

## **South African Reserve Bank Working Paper**

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### **Where has all the money gone? Wealth and the demand for money in South Africa**

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George S Tavlas***

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**South African Reserve Bank**

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**South African Reserve Bank Working Paper**  
Research Department

**Where has all the money gone? Wealth and the demand for money in South Africa\*\***

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**Abstract**

After trending upward for about 25 years, the income velocity of money in South Africa reversed course in 1994 and began a steep decline that continues to the present day. Some writers have argued that the change in income velocity is symptomatic of an unstable demand for money, the implication of this argument being that movements in the money supply provide little useful information about medium-to-long-term inflationary developments. We argue otherwise. Our basic premise is that there is a stable demand-for-money function but that the models that have been used to estimate South African money demand are not well specified because they do not include a measure of wealth. Using two empirical methodologies – a co-integrated vector equilibrium correction (VEC) approach and a time-varying coefficient (TVC) approach – we find that a demand-for-money function that includes wealth is stable. Consequently, our results suggest that the present practice of the South African Reserve Bank whereby M3 is used as an information variable in the Bank's inflation-targeting framework is well-placed.

JEL classification: C20; E41

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## 1 Introduction

The stability of the demand for money has been a recurring area of interest of empirical research on the South African economy. Underlying this interest in the behavior of money demand is the potential role of movements in monetary aggregates as indicators of future developments in inflation. Specifically, if a stable relationship exists between the demand for money and its determinants, changes in the money supply can provide useful information about inflation in the medium and longer terms<sup>4</sup>.

Although earlier (*i.e.*, pre-late 1990s) work on South African money demand suggested the existence of a stable relationship between M3, the monetary aggregate targeted by the South African Reserve Bank from 1985 – 99, and its determinants<sup>5</sup>, recent work has provided mixed results. In this connection, Moll (1999), using quarterly data over the interval, 1960:1 – 1996:4, found that money-demand relationships did not cointegrate. Based on his findings, the author called into question the use of M3 as an intermediate-target variable (Moll, 1999, p. 59). Nell (2003), using annual data over the estimation period, 1965 – 99, and a vector equilibrium correction (VEC) estimation approach, found that, while money-demand was stable during 1965 – 1997, the addition of data for 1998 and 1999 resulted in unstable and insignificant coefficients. Similarly, Tlelima and Turner (2004), using an error correction model and employing data over the period, 1970:1 – 2002:3, found “strong evidence” of instability in their estimated equation. In contrast to the above results, Moll (2000) used a general-to-specific specification search and found evidence of stability for the period 1965:3 – 1998:3. Jonsson (2001), employing a structural VEC to estimate a relationship among money, prices and the exchange rate during 1970:1 – 1998:2, found evidence of a stable money-demand-type relationship. Todani (2005) used VEC estimation on quarterly data over the sample period 1980:1 – 2003:4 and found evidence of stability until 1998, but instability over

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<sup>4</sup> The view that money demand needs to be viewed as a long-run relationship was put forth by Friedman (1959), who estimated the demand for money in the United States using time-series data that treated each business cycle as a single observation – in other words, the data abstracted from the cycle. Also, in his empirical specification, Friedman did not include a lagged dependent variable to pick up short-run adjustment costs. The view that a stable money-demand function provides information about medium-to-longer-run inflationary developments is a key component of the monetary framework used by the European Central Bank. See Issing, Gaspar and Angeloni, and Tristani (2001).

<sup>5</sup> See, for example, Tavlas (1989) and Hurn and Muscatelli (1992).

the entire sample period. Todani also obtained a very high (i.e. 3,2) income elasticity, a result that the author argued could be due to omitted variable bias.

This paper considers South African money demand in the context of the portfolio-balance framework proposed by Brainard and Tobin (1968) and Tobin (1969)<sup>6</sup>. This framework contains the following implication for the empirical specification of money demand. Unlike other conceptual approaches, which treat income and wealth interchangeably as determinants of transactions money demand, in the portfolio-balance model wealth is the variable that constitutes the total budget constraint on the holdings of assets, including money. An increase in wealth results in increased demands for all assets, whereas an increase in income increases the demand for money at the *expense of* other assets, so that *both* income and wealth belong in the money-demand function. However, in light of the absence of a measure of wealth, empirical work on South African money demand has used income, in the place of wealth, as the scale variable<sup>7</sup>. In this paper, we use stock-market valuation as a proxy for wealth, and we consider a variable that captures the difference between real stock-market valuation and real income as a determinant of money demand. It is important to stress that the wealth variable should in theory include all wealth, that is, financial wealth, housing wealth, human wealth, and other assets. In the absence of reliable data, a proxy for this variable is included in the money-demand function.

The idea that the demand for money can be related to the level of stock-market prices was proposed by Friedman (1988), who argued that a negative relation between equity prices and monetary velocity (or direct relation between stock prices and the level of real cash balances per unit of income) can be explained in three ways. (1) A rise in equity prices involves, other factors held equal, an increase in wealth and generally, given the wider fluctuations in stock prices than in income, also in the ratio of wealth to income. The higher wealth-to-income ratio can be expected to be reflected in a lower velocity, or a higher money-to-income ratio. Friedman (1988) considered the nominal value of equity values in his empirical work. Our focus is on

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<sup>6</sup> Friedman (1956) also argued that a fully-specified money-demand model should include both income and wealth. Friedman, however, did not propose a portfolio-balance framework.

<sup>7</sup> As Tielima and Turner (2004:26) noted, “we rarely have good data for [South African] wealth and 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”.

the missing impact of *real* wealth on money demand, so that we consider *real* equity values. (2) A rise in equity values may reflect an increase in the expected return from relatively-risky assets compared with relatively safe assets (such as money). Since the change in relative valuation needs not be accompanied by a lower degree of risk aversion or greater risk preference, the resulting increase in risk could be offset by increasing the weight of relatively safe assets in the aggregate portfolio, for example by increasing the weight of short-term fixed-income securities plus money. (3) A rise in equity prices may imply a rise in the nominal value of financial transactions, raising the demand for money-for-transactions purposes<sup>8</sup>.

Our basic premise is that there is a stable, but complex, demand-for-money function, but the models that have been used to estimate South African money demand are not well-specified, given that they do not include a measure of wealth<sup>9</sup>. The level of wealth, as proxied by stock-market valuation, has been rising in recent years. If money demand depends on wealth (in addition to real income and an opportunity cost variable), then, all other factors held the same, the demand for money should rise because of the increase in wealth. Alternatively, the rise in wealth, *in and of itself*, should have contributed to a decline in velocity. Consequently, we argue that in the absence of a well-specified model that includes wealth, studies on South African money demand that incorporate recent data tend to exhibit instability. We adopt two empirical methodologies to shed light on this issue – a co-integrated vector equilibrium correction (VEC) approach and a time-varying coefficient (TVC) approach. The latter approach is designed to reveal the biases in coefficients that may result from model misspecifications. Applying the VEC methodology to a portfolio-balance model, our results provide support for the view that a portfolio-balance specification of M3 demand is stable over the estimation period, 1970:Q1 – 2006:Q4. Two key implications of our results are the following. First, it is important to

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<sup>8</sup> Offsetting these three factors is a substitution effect; the higher the real stock price, the higher the rate of return on equities, so that holding equities is more attractive compared with money. As Friedman (1988) noted, the relative strength of these various factors is an empirical issue.

<sup>9</sup> By “complex” we do not mean that the stable demand-for-money function is necessarily complicated, but that it may be non-linear with several heteroscedastic and contemporaneously and serially correlated error terms, with possibly more explanatory variables than included in the models presently used to estimate South African money demand. This stable model may appear complicated, but is the result of correcting for model misspecifications which, if uncorrected, can result in misestimated coefficients. Before accepting a model as well-specified, it is a good idea to check whether appropriate corrections for the model misspecifications have been applied to it, since model misspecifications are unavoidable for reasons given in Swamy and Tavlas (2001). Zellner (2007:335) is a critic of complicated models.

incorporate a wealth variable in the money-demand specification. Second, although we do not suggest that target ranges for M3 growth should be resuscitated, we do suggest that the time has not yet arrived to relegate M3 to the dustbin. While the effects of the determinants of the demand for M3 may be time-varying, M3 continues to provide useful information about inflation from a medium-to-long term prospective.

The remainder of the paper consists of four sections. Section 2 presents some stylised facts about the South African economy. Section 3 presents the model and the empirical approaches. Section 4 describes the data and presents the empirical results. Section 5 concludes.

## 2 **Stylised facts**

Beginning in 1985, the South African Reserve Bank adopted target ranges for growth in M3; the target ranges were gradually lowered in order to reduce (CPI) inflation, which peaked at rates near 20 per cent in the mid-1980s (see Figure 1). M3 growth often exceeded the upper limits of its target ranges during the period 1986 – 99, but inflation nevertheless declined, falling to about 7 per cent in 1999 (see Figure 1). Although the South African Reserve Bank emphasised that the money growth ranges should be interpreted as informal guidelines, in practice a more eclectic approach was apparently followed (Jonsson, 2001:244). The approach involved the monitoring of a number of indicators, including various price indices, the shape of the yield curve, the nominal exchange rate, and the output gap.

The use of guidelines for M3 growth was predicated on the supposition that a stable relationship existed between changes in M3 and changes in key macroeconomic variables. During the 1980s and (especially) the 1990s, however, a number of structural changes in the South African economy appeared to alter the relation between M3 and GDP. These changes included the growing integration of global financial markets, the related increase in non-resident participation in South Africa's financial markets following the liberalisation of those markets, the gradual relaxation of exchange controls, and the extension of banking institutions (Casteleijn, 1999). One result of these changes was that M3 income velocity, which followed a generally rising trend between 1970 – 93, changed course thereafter, falling by an average rate

of about 3 per cent annually from 1994 – 2006 (see Figure 2). In light of the ongoing changes that had occurred during the 1990s, the South African Reserve Bank adopted a monetary-policy “package”, under which, in addition to movements of M3, other leading indicators, including movements in the exchange rate and changes in bank credit, were taken into account in the formation of monetary policy.

In February 2000, the South African Reserve Bank moved to a formal inflation-targeting framework. Under this framework, the Minister of Finance, in consultation with the Governor of the South African Reserve Bank, announces target ranges for the overall consumer price index excluding the effects of changes in mortgage costs. In November 2003, an annual average specification for inflation was replaced by a continuous range under which the target range was expected to be achieved each month (on a year-over-year basis) in “the coming years” (van der Merwe, 2004, p. 6). The range that was specified for the years 2005 and 2006 was 3 to 6 per cent. As shown in Figure 1, inflation was within its target range in both those years. At the same time, M3 growth accelerated to rates in the vicinity of 15 to 20 per cent. Consequently, the following question arises. What has kept the robust growth rate of M3 from feeding through into inflation? Alternatively, what has caused the decline in income velocity?

As we have argued, a rise in real wealth may have contributed to the decline in income velocity (or the rise in real money-demand) observed since 1994. Moreover, we have noted that, in the absence of a comprehensive measure of wealth for South Africa, we will use share market values as our proxy of wealth. Figure 3 shows the evolution of nominal share market values, real share market values (nominal share market values divided by the GDP deflator) and real income. As shown in the figure, after remaining fairly stable (on balance) from 1970 until 1992 (though subject to considerable volatility), real share market values began an upward trend in 1993. Real share market values rose by an average of about 10 per cent per year between 1993 and 2006. We now proceed to an analysis of the impact of real wealth, as measured by real share market values, on the demand money.



### 3 Theoretical and empirical underpinnings

#### 3.1 Theoretical framework

As noted above, our approach is to use the portfolio-balance model to estimate the demand for money. Specifically, assuming that the asset choices of investors involve money (M) and equities, the demand for real money balances can be written as follows:

$$m - p = f(y^+, w^+, r^m - \dot{p}^e, r^i - \dot{p}^e) \quad (1)$$

where  $m$  is the log of nominal M3,  $p$  is the log of the price level,  $y$  is the log of real income,  $w$  is the log of the real value of wealth,  $r^m$  is the own rate of return on money,  $\dot{p}^e$  is the expected inflation rate, and  $r^i$  is the rate of return on t-bills. In Equation 1, real rates of return are approximated by nominal rates minus the expected inflation rate.

We also assume rate-of-return homogeneity of degree zero, implying that, if all rates of return change by  $x$  per cent, real quantities of assets in investors' portfolios relative to real income and real wealth will not change. Thus, only rates-of-return differentials affect money demand. Rate-of-return homogeneity implies that we can use interest differentials, selecting one of the assets as numeraire; we use  $m$  as a numeraire. Therefore, the money-demand function can be re-written as:

$$(m - p) = f(y^+, w^+, r^i - r^m) \quad (2)$$

When  $f$  is linear, the money-demand function (in semi-logarithmic form) becomes:

$$(m - p)_t = a_0 + a_1 y_t + a_2 w_t + a_3 (r^i - r^m)_t + u_t \quad (3)$$

where  $u_t$  is an added error term<sup>10</sup>. Adding and subtracting  $a_2 y_t$  on the right-hand side of (3) gives:

$$(m - p)_t = a_0 + a_1' y_t + a_2 (w - y)_t + a_3 (r^i - r^m) + u_t \quad (4)$$

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<sup>10</sup> Typically,  $u_t$  is assumed to fulfill certain conditions (e.g., independence of  $u_t$  and the explanatory variables included in (3)) to produce unbiased or consistent estimators of the coefficients of (3). For a critique of these conditions, see Pratt and Schlaifer (1988:34). As discussed in Swamy and Tavlas (2001), the TVC procedure is not subject to this critique.

where  $a'_1 = a_1 + a_2$ .<sup>11</sup> The functional form of model (2) may or may not be linear as we assumed here and hence model (4) derived from this linearity assumption may or may not accurately represent a long-run demand function for the real money stock M3. We consider both the possibilities in this paper. Specifically, we consider both a VEC approach that assumes the linearity of (2) and a TVC approach that does not do so.

### 3.2 Estimation approaches

Two estimation procedures – VEC and TVC – are used to assess the properties of money demand. These approaches are very different in nature, but have a surprisingly common underlying philosophy.

The VEC procedure is an implementation of the approach to modeling developed within the dynamic modeling tradition (for a detailed account, see Cuthbertson, Hall and Taylor (1991)). The approach begins with a general statement of the true economic system, referred to as the data generating process (DGP). The DGP, by definition, is correct and well-specified, but the approach also recognises that no empirical model can fully capture the DGP. The process of modeling is viewed as an attempt to provide a reasonable approximation to the DGP (a congruent model) through an iterative search procedure involving marginalising, conditioning and model specification, and an extensive formal set of econometric tests. Even at the end of a successful modeling exercise, a claim of having uncovered the truth cannot be made. All that can be claimed is that a reasonable approximation to certain aspects of the DGP has been found.

The TVC approach (for descriptions, see Swamy and Tavlas (1995, 2001, 2005, 2007)) also takes as its point of departure the idea that there is a true, changing economy. Unlike the VEC approach, however, the TVC approach takes the view that any econometric model is almost certainly a misspecified version of the truth. This misspecification may take the form of omitted variables, endogeneity problems, measurement errors, and incorrect functional form (broadly, the dynamic modeling ideas of marginalisation, conditioning and model specification). These problems are

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<sup>11</sup> Our specification is identical to that derived by Tobin (1969:20, Equation (1.2)), except that Tobin

expected to produce estimated coefficients that will be unstable and time-varying. Hence, a TVC estimation technique is used that tries to identify the causes of the coefficient instability by using a set of 'driving' variables<sup>12</sup>. The idea underlying the technique is to, first, estimate a model with coefficients that are allowed to vary as a result of the fundamental misspecifications in the model, and, then, to identify the specification biases that are occurring in the underlying coefficients and to remove them. If the process is successfully done, we observe a set of biased coefficients, which should exhibit considerable time variation, and a set of bias-corrected coefficients; the latter should reveal the underlying stable parameters of interest<sup>13</sup>.

A great advantage of the TVC approach is that it is robust to the true model being highly non-linear. Non-linearity, of course, is almost certainly the case and we can often see serious problems with standard linear models. For example, many money demand functions find the income elasticity to be above 1. This result, however, cannot be a permanent feature of a model because, if income grows continuously, the money supply would eventually become larger than total income. In fact, either the model must be non-linear or the coefficients must change to ensure that this impossible event does not occur. The TVC approach does exactly this. The VEC approach, therefore, can only really be seen as a local approximation to the true non-linear model. Typically, we would expect that the condition is difficult to specify. In the context of our study, an issue is whether the approximation is a useful and congruent one.

In practice, the VEC approach usually begins by testing for the existence of a long-run equilibrium, or co-integrating, relationship among the variables in Equation (4). If such a relationship exists, it is augmented with lagged differences of those variables and other stationary variables that economic theory may suggest as belonging in Equation (4) in an attempt to capture the short-run dynamics of the variables in the system. Standard methodology employs a three-step procedure. In the first step, the variables are tested for stationarity. The second step involves vector autoregressive (VAR) estimation and misspecification testing, and tests for co-integration. Provided that one or more co-integrating relationships exist, the third step involves the

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included the ratio of income to wealth rather than the ratio of wealth to income.

<sup>12</sup> As noted below, these variables are called "coefficient drivers".

<sup>13</sup> In contrast to the VEC approach, the TVC approach involves no pretesting. For criticisms of pretesting, see Maddala and Kim (1998:229 – 231) and Friedman and Schwartz (1991:47 – 49).

estimation of a VEC specification containing the co-integrating relationship(s), lagged differences of the variables in the co-integrating relationship(s), and any stationary variables thought to influence money demand.

Under the TVC approach, the coefficient of each explanatory variable included in (4) can be viewed as the sum of three terms: (1) A component measuring the direct effect of the explanatory variable on  $m - p$  without specification biases, that is, the bias-free component, (2) the omitted-variables bias component, and (3) the measurement-error-bias component.<sup>14</sup> We are interested in obtaining the bias-free component because if it is zero the relationship between  $m - p$  and the explanatory variable is considered to be spurious<sup>15</sup>. To separate this component from the remaining two components, we use “coefficient drivers” in conjunction with the TVC model<sup>16</sup>. Intuitively, coefficient drivers, which should be distinguished from instrumental variables, may be thought of as variables, though not part of the explanatory variables of money demand, serve two purposes. First, they deal with the correlation between the included explanatory variables and *their coefficients*<sup>17</sup>. In other words, even though it can be shown that the included explanatory variables are not unconditionally independent of their coefficients, they can be conditionally independent of their coefficients given the coefficient drivers. Second, the coefficient drivers allow us to decompose the coefficients of the TVC model into their respective components. TVC estimation is apt to be an especially relevant procedure for capturing dynamics during periods of structural change, as experienced by the South African economy since the early 1980s. In effect, the driver variables are capturing the misspecifications in the econometric model<sup>18</sup>.

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<sup>14</sup> The intercept of (4) also consists of three components (Swamy and Tavlas, 2001).

<sup>15</sup> See Swamy, Tavlas and Mehta (2007). The definition of spurious regression presented by those authors applies to both linear and non-linear regression models and, unlike Granger and Newbold's (1974) definition, takes into account the specification biases contained in the coefficients of those models.

<sup>16</sup> The TVC procedure is required because each of the three components is likely to be time-varying. All the three components are time-varying if the underlying “true” model is non-linear. The omitted-variables bias component is time-varying if the set of omitted variables changes over time and the relationship between included and excluded variables is non-linear. The measurement-error-bias component is time-varying if these errors change over time.

<sup>17</sup> A formal definition of coefficient drivers is provided in Swamy and Tavlas (2006).

<sup>18</sup> Pratt and Schlaifer (1988, p. 49) pointed out that a Bayesian will do much better to search like a non-Bayesian for concomitants that absorb ‘proxy effects’ for excluded variables. The rationale underlying our search for coefficient drivers is identical with the rationale provided by Pratt and Schlaifer for the need to search for concomitants.

We bring together the two estimation approaches in this study. First, we undertake an assessment of the co-integration properties of our model, finding that it supports co-integration. Next, we turn to the TVC approach, using additional variables as coefficient drivers. We find that they do successfully remove the time variation in the estimated coefficients and reveal underlying bias-free components with stable parameters. Thus, in the case of South African money demand, the results from the two techniques support each other.

#### 4 Data and empirical results

The estimates reported below are based on quarterly data for South Africa over the period 1970:Q1 – 2006:Q4. The variables used in the money-demand function are broad money (M3), real GDP, the GDP deflator, the three-month t-bill rate and share prices. The latter series is the value of the All Share Index on the Johannesburg Stock Exchange. In addition to the use of the foregoing variables in the VEC specification, for TVC estimation we used the following coefficient drivers (in addition to the constant term): The lagged change in the inflation rate, the lagged change in the 10-year government bond rate, and the lagged stock returns (measured as the annual per cent change in share prices). All data were obtained from the IMF's *International Financial Statistics* (IFS). M3, real GDP and the GDP deflator were seasonally adjusted. In the absence of the availability of a series on the own rate of return on money, we did not include the own rate in our estimations.

The stock of real M3 (m-p) was measured by the log of M3 minus the log of the GDP deflator. Real income,  $y$ , was measured as the log of real GDP. The t-bill rate was used as the opportunity cost of holding money. A problem that we faced is that a comprehensive wealth variable for South Africa does not exist. Hence, a proxy for the log of real wealth to real income ratio ( $w-y$ ) was constructed as the log of the ratio of observed share prices to nominal income (log of real share prices minus log of real income). That is, we used the share price variable as a proxy for wealth; the proxy was employed to construct a variable that captures the difference between real wealth (as reflected by real stock-market valuation) and real income. The variable representing the return on equities is the annual lagged change in the log of real share prices.

The time series properties of all the variables were evaluated employing standard unit-root tests – the augmented Dickey-Fuller (ADF), Phillips-Perron (PP), and the Kwiatkowski et al. (KPSS) test<sup>19</sup>. All these tests suggested that real money, real income, the ratio of real wealth to real income, the t-bill rate and the 10-year government bond rate were (unit-root) non-stationary, while their first differences were stationary<sup>20</sup>. Stock returns and the annualised inflation rate were I(0). (The annualised inflation rate ( $\dot{p}$ ) was calculated using the change in the log of GDP deflator.) Consequently, real money balances, real income, the t-bill rate and the ratio of real wealth-to-real income were included as I(1) variables in the VAR specification.

#### 4.1 VEC results

Our point of departure in estimating the long-run money-demand equation was to construct a VAR system with the vector of four endogenous variables,  $m-p$ ,  $y$ ,  $(r^i)$ ,  $w-y$ , and one exogenous variable – current changes in the annualised inflation rate ( $\Delta p$ ) (relaxing short-run price homogeneity).

The next step in the estimation procedure involved VAR estimation, misspecification testing and tests for co-integration among the variables<sup>21</sup>. To determine the lag length of the VAR model, alternate versions of the system were initially estimated using different lags. The likelihood ratio test was used to test the hypothesis that all these different versions are equivalent. The test revealed that four lags should be used. Therefore, a VAR model of order four was used in the estimation procedure of co-integration.

The number of co-integrating relationships in the system was tested using the Johansen procedure (Johansen, 1995). This approach enabled us to (a) determine the number of co-integrating vectors and (b) identify and estimate the co-integrating vectors subject to appropriate specification testing. With four endogenous variables

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<sup>19</sup> For a discussion of these tests, see Maddala and Kim (1998:45 – 146).

<sup>20</sup> The linearity of Equation 2 is an important assumption underlying all these tests.

<sup>21</sup> For a discussion of this procedure of estimation and testing, see Maddala and Kim (1998:155 – 242).

in Equation 1 (real money balances, real income, the t-bill rate and the ratio of real wealth to real income), the Johansen procedure yields at most four co-integrating vectors. As shown in Table 1, the tests based on both maximum eigenvalue and trace statistic led to the rejection of the null-of-zero co-integrating vectors in favor of one vector at the 1 or 5-per-cent levels of significance.

It should be noted that the above VAR model is not in a closed form where all the included variables are endogenous. It has one exogenous variable. This model is analogous to that studied by Davidson and Hall (1991). Pesaran and Shin (2002) outline the basic rank and order conditions for identifying the co-integrating vectors uniquely in this model. The basic order condition is that we require  $r^2$  restrictions for exact identification, where  $r$  is the co-integrating rank. One identified co-integrating vector is used to form the money-demand equation. To see how the variables,  $(m-p)_t$ ,  $y_t$ ,  $(w-y)_t$  and  $(r^i)$  in this money-demand equation diverge from equilibrium in the short run, consider the error correction model

$$\Delta(m-p)_t = \alpha + \lambda[(m-p)_{t-1} - z'_{t-1}\theta] + x'_t\beta + \varepsilon_t \quad (5)$$

where  $z'_{t-1} = [y_{t-1}, \Delta(w-y)_{t-1}, r^i_{t-1}]$ ,  $\Delta$  is the first-difference operator, the variables,  $\Delta(m-p)_t = (m-p)_t - (m-p)_{t-1}$ ,  $x'_t = [\Delta(m-p)_{t-1}, \Delta(m-p)_{t-2}, \Delta(m-p)_{t-3}, \Delta y_{t-1}, \Delta y_{t-2}, \Delta y_{t-3}, \Delta(w-y)_{t-1}, \Delta(w-y)_{t-2}, \Delta(w-y)_{t-3}, \Delta r^i_{t-1}, \Delta r^i_{t-2}, \Delta r^i_{t-3}, \Delta p_t]$ , and  $[(m-p)_{t-1} - z'_{t-1}\theta]$ , are  $I(0)$ ,  $[1, -\theta']'$  is the co-integrating vector,  $[(m-p)_{t-1} - z'_{t-1}\theta]$  is the error-correction term (ECT). This equation describes the variation in  $(m-p)_t$  around its long-run trend in terms of a set of  $I(0)$  variables,  $x_t$ , and the error correction,  $[(m-p)_t - z'_t\theta]$ , which is the equilibrium error in the model of co-integration (Greene, 2003, p. 654).

In Table 2, the estimates under the label “(a) Co-integrating Equation” are those of the elements of the co-integrating vector and the estimates under the label (b) parsimonious Dynamic money demand equation estimates” are those of the estimated co-integrating vector reported as Equation (a) and the estimated  $\lambda$ ,  $\beta$  and  $\alpha$ . As shown in this table, the coefficients on income, the t-bill rate and the log of the ratio of wealth to income in the money-demand equation are 1,457, -0,015 and 0,311, respectively; the t-ratio indicate that the estimated coefficients are statistically

significant at the 1-per-cent level. The coefficient on income has the correct sign (that is, the income elasticity of money demand is +1,457), while the likelihood ratio tests (described in Johansen (1992)) reject the null hypothesis that the income coefficient is equal to one at the 5 per cent level of significance (the likelihood ratio (LR) = 4,31).

An inference of the portfolio-balance model is that both income and wealth affect the demand for real money balances; the results reported above support that inference. The coefficient on the log of the ratio of wealth to income indicates that, other things being equal, as the ratio of wealth to income rises, the demand for real money balances also increases. The coefficient on the wealth-to-income ratio is .311, so that if the ratio of wealth to income rises by 10 per cent, we would expect real money demand to rise by about 3,1 per cent. As discussed in Section 2, real share market values rose by an average of around 10 per cent between 1993 and 2006, while the income velocity of money declined by about 3 per cent a year during 1994 – 2006. Real GDP rose by an average of about 3,5 per cent during this period. Thus, the estimated coefficient on the wealth-to-income variable provides an explanation for some of the decline in velocity, although, as we argue below, this estimated coefficient may be too high.

We estimated the VEC recursively to test the stability of money-demand equation. As reported in Figure 4, the recursive estimates of the coefficients of  $y$ ,  $r^i$  and  $w-y$  variables indicate that these coefficients are fairly stable over the estimation period. As shown in Figure 5, the constancy of the coefficients of the short-run money-demand equation was tested using the CUSUM and CUSUM of squares (CUSUMQ) tests. In general, there is no sign of parameter instability in the estimated short-run money-demand equation.

#### 4.2 TVC results

Next, we estimated the long-run money-demand equation using TVC technology. To do so, we modified equation (4) as follows:

$$(m - p)_t = a_{0t} + a_{1t} y_t + a_{2t} (w - y)_t + a_{3t} r^i \quad (6)$$

where the coefficients are time-varying. It is assumed that for  $j = 0, 1, 2$ :



$$a_{jt} = \pi_{j0} + \pi_{j1} z_{1t} + \dots + \pi_{jp} z_{pt} + \varepsilon_{jt} \quad (7)$$

where the  $\pi$ 's are constant parameters, the  $\varepsilon_{jt}$  are contemporaneously and serially correlated as in Swamy and Tavlas (2001, p. 419), and the  $z$ 's are the coefficient drivers. Note that we call the coefficients of Equation 7 “the parameters” and those of Equation 6 “the time-varying coefficients”. Several points about this model are worth noting. First, equation (6) with time-varying coefficients can represent a long-run equilibrium equation even when the latter equation is non-linear. Second, under assumption (7), TVC model (6) gives an improved fixed-coefficient model with one homoscedastic and three heteroscedastic error terms, all which are contemporaneously and serially correlated when equation (7) is substituted into Equation 6. Finally, the explanatory variables of (6) may not be unconditionally independent of their coefficients but can be conditionally independent of their coefficients given the coefficient drivers<sup>22</sup>.

Four coefficient drivers were included in the TVC estimation: The constant, the first difference of lagged inflation rate, the first difference of the lagged 10-year government bond rate and the lagged annual stock returns. Effectively, these coefficient drivers can be viewed as capturing the effects of specification errors, including omitted variables.

For  $j = 1, 2, 3$ ,  $a_{jt}$  is treated as a total coefficient while a portion of  $a_{jt}$  as a bias-free effect. This latter portion is defined as  $\sum_{k \in S_1} \pi_{jk} z_{kt}$ , where  $S_1$  is a subset of  $\{0, 1, \dots, p = 3\}$ . That is, to derive the total coefficients, we used the three coefficient drivers plus the constant term. Next, to identify the bias-free portions, we needed a subset of four coefficient drivers, one of which is the constant term. We settled on a subset of two coefficient drivers to identify the bias-free components: the constant term and the lagged change in the 10-year government bond rate<sup>23</sup>.

<sup>22</sup> For detailed discussions, see Swamy and Tavlas (2001 and 2007).

<sup>23</sup> Other subsets of coefficient drivers yielded very similar results.

Table 3 presents both the total coefficients and the bias-free coefficients. Regarding the total coefficients, the (average) elasticity of income is 1,323<sup>24</sup>; it is statistically significantly different from unity at the 1-per-cent level. The coefficient on the wealth-to-income ratio is positive (0,137) and significant<sup>25</sup> and the coefficient on the t-bill rate is significant and equal to -0,007<sup>26</sup>.

The bias-free coefficients are quite different from the total coefficients. The (average) bias-free income elasticity is 1,236;<sup>27</sup> the null hypothesis that the bias-free coefficient on income equals unity is rejected at the 1-per-cent level. The bias-free coefficient for wealth-to-income ratio is positive and significant (0,090)<sup>28</sup> and the bias-free coefficient for  $r^i$  is negative and significant (-0,009) (Table 3, equation (2))<sup>29</sup>. Figure 6 presents the time profiles of the total coefficients and the bias-free effect yielded by TVC estimation for the real income variable. Figures 7 and 8 provide the corresponding profiles for the wealth-to-income and interest-rate variables.

These time profiles warrant several comments. First, the profiles reported in Figure 6 show that the total coefficient (which is not corrected for omitted-variable and measurement errors biases) on real income has risen over the estimation period, from below unity in the early part of the period to about 1,5 at the end of the period<sup>30</sup>. A rise in the income elasticity of money demand has also been reported in other studies on the demand for money in South Africa. In this connection, Tlelima and Turner (2004:33), using recursive estimation, reported “a long term drift upwards in the value of this [income] elasticity from a value of about 0.5 in 1981 to 1.2 in 2002.” Similarly, Jonsson (2001:257), reported a recursively estimated income coefficient that rose from about 1,2 in the late 1980s to about 2,0 in the late 1990s. Our finding,

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<sup>24</sup>  $(1/T) \sum_{t=1}^T \hat{a}_{1t} = 1,323$ , where  $\hat{a}_{1t}$  is an iteratively rescaled generalized least squares (IRSGLS) estimator of  $a_{1t}$  and T is the total number of observations.

<sup>25</sup>  $(1/T) \sum_{t=1}^T \hat{a}_{2t} = 0,137$ , where  $\hat{a}_{2t}$  is an IRSGLS estimator of  $a_{2t}$ .

<sup>26</sup>  $(1/T) \sum_{t=1}^T \hat{a}_{3t} = -0,007$ , where  $\hat{a}_{3t}$  is an IRSGLS estimator of  $a_{3t}$ .

<sup>27</sup>  $(1/T) \sum_{t=1}^T \sum_{k \in S_1} \hat{\pi}_{1k} z_{kt} = 1,236$ , where  $\hat{\pi}_{1k}$  is an IRSGLS estimator of  $\pi_{1k}$ .

<sup>28</sup>  $(1/T) \sum_{t=1}^T \sum_{k \in S_1} \hat{\pi}_{2k} z_{kt} = 0,090$ , where  $\hat{\pi}_{2k}$  is an IRSGLS estimator of  $\pi_{2k}$ .

<sup>29</sup>  $(1/T) \sum_{t=1}^T \sum_{k \in S_1} \hat{\pi}_{3k} z_{kt} = -0,009$ , where  $\hat{\pi}_{3k}$  is an IRSGLS estimator of  $\pi_{3k}$ .

<sup>30</sup> Recall, the results reported in Table 3 are *average* coefficients.

however, of a stable *bias-free* coefficient, suggests that the upward drift reported by other authors may reflect specification errors, including the omission of a wealth variable. In other words, the (rising) income coefficient reported in previous studies appears to be a manifestation of the income variables' tendency to pick-up the effect of wealth. This conclusion is reinforced by our finding that the recursive estimate of the income coefficient in the VEC specification (with the wealth-to-income ratio included) does not display drift (see Figure 3).

Second, the bias-free coefficient on the wealth-to-income ratio has been stable at around 0,10, despite some volatility in the total coefficient. It is important to stress that, although we are using a proxy for wealth, the bias-free coefficient on the wealth proxy can be free of specification errors, including the effects of omitted variables and measurement errors in the wealth proxy. That is, the bias-free coefficient reflects the impact on money demand due to wealth, provided our corrections for specification errors are accurate. In this regard, a comparison with the coefficient on the stock-market variable that we estimated using the VEC procedure is instructive. That coefficient, estimated to be .311, was not purged of effects stemming from omitted variables and measurement errors. The high value obtained relative to the bias-free estimate could reflect, for example, an upward (omitted-variables' and measurement-erros') bias due to the effects of other components of wealth, such as housing wealth, which tend to exhibit positive co-movements with real share market values, which were excluded from our measure of wealth.

## 5 Conclusions

We have argued that the demand for money in South Africa is a stable function of a small set of variables. In particular, we believe that wealth is an important determinant of money demand and that we may not expect to find a stable relationship if we ignore this important factor using conventional, fixed-coefficient technology. With the portfolio-balance framework as our point of departure, we used stock-market valuation as a proxy for wealth. As we have shown, this specification yields a stable money-demand relationship. Apart from confronting this relationship with a variety of stability tests, all which rely on the assumption of a semi-log linear functional form, how much assurance can we have that this fixed-coefficient

relationship approximates the true underlying relationship? To shed light on this issue, we used a TVC approach, which attempts to remove the biases caused by model misspecifications and attempts to recover the underlying bias-free coefficients of the system. This technique can reveal the underlying set of bias-free coefficients. Thus, both VEC and TVC techniques suggest that there is, in fact, a stable relationship determining the demand for money in South Africa.

To be sure, our measure of wealth is far from comprehensive. One conclusion that emerges from our study is the need for more resources devoted to developing inclusive measures of South African wealth. Another conclusion is the usefulness of testing empirical specifications using both fixed-coefficient and time-varying coefficient estimation methods. In those cases, such as in our specification of a portfolio-balance approach to money demand, in which the methods yield similar results, a linear approximation can be considered useful and congruent. Finally, our results suggest that there continues to be a role for considering movements in the money supply in the formation of monetary policy. A fully-specified money-demand function, that is, a function that includes both income and a measure of wealth, exhibits parameter stability, suggesting that movements in M3 provide useful information about inflation in the medium term. Consequently, our results suggest that the present practice of the South African Reserve Bank whereby M3 is used as an information variable in the Bank's inflation-targeting framework is well-placed.

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## Appendix

**Table 1 Johansen co-integration tests**

Long-run demand for money in South Africa: Sample 1970:Q1-2006:Q4				
VAR of order 4, variables: (m-p), y, $r^i$ , (w-y) relaxing short-run price homogeneity				
<i>Maximum Eigenvalue</i>				
Null	Alternative	Eigenvalue	Critical values	
			95%	99%
r=0	r=1	38.71***	27.07	32.24
r<=1	r=2	12.50	20.97	25.52
r<=2	r=3	9.55	14.07	18.63
r<=3	r=4	1.70	3.76	6.65
<i>Trace Statistic</i>				
Null	Alternative	Trace	Critical values	
			95%	99%
r=0	r>=1	62.48***	47.21	54.46
r<=1	r>=2	23.76	29.68	35.65
r<=2	r>=3	11.26	15.41	20.04
r<=3	r>=4	1.71	3.76	6.65

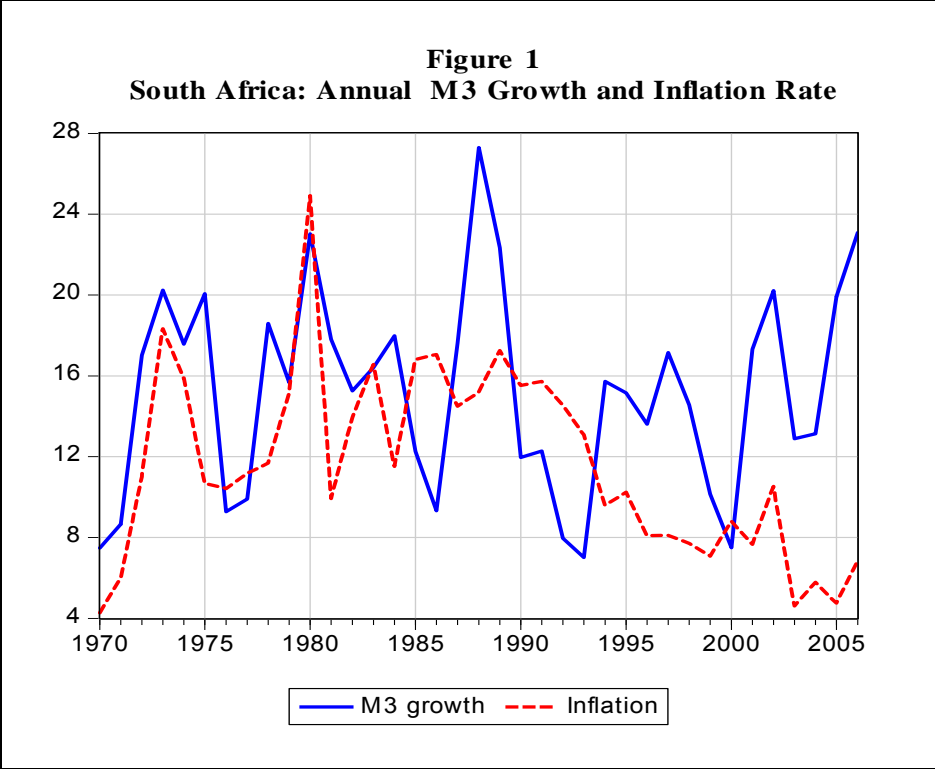
*Note:* r indicates the number of co-integrating relationships. The maximum eigenvalue and trace statistic tests are compared with the critical values from Johansen and Juselius (1990). \*\*, \*\*\* indicates rejection of the null hypothesis at 5 and 1 per cent level.

<b>Table 2 VEC model estimation</b>						
<i>(a) Co-integrating equation</i>						
$(m-p)_t$	$y_t$	$(w-y)_t$	$(r^i)_t$			
1.000	-1.457	-0.311	0.015			
	(-7.41)	(-2.80)	(2.82)			
<i>(b) Dynamic money demand equation estimates</i>						
	Variables					
	Short-run dynamics					
	ECT	$\Delta(m-p)_{t-1}$	$\Delta(m-p)_{t-3}$	$\Delta r_{t-3}^i$	$\Delta p_t$	Constant
Parsimonious model	-0.052 (-4.34)	0.100 (1.65)	0.127 (2.06)	0.003 (2.38)	-0.002 (-10.94)	0.029 (11.25)
R <sup>2</sup>	0.53					
Adj-R <sup>2</sup>	0.51					
F-statistic	30.58					
Sum sq. residuals	0.03					
LM test of Autocorrelation F-statistic	0.98					
ARCH F-statistic	1.42					
Note: t-ratios are in parentheses.						

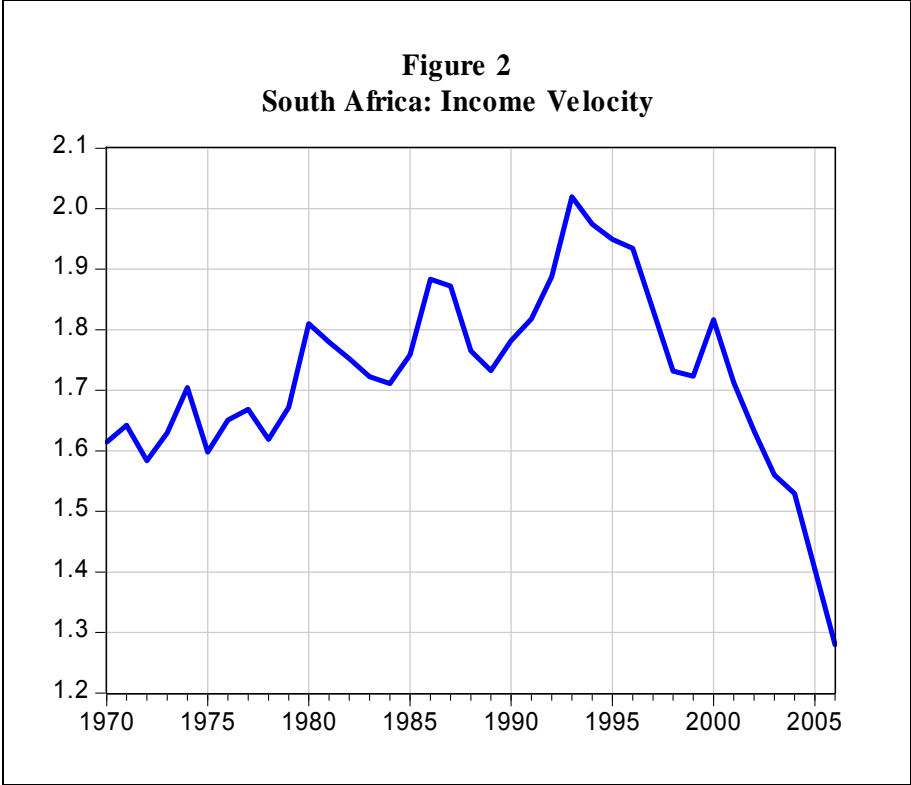
<b>Table 3 TVC Estimation of Long-run money demand for South Africa</b>		
<b>Variables</b>	Total coefficients (1)	Bias-free coefficients (2)
Constant	-10.261*** [-10.86]	-9.117*** [-7.82]
y	1.323*** [14.31]	1.236*** [16.45]
w-y	0.137*** [3.46]	0.090*** [2.04]
$r^i$	-0.007*** [-3.90]	-0.009*** [-4.40]
$\bar{R}^2$	0.99	0.99
Notes: Figures in brackets are t-ratios. *** indicates significance at 1% level. The estimates in column (1) are obtained using as coefficient drivers the constant, one period lagged change in the inflation rate, one period lagged change in the 10-year government bond rate and one period lagged of annual real stock returns. The bias-free effects are estimated using two coefficient drivers: the constant term and one period lagged change in the 10-year government bond rate.		



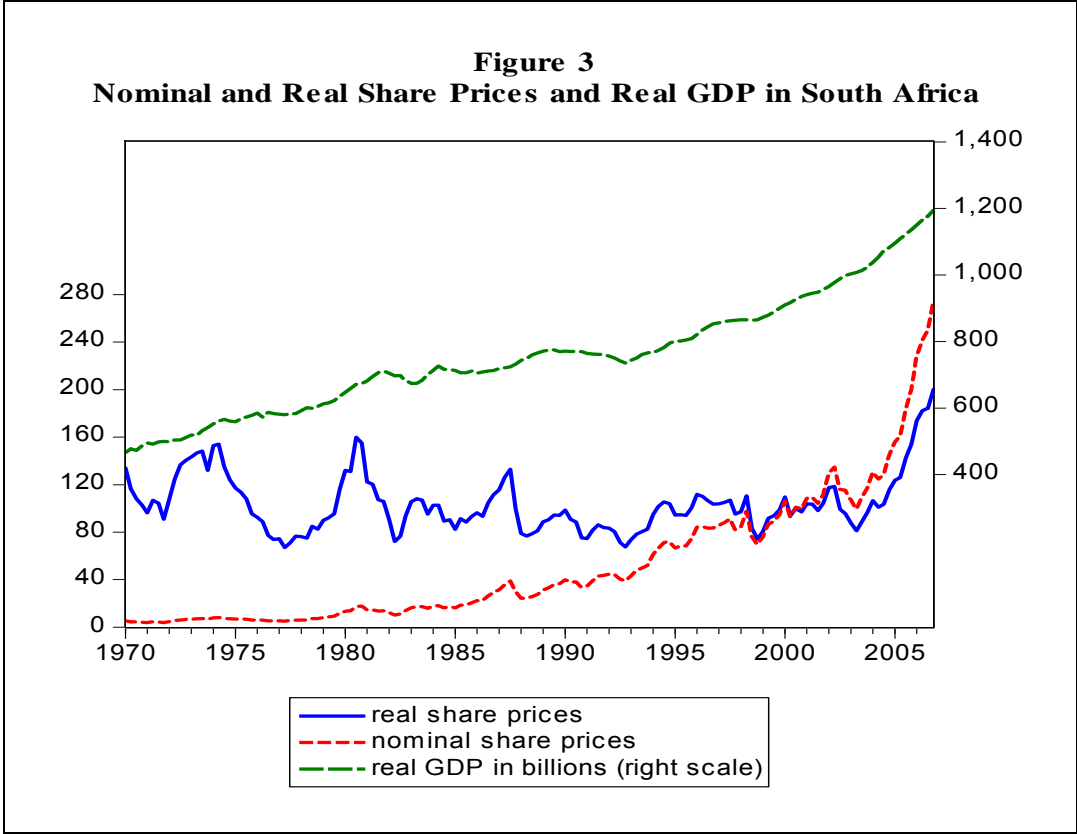
**Figure 1 South Africa: Annual M3 growth and inflation**



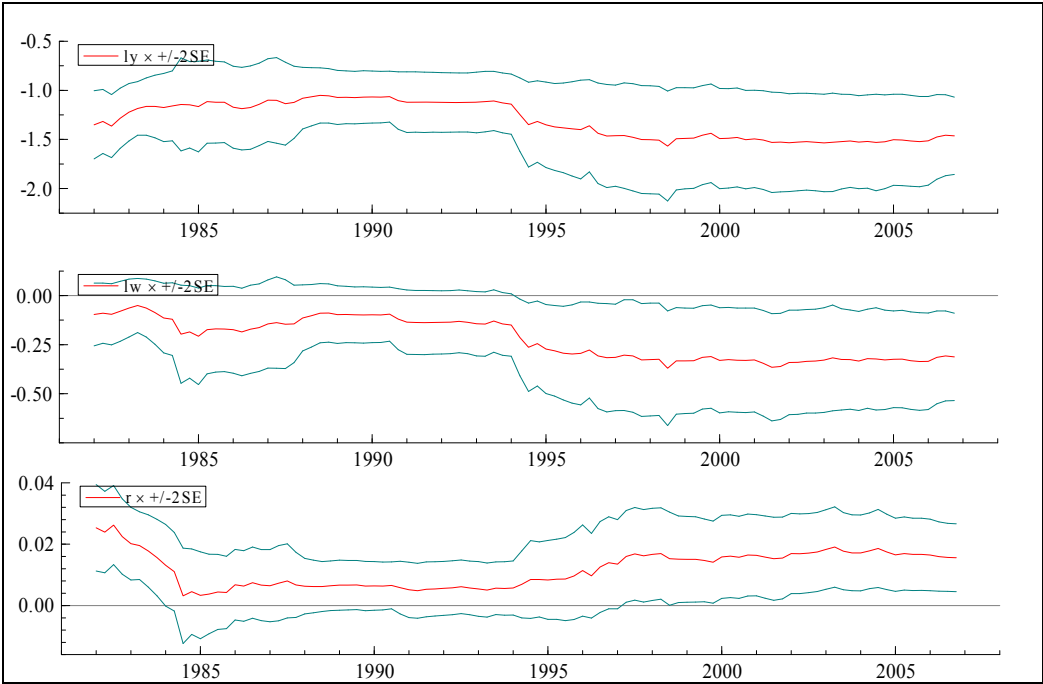
**Figure 2 South Africa: Income velocity**



**Figure 3 Nominal and real share prices and real GDP in South Africa**



**Figure 4 Recursive estimates of long-run money-demand equation**



**Figure 5 CUSUM and CUSUMQ tests for the short-run money-demand equation**

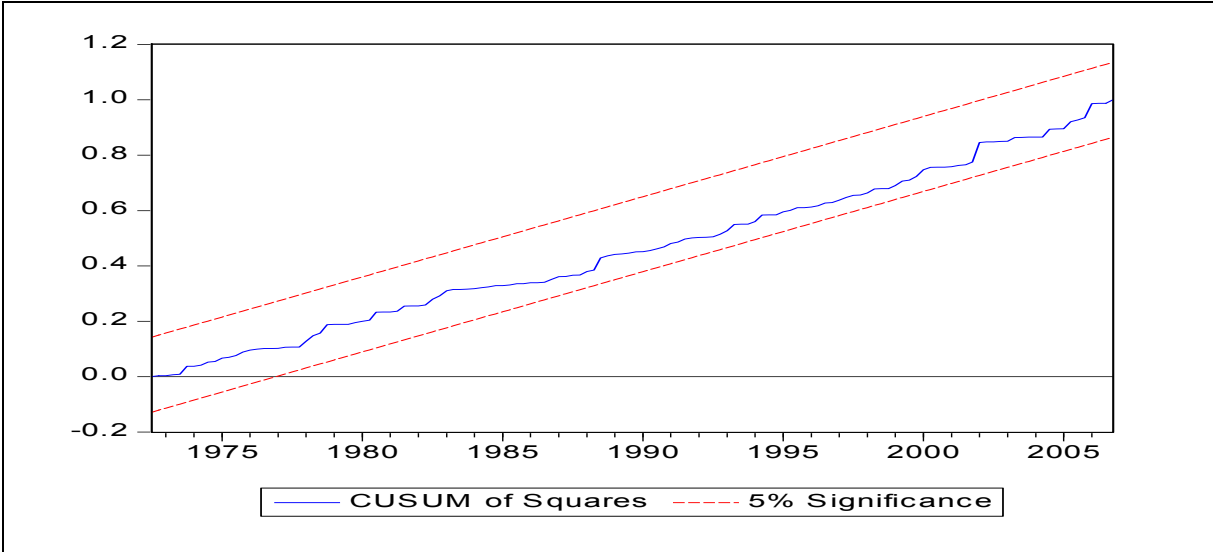
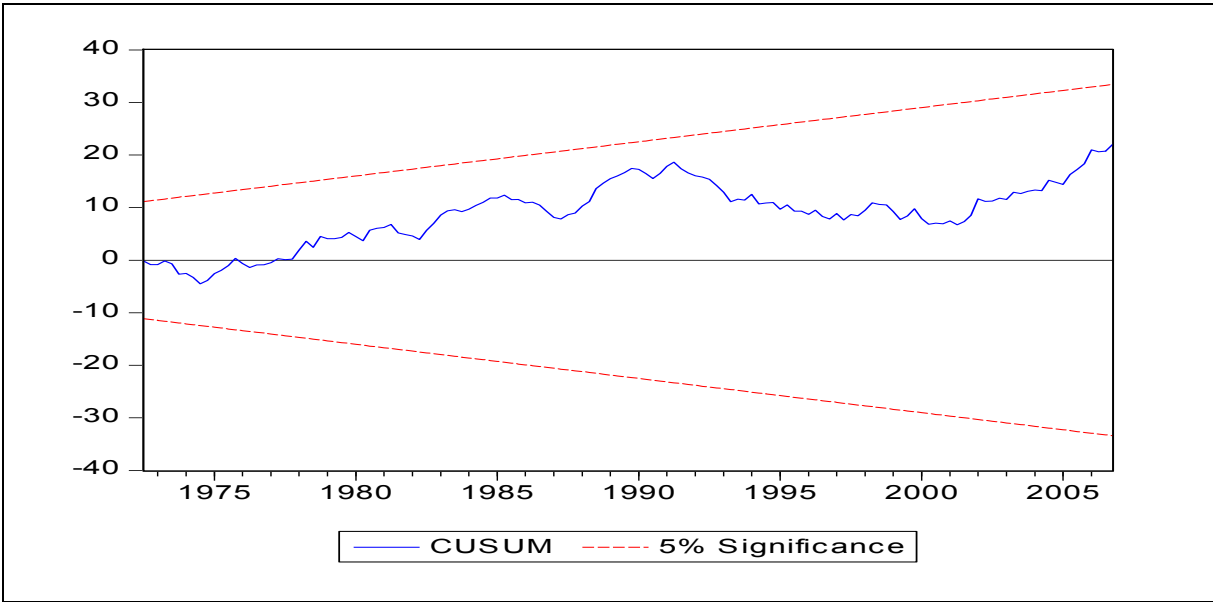


Figure 6 Estimates of total and bias – free coefficient of real income

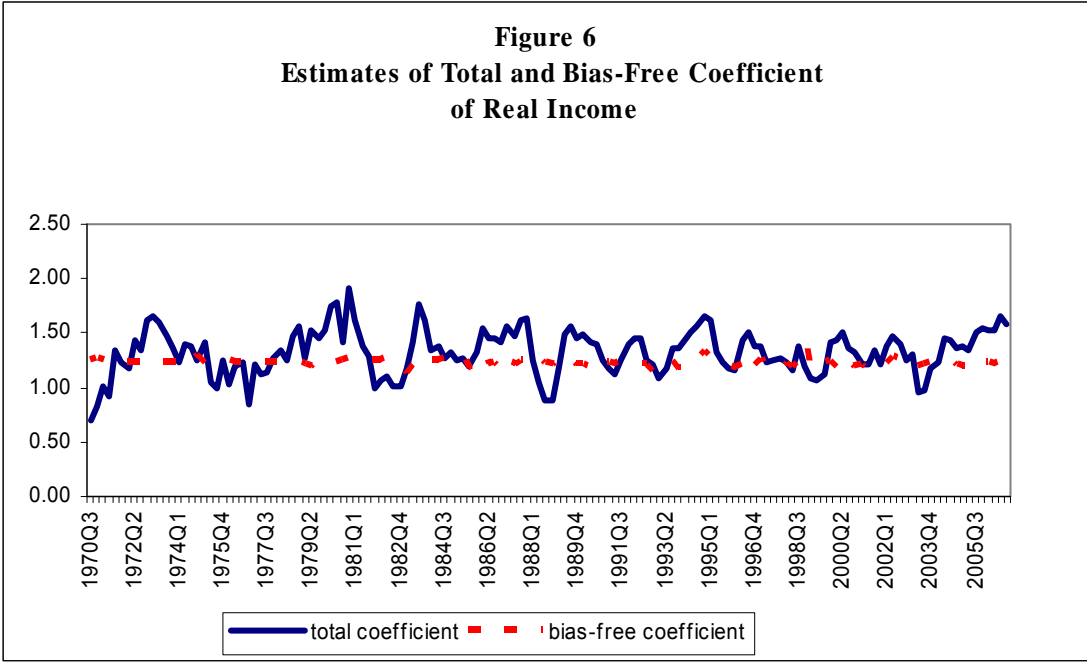
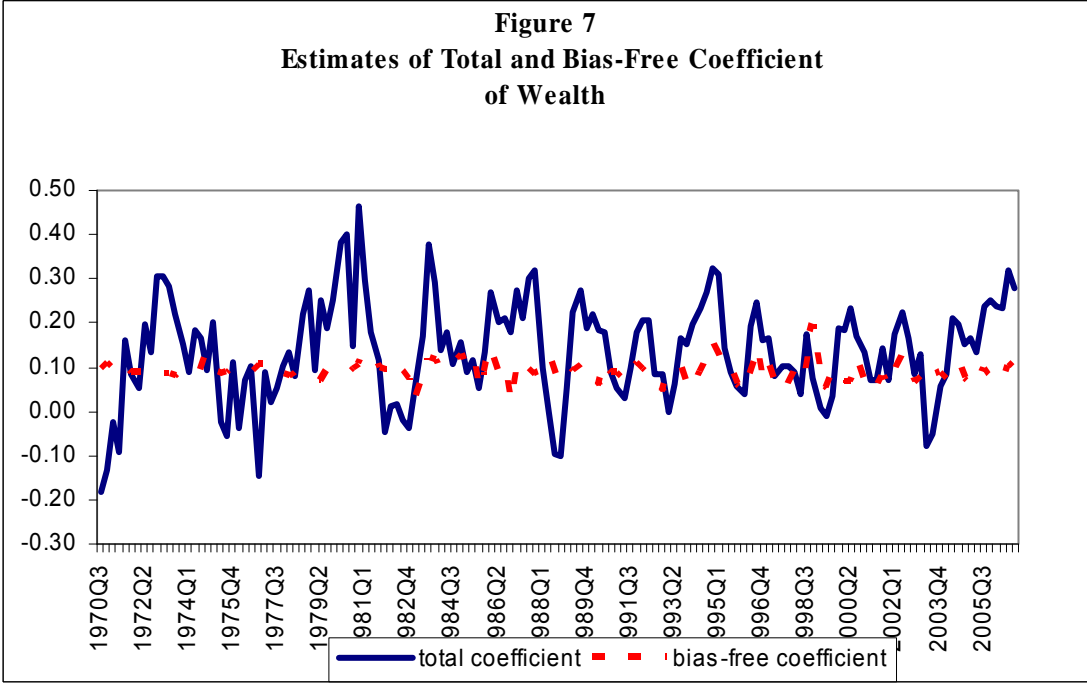


Figure 7 Estimates of total and bias-free coefficient of wealth



**Figure 8** Estimates of total and bias-free coefficient of t-bill rate

