Modelling the Demand for Money in New Zealand

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Abstract: The paper reports on the results of estimating both the long- and short-run demand for money function in New Zealand, 1990-2000 using quarterly data and cointegration- and error-correction-based models. It is found that price, real income and interest rate variables are integrated of order 1 or I(1). Using Phillips and Hansen (1990) fully modified estimation methods, we establish the existence of a long-run cointegrating relationship among these three variables. Using the residuals from this model to represent the error-correction mechanism (ECM) term, we identify a short-run model utilising Hendry's General-to-Specific (GTS) approach. The model is shown to satisfy the typical diagnostic requirements of a multiple regression model. Three event dummies are used to capture key events of relevance to monetary policy in New Zealand.

Keywords: Demand for money; New Zealand; Cointegration; ECM.

1. INTRODUCTION

Factors determining the demand for money in the economy have been a central focus of monetary economics and monetary policy since the birth of the economics discipline. Debates between monetarist and Keynesian economists on the role of money and the stability of the demand for money function have provided a fertile field for both theoretical and applied macroeconomic research.

The late 1960s and 1970s saw a vast research programme directed towards the estimation of the demand for money functions in almost every country see for example Hacche (1974), Hamburger (1977), Boughton (1981), Laidler and Parkin (1970), Den Butter and Fase (1981) and Oxley (1983, 1986). Almost universally the apparent observed stability of the function identified in post-war data appeared to ‘disappear’ as economies progressed into the 1980s. Oil price shocks to demand, rapid technological change in the banking sectors, and increased Central Bank autonomy all contributed to a climate of change impacting upon both the demand and supply of money.

As a consequence of the ‘missing money’ (see Goldfeld (1976)) episodes and independent developments in econometrics, two approaches to modelling the demand for money function have emerged as ‘industry standards’. The first approach combines elements of Sargan’s (1964) COMFAC approach, with the -to-Specific’ approach of Hendry, the Error-Correction Mechanism (ECM) see Alogoskoufis and Smith (1991) and the long-run cointegrating regression ideas of Engle and Granger (1987) and Johansen (1988). This approach is typically followed by UK, European and Australasian modellers and will be adopted in this study of the New Zealand demand for money function. The second approach follows the more traditional VAR formulations of Sims (1980) and is typically adopted by N. American researchers.

2. THE NEW ZEALAND MONETARY SECTOR

"New Zealand's monetary policy has undergone a revolution since 1984", Grimes (1996). Perhaps the most fundamental changes came with the passing of the Reserve Bank Act (RBA) in 1989 and its operational implementation in February 1990. Documentaries explaining the details of the changes can be found in a number of sources including the Reserve Bank's www page[1], and Grimes (1996). However, the fundamental changes involved the identification of a single primary 'goal' of the Bank - maintaining and achieving stability in the general level of prices, and a degree of autonomy in seeking this goal.

[1] http://www.rbnz.govt.nz/

The main instrument of monetary influence in the post-RBA period operated via the 'settlement cash' route. The Bank would influence the price (or quantity - at various time the Bank uses the two interchangeably) of the 'cash' balances in settlement accounts at the Reserve Bank. The assumption was that this price (interest rate) would then influence other short-term interest rates, longer-term rates and the exchange rate.

In March 1997 the Bank issued a Discussion Paper that reviewed technical aspects of monetary policy implementation in New Zealand. The Paper proposed a switch from targeting settlement cash balances to targeting overnight inter-bank rates. On 17 March 1999, the Bank moved to a system where the announced overnight interest rate - the Official Cash Rate (OCR) - was to be targeted. The intention was that, "by directly managing the market cash rate, we will be able to influence the level of other short-term rates and *hence monetary conditions more generally*" (RBNZ, 1999, p.46, emphasis added). The weekly Wednesday morning "window" for commenting on monetary conditions was to be discontinued and the MCI though still measured would have a somewhat lower profile as a simple indicator. The Bank stated that "the changes *will alter quite substantially*, and will materially simplify, the mechanics of the Reserve Banks' interactions with the financial markets" (RBNZ, 1999, p. 46, emphasis added). "By setting the OCR, the Reserve Bank is able to *substantially influence short-term interest rates, such as the 90-day bank bill rate, floating mortgages and the like*[2]" (emphasis added).

The period 1990-2000 therefore comprises an interesting period in New Zealand monetary history. In the paper presented below we will investigate certain aspects of the identification of a demand for money function following the European/Australasian modelling approach of Hendry *et al.*

3. ECONOMETRIC METHODOLOGY

The Hendry et al. and Engle-Granger approach to modelling and estimating short-run and long-run demand for money functions has been discussed extensively in the literature see for example, Muscatelli and Hurn (1992), Alogoskoufis and Smith (1991), Doornik et al. (1998), and Hendry and Ericsson (1991), to which the interested reader is referred. In the discussion to follow we will simply identify some of the salient features of the approach.

Recent work on the implications of estimation with non-stationary data has identified the importance of ascertaining the order of integration of the univariate data series used in estimation.[3] Different authors have different views on the need for pre-testing of univariate series based upon the power of the current generation of tests. However, the 'industry standard' appears to support the pre-testing notion. Consequent on the outcome of the univariate tests, the normal next stage is to identify the long-run demand for money function either via cointegration-based methods (if the data are integrated of order 1, denoted I(1)) or more traditional methods if the data is stationary (or rendered stationary by some appropriate transformation). The third stage would typically involve the identification of a short-run model, often an ECM approach using information from the long-run cointegration model and perhaps the modelling approach of Hendry's GTS.

In summary the approach would typically entail:

1. Univariate tests of the relevant data series to identify the order of integration of the data.
2. Consequent on the outcome of 1., the attempt to identify a long-run demand for money model with appropriate statistical and economic characteristics. These characteristics would typically include appropriate signs and magnitudes of coefficients and/or elasticities.
3. Identify a short-run demand for money model consistent with the long-run model identified in 2. above. This model would normally be expected to 'pass' the typical diagnostic tests see McAleer (1994), in addition to the stringencies of economic theory.

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[2] What is the Official Cash Rate? http://www.rbnz.govt.nz/fs4.htm
[3] An exception would be the ARDL approach of Pesaran and Smith (1998) which de-emphasises the pre-testing of orders of integration.

Monetary theory has established the broad parameters of a demand for money function:

$$M_{dt} = f\left(Y_t, R_t, P_t\right) + e_t \qquad (1)$$

Where M_{dt} denotes money demand (assumed equal to money supply $\forall t$); Y_t real income; R_t the opportunity cost of money typically proxied by the rate of interest; P_t the price level and ε_t a random disturbance term. The functional form f is typically assumed log-linear and either by assumption or consequent upon testing the real money demand function (setting the implied coefficient on $P_t=1$) replaces the nominal relationship of (1) above. Economic theory would suggest that the sign attached to Y, R and P would be +, -, and + respectively.

4. THE DATA

Data definitions adopted in this study are as follows. M is defined as M3. Y is measured as real (1991/92 prices) expenditure on gross domestic product (GDP) and its implicit price deflator represents the price variable P. The 90-day bank bill yield measures the opportunity cost of holding money, R. All the series used are quarterly and seasonally unadjusted. The original monetary aggregate (M) and interest rate (R) are monthly data transformed to quarterly data. All the variables are transformed to natural logarithms, except the interest rate which is log(1+R). The data used are taken from the New Zealand Time Series, PC-Infos database and cover the period March 1988 to June 2000.

5. RESULTS

Stage 1 involves univariate tests of the series of interest. Table 1 below reports the results of this exercise.

Table 1. *Variables and Unit Root Tests*
(1988:3-2000:2)

Variable	ADF	First Differences	ADF
M	-1.298 [C,T,0]	ΔM	-7.261** [C,0]
Y	-2.036 [C,T,3]	ΔY	-13.80** [C,T,2]
P	-2.272 [C,T,4]	ΔP	-6.421** [C,1]
R	-2.031 [C,1]	ΔR	-4.113** [C,0]

Note: M=log of real money M3, Y=log of real GDP, P=log of (nominal GDP/real GDP), and R=log(1+interest rate).
Δ is the first difference operator. ** denotes rejection of the Null at the 1% significance level. The content of the brackets [..] denotes **C**onstant, **T**rend and the order of augmentation of the ADF test equation respectively.

On the basis of these results the assumption that the variables of interest contain a single unit root is not rejected.

Stage 2 involves testing for cointegration. Tables 2(i) and 2(ii) below present the results of invoking the Johansen (1988) approach to estimation and testing of the number of significant cointegrating vectors.

Estimating and Testing Cointegrating Vectors for M3 (1988:3-2000:2)

Table 2(i)
Cointegration with unrestricted intercepts and no trends in the VAR.
Cointegration LR Test Based on Maximal Eigenvalue of the Stochastic Matrix. VAR=1.

Null	Alternative	Statistic	95% CV	90% CV
$r = 0$	$r = 1$	43.935*	27.420	24.990
$r \leq 1$	$r = 2$	12.832	21.120	19.020
$r \leq 2$	$r = 3$	9.307	14.880	12.980
$r \leq 3$	$r = 4$	1.553	8.070	6.500

Table 2(ii)
Cointegration with unrestricted intercepts and no trends in the VAR.
Cointegration LR Test Based on Trace of the Stochastic Matrix. VAR=1.

Null	Alternative	Statistic	95% CV	90% CV
$r = 0$	$r \geq 1$	67.627*	48.880	45.700
$r \leq 1$	$r \geq 2$	23.692	31.540	28.780
$r \leq 2$	$r \geq 3$	10.860	17.860	15.750
$r \leq 3$	$r = 4$	1.553	8.070	6.500

Note: * denotes rejection of the Null at the 5% significance level. CV denotes critical value.

The long-run model implied by the Johansen estimation is given by:

$$M = 1.650\,Y + 2.081\,P - 1.548\,R \qquad (2)$$

On the basis of the existence of a single significant cointegrating vector estimation using the Phillips and Hansen (1990) approach was also undertaken with the following outcome for the long-run model (1988:3-2000:2):

$$\begin{aligned} M = {} & -13.155 + 1.428\,Y + 2.194\,P - 1.108R + 0.082\,SC1 \\ & (0.867) \quad (0.152) \quad (0.265) \quad (0.354) \quad (0.021) \\ & + 0.091\,SC2 + 0.181\,SC3 + ECM \\ & (0.019) \quad (0.024) \end{aligned} \qquad (3)$$

Here three centred seasonal dummies, SC1, SC2, and SC3 are included and ECM refers to the random disturbance term utilised in the third stage of the process, i.e., establishment of a short-run ECM model.

Table 3 below presents two alternative models of the short-run demand for money which are the outcomes of a Hendry-type GTS process. Both models satisfy the standard diagnostic tests, however the negative coefficient attached to ΔY is a concern in Model 2. Both models include three dummy variables to capture three events in New Zealand monetary history which appear to have outlying effects. These are discussed in more detail below.

Table 3. *Alternative short-run models of the demand for money in New Zealand*: 1989:3-2000:2

Model 1	ΔM	
Variables	Coefficient	Standard Error
C	0.018^{**}	0.002
ΔY_{t-4}	0.064^{*}	0.027
ΔP_{t-1}	-0.517^{**}	0.171
ΔR_{t-4}	-0.479^{*}	0.226
ECM_{t-1}	-0.106^{*}	0.042
D904	0.043^{**}	0.013
D962	0.046^{**}	0.012
D994	-0.041^{**}	0.013
AIC=129.706 SBC=122.570	R^2=0.631 σ=1.17% DW=1.822	ξ_1 (4) =3.856 ξ_2 (1) =1.770 ξ_3 (2) =0.044 ξ_4 (1) =0.361

Model 2	ΔM	
Variables	Coefficient	Standard Error
C	0.173^{**}	0.002
ΔY_{t-1}	-0.054^{*}	0.238
ΔP_{t-1}	-0.331^{*}	0.162
ΔR_{t-4}	-0.498^{*}	0.228
ECM_{t-1}	-0.121^{**}	0.043
D904	0.047^{**}	0.012
D962	0.044^{**}	0.012
D994	-0.038^{**}	0.013
AIC=129.468 SBC=122.331	R^2=0.627 σ=1.18% DW=1.807	ξ_1 (4) =3.758 ξ_2 (1) =2.714 ξ_3 (2) =0.083 ξ_4 (1) =0.423

Note: σ is the standard error of regression. AIC is Akaike Information Criterion and SBC is Schwartz's Bayesian Criterion. ξ_1, ξ_2, ξ_3, and ξ_4 are the diagnostic test statistics for serial correlation, functional form, normality, and heteroscedasticity, respectively. One (two) asterisk(s) indicates a rejection of the Null at the 5%(1%) significance level.

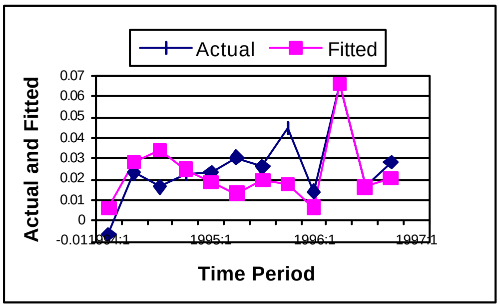
With only the lags on ΔY varying between the two models, the standard non-nested tests lead to non-rejection of either model by the other (Table 4 below). However, on the basis of AIC and SBC Model 1 is favoured which would be support ed by the sign of the coefficient attached to ΔY in Model 1. On this basis we propose to select Model 1 for further analysis.

Table 4. *Alternative Tests for Non-Nested Regression Models*

Dependent variable is ΔM 44 observations used from 1989:3 to 2000:2			
Regressors for Model 1 (M_1): C ΔY_{t-4} ΔP_{t-1} ΔR_{t-4} ECM $_{t-1}$ D904 D962 D994			
Regressors for Model 2 (M_2): C ΔY_{t-1} ΔP_{t-1} ΔR_{t-4} ECM $_{t-1}$ D904 D962 D994			
Test Statistic	M_1 against M_2		M_2 against M_1
N-Test	-0.777[0.437]		-1.147[0.252]
NT-Test	-0.492[0.623]		-0.779[0.436]
W-Test	-0.484[0.629]		-0.759[0.448]
J-Test	0.623[0.533]		0.880[0.379]
JA-Test	0.623[0.533]		0.880[0.379]
F(1,35)	0.388[0.538]		0.774[0.385]
Model	DW	$\bar{R}^2$	Log-likelihood
M_1	1.822	0.559	137.706
M_2	1.807	0.554	137.468
M_1+ M_2	1.810	0.551	137.949
AIC of M_1 versus M_2 = 0.239 favours M_1 SBC of M_1 versus M_2 = 0.239 favours M_1			

Figure 1 below plots the actual and fitted ΔM for the period 1989:3-2000:2. As one should expect, the three event dummies capture the outlier effects. However, there are two periods where the estimated model fails to fit actual events well. These periods include 1994:2-1994:4 where actual money demand growth is below predicted and 1994:4-1996:1 where the reverse holds.

Figure 1: *Actual and Fitted* ΔM
1994:1-1997:1



As shown in Table 3, the three event dummies are highly significant and Figure 1 shows their importance graphically. The rationale for their inclusion is now considered using information compiled from various Reserve Bank Monetary Policy Statements. The D904 dummy captures the publication of the first Policy Targets Agreement required by the Minister of Finance and the Governor of the Reserve Bank which reaffirmed the definition of price stability as 0-2 percent annual CPI increases as the target date of December 1992. The D962 dummy captures the December quarter CPI outcome where Headline inflation for the year to December 1995 reached 2.9 % against a predicted annual rate of 2.0 %. The D994 dummy captures not only the production GDP figures showing that the New Zealand economy grew 0.7 percent in the December 1998 quarter, and fell by 0.3 percent for the year to December 1998, but also the upcoming change to the OCR.

As to the periods 1994:2-1994:4 and 1994:4-1996:1 where actual money demand grew below predicted and vice-versa respectively, these periods relate to occurrences where the Reserve Bank 'excessively' loosened monetary control and then to re-establish credibility 'excessively' tightened.

6. CONCLUSIONS

In this paper we have attempted to model the demand for M3 money balances in New Zealand for the period 1990-2000. This period represented an era of significant change in the design and implementation of monetary policy in New Zealand heralded by the passing of the Reserve Bank Act in 1989.
The results presented in this paper show that the long run demand for money function can be represented via a cointegrating regression framework including 'traditional' determinants of demand including real income, the price level and nominal interest rates. The long run elasticities of these variables conform generally to expectation. The short-run demand for money was modelled via an ECM framework with the final model selected via a GTS approach. It proved necessary to include three dummy variables to capture idiosyncratic policy changes during the estimation period and the rationale for their inclusion was discussed in section 5 above.

Although the results presented here are promising, further work is proposed to investigate the stability of the cointegrating regression(s) and the role of the switch to the Official Cash Rate (OCR) in 1999 and its possible effects on the choice of interest rate proxy.

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