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Broad money demand and financial liberalisation in South Africa

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Financial liberalisation and changes in the technology of payments and settlements have led to large volatilities in money demand worldwide. The South African economy has also undergone a number of important structural changes during the past two decades, including the relaxation of exchange controls, financial innovations and the integration of the South African financial market into the global financial markets. This may have caused money demand functions to become structurally unstable. A fixed-coefficient error-correction model for broad money demand (M3) in South Africa was developed for the period 1971:1 to 2000:4. Despite large fluctuations in the income parameter, the other long-run parameters of the estimated model are remarkably stable. Allowing some coefficients to vary over time also improved the forecasting performance of the money demand equation over the forecasting period 2001:1 to 2002:2. As a methodology for calibrating fixed-coefficient models and for testing the stability of their coefficients, the varying-parameter regression approach proved very useful.

1. Introduction

Recent changes in the South African financial system pose challenges to the conduct of monetary policy. Changes in the implementation of monetary policy, financial innovations, the integration of international financial markets and the removal of most external capital controls are all factors that alter the equilibrium relationship between the variables that determine the demand for money.

A money demand function, generally in the form of a structural single-equation model, is a centrepiece in the design of monetary policy in most countries. It is sometimes used to forecast the path of nominal income, conditional on simulated paths for real money supply and prices. Alternatively, it can be used to design the money supply path consistent with target paths in real economic growth and inflation. However, the main shortcoming emerging from the time instability of an estimated money demand function is precisely the possibility that its forecasting performance may deteriorate. If that is the case, its use as a tool for monetary policy design becomes questionable.

In South Africa, the achievement of price and financial stability was made even more difficult by the impact that changing world conditions have had on the monetary policy transmission mechanism. Financial innovation and financial liberalisation during the 1990s are potential challenges to research into money demand. The switch in policy emphasis from monetary to inflation targets in February 2000 does not alter the prospect that policy-induced changes in the repurchase rate may cause money demand instability. Conventional money demand structures invariably contain interest rates and often include commodity prices or inflation, all of which may be influenced by monetary policy actions.

In this study the stability of a money demand equation was tested and the results obtained from a fixed-coefficient error-correction approach were compared to those of an alternative econometric methodology based on time-varying coefficients. After using 1971:1 to 2000:4 as the estimation subsample, a forecast was generated from 2001:1 to 2002:2, using a varying-parameter regression model, which was then compared to that of a simpler fixed-coefficient money demand function. It was found that, despite significant fluctuations in the income parameter, the other long-run parameters of the estimated model were remarkably stable. Allowing some coefficients to vary over time also improved the forecasting performance of the money demand equation significantly over the forecasting period.

1 Valuable assistance in the Paper's preparation was provided by Messrs B L de Jager and S de Jager from the Research Department of the Reserve Bank. Assistance in the form of helpful comments and suggestions by various staff members of the Reserve Bank is also gratefully acknowledged. However, the views expressed in this Paper are those of the author and do not necessarily reflect those of the South African Reserve Bank.

A literature review on the topic is provided in Section 2, and in Section 3 recent developments in broad money demand and its determinants are described. Possible reasons for changes in the income velocity of circulation of money aggregates are also given in this section. The error-correction model (ECM) for the demand for M3 is described in Section 4. Both the long-run and short-run dynamic behavioural patterns of M3 are analysed in Section 5. This section also gives the finding that some of the parameters of the money demand function are time varying. Finally, in Section 6, *ex ante* forecasts are used to judge the performance of the fixed-coefficient ECM and the alternative varying-parameter regression specifications. The paper concludes with some brief remarks on the validity of the study.

2. Literature review

The importance of the behaviour of the money demand relationship to the formulation of successful monetary policy is widely recognised by many economists. A stable demand for money plays an integral role in any macroeconomic model. A money demand equation expresses money as a function of prices and other macroeconomic variables such as real income and interest rates. Another feature that distinguishes recent studies from earlier ones is the emphasis on the related characteristics of parameter stability and the capacity to predict.

The existence of a stable money demand relationship has been questioned in the United States where, for instance, Friedman and Kuttner (1992) found cointegrating relationships among monetary aggregates, income and interest for the period 1960-1979 but once data from the 1980s are added, the relationships break down (also see Friedman, 1988). Laidler (1999) criticises the lack of focus of monetary policy by the Bank of Canada and the existence of instability in the demand for money. He states that it is important to be able to recognise structural shifts when they occur, and to make allowances for their effects when interpreting the significance of the observed behaviour of money.

Hayo (1999) suggests a stable money demand function is imperative in the new policy era of inflation targeting. He makes the obvious point that inflation cannot be controlled directly and that the term “inflation targeting” under-emphasises the complexity of the link between monetary policy and inflation. From a South African perspective, the study by Nell (2001) shows that the M3 money demand function suffers from structural instability over the period 1998-1999, as a direct result of the financial crisis in 1998.

Brand, Gerdesmeier and Roffia (2002) used a time-varying parameter (TVP) regression approach (based on the Kalman filter) to investigate the stability of money demand models in the euro area. They found that the parameter estimates of the single-equation time-varying money demand model are broadly in line with the OLS estimates of the fixed-coefficient error-correction model. Since the South African economy has undergone a number of important structural changes during the past two decades, a similar approach to Brand et al. (2002) is used to test and estimate a money demand function in South Africa.

3. Developments in broad money demand

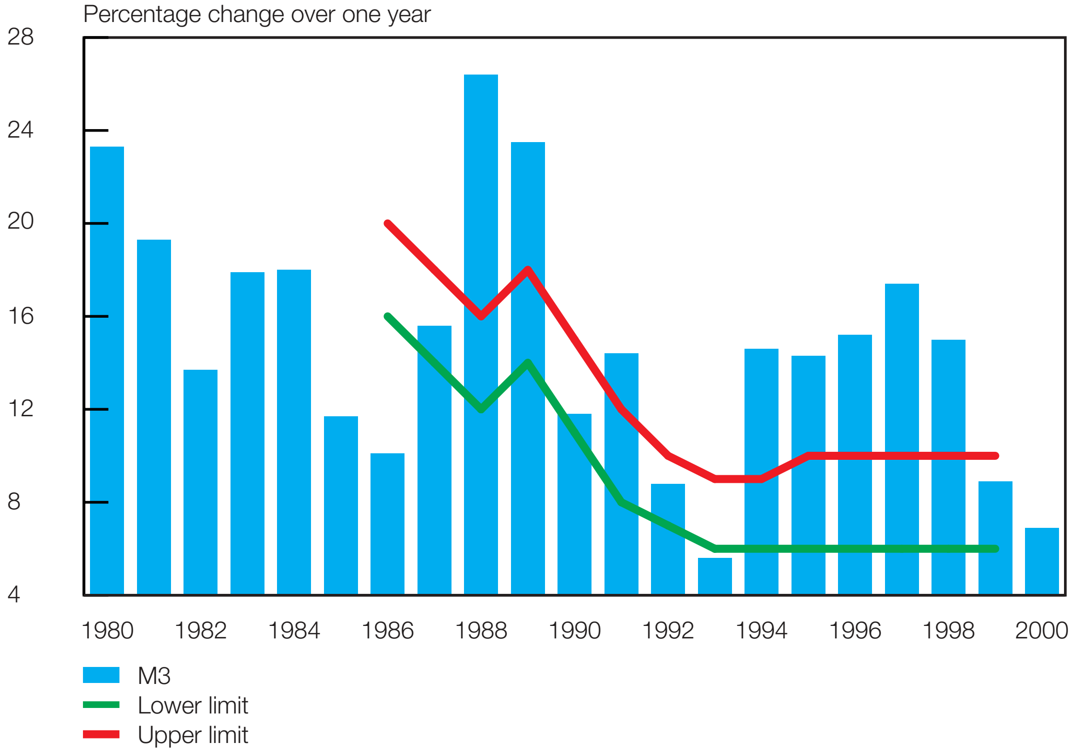
Financial liberalisation and changes in the technology of payments and settlements have led to large volatilities in money demand equations internationally. As a result, the parameters of the money demand function could be dominated by the technology of transaction services, causing it to be unstable over time. It is in this context that the Deputy Governor of the Bank of England, Mervyn King (2002), stated that the instability was derived not from the irrelevance of money, but from changes in technology.

In South Africa, the economy has also undergone a number of important structural changes during the past two decades (including long periods of trade sanctions, the presence of the financial rand system and widespread exchange controls on residents, different monetary policy regimes, considerable swings in the terms of trade as well as financial liberalisation and innovations). All of these factors may have caused money demand functions to become structurally unstable over time.

Since 1986 the South African authorities have used a monetary target range (which later became a guideline in 1990) for M3 growth, to signal the monetary authorities' determination to combat inflation and to guide inflationary expectations. The success of this policy depended on the existence of a stable money demand relationship, but the authorities' ability to control M3 was limited. Realised M3 growth fell outside the target/guideline band in nine of the 13 years from 1987 to 1999 (see Figure 1).[2]

2 The Reserve Bank has announced annual guidelines for growth in broad money from 1986 to 1999 (i.e. 6 – 10 per cent from 1995 to 1999). However, actual growth in M3 has substantially exceeded the guideline range during the last few years, and the authorities have on several occasions announced that the Reserve Bank in practice is guided by developments in a number of different indicators, including various price indices, the shape of the yield curve, the nominal exchange rate and the output gap.

Figure 1 M3 money supply growth and the M3 target range

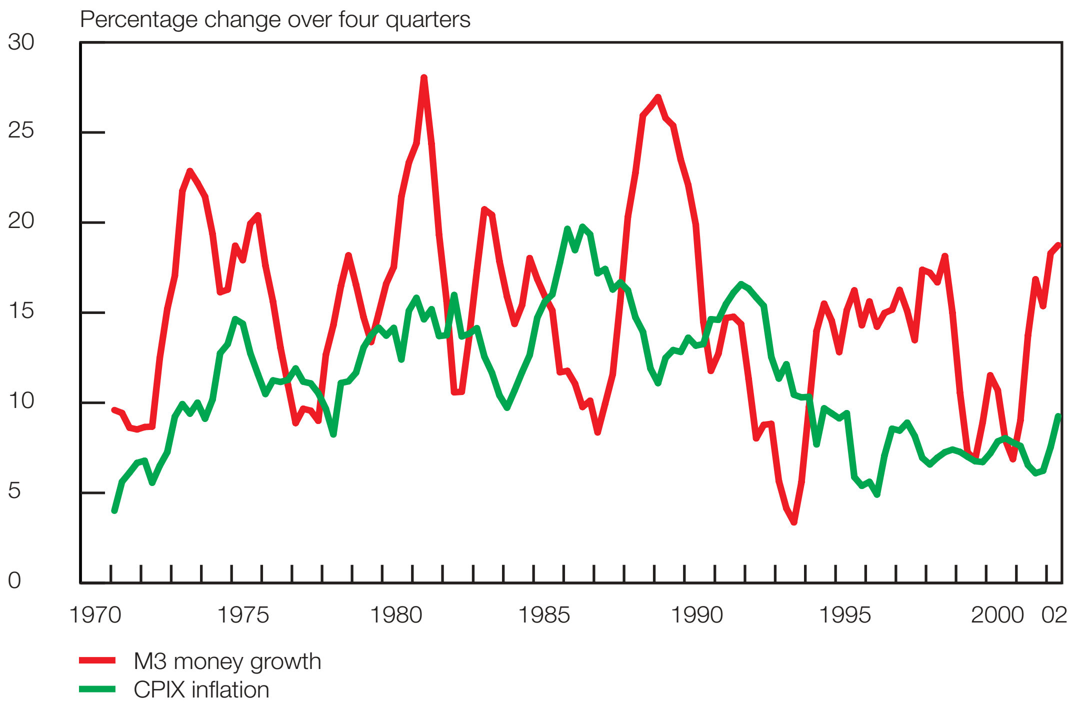


Inflation has fallen considerably, particularly during the 1990s. Annual growth in the underlying consumer price index fell from 18 per cent in 1991 to 13 per cent in 1993 and further to 7 per cent in 1998. However, developments in broad money (M3) have not followed the same pattern. Although the annual growth rate in M3 fell from about 14 per cent in 1991 to 5 per cent in 1993, it increased later to 17 per cent in 1998. The contrasting developments in inflation and money growth during the 1990s have led analysts to question whether money demand is stable.[3]

3 Strictly speaking, an unstable relationship between money growth and inflation does not necessarily imply that money demand is unstable, as the latter would be expected to vary with fluctuations in other variables, such as real income and nominal interest rates.

Money supply growth and inflation have moved relatively closely overall, though they diverged after 1993 (see Figure 2). Somewhat perversely, the M3 surge may have been driven partly by falling inflation, against the backdrop of high levels of interest rates. Lower inflation reduced the risk of holding money and raised its real return. M3 money supply accordingly grew by a robust 17,8 per cent year on year in July 2001. Against real growth in output estimated at less than 3 per cent, the expansion in money supply would seem excessive, implying that the income velocity of money has changed. However, a sizeable portion of the growth in M3 was concentrated in longer-term deposits, which are more of an investment vehicle than a temporary store of purchasing power. The shift into longer-term deposits might also have been motivated by fears of losses in equity investments. The rise in broad money may therefore partly reflect shifts in the demand for money in asset portfolios, rather than intentions about future spending. Another possibility is that money demand might have grown because inflation was regarded as being under control. The money growth boom might not be a harbinger of accelerating inflation but merely a temporary response to a changed environment.

Figure 2 M3 money growth versus CPIX inflation

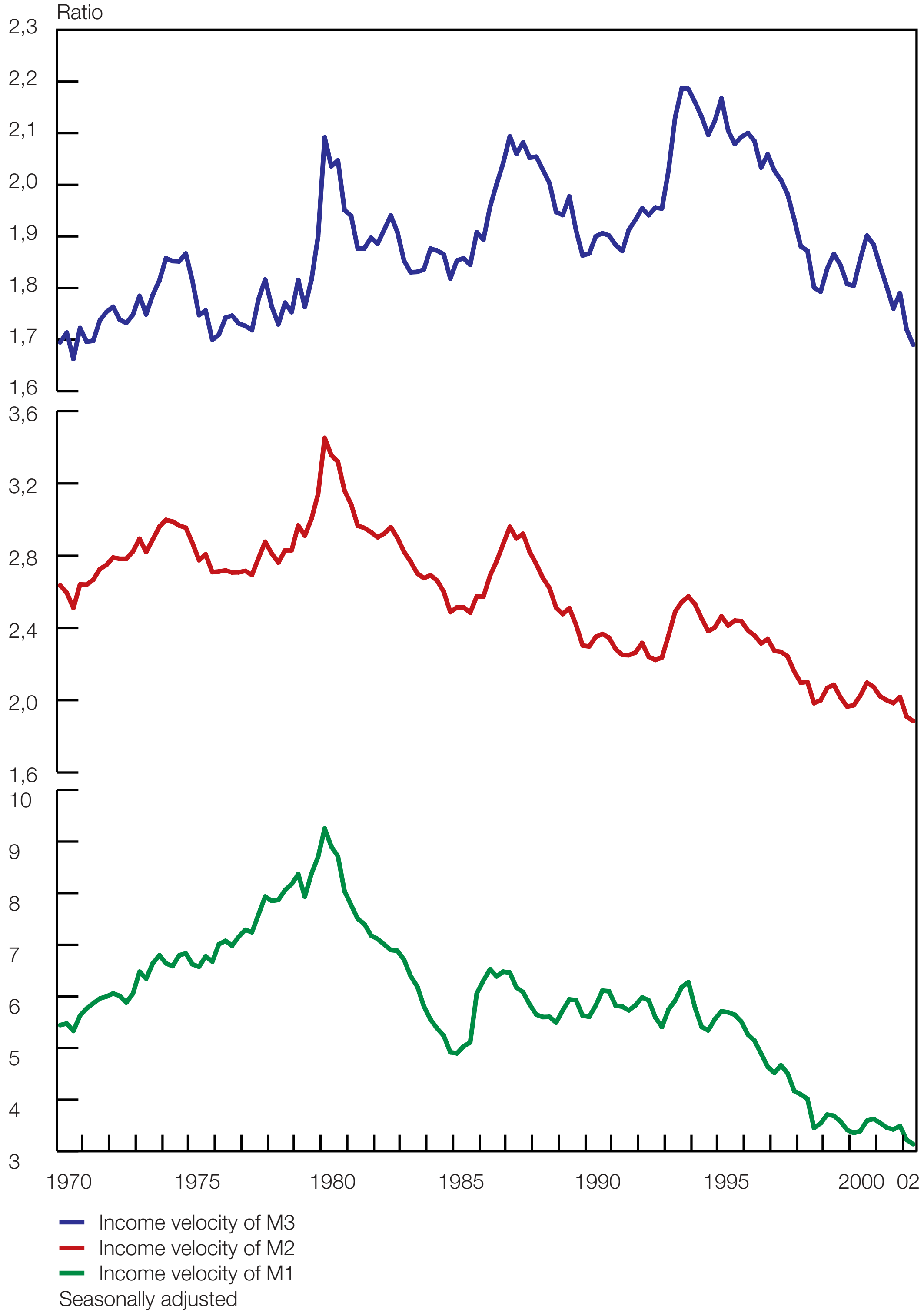


Although the objective of monetary policy has been better focused within the context of globalisation, the integrated world economy has resulted in a more complex mechanism for transmitting monetary policy. The relationship between changes in interest rates, money demand, income and inflation has become less clear under these new conditions, than in the period when South Africa was more isolated from external influences. There are also longer time lags between policy changes and their desired impact on the real economy. The Governor of the South African Reserve Bank, Mr T T Mboweni (2001), also argues that as a result of large international capital flows, the effects of policy changes are being transmitted to a greater extent through critical indicators such as bond yields and exchange rates.

Therefore, the integration of financial markets and financial innovations made the demand-for-money function less stable. This was clearly reflected in a consistent decline in the income velocity of circulation of money[4] (see Figure 3). The decline in the income velocity of M1 and M2 since 1980 could be a result of the use of credit cards and other financial innovations in the financial sector of the economy (i.e. the introduction of automatic teller machines). There was a substantial shift from the longer-term deposit category (long-term plus other short-term and medium-term deposits) to the shorter-term category between 1990 and 2001. The income velocity of M3 money declined by nearly 15 per cent from the end of 1994 to the end of

4 The ratio of GDP at current prices, seasonally adjusted, to the average value of the relevant seasonally adjusted monetary aggregate.

Figure 3 Income velocity of monetary aggregates



1999, and decreased from 1,72 in the first quarter of 2002 to 1,69 in the second quarter – the lowest level in more than 22 years.

Factors that could have contributed to this decline include the upward trend in private-sector liquidity preference, stemming from the heightened uncertainty concerning interest rates and share and bond prices. A process of financial deepening and market penetration was also experienced as the general South African public gained more access to the banking sector after the political transition of 1994. In 1995 M3 may have been distorted by some special factors, including the portfolio shifts caused by a significant increase in the long-term interest rate. This pattern is mirrored in the behaviour of the income velocity of M3 in South Africa. After 1996 the increase in money holdings was attributable to the declines in inflation and a greater confidence in money as a store value. In this context, a number of specifications of a structural break in established relationships are investigated in Section 5.

4. Methodology

4.1 The fixed-coefficient error-correction representation

The now standard approach in empirical studies on the demand for money involves estimating error-correction methods. Since the development of the cointegration methodology by Engle and Granger (1987) and Johansen and Juselius (1990) it has become customary to specify and estimate money demand functions in error-correction form in order to capture the nonstationarity of the underlying time series. This approach has been applied to money demand equations for the USA, the UK and other countries (see, for example, Ericsson, Hendry and Prestwich, 1998).

This methodology is particularly appropriate for the problem at hand for two reasons. First, though money stocks, price levels and income levels are nonstationary, they may well be cointegrated. If so, econometric models that disregard this property of the data are misspecified. Second, error-correction models allow for a broad range of dynamic interrelationships between the variables. As noted by Boughton (1992), one important reason why traditional money-demand functions of a partial adjustment type display parameter instability is that they impose (untested) constraints on lag patterns which are typically rejected by the data. Given the interest in the stability of the money demand function, the error-correction strategy is therefore used.

Agents may hold money either as an inventory to smooth differences between income and expenditure, or for its yield as an asset in a portfolio. Either theory suggests a specification in which the money demanded depends on a scale variable such as national income or expenditure, inflation and the rates of return to money and to alternative assets. The theory makes most sense when applied to real money and real income rather than their nominal equivalents.

The single-equation error-correction representation for M3 on which the variable parameter representation will be based, has the following form:

$$\Delta(m-p)_t = c + \alpha[(m-p)_{t-1} + \beta_1 y_{t-2} + \beta_2 l_{t-1} + \beta_3 (s\text{-}own)_{t-1}] + \gamma_{11}\Delta(s\text{-}own)_t + \gamma_{12}\Delta p_t + \gamma_{13}\Delta p_{t-1} + \gamma_{14}\Delta(m-p)_{t-1} \quad (1)$$

where *m, p,* and *y* denote, respectively, nominal M3, the consumer price index, excluding mortgage interest rates and real GDP. The variables *s, l and own* denote a short-term market interest rate, a long-term market interest rate, and an own rate of M3, respectively.[5] All the variables except interest rates are in natural logarithms,

5 *It is worth noting that, in line with recent results for the euro area (see Dedola et al., 2001), the long-run specification does not include inflation as a measure of the opportunity cost of holding money. The fact that inflation does not enter the long-run relationship could be interpreted in the sense that this variable is regarded as not having additional explanatory content for money demand compared with the nominal long-term interest rate.*

and time differences are denoted by Δ. The variables in brackets represent the long-run equation in the error correction methodology.

Equation 1 can be estimated using OLS, in this way obtaining the long-run coefficients and the dynamic coefficients in one step (the main modelling strategy lies in the fact that it can be applied irrespective of whether the regressors require time differencing to yield stationarity or not (see Pesaran et al., 1996). It is expected that $\beta_1>0$ and β_2, $\beta_3<0$.

4.2 The varying-parameter regression approach

Theoretical criticisms and econometric objections have cast doubt on the traditional structural econometric models. One of the major theoretical criticisms of the traditional approach is based on the work of Lucas (1976). He argues that the identification of a time-invariant structure is a necessary condition for policy-oriented models.

The varying-parameter regression (VPR) technique uses the basic idea that the parameter vector in an econometric relationship may be subject to sequential variation over time because of the problems of structural change, misspecification and aggregation. Under this approach, an econometric relationship is stable if the parameters do not illustrate permanent changes over time.

Watson and Engle (1983) discuss general approaches to the estimation of time-varying parameters. The essence of their approach is to formulate an economic equation as a Kalman filter state-space model and to use a recursive algorithm to maximise the log likelihood function via a combination of the iterative EM (estimation and maximisation) and Scoring techniques (see Atkinson et al., 1997). This model can either be applied in cases where the parameters of the regression model follow a non-stationary random walk, a stationary AR(1) or an I(2) trend process (see Goodrich, 1990).[6] A random walk option is used if one believes that the shocks to the random coefficients will persist indefinitely, and an AR(1) option is used if the random coefficients eventually return to their mean values. The I(2) process often leads to a much smoother variation than the random walk processes for parameter variation.

6 The general VPR model is $y_t = Z_t\alpha + X_t\beta_t + \varepsilon_t$ where the changing parameter vector β_t (referred to as the state equation) can either be described as a non-stationary random walk process with $\beta_t = \beta_{t-1} + \eta_t$, a stationary AR(1) process with $(\beta_t - \beta_{mean}) = \phi(\beta_{t-1} - \beta_{mean}) + \nu_t$, or an I(2) trend process described with $\Delta\beta_t = \Delta\beta_{t-1} + \gamma_t$. The ε_t 's are iid $N(0, \sigma^2_{(t)})$.

VPR models are most suitable when one or more of the coefficients vary smoothly in time, and when specific statistical tests reject the null hypothesis of fixed parameters. The Watson-Davies (together with other more conventional) tests are used to investigate whether the smoothly time-varying coefficients vary via some random walk or AR(1) process before the VPR method is used (see Watson and Engle, 1985). The forecast of the VPR model will use the last available value of the changing parameter over the forecast period, and will almost certainly yield better forecasts than a model that uses a fixed value over the entire data set. Therefore, apart from offering insights into improved methods of analysing time-series data, the most promising direct use for point estimates derived from time-varying coefficients is as an aid in calibrating fixed-coefficient money demand models (see Swamy, Kennickell and von zur Muehlen, 1990).

5. Empirical results

5.1 The data

The money demand model is estimated using quarterly data from 1971:1 to 2000:4, and excludes data from 2001:1 to 2002:2 for *ex post* forecasting evaluations.

The quarterly data on the money stock *(m)* are the weighted averages of the monthly observations. For real income and prices, the study uses real GDP *(y)* and first-quarter differences in the log of the consumer price index, excluding mortgage interest rates, Δp. These time series are all seasonally adjusted. Two interest rates are used for the analysis: the return on 10-year government bonds *(l)* and a measure of the yield on M3, referred to as the 'own rate' which is measured by a weighted average of the interest rates applicable to the various components of M3.

Real M3 money demand is therefore modelled as being dependent on the following variables:
- Real GDP as a scale income variable for transaction purposes;
- the return on 10-year government bonds, as an indicator of the yield on substitute assets;
- the interest rate spread between the prime overdraft rate and the deposit rate (as an own interest rate) to capture the effect of disintermediation-reintermediation; and
- an inflation variable to make allowance for the opportunity cost of holding money.

All variables are in logarithms with the exception of the interest rates. Of course, other definitions could be used for the explanatory variables. However, these explanatory variables are so "standard" that if a demand function estimated using them was found to be stable, it would cast serious doubt on the claim that the behaviour of South African M3 has become fundamentally unstable over time.

Before turning to the modelling and out-of-sample prediction aspects of the money demand equations, attention is given to the issue of whether money, prices and income are non-stationary or cointegrated and, if so, what the values of the long-run price and income elasticities are likely to be.

5.2 Unit root tests

As a preliminary step, unit root tests were performed to provide some guidance on whether the variables in the analysis are stationary or not (i.e. to determine whether they should be used in differenced or level form). It is well known by now that such tests are usually not very powerful (see Harris, 1995).

A unit root test that does not take account of a structural break in the time series has very low power. Banerjee, Lumsdaine and Stock (1992) propose rolling augmented Dickey-Fuller (ADF) tests of unit roots if the break in the series is unknown. The minimum of the ADF test statistic is calculated over various subsamples (equal in size) of the data. They prove that the standard ADF test statistic is unreliable, and that the new minimum test statistic has reasonable size and power properties on the basis of Monte Carlo experiments. The minimum rolling ADF tests, and the less powerful Phillips-Perron (PP) unit root tests of the variables are presented in Table 1.

The lag length gives the number of lagged differenced terms in the rolling ADF, or truncation lags in the PP test, required for white-noise residuals in the test equations. The lag length was chosen by using the general-to-specific approach suggested by Campbell and Perron (1991) and uses the minimum value for the Bayesian Schwartz criterion (BIS) calculated from the estimation as the key criteria. The terms 'c + t' refer to the situation where both a constant and a time trend were included in the unit root test equation.

Table 1 Unit root test results: South African money-demand variables

Variables in level terms	Minimum rolling ADF test statistic chosen from equal subsample periods		Phillips-Perron (PP) test statistic over the total sample period	
	c + t	Lag length	c + t	Lag length
m-p = ln (real M3)	-3,384	3	-2,234	3
y = ln (real GDP)	-3,507	2	-2,103	2
l = long-term bond rate	-2,991	3	-1,870	3
s-own = prime-deposit rate	-3,196	2	-3,784**	2
Δp = dln (CPIX deflator)	-2,394	3	-6,641**	3

Sample period: 1971:1 to 2000:4, excluding the *ex post* forecasting period from 2001:1 to 2002:2

Notes: Seasonally adjusted data. Critical values for the rolling ADF test statistic were obtained from Banerjee, Lumsdaine and Stock (1992), and for the PP test from MacKinnon (1991).
The ** indicates (stationary) significance at a 5 per cent level.

All variables with the exception of the two interest rate measures are measured in logarithms. Values of the test statistic that are less than the critical value (in absolute terms) indicate rejection of the null hypothesis that the variable is stationary. Two findings are therefore of interest. First, according to the minimum rolling ADF test, all variables are non-stationary in levels. Second, the less powerful (under conditions of structural changes) PP test does not reject the hypothesis of a unit root in the interest rate spread (s-own) and in the price variable (Δp). With the exception of these variables, all the other variables are non-stationary using the PP test.

5.3 A single-equation error-correction representation of M3 money demand

This section presents estimates for the single-equation, error-correction model for a South African money demand function. The starting point for the econometric analysis is to estimate a deliberately overparameterised money-demand equation in order to explore the dynamics of the equation. After experimentation with several lag lengths and combinations of variables, the following estimated (parsimonious) version of Equation 1 was found to fit the data sufficiently well (see Table 2). All variables are in logarithms with the exception of the interest rate variables.

To avoid bias and to obtain more efficient parameter estimates, the complete structural error-correction equation was estimated in one step (allowing for up to two lags for the changes of the variables without imposing any restrictions). In addition, an inflation variable with its own lag was included. The inflation rate is often interpreted as measuring the opportunity cost of holding money. The significance of the error-correction term suggests that money, income and long-term interest rates are cointegrated.

The long-run relationship underlying Equation 1 (reflected in Table 2) is:

$$(m - p)_t = 1{,}84\, y_{t-1} - 2{,}76\, l_t - 5{,}11(s\text{-}own)_t \qquad (2)$$

The long-run income elasticity suggests that a 1 per cent increase in income leads to a 1,84 per cent increase in real M3 money demand. The same interpretation holds true for the semi-elasticities of the short-term interest rate spread and the long-run interest rate, which is, for example, obtained by dividing the semi-elasticity of (–0,0022*100) by the adjustment parameter of 0,07957.

Table 2 Real M3 money demand equation

Dependent variable: $\Delta(m - p)_t$
Method: Least Squares
Sample: 1971:1 to 2000:4 (hold-out period for *ex post* forecasting evaluations: 2001:1 to 2002:2)
Included observations: 120

Variable	Coefficient	t-Statistic	Probability	Watson-Davies test phi-value	Watson-Davies test p-value
$(m - p)_{t-1}$	-0,079573	-3,279306	0,0014	0,550	0,334
y_{t-2}	0,146609	4,078262	0,0001	0,850	0,331
l_{t-1}	-0,002201	-2,764598	0,0067	0,550	0,431
$(s\text{-}own)_{t-1}$	-0,004072	-2,644959	0,0094	0,550	0,865
constant	-0,671008	-3,394973	0,0010	0,550	0,431
$\Delta(s\text{-}own)_t$	-0,003128	-1,600007	0,1124	0,850	0,524
Δp_t	-1,057700	-8,768821	0,0000	0,550	0,301
Δp_{t-1}	0,582152	4,015809	0,0001	0,550	0,320
$\Delta(m - p)_{t-1}$	0,444134	5,353259	0,0000	1,000	0,239

R-squared	0,625297	Mean dependent variable	0,007354
Adjusted R-squared	0,598291	S.D. dependent variable	0,018410
Standard error of regression	0,011668	Akaike inform. criterion	-5,991885
Sum squared residual	0,015112	Schwarz criterion	-5,782823
Log likelihood	368,513100	F-statistic	23,154290
Durbin-Watson statistic	1,915046	Probability (F-statistic)	0,000000

Notes: *Δ = time difference of a series on a quarter earlier: $\Delta x_t \equiv x_t - x_{t-1}$, where x_t denotes a time series at time t =1,….,T.*

List of variables

m	=	*weighted averages of the monthly M3 money demand*
p	=	*consumer price index, excluding mortgage interest rates (measured by the CPIX deflator, 1995=1)*
y	=	*gross domestic product at constant 1995 market prices (proxy for the volume of real transactions in an economy)*
l	=	*long-term nominal interest rate (10-year government bond yield)*
s	=	*short-term nominal interest rate (prime overdraft rates)*
own	=	*a weighted average of short-term, medium-term and long-term deposit rates (own rate of return on M3 holdings)*

5.4 Stability of the M3 money demand model

5.4.1 Diagnostic tests and recursive estimates

The quest for a well-determined, stable money-demand relationship is a pragmatic consideration for those using macroeconomic structures for forecasting purposes. Another motive for studying the long-term stability of money demand is its significance for monetary policy.

It has sometimes been argued that money demand instability is due to erroneous model specification, and that a more adequate treatment of non-stationarity might solve this problem to some extent. The two results mentioned support the evidence that even though the separate modelling of short and long-run effects of monetary policy (built into an error-correction model) is a possible strategy, some important problems still remain. In particular, error-correction models do not seem to be able to overcome the time instability of more traditional money-demand functions (see Garcia-Ferrer and Novales, 1998).

It should be borne in mind that the stability tests actually focus on the stability of the entire equation (including its short-run dynamics, and not just its long-run parameters). Therefore, if such a test were to reveal instabilities, this would not necessarily imply instability in the long-run parameters of the money demand equation.

A battery of stability tests[7] is presented in Table 3 to determine the stability of the money demand relationship (see Feldstein and Stock, 1994).

7 *The graphical analysis of the respective tests is available from the author on request.*

Table 3 Tests for structural breaks

Model	Was structural stability observed with the following diagnostics/tests?					
	Chow test dates			Recursive tests		
	1986:2	1990:2	1993:1	CUSUM	CUSUM of squares	Recursive coefficients
M3 money demand	Yes (p=0,04)	Yes (p=0,08)	Yes (p=0,08)	No	Yes (in 1990:1)	Yes (for y and Δp coefficients)

Note: The log-likelihood p-values of the Chow test are in brackets.

The Chow test for a mid-sample break (1986:2) rejects the hypothesis of parameter constancy. The first break coincides with the start of an era of flexible money supply targeting. Important financial innovations in the financial sector of the economy (i.e. the use of credit cards and the introduction of automatic teller machines) were also introduced in the 1980s. The second break in 1990 was associated with a change in the monetary policy regime (in which price stability was greatly emphasised) and the third break relates to the abnormal demand for money prior to the 1994 elections.

The plots of the recursively estimated parameters, mentioned in Table 3, suggest further that the long-run income and short-run inflation coefficients are slightly unstable over the estimation period. This conclusion is supported by evidence obtained from the CUSUM test and the CUSUM of squares test.[8] With the possible exception of the CUSUM test (the less powerful of the two), these plots do not provide conclusive evidence that the demand-for-money equation is stable. This instability was also largely confirmed by the results of the varying-parameter regressions.

8 *These tests plot the cumulative sums and sum of squares of the residuals against two 5 per cent critical lines over time.*

In the analysis of the long-run stability of the relationships, the recursive estimates of the coefficients in the dynamic OLS regression on M3 become less volatile as the sample size increases. However, sequentially updated parameter estimates tend to cloud the distinction between revisions of estimates due to the increase in the sample size and the behaviour of parameters driven by the potentially time-varying processes. A more formal test for parameter stability was therefore conducted using the Watson-Davies test described earlier.

5.4.2 A varying-parameter regression analysis

Financial innovations affect the demand for money. These innovations are seldom radical and their adaptation is usually gradual. They are essentially an unobserved variable in money demand regressions, and one hopes that future research will help to account for their effects more thoroughly.

To provide and illustrate additional details on the stability of the parameters in the model, a single-equation money demand function based on the specification of Equation 1 was estimated, where a VPR technique was adopted, i.e. a technique that allows the model coefficients to vary randomly (based on the Kalman filter).[9] The Watson-Davies test can be used as a guide to determine the time-varying process of the parameters. When phi is 1 (or close to 1), the process is equivalent to a random walk or an I(2) smooth trend, otherwise an AR(1) may be specified. With this tool, it is possible to look at the evolution of the parameters over time. All model coefficients were allowed to vary independently one at a time, and the evolution of the long-run coefficients of the monetary equilibrium and the adjustment coefficient of the monetary disequilibrium can be implicitly calculated from the trend of the respective elements of the state variable. The final estimate of the single money demand equation using a VPR method was found to be broadly in line with the OLS estimates.

9 The estimation carried out in this section was done using Forecast Master Plus (FMP) and Eviews4. FMP automatically fits a VPR model to the data to control the transition of the time-varying parameters from one point in time to the next.

The values of the long-run coefficients are displayed in Figure 4. The graphs show the evolution of the income coefficient, the interest rate spread coefficient, the long-term bond rate coefficient and the adjustment coefficient from 1971:1 to 2002:2. All parameter estimates are smoothed-trend estimates, using the Kalman filter estimation technique.

The coefficient on income in the M3 specification, which accounts for the trend behaviour of velocity (under the assumption of price stability), seems to be drifting upwards. The upward drift in income elasticity is commensurate with the decrease in velocity since 1994. The constant, the interest rate spread coefficient as well as the adjustment coefficient, shows a fairly stable picture over time. Although there are some fluctuations in the short-term interest rate spread coefficient and the long-term bond rate coefficient, their scales are absolutely negligible. The long-term bond rate coefficient, however, turns positive towards the end of the sample period, which is in line with the greater uncertainty surrounding the estimate of this coefficient in the linear model (see Brand, Gerdesmeier and Roffia, 2002). The demand for money equation appears to be stable before 1994, implying a close link between the demand for money and income. Since then money demand has been less predictable and the relationship appears unstable.

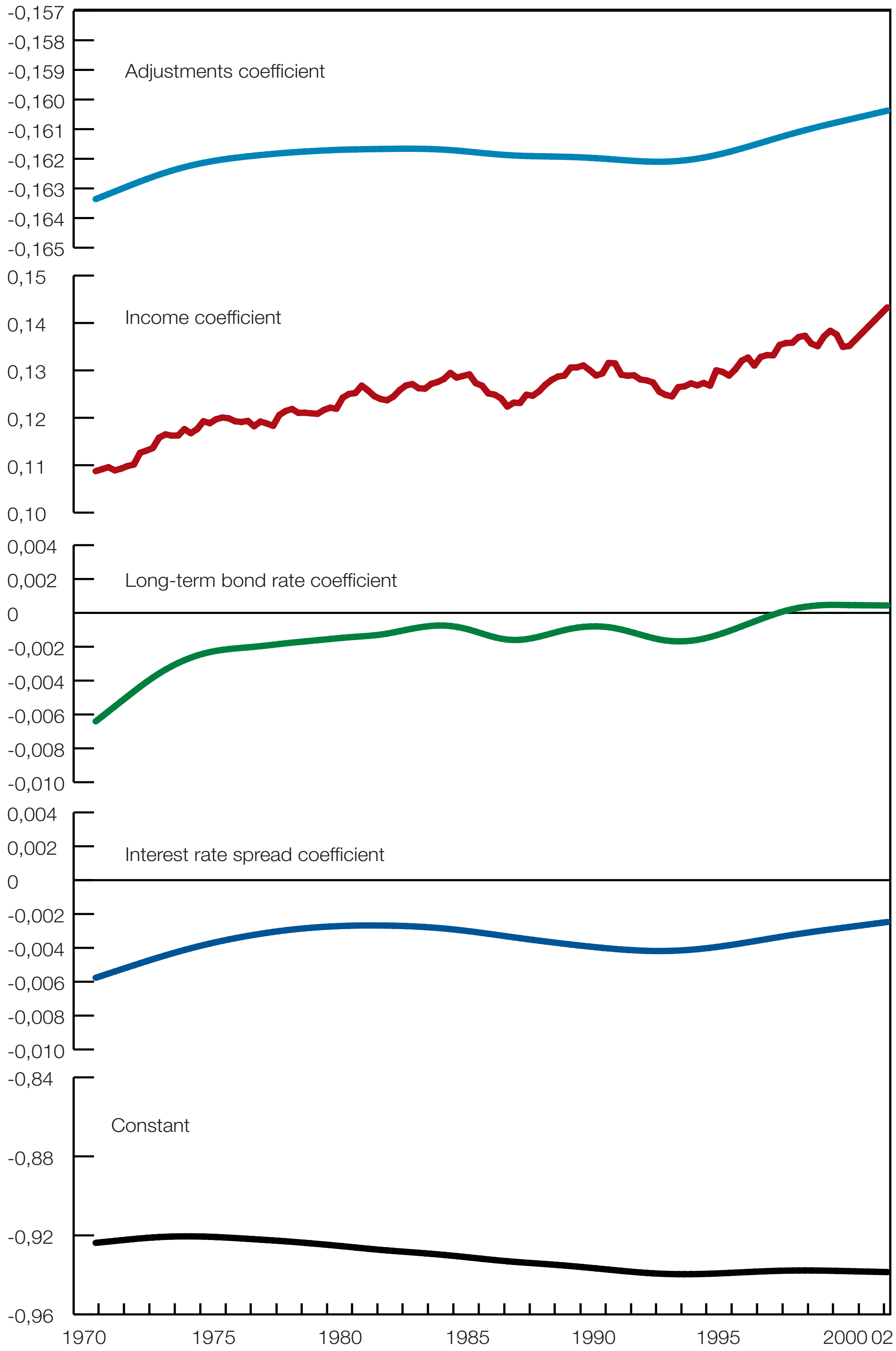
A striking feature of the stochastic estimates of the adjustment coefficient (corresponding to α in Equation 1) is that it is about half the size of the respective coefficient obtained within the VPR approach. Therefore, the forces pulling the variables towards the monetary equilibrium are generally slower in the fixed-coefficient model. However, the VPR model suggests that these forces have varied over time; and that from about 1991 to 1994 they seem to have been particularly weak.

Though these results imply that there is considerable variation in the income coefficient, accounting for the declining velocity trend, the interest rate coefficients of the demand for M3 are remarkably stable. Since the income velocity of circulation of M1 and M2 money shows a decline from 1980 (see Figure 3), a similar behaviour was observed in the long-run income parameter of these functions.[10] The greatest benefit of incorporating time variation might accrue from modelling the cointegrating

10 Except for the income parameter, the other long-run parameters of the M1 and M2 equations behaved in a fairly stable manner over the sample period.

relationship as evolving slowly over time. The use of rolling windows and recursive estimation of the cointegrating relationship probably does not capture the behaviour of money demand adequately (Brand et al., 2002).

Figure 4 Evolution of long-run coefficients in the money demand equation



6. Forecasting

Regardless of the monetary policy framework in South Africa, the stability of the money demand function cannot be ignored when monitoring and forecasting inflation developments. In spite of being such an important tool for policy analysis, the tradition of empirical research on the specification and estimation of money demand is in all countries a sequence of notorious prediction errors, explained *ex post* by the need to incorporate dummy variables to take care of events which were unforeseeable *(a priori)* and additional lags to capture forecast errors in the vicinity of turning points. The purpose of the study is to evaluate the extent to which the time instability of money-demand functions leads to a deterioration in the forecasting performance of the model.

The out-of-sample testing procedures of Ericsson (1992) were used to evaluate the forecasting performance of the models. The underlying intuition is that it is easy, with time series data, to secure a good within-sample fit, and the real test is whether it can predict beyond the sample better than a simpler approach such as the fixed-coefficient error-correction method. The root mean square errors (RMSE) of the estimated models were used for evaluation purposes. Forecasting with sequential estimation is less appropriate for exposing and isolating the potential weaknesses inherent in fixed-coefficient modelling. To illustrate, sequentially updated parameter estimates tend to cloud the distinction between revisions of estimates due to the increase in the sample size and the behaviour of parameters driven by the potentially time-varying processes.

The forecasting performance of the fixed-coefficient money demand model was compared with that of a number of alternative, varying-parameter specifications. This exercise is crucial, because the standard use of empirical money demand functions in monetary policy design is a pure forecasting exercise. Standard ARIMA specifications, as well as more ad hoc simple reduced-form models used as baseline references, perform generally better in out-of-sample forecasting (Swamy et al., 1990). However, one has to accept that reduced-form models are less affected by time-varying parameters. Running the Kalman filter specifying different VPR processes for each long-run parameter (one at a time) yields the out-of-sample root mean square errors (RMSEs) presented in Table 4.

Table 4 Root mean square errors for different VPR specifications over 2001:1 to 2002:2

VPR process selected for varying parameter	Selected variable with varying long-run parameter in the M3 equation (and % improvement over fixed-coefficient specification)				
	$(m - p)_{t-1}$	y_{t-2}	I_{t-1}	$(s\text{-}own)_{t-1}$	constant
VPR = random walk	0,0109 (16,79%)				0,0131 (0,0%)
VPR = AR(1)		0,0133 (0,01%)	0,0109 (16,79%)	0,0105 (19,85%)	

The equation was fitted on data from 1971:1 to 2000:4, which were used to generate out-of-sample predictions of M3 demand in the period 2001:1 to 2002:2. These predictions are "dynamic", that is, actual values of the exogenous and lagged dependent variables have been used to compute predictions of money growth. The out-of-sample RMSE of the fixed-coefficient money demand model was calculated to be 0,0131. In most cases the VPR specification outperformed its fixed-coefficient counterpart in terms of RMSE, because the VPR model uses the last available value of the changing parameter over the forecast period. The best forecasting results, in which a 19,85 per cent improvement over the fixed version was observed, was obtained from the VPR model, specifying the *(s-own)* parameter as an AR(1) process. This could be due to the fact that this parameter is following some AR(1) process which yields a more reliable parameter for forecasting purposes. Since the forecast of the VPR model uses the last available value of the changing parameter over the forecast period, it will almost certainly yield better forecasts than a model that uses a fixed-averaged parameter over the entire data set.

As a final caveat, it should be emphasised that in actual prediction environments the relevant future values of the independent variables are generally not known and would also have to be projected (i.e. exogenous assumptions and endogenous results of the model tend to have an impact on the forecasting ability of the model as well).

7. Summary

Financial liberalisation and changes in the technology of payments and settlements have led to large volatilities in money demand worldwide. As a result, the parameters of the money demand function could be dominated by the technology of transaction services, and may be unstable over time. Therefore, the instability derives not from the irrelevance of money, but rather from changes to technology and from financial liberalisation.

In South Africa the economy has also undergone a number of important structural changes during the past two decades, including the relaxation of exchange controls and the integration of the South African financial market into the global financial markets. These might have caused money demand functions to become structurally unstable.

The first issue in this study was to determine whether a fixed-coefficient error-correction method could overcome the traditional instability inherent in standard money-demand functions over the period 1971:1 to 2000:4. Though the results imply that there is considerable variation in the income coefficient, reflecting the declining income velocity of money, the interest rate coefficients of the demand for M3 are remarkably stable. Even though the relationships investigated were not completely stable, much of their instability seemed to be evolving over time. That is, the changes in the long-run income coefficient appear to occur gradually. This observation suggests that a modelling strategy that allows the parameters to vary over time (rather than holding them constant) would better explain a money demand equation and therefore improve its forecasting ability.

Forecasts from fixed-coefficient and varying-parameter regression models for money demand were generated for the quarters 2001:1 to 2002:2. The forecasting performances were compared in terms of root mean square errors (RMSEs). The fixed-coefficient models' forecast errors were fairly large, and the time-varying coefficient models seemed to produce better forecasts than the fixed-coefficient alternatives.

Through testing the stability and modelling the evolution of long-run parameters in the money demand equation, this study may contribute to a better understanding of the effects that financial liberalisation and innovation have on broad money demand in South Africa. The nexus between monetary policy and the stability of money demand has not been removed by the switch to inflation targeting, and the debate about the stability of the South African money demand remains relevant. Long-run causality from money growth to price inflation may exist due to an accommodating monetary policy or the use of inflation targeting by the monetary authority, but the long-run stability of money demand may be affected by the changes and turbulence evident in the financial sector since the mid-1990s.

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