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THE DEMAND FOR MONEY IN SOUTH AFRICA: SPECIFICATION AND TESTS FOR INSTABILITY

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THE STABILITY OF THE DEMAND FOR MONEY function has long been a topic of research with important policy implications. Some monetary economists have made strong claims about the stability of this relationship even when the economy in question is subject to significant economic shocks. The South African economy would therefore seem an ideal testing ground for the stability of this model given that it has undergone major shocks to the economy, the political system and the financial sector over the last three decades. Therefore in this paper we seek to estimate and test a demand function from broad money for the South African economy using quarterly data for the period 1970.1 to 2002.3 and to subject our model to tests for the instability of its parameters of interest.

There are already a number of studies of the South African money demand function which have addressed similar issues. Tavlas (1989) claims to identify a stable demand for $M3$ (broad money). Hurn and Muscatelli (1992) use the Johansen method to estimate a cointegrating vector which links broad money to prices and interest rates. Although they succeed in identifying such an equilibrium relationship, they find some problems in interpreting it. In particular the result that the long run response of nominal money to the price level is less than proportionate makes it hard to interpret their model as a standard demand for money function.

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Moll (2000) uses the general to specific modelling approach and claims to identify a stable demand function. However, Jonsson (1999) claims to detect parameter instability following the economic and political changes of the 1990s.

The methodology adopted in this paper is to use the general to specific modelling approach to identify the best possible model we can for the entire sample period. We also test between the use of GDP and consumption as the scale variable for the demand function. We then investigate the stability of the model by re-estimating it using Bewley's (1979) transformation to estimate the parameters of interest of the model directly. By focussing on the equilibrium elasticities we show that there is strong evidence of instability in the estimated equation. The plan of the paper is as follows. In section 1 we discuss the underlying theory of the money demand function and its implications for estimation. Section 2 then presents our empirical results including alternative model specifications and stability tests. Finally, section 3 contains our conclusions.

1. THE MODEL

Following Tobin (1958) the traditional approach to demand for money theory has been to adopt a portfolio model. This naturally leads to a specification in which holdings of money balances are related to a scale variable and one or more opportunity cost variables. Thus the general form taken by the demand for money function is as shown in equation:

$$m = L(y, i) \quad (1)$$

where m is the real money stock, y is real income and i is an opportunity cost variable or possibly a vector of such variables. It would be more consistent with the theory if we were to use wealth rather than income as the scale variable but we rarely have good data for wealth and instead rely on the fact that wealth can be thought of as a discounted present value of income to make use of the more readily available series on aggregate income.

In recent years there has been an increasing emphasis on the derivation of aggregate relationships from intertemporal utility maximisation by a representative agent. For the demand for money, this literature originates with Sidrauski (1967) and is now well established. Sidrauski analyses the case in which the representative agent is an infinitely lived household which maximises lifetime utility which is a function of consumption and holdings of real money balances. The constraints facing the household are the sequence of budget constraints and the ‘No Ponzi Game’ constraint which prevents it from unsustainable borrowing to finance current consumption. The optimisation problem for such a household can be set out as follows:

$$\text{Max}_{c_t, m_t} \sum_{t=0}^{\infty} \left(\frac{1}{1+\delta} \right)^t u(c_t, m_t) \quad (2)$$

where c_t and m_t are consumption and holdings of real money balances and δ is the rate of time discount. We assume that assets (a_t) can be held in the form of either non interesting bearing money or an interest bearing bond. The sequence of budget constraints facing the household can therefore be written:

$$a_t = \frac{1}{1+\pi_t} \{ (1+i_{t-1})a_{t-1} - i_{t-1}m_{t-1} - c_t + y_t \} \quad (3)$$

where i_t is the nominal interest rate and π_t is the rate of inflation. In addition the initial value of the stock of assets is fixed $a(0) = a_0$ and we have the transversality condition $\lim_{t \rightarrow \infty} a_t u_{c,t} e^{-\delta t} = 0$ where $u_{c,t}$ is the marginal utility of consumption at date t .

The first order conditions for this problem can be written:

$$\begin{aligned} \beta^t u_{c,t} - \mu_t &= 0 \\ \beta^t u_{m,t} - i_t \mu_t &= 0 \\ \mu_t (1+i_t) - \mu_{t-1} (1+\pi_t) &= 0 \end{aligned} \quad (4)$$

where $\beta = \frac{1}{1+\delta}$ and μ_t is a costate variable which can be interpreted as the marginal utility of consumption at date t evaluated at $t=0$.

The first and third of these conditions combine to give the familiar consumption Euler equation while the first and second combine to yield equation (5):

$$\frac{u_{m,t}}{u_{c,t}} = i_t \quad (5)$$

Equation (5) can be interpreted as an implicit money demand function. For example, if we take the simple utility function $u(c, m) = c^\alpha m^{1-\alpha}$ then (5) implies a money demand function of the form $m = \frac{(1-\alpha)c}{\alpha i}$. Note that the simple nature of the utility

function in this case produces very strong restrictions on the consumption and interest elasticities. However, we see no need to impose these restrictions at this stage.

The most obvious difference between the specification of the money demand function in (1) and that implicit in (5) is that the latter equation naturally leads to the use of consumption rather than income as the scale variable. An important part of the empirical work which follows in section 1 concerns the testing of these alternatives within a non-nested framework.

2. DATA AND ESTIMATION

To make our model operational we use data taken from the IMF: *International Financial Statistics* database. m consists of money plus quasi money adjusted by the GDP deflator, y is real GDP in 1995 prices, c is household consumption expenditures deflated by the consumer price index and i is the treasury bill rate. Our data are quarterly and the sample period is 1970.1 to 2002.3.

The first stage of the analysis is to test for the existence of a cointegrating relationship between the demand for real money

balances, the scale variable and the opportunity cost variable(s). In doing so we adopt a specification in which the variables are (log) real money, (log) real income, the treasury bill rate and the annual rate of inflation. We performed five different tests for cointegration – the Engle-Granger test, the error correction levels test, the error correction t-test and Johansen’s maximum eigenvalue and trace tests. The results are reported in Table 1.

Table 1. *Cointegration tests*

	Scale Variable = GDP	Scale Variable = Consumption
Engle-Granger	-1.64	-1.06
ECM Levels Test	5.42*	5.03*
ECM T-Test	-2.59	-1.79
Johansen Maximum Eigenvalue	27.97*	29.05*
Johansen Trace	51.18*	49.74*

* indicates test statistic rejects the null of no cointegration at the 5 per cent level.

The Engle-Granger and Johansen tests are well known and do not need further comment. However, the two error correction (ECM) tests are less widely used and require some further explanation. The ECM T-test is based on the t-ratio of the coefficient on the deviation from equilibrium in an error correction equation. This test is discussed by Kremers *et al.* and Ericsson and MacKinnon (2002) who demonstrate that although this is a powerful test it suffers from the problem that the critical values depend on number of nuisance parameters such as the relative variances of the variables entering the equilibrium relationship and the short term adjustment coefficients of the error correction equation. Kanioura and Turner (2003) show that the asymptotic 5 per cent critical value can lie between -1.61 and -2.89 depending on these values. However, Kanioura and Turner also suggest the use of a test based on the joint significance of the levels terms in an error correction equation. This is less powerful than the ECM T-test but has the advantage that the critical values do not depend on nuisance parameters.

The results reported in Table 1 show a familiar pattern. The Engle-Granger tests fail to reject the null of no cointegration but the more powerful Johansen tests do reject. In terms of the ECM tests, we find it hard to draw any conclusions from the ECM T-test

since the test statistics lie within the range of possible values for the 5 per cent significance level. However, the ECM levels tests do reject the null in both cases. We believe therefore that the balance of the evidence is in favour of the existence of a cointegrating vector for long run money demand.

In the next stage of our analysis we estimate error correction equations for money demand using GDP and consumption as alternative scale variables. The methodology adopted was the general to specific approach. We began with equations containing four lags of each variable and then eliminated insignificant variables to obtain a parsimonious specification. We then reparameterised this form of the equation to obtain the error correction equations reported below:

Model 1: Money Demand Function with GDP Scale Variable

$$\Delta m_t = 0.0993 \Delta y_t + 0.1626(i_{t-1} - i_{t-4}) + 0.1662(\pi_{t-1} - \pi_{t-4}) - 0.4493 \Delta \pi_t \quad (6)$$

$$- 0.0827 \left(m_{t-1} - 1.2007 y_{t-1} + 1.9658 i_{t-1} + 2.0091 \pi_{t-1} \right) + \varepsilon_t$$

$$R^2 = 0.31 \quad \hat{\sigma} = 0.02 \quad DW = 2.04$$

$$LM_4 = 1.94(0.11) \quad ARCH = 0.09(0.77) \quad NORM = 3.80(0.15)$$

Model 2: Money Demand Function with Consumption Scale Variable

$$\Delta m_t = 0.1618(i_{t-1} - i_{t-4}) + 0.1281(\pi_{t-1} - \pi_{t-4}) - 0.4440 \Delta \pi_t \quad (7)$$

$$- 0.0513 \left(m_{t-1} - 0.8277 c_{t-1} + 3.1539 i_{t-1} + 2.4976 \pi_{t-1} \right) + \varepsilon_t$$

$$R^2 = 0.29 \quad \hat{\sigma} = 0.02 \quad DW = 2.06$$

$$LM_4 = 2.11(0.08) \quad ARCH = 0.19(0.67) \quad NORM = 3.43(0.18)$$

Numbers reported in parentheses below coefficients are absolute values of t-ratios. Coefficients without associated t-ratios are the result of the coefficient restrictions imposed to reparameterise the general autoregressive distributed lag model into error correction form¹. R^2 is the coefficient of determination, $\hat{\sigma}$ is the standard

¹ We also estimated unrestricted versions of each equation for the purposes

error of the regression, DW is the Durbin-Watson test statistic, LM_4 is the F-form of the Lagrange Multiplier test for 4th order serial correlation, $ARCH$ is the F-form of the Lagrange Multiplier test for a 1st order autoregressive conditional heteroscedastic process in the residuals and $NORM$ is the Jarque-Bera test for non-normality of the residuals. Number in parentheses after these test statistics are p-values.

Both equations perform reasonably well from a statistical point of view in that none of the diagnostic statistics indicate significant misspecification. However, there are some indications that the equation using GDP as the scale variable performs better from the point of view of its economic interpretation. In particular, we note that the error correction coefficient achieves a higher level of significance when GDP is the scale variable as do the two opportunity cost variables. To obtain a more formal comparison of the two models we applied the Davidson and MacKinnon (1981) J-test. The test statistic here follows an asymptotically normal distribution with mean zero and variance one. When Model 1 is treated as the basic model and Model 2 the alternative we obtained a test statistic of -0.94 and when these were reversed we obtained a test statistic of 1.51 . Therefore the test is inconclusive in that neither model can reject the other. However, the relatively better performance in economic terms of Model 1 means that we decided to treat this as our maintained

of comparison. In the case of equation (6) the t-ratios for the coefficients on $\Delta y_t, (i_{t-1} - i_{t-4})$ and $(\pi_{t-1} - \pi_{t-4})$ were 1.17, 2.53 and 3.05 respectively. An F-test for the restrictions involved in moving from the unrestricted equation to the error correction equation yielded a value of 0.33. The 5% critical value for an F-statistic with (116,3) degrees of freedom is 2.68 and therefore the restrictions are acceptable. In the case of equation (7) the unrestricted equation yielded t-ratios on $(i_{t-1} - i_{t-4})$ and $(\pi_{t-1} - \pi_{t-4})$ of 2.71 and 2.55 respectively. An F-test for the restrictions in equation (7) yielded a value of 0.37 which compares with a 5% critical value of 3.07 for an F-statistic with (117,2) degrees of freedom. Therefore the restrictions involved in moving from the unrestricted model to the error correction model are also acceptable for equation (7).

hypothesis for the rest of this paper.

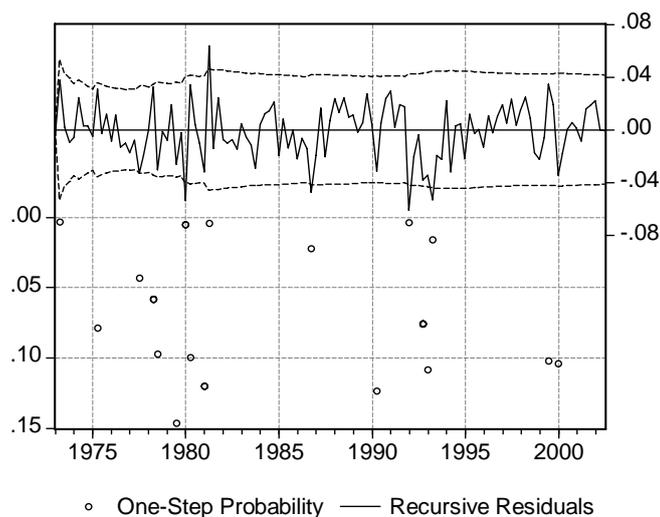


Figure 1. Recursive Residuals and One Step Ahead Chow Tests

The issue of stability has always been central to empirical research on the demand for money. Since South Africa has experienced significant economic and political shocks during the sample period we might expect this to be reflected in the demand for money function. With this in mind we investigated our equation for signs of instability. As a first stage we examined the plot of recursive residuals and one-step ahead Chow tests shown in Fig. 1. Since the early part of the period involves estimation with relatively few observations we concentrate on the later part of the sample for evidence of instability. From the plot we note three quarters in which the recursive residuals exceed the standard error bounds, these are 1986.4, 1992.1 and 1993.2. The reason for the 1986 structural break may lie in changes to the supply side process since monetary targets were adopted after this period (cf. Jonsson). In addition the economy suffered increasingly from economic sanctions during this period resulting in problems servicing international debt and the introduction of capital controls. The breaks in 1992.1 and 1993.2 can be linked to the transition to

majority rule during this period. It is noticeable that these breaks predate the reforms of the financial system which took place during 1995. This may indicate that political changes were more important than economic changes for money demand or alternatively that agents correctly anticipated that political change would lead to economic reform.

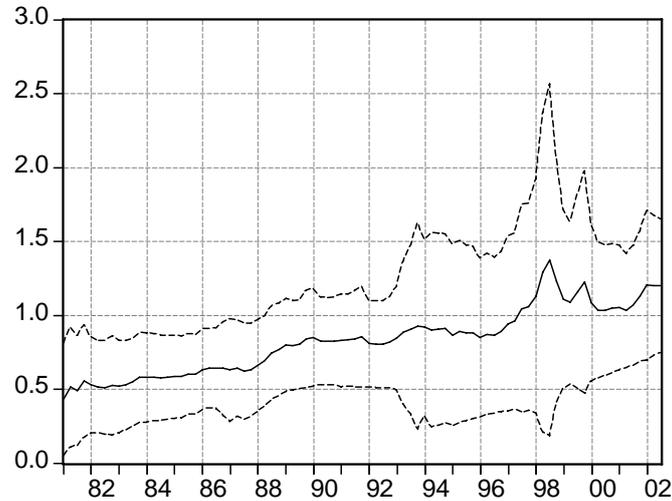
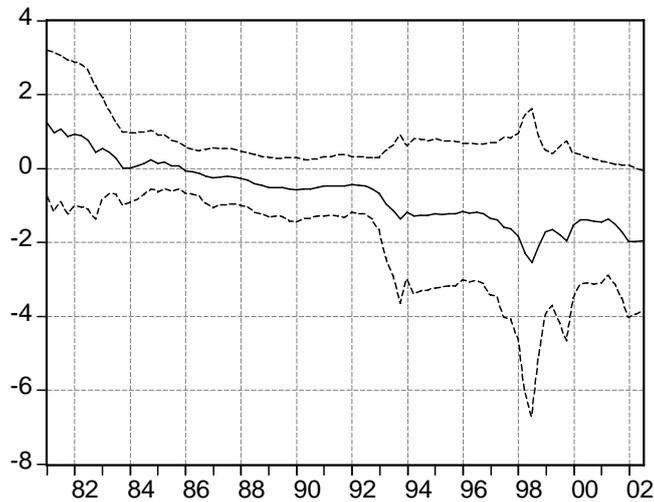


Figure 2. *Income Elasticity of Demand for Money – Recursive Estimates 1981.1 – 2002.3*

To investigate the nature of the structural breaks in the demand for money further, we applied the method of recursive least squares to the model. Since the focus of our interest is on the long run or steady-state responses of money demand to income, interest rates and inflation, we applied Bewley's (1979) transformation to estimate the steady-state parameters directly along with the associated standard errors. The results are shown in Fig. 2-4.

Fig. 2 shows recursive estimates of the equilibrium income elasticity of demand over the period 1981.1 to 2002.3. These indicate a long term drift upwards in the value of this elasticity from a value of about 0.5 in 1981 to 1.2 in 2002. There are also noticeable periods in which the coefficient or its standard error

change sharply. In particular the standard error bands widen considerably during 1993, probably reflecting the instability detected using the one step ahead Chow tests in Fig. 1. In 1998 we observe sharp changes in both the central parameter estimate and the standard error bands. Interestingly, this was not detected using the recursive residuals and thus illustrates the value of examining the recursive coefficient estimates.



*Figure 3. Interest Rate Elasticity of Demand for Money-
Recursive Estimates 1981.1-2002.3*

Fig. 3 and 4 indicate that the pattern of instability is very similar in both the elasticities associated with the interest rate and the rate of inflation. This similar pattern probably reflects the fact that both these variables are capturing the opportunity cost of holding money balances. In both cases we observe a general trend upwards in the absolute value of these coefficients indicating that money demand becomes more sensitive to its opportunity cost. As with the income elasticity, we also observe two noticeable periods of instability. In 1993 the standard error bands widen and there is step increase in the absolute values of the elasticities. A similar pattern is observed in 1998.

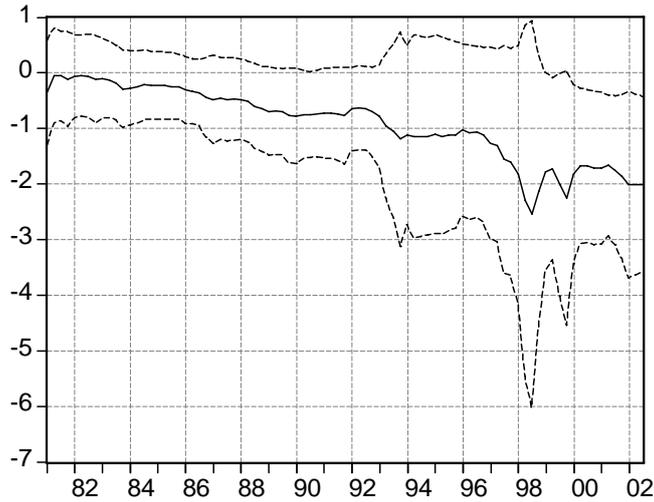


Figure 4. Inflation Elasticity of Demand for Money – 1981.1-2002.3

3. CONCLUSIONS

In this paper we have estimated a demand for broad money function for the South African economy over the period 1971.1 to 2002.3. The estimates for the whole sample period are economically reasonable and appear to fit the data well with little evidence of dynamic misspecification. However, recursive estimates of the steady-state elasticities with respect to income, the interest rate and the inflation rate indicate that these important parameters are not stable through the period. We find evidence that the income elasticity of money demand has increased significantly through the period as has the sensitivity of money demand to the opportunity cost of holding money balances. In addition to these trend changes in the parameters we also observe step changes associated with economic and political disturbances during the 1990s.

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