifications and to enter the parameters as arguments into the demand equations. This procedure follows from the methods devised by Heller and Khan (1979) and refined by Bilson and Hale (1980), Allen, Hatfield and Williams (1981) and Allen and Hafer (1983). Equations are estimated for the components of both narrow and broad definitions of money and conclusions reached that the term structure of interest rates does indeed influence the various monetary measures.

An outline of the paper is as follows. Section II discusses some theoretical issues raised by our inclusion of the entire yield curve into the estimating equations. Section III summarises the empirical results from estimating standard specifications of the various monetary aggregates. Estimates are then presented which include the term structure of interest rates and the results are compared and contrasted with the standard equations. The final section summarises the argument and draws conclusions.

II THE THEORY

Monetary economists have long taken the view that more than one rate of interest might reasonably be expected to influence the demand for money. Multicollinearity between different interest rates, however, has hampered research into the issue. This is not to say that empirical work on the demand for money equation has not had a multi-interest rate aspect for some time. It began by comparing two interest rates, one long and one short rate. The results often varied according to the definition of money being employed and the country for which the equation was being estimated. Short rates tended to be more significant determinants of narrow rather than broad money holdings while long rates tended to perform better on British than on American data (see Laidler (1977)).

More recently, Heller and Khan (1979) developed an efficient way to represent the entire structure of interest rates in terms of a few parameters. Their approach is to estimate the entire yield to maturity curve using a quadratic approximation for each time period, and to enter the parameters as arguments into the money demand equation. This procedure has the advantage of representing the entire yield curve in terms of a few parameters which are less collinear than the interest rates themselves. In addition, the approach allows inspection of how changes in the intercept, slope and curvature of the yield to maturity curve influence the demand for money. There is a cost involved in pursuing this approach, namely, that the term structure approximation equation has an error term so that the fitted values may not provide a good description of the actual data. We shall see below, that in terms of the data employed in this study, the cost is indeed low relative to the insights which are obtainable.

A general description of the term structure approximations employed in this study[1] is as follows.

1. Honohan (1981) describes the estimation of the yield to maturity curve for Ireland.

$$\ln Rm_t = \alpha_1 + \alpha_2 \ln m_t + \alpha_3 \ln m_t^2 + \alpha_4 \ln m_t^3 + Vm_t \tag{1}$$

where ln stands for natural logs and

Rm_t = nominal interest rate of maturity m at time t,
α_i = parameters (i = 1 . . . 4)
Vm_t = independently distributed random variable with zero mean and a variance which is constant for all values of the maturity variable.

A number of variations on this logged cubic specification have been used in order to introduce the term structure of interest rates into the money demand function. Bilson and Hale (1980) set $\alpha_4 = 0$ in proposing a logged quadratic approximation and Allen and Hafer (1983) proposed an unlogged version of Equation (1) in order to capture humps in the yield curve.

In the next section we provide evidence on the relationship between the demand for money function in Ireland and the term structure of interest rates. We employ both quadratic and cubic estimates of the yield curve and experiment with specifications in levels as well as in logarithms. We also consider both narrow and broad definitions of money and in the case of the latter we disaggregate into chequeable and time deposits in order to uncover influences which are not obvious in broad money demand functions.

III EMPIRICAL RESULTS

Conventional Estimates

Standard specifications of the demand for money function propose the following relationship:

$$\ln m_t^d = \beta_0 + \beta_1 \ln y_t + \beta_2 r_t + u_t \tag{2}$$

where m_t^d = the desired level of real balances,
y_t = real income,
r_t = nominal interest rate,
u_t = a disturbance term.

If actual real balances partially adjust towards their desired level[2]

$$\Delta \ln m_t = \lambda(\ln m_t^d - \ln m_{t-1}) \tag{3}$$

where λ is the coefficient of adjustment and $0 < \lambda < 1$. Substituting Equation (2) into (3) yields the standard estimating equation.

$$\ln m_t = \gamma_0 + \gamma_1 \ln y_t + \gamma_2 r_t + \gamma_3 \ln m_{t-1} + \gamma_4 U_t \tag{4}$$

2. Milbourne (1983) examines the adjustment of *nominal* money balances.

Previous research on estimating money demand functions for Ireland has examined a variety of alternative specifications of this equation and it is not our purpose to duplicate these results.[3] Our concern here is to capture the effects of different opportunity cost variables in the demand for money equation. The correlation between seven domestic interest rates of various maturities is presented in Table 1 and highlights the problems of multicollinearity which confront the researcher who attempts to include a number of opportunity cost variables in the estimating equation. The table clearly shows a substantial degree of correlation among the various rates, decreasing slightly as the difference in the term to maturity rises.

It is interesting to compare the results of employing alternatively short and long rates of interest as the opportunity cost variable in conventional specifications of the demand for money function. This exercise was conducted by estimating Equation (4) for the various monetary aggregates (i.e., currency, current accounts at banks, M1, deposit accounts and M3 using the seven interest rates mentioned above. All equations were estimated on quarterly non-adjusted data over the period 1971(2)-1981(4) with dummy variables (SD) included to capture the influence of seasonal trends. A full description of the data employed is provided in the Appendix. Table 2 provides a representative summary of the results of this exercise using auto-

Table 1: *Correlation matrix for seven rates of interest of different maturities, Ireland: 1970-81*

	r_1	r_2	r_3	r_4	r_5	r_6	r_7
r_1	1	.966	.929	.902	.891	.872	.818
r_2		1	.978	.954	.945	.928	.876
r_3			1	.989	.983	.969	.921
r_4				1	.997	.987	.950
r_5					1	.995	.967
r_6						1	.984
r_7							1

r_1 = Central Bank Overnight Rate
r_2 = 3 Month Exchequer Bills
r_3 = 1 Year Rate
r_4 = 3 Year Rate
r_5 = 5 Year Rate
r_6 = 8 Year Rate
r_7 = 15 Year Rate

3. References are: Browne and O'Connell (1979), Browne (1984), Carey (1981), and den Butter and Fase (1981).

regressive least squares (ARI) to estimate the demand for M1 balances. It shows the estimated values of the elasticities and their associated t-ratios along with the adjusted coefficients of determination ($\bar{R}^2$), the Durbin-Watson test statistic (DW), Durbin's h-statistic (DH) and the computed value of rho with its associated t-ratio.

Both the income and interest rate coefficients are correctly signed and statistically significant at the 5 per cent level in all the equations. An interesting pattern emerges in so far as both short-run elasticities tend to rise with the term to maturity of the asset whose yield is included in the equation. Also, adjustment speeds become greater as the longer rates are included. As a result of this, the long-run income elasticities tend to become smaller (i.e., closer to one) as the term to maturity of the competing asset rises. No clear pattern of this kind emerges for the long-run interest rate elasticities. The overall explanatory power of the equations as measured by the adjusted R^2s tend to improve as longer rates are employed. Similar results were obtained for the narrower definitions of money measured by currency and current accounts. Wider definitions such as deposit accounts and M3 balances differed in so far as they were not very sensitive to interest rate changes and the income elasticities did not vary with the interest rate maturity. The former result concurs with that obtained by other researchers (e.g., Browne and O'Connell (1979) and Carey (1981)).

Estimation with the Term Structure

The estimating form of the money demand equation incorporating the logged quadratic approximation of the term structure is given below. A log specification of the yield curve, as in Equation (1) above, was preferred on empirical grounds. Use of the cubic yield curve approximation added little to the fit of the demand for money equation. Hence, only results for the quadratic specification are reported here.

$$\begin{aligned} \ln M_t = \gamma_0 + \gamma_1 \ln y_t + \gamma_2 \alpha 1_t + \gamma_3 \alpha 2_t \\ + \gamma_4 \alpha 3_t + \gamma_5 \ln m_{t-1} + \gamma_6 U_t \end{aligned} \tag{5}$$

The results of estimating Equation (5) for the various monetary aggregates are presented in Table 3. The equations perform as well as the conventional estimates in terms of overall goodness of fit. Adjustment speeds are slightly faster than the average obtained from the conventional specifications. The short run and long run income elasticities are also comparable to those obtained using the standard specifications. This can be seen by comparing the results for M1 balances with those reported in Table 2.

The three yield curve coefficients are all correctly signed and statistically significant at the 5 per cent level in the equations for currency, current

Table 2: *ARI Results: M1 balances, standard equations*

			Interest rates														
Regression	*Constant*	*Income*	*Call money*	*3 months*	*1 year*	*3 years*	*5 years*	*8 years*	*15 years*	*Lagged variable*	*SD1*	*SD2*	*SD3*	$\bar{R}^2$	*DW*	*DH*	*Rho*
1	−.109	.204	−.008	–	–	–	–	–	–	.920	−.005	−.025	−.031	.87	2.05	−.18	−.22
	(.99)	(2.86)	(3.90)							(14.50)	(2.50)	(1.38)	(1.46)				(1.39)
2	−.079	.209	–	−.008	–	–	–	–	–	.893	−.062	−.027	−.034	.88	2.08	−.29	−.26
	(.79)	(3.09)		(4.28)						(14.79)	(2.83)	(1.60)	(1.59)				(1.65)
3	−.117	.256	–	–	−.010	–	–	–	–	.887	−.067	−.028	−.034	.91	2.13	−.46	−.32
	(1.25)	(3.89)			(5.09)					(16.03)	(3.06)	(1.64)	(1.59)				(2.03)
4	−.116	.300	–	–	–	−.014	–	–	–	.886	−.068	−.025	−.037	.91	2.12	−.42	−.31
	(1.27)	(4.28)				(5.29)				(15.77)	(3.16)	(1.74)	(1.76)				(1.98)
5	−.096	.316	–	–	–	–	−.015	–	–	.842	−.067	−.029	−.038	.92	2.13	−.46	−.31
	(1.10)	(4.59)					(5.63)			(15.58)	(3.20)	(1.84)	(1.85)				(2.05)
6	−.071	.320	–	–	–	–	–	−.015	–	.817	−.064	−.028	−.038	.92	2.13	−.46	−.33
	(.85)	(4.79)						(5.91)		(15.21)	(3.11)	(1.78)	(1.86)				(2.12)
7	.002	.321	–	–	–	–	–	–	−.015	.771	−.063	−.027	−.038	.91	2.11	−.33	−.33
	(.02)	(4.76)							(5.86)	(13.58)	(3.01)	(1.75)	(1.86)				(2.14)

Table 3: *Results with the term structure of interest rates quadratic approximation*

Dependent variable	Constant	Income	Term structure: Intercept (α_1)	Term structure: Maturity (α_2)	Term structure: Maturity^2 (α_3)	Lagged Dependent variable	SD1	SD2	SD3	$\bar{R}^2$	DW	DH	Rho
CURR.	−.064	.222	−.085	−.555	−1.837	.833	−.044	−.024	−.002	.92	1.90	.36	.04
	(1.20)	(4.55)	(3.68)	(3.08)	(1.74)	(13.35)	(4.87)	(2.86)	(.23)				(.21)
CUR A/C	.250	.438	−.287	−1.418	−7.649	.740	−.062	−.021	−.053	.86	2.05	−.19	−.34
	(1.66)	(3.88)	(4.23)	(2.73)	(2.65)	(9.47)	(1.75)	(0.84)	(1.60)				(2.17)
M1	.266	.356	−.203	−1.056	−5.314	.765	−.055	−.022	−.033	.91	2.04	−.15	−.31
	(2.15)	(4.53)	(4.53)	(3.04)	(2.71)	(10.85)	(2.42)	(1.31)	(1.58)				(1.93)
DEP A/C	−.056	.276	.051	−.038	1.47	.776	−.040	−.032	−.029	.97	1.82	.68	.38
	(0.68)	(3.20)	(1.16)	(0.14)	(1.07)	(10.30)	(4.43)	(3.63)	(3.69)				(2.43)
M3	.158	.302	−.030	−.328	−.905	.787	−.043	−.029	−.030	.96	1.97	.12	.14
	(1.71)	(3.77)	(0.86)	(1.50)	(0.74)	(9.42)	(3.96)	(2.81)	(3.18)				(.85)

accounts and M1 balances. The coefficient on the intercept parameter, α_1, indicates that a uniform upward shift of the entire term structure by 1 per cent will result in a decrease of current accounts and M1 balances by .287 and .203 per cent, respectively. These effects are considerably larger than the elasticities obtained by using any of the individual interest rates as shown in Table 2. An increase in the slope of the term structure, with an unchanged intercept and curvature, will reduce the demand for these balances. This is consistent with the expectation that an increase in long rates of interest with fixed short rates will reduce the demand for money. The equation for deposit accounts is less well determined with respect to the yield curve coefficients. This finding is consistent with the results of employing standard specifications and explains the extent to which the broad money demand equation is less responsive to the yield curve coefficients. Indeed the small magnitude of the intercept term in these equations is consistent with the view that broad money holdings are best seen as determined by interest rate differentials rather than levels because, unlike the narrower aggregates, the own rate is certainly not equal to zero.

IV SUMMARY AND CONCLUSIONS

This paper has examined the extent to which the Heller and Khan (1979) procedure for including the entire yield curve in estimated money demand equations can be successfully employed on data drawn from the Irish economy. The answer is in the affirmative. Using this methodology, we find a considerably greater response of the demand for money to a uniform upward shift in the yield curve than is obtained from conventional estimates which use only a single rate of interest. We are also able to obtain an indication of the differential response of the demand for money to short and long rates of interest. Finally, this study confirms that narrow measures of money are more responsive to changes in the structure of interest rates than are their broader counterparts.

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DATA APPENDIX

Non-adjusted quarterly data from 1971(1)-1981(4) is employed in the empirical tests reported in the paper.

Monetary Aggregates

These were obtained from the Banking Department of the Central Bank and include the following:

(i) Currency outstanding
(ii) Current accounts
(iii) Deposit accounts at Associated Banks
(iv) Deposit accounts at non-Associated Banks

Narrow money M1 is the sum of (i)-(ii) and broad money M3 includes (iii)-(iv) in addition.

Interest Rates

All rates are quarterly averages and were obtained from the Central Bank's *Quarterly Bulletin*. Rates are the following.

r_1 = Central Bank overnight rate
r_2 = 3 month Exchequer Bills
r_3 = 1 year rate
r_4 = 3 year rate
r_5 = 5 year rate
r_6 = 8 year rate
r_7 = 15 year rate

Income and Prices

These were obtained from the Research Department of the Central Bank as updates on O'Reilly and Lynch (1983). Nominal GNP was deflated by the Consumer Price Index to obtain the series for real income which is used in the estimated equations.