Interest rate effects on output: evidence from a GDP forecasting model for South Africa.*

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20 November 2001

Abstract: Forecasting models for output are presented, which applied to South African data perform well over almost four decades. Recent research finds multi-step forecasting superior to recursive forecasting from a VAR model when structural breaks are present - there are important political and policy regime breaks in South Africa. The equilibrium correction models have a four-quarter-ahead forecast horizon, allowing more fundamental forces to reveal themselves than in conventional VAR models with restricted dynamics. A stochastic trend measures underlying shifts in productivity and other supply-side trends. The inclusion of important monetary policy regime shifts, and use of the Kalman filtering approach to control for other structural changes (e.g. trade liberalisation), addresses the Lucas critique in forecasting output growth. A key feature of the model is the interest rate transmission effect to output, the *direct* effect of which has altered with the monetary policy regime. High real interest rates significantly constrained growth in the 1990s. We investigate the role of international capital flows, of financial liberalisation using our own indicator, and altered sensitivity to the exchange rate with trade liberalisation in the 1990s. Finally, there are implications for constructing alternative output gap measures, an integral part of inflation forecasting models under inflation targeting.

* Paper prepared for the 2nd Annual Research Conference, International Monetary Fund, 29-30th November, 2001. We acknowledge funding from the Department for International Development, U.K., for the project "*New Monetary Policy Challenges for Sustainable Growth in South Africa*", grant number R7291. John Muellbauer acknowledges additional research support from the Economic and Social Research Council, U.K., under grant number R000237500.

1. Introduction

Monetary policy in South Africa has recently undergone a rapid transition. In earlier years, an old-fashioned, partly monetarist view assumed a simple connection between the money supply and inflation. Accumulated international evidence does not support this view, and in South Africa itself force of circumstance has compelled a move away from these ideas. The shift to inflation targeting from late 1999 demands good forecasting models of inflation, clarity on the mechanisms of monetary transmission, an institutional design that guarantees the transparency and accountability of policy, and a shared understanding with the private sector of the effectiveness of monetary policy for inflation and for output (Leiderman and Svensson, 1995). We have recently confirmed the role of the output gap in South Africa's inflation process, among other factors, in a sophisticated inflation forecasting model (Aron and Muellbauer, 2001a). One of the main transmission channels of interest rates onto inflation is therefore via output. This emphasises the importance of robust quantitative evidence on the effects of interest rates on output.

The quarterly econometric macro-model of the South African Reserve Bank (SARB) has recently been undergoing wholesale revision, but has not yet been published. In the determination of aggregate expenditure and output, the previous vintage of the SARB's models appears to omit two important interest rate transmission channels: that via wealth effects, and hence asset prices (except for the exchange rate); and that via expectations. Consequently, it is difficult to arrive at a well-informed view of the size and dynamics of the effects of monetary policy. Further, these models gave insufficient attention to the consequences of regime shifts, such as financial liberalization, and, more generally, to the influential Lucas Critique of the use of policy modelling (Lucas, 1976). Omitted structural breaks in earlier U.K. models played a major role in the costly macroeconomic policy failures of the late 1980s and early 1990s.

A popular alternative to forecasting with a large, quarterly, structural macro-econometric model (which may be misspecified), is to develop reduced-form forecasting models with plausible long-run properties. This could be done in the context of a quarterly vector autoregressive model (VAR) (see Jonsson (1999) for a small VAR model of prices, broad money, real income, interest rates and the exchange rate for South Africa). However, as we argue below, VARs are just as prone to forecast failure from omitted structural breaks, and often omit key variables and lags. An alternative to VARs are single equation multi-step models such as those developed by Stock and Watson (1999, 2000, 2001), where the dependent variable is, for example, the four-quarter-ahead rate of growth or inflation. Recent research shows that for VAR models suffering from certain specification errors such as omitted moving average error components or structural breaks – both important in South Africa - single-equation, multi-step forecasting can provide more robust forecasts (Weiss, 1991; Clements and Hendry, 1996, 1998).

Our approach differs from that of Stock and Watson's in several ways, summarised as follows: (i) careful attention to testing for structural breaks; (ii) use of a stochastic trend to capture shifts in underlying capacity trends; (iii) use of 'general-to-specific' model selection procedures, from a rich class of models subject to strong sign priors derived from economic theory (Hoover and Perez, 1999; Hendry and Krolzig, 1999); and (iv) permits long lags without loss of parsimony by restricting nature of longer lags.

Quarterly estimation covers the period 1963-2000 for a core model applying to a subset of the data, and for 1970-2000, for which a wider range of variables is available. A key feature of the model is the interest rate transmission effect to output, the *direct* effect of which has altered with the monetary policy regime. We also find evidence for a structural break in the effect of the real exchange rate, related to the openness of the economy.

The outline of the paper is as follows. Section 2 sets out a theoretical framework for forecasting the growth of real GDP, which emphasises a range of factors for forecasting output, including oil prices and the terms of trade, exchange rates and the current account, supply/demand imbalances, interest rates, asset prices and wealth effects, volatility and uncertainty measures, credit availability, private investment and capital to labour ratios, yield gaps and corporate to government bond spreads, government debt, and measures of foreign demand. Section 3 explains our econometric methodology.

Section 4 gives the background on important political and policy regime breaks and shocks in South Africa. During the 1980s, there was substantial financial liberalisation and the move to new operating procedures for monetary policy. Periodically, serious political crises entailed increasing international isolation, reflected in diminished trade and finance. South Africa's mineral dependency as a primary exporter gives an important role to terms-of-trade shocks in determining output growth. This section also examines productivity trends for evidence of changes in the growth rate of the economy's capacity to produce.

Section 5 presents the findings from our multi-step forecasting models for the rate of growth of real output, taking into account these regime changes, and the wide range of other influences emphasised in the theoretical model. Section 5 further considers some of the implications of this research for the construction of alternative measures of the output gap, which is of general interest. (South Africa does not publish measures of the output gap, and has used a production function approach). Use of such measures is an integral part of inflation forecasting models under inflation targeting.

Section 6 draws out the implications of our findings for the monetary transmission process and discusses the policy significance of the findings more generally. We consider the role of international capital flows; of financial liberalisation; altered sensitivity to interest rates under different monetary policy regimes; and altered sensitivity to the exchange rate with changes in the trade regime, as well as the effects of different exchange regimes themselves on output.

2. Theoretical Background

Important results on output forecasting arise in the context of empirical work on the monetary transmission mechanism. Economic theory suggests higher interest rates curtail consumer and investment spending, impacting both directly and via their indirect effects on asset values and income expectations. Many studies use Vector Autoregressive Models (VARs) to examine effects of short-term interest rates or other monetary policy indicators on subsequent output growth, see Sims (1980, 1987, 1996), Todd (1990), and Bernanke (1990). More recently, attention has been given to the 'credit channel', Bernanke and Blinder (1992), Bernanke and Gertler (1995) or the 'financial accelerator', Bernanke, Gertler and Gilchrist (1996, 1999). In this framework, the credit terms available to firms depend on the source of finance (e.g, inside versus outside finance) and the terms of such finance can vary with economic conditions. For example, a fall in a firm's net worth reduces the effective collateral a bank may be able to access in the event of a loan default. Changes in asset prices are thus likely to influence credit terms. More generally, increased uncertainty, a downturn in the economic outlook or a fall in the net worth of banks themselves, can all influence the cost of outside finance available to firms, by altering the willingness or ability of banks to provide such finance. Some empirical research has proxied credit conditions using spreads between corporate and government bonds as one proxy for such credit terms, see Gertler and Lown (1999), though others have interpreted such spreads instead as a proxy for uncertainty.

Asset prices should play an important role in the transmission mechanism, whether one takes a 'conventional' asset markets view, see Taylor (1999), or the credit channel view. Research has examined the effects of asset prices and asset price volatility on GDP growth, see Hamilton and Gang (1996) and Estrella and Mishkin (1998). Another financial variable, which has received much attention as a predictor of cyclical activity (as well as of inflation), is the yield curve or the yield gap between short-term and long-term bonds, see Campbell (1995), Estrella and Mishkin (1998), Bernard and Gerlach (1998), and Peel and Taylor (1997). Recently, Stock and Watson (2001) have examined the role of asset prices, including equity prices, bond prices, yield gaps, spreads and exchange rates, in forecasting both output and inflation in seven OECD economies.

Finally, output effects of the terms of trade are widely acknowledged, seen in the U.S. context in the research on the effects of real oil prices, see Hamilton (1983), Hooker (1996) and Clements and Krolzig (2001).

Nevertheless, it is necessary to embed credit, monetary transmission, asset and terms of trade variables in a more general macroeconomic framework. Following Muellbauer (1996) and Muellbauer and Nunziata (2001), output growth is captured in a dual adjustment process: firstly, of output to equilibrium output given by an income - expenditure model; and secondly, of output to trend output. Trend output is determined, in principle, by the state of technology and physical and human capital stocks. The adjustment process involves spontaneously occurring recovery forces operating in recessions. These might include real wages and some material and investment goods prices falling far enough relative to productivity trends to make production, employment and investment more profitable again, as well as rising replacement demand and low interest rates resulting from the low investment rates associated with recession. The reverse mechanisms operate in booms, together with the high marginal costs associated with over-time hour premia and, in the limit, sheer capacity or skilled labour supply constraints.

Large macroeconometric models articulate many elements of these processes. In what follows they will be summarized by a single adjustment equation. In this equation, two variables capture the self-correcting tendency of growth to fall after final expenditure has overshot capacity and to recover when output is below capacity. The first of these is the deviation of output from trend. The second is the trade balance to GDP ratio, since excess demand spills over into higher imports. A third possible measure is the deviation of inflation from average inflation in recent years. However, while this makes sense in a large, relatively closed economy such as the U.S., see Muellbauer and Nunziata (2001), it is less likely to be relevant in an open economy like the U.K. or South Africa, where the exchange rate plays a major role in the inflation process.

The dual adjustment process mentioned above can be articulated as follows. When goods markets are in equilibrium, the gross domestic product (GDP) equals total expenditure (Y), which is the sum of consumption (C), investment (I), government expenditure on goods and services (G) and exports (X), less imports (M). Let private expenditure depend linearly on the GDP less taxes (T), plus an autonomous element (A), which reflects, for example, interest rates, wealth, the real exchange rate, uncertainty and growth expectations. Then, in goods market equilibrium, the equilibrium GDP, denoted by Y* is given by:

$$Y^* = a(Y^* - T) + A + G + X - M \tag{2.1}$$

so that

$$\begin{aligned} Y^* &= \frac{1}{1-a}[A + G - aT + X - M] \\ &\approx \frac{1}{1-a}[A + G - T + X - M] \end{aligned} \tag{2.2}$$

if a is of the order of 0.8 or more.

There is also some process of adaptation of GDP to trend income (TY), depending on the level of equilibrium technology, human and physical capital.

Let the adjustment mechanism linking actual Y both with Y* and with trend Y be:

$$\Delta Y_t = b_1(Y_t^* - Y_{t-1}) + b_2(TY_{t-1} - Y_{t-1}) \tag{2.3}$$

Deflating by Y_{t-1} gives the log approximation:

$$\Delta \ln Y_t \approx b_0^* + b_1^* \left(\frac{Y_t^*}{Y_{t-1}} \right) + b_2^* (\ln TY_{t-1} - \ln Y_{t-1}) \tag{2.4}$$

where ($\ln TY_{t-1}$ - $\ln Y_{t-1}$) corresponds to the usual concept of an output gap.

Let the government surplus to GDP ratio or (-(G-T)/Y) be denoted by GSUR; and the trade deficit to GDP ratio or (-(X-M)/Y) be denoted by TDEF. Then (2.4) becomes

$$\Delta \ln Y_t \approx b_0^* + \frac{b_1^*}{1-a} [\frac{A_t}{Y_{t-1}} - GSUR_t - TDEF_t]$$
$$+ b_2^* (\ln TY_{t-1} - \ln Y_{t-1}) \tag{2.5}$$

Equation (2.5) is the economy's approximate structural adjustment equation. This becomes a forecasting equation when the term $[\frac{A_t}{Y_{t-1}} - GSUR_t - TDEF_t]$ is replaced by variables dated t-1, which can forecast it. This forecast will implicitly incorporate monetary and fiscal policy feedback rules and, in principle, is therefore subject to the Lucas critique.

It should be noted that many economies possess insufficient data to estimate some of the key effects found for the U.S. (Muellbauer and Nunziata, 2001). Stock and Watson (2001) make a similar point, that even the next largest six OECD economies do not have adequate measures of, for example, corporate bond yield spreads. We return to these constraints in the South Africa case in section 5.

3. Methodological Issues: Multi-Step Forecasting Models

Practically, forecasts of output are usually made from a large quarterly 'structural' or 'policy' econometric models, of the type usually run by central banks or ministries of finance, or from VARs usually containing fewer than ten variables, often below five.

In this paper, we present single equation models for forecasting output four-quarters ahead. Methodologically, these models can be regarded - but for one important difference - as single equation, reduced-forms of the related VAR system. The important difference is that our model contains a smooth non-linear stochastic trend - effectively the Kalman filter applied to a time-varying intercept (explained in more detail below) - while VARs generally do not. However, in some VAR studies, the Hodrick-Prescott filter is used to de-trend output and other variables in advance of estimating the VAR. While this is different, and in our view inferior, to estimating the trend within the model (see Harvey and Jaeger, 1993), in some contexts the Hodrick-Prescott filter may give broadly similar results.

Three kinds of criticisms are directed at the VARs commonly used for forecasting: the omission of structural breaks, the omission of relevant variables and the omission of relevant lags. Clements and Hendry (1999) show that intercept-equivalent structural breaks are the single most serious cause of forecast failure. Examples include the financial liberalisation in U.K. consumer credit markets in the 1980s, and the shift in the fiscal and monetary policy regimes in the U.K. around 1979-80. These structural breaks almost certainly shifted consumption and investment functions, and hence would perturb a VAR describing output, inflation, interest rates and so on. Such breaks are commonly neglected in VAR studies e.g., Garratt, Lee, Pesaran and Shin (1998, 2000) and Britton and Whitley (1997). From this perspective, Hendry and Mizon (2000) criticise VAR methodology and the resulting impulse response functions.

Many VARs designed to study monetary policy now use monthly data, as the frequency of meetings of monetary policy committees and interest rate decisions is approximately monthly. For example, Johansen and Juselius (2000) use monthly U.S. data for 1985-99 with a maximum lag length of three months. More generally, a VAR system with n variables and k lags uses (nk+1) parameters per equation. To avoid the risk of structural breaks contaminating the model, the decision is often made to restrict the length of the sample. This makes the trade-off between the lag-length and the number of variables all the more severe, if conventional levels of degrees-of-freedom are to be preserved. However, increasing data frequency - for example, from quarterly to monthly data - is of little help where data are highly persistent, as is mostly the case with macroeconomic time series.

It is also worth noting that omitting relevant variables from a VAR amounts to allowing them to be approximated by distributed lags of the included variables. If a VAR with n variables and a maximum lag of k is represented by a smaller system of r (< n) variables, the maximum lag is, in general, greater than k. This makes all the more plausible that small systems with very short lags are mis-specified.

Other routes to reduce over-parameterisation have been chosen. One is to use Bayesian priors, as in the Minnesota VAR, see Doan et al (1984). This gives a tendency towards random-walk specifications being chosen for many of the equations in the model, which reduces the interdependence of the system and hence the number of parameters to be estimated. Another type of restriction is to use recursive or block diagonal restrictions, again adopted in the Minnesota VAR, and also by Dungey and Pagan (2000). The latter argue that the small, open economy nature of Australia makes a recursive structure and a number of other restrictions plausible, which makes it possible to use a maximum lag length of three quarters, despite the VAR including 11 variables, estimated for 1980 -98.

As noted in the Introduction, a third forecasting approach is the use of multi-step single equations as seen in the work of Stock and Watson (1999, 2000, 2001), Forni and Reichlin (2001) and in neural networks approaches, see Tkacz (2001). Previous research suggests circumstances when multi-step forecasting can be superior to recursive forecasting from a VAR model, especially where negatively-correlated moving average errors or structural breaks are present in the VAR system (Weiss, 1991; Clements and Hendry 1996, 1998). These features have relevance for modelling output growth in South Africa. On structural breaks, apart from policy-related breaks, such as extensive financial and trade liberalisation and monetary and exchange rate regime changes, South Africa has experienced considerable political schisms from the 1960s onwards. The economic effects have been profound, yet the impact of such breaks is usually difficult to model. We use a smooth non-linear stochastic trend to help deal with these changes, as well as testing for known institutional changes.

We follow Harvey (1993) and Harvey and Jaeger (1993) in defining a stochastic trend μ_t as follows:

$$\begin{aligned} \mu_t &= \mu_{t-1} + \gamma_t + \eta_{1t} \\ \gamma_t &= \gamma_{t-1} + \eta_{2t} \end{aligned} \tag{3.1}$$

where η_{it} are white noise errors. When var $\eta_{2t} = 0$, μ_t is an I(1) trend with drift. When var $\eta_{1t} = 0$, μ_t is a smooth, formally I(2) trend, and this is the type we use to capture the evolution of the supply side. These non-linear trends can be estimated, via the Kalman filter, in the STAMP package (Koopman et al, 2000).

The multi-step forecasting single equation model developed here has the advantage of simplicity over a full VAR system, and, it turns out, of economic interpretability. We use another device to save on degrees of freedom while permitting long lags to appear. For lags longer than four, the lag structure is restricted to fourth changes and four-quarter moving averages to prevent over-parameterisation. This allows the examination of longer lags than is possible in a conventional VAR model.

A possible disadvantage of a multi-step forecasting model is that there may be some positive residual auto-correlation, as the dependent variable is the four-quarter-ahead rate of growth of GDP, which has a three-quarter overlap with its lagged value. Thus, estimated t-ratios and standard errors may require some adjustment.

4. South African Policy Regime Changes

During the 1980s in South Africa, there were significant regime changes with the move to new operating procedures for monetary policy and a series of internal financial liberalizations. Periodically, macroeconomic management has been complicated by large changes in capital flows, following major shocks in the form of significant gold price fluctuations and political events. A series of political crises for the "Apartheid" government from 1976 entailed the increasing international isolation of South Africa, reflected in diminished trade and finance. In particular, from late 1985 until the democratic elections of 1994, South Africa had little access to international capital (apart from trade finance), and domestic policy was directed at maintaining current account surpluses through large import surcharges, exchange rate depreciation and interest rate policy. Capital flows to the country increased markedly after the elections, though from a very low base, and accelerated with the effective removal of exchange controls on non-residents in March, 1995. A large proportion of the inflow was short-term in nature, and the economy was vulnerable to flow reversals. These constraints, together with South Africa's mineral dependency in exports, are expected to give an important role to terms-of-trade shocks and the current account balance in determining output growth.

4.1 Monetary Policy Regimes and Financial Liberalisation

Broadly speaking, there have been three monetary policy regimes since the 1960s (Table 1). The first regime, in effect until the early 1980s, was one based on liquid asset ratios, with quantitative controls on interest rates and credit. Limited importance was attached to the interest rate as a corrective tool. Commercial banks were obliged to hold certain assets defined as “liquid” as a specified minimum proportion of their deposits. The limited supply and low yields of these assets were expected to curtail bank lending and money supply growth. Considerable disintermediation occurred under this system, particularly between 1976 and 1980, distorting the credit supply figures (see Aron and Muellbauer, forthcoming).

Increasing dissatisfaction with the liquid asset ratio–based system led to a range of reforms from the early 1980s, moving toward a cash reserves–based system following the recommendations of the De Kock Commission (De Kock, 1978, 1985). The removal of some direct controls (such as those on deposit rates) in March 1980, and bank credit ceilings later that year, resulted in re-intermediation and a decline in the velocity of circulation. There were also technical changes to asset requirements over a few years, and the role of the discount rate was redefined. The main policy emphasis was on using the central bank’s discount rate to influence the cost of overnight collateralised lending and hence market interest rates. The second regime was in full operation by mid-1985, with pre-announced, flexible monetary targets used for the first time beginning in 1986.

Financial liberalization began in the early 1980s, rapidly expanding credit growth, and with a more open capital account in the 1990s, the usefulness of such targets was much diminished. In later years the targets were supplemented by a broader set of indicators (see *South African Reserve Bank Quarterly Bulletin,* October 1997), though it is likely that such indicators played a role in previous years as well.[1] With the removal of interest rate controls, credit restrictions and barriers to competition, the supply and demand for credit have become increasingly market-determined. This has the implication, other things being equal, that higher rates of interest are required to equilibrate the market for credit.

Under the third system of monetary accommodation, introduced in 1998 and based on daily tenders of liquidity through repurchase transactions, the repurchase interest rate is determined at auction. In theory, rather than controlling the price of liquidity by setting the discount rate, monetary policy effectively rations the quantity of liquidity. The SARB signals its policy intentions on short-term interest rates to the market through the amount offered at the daily tender for repurchase transactions (see *South African Reserve Bank Quarterly Bulletin*, June 1999). However, in practice there has been little difference in interest rate behavior between the current and the previous regime. Even under price auctioning, the

[1] The factors that in practice influenced the setting of monetary policy in this second regime have recently been

commercial banks collectively have remained heavily influenced by SARB-directed preferences for the level of the interest rate. Monetary growth guidelines were announced on a three-year rather than an annual basis, and informal target ranges for core inflation were given in 1998. However, from late 1999, an inflation targeting regime was instituted.

4.2 Exchange Rate Policy Regimes[2]

South Africa's exchange rate policy during the 1970s mirrored volatile developments on the international front, and throughout the period a number of significant regime shifts occurred. Until 1979 the rand was pegged to either the U.S. dollar or the pound sterling. Alterations in the rate were determined by policymakers and took the form of discrete step changes. Exchange controls restricted residents' capital flows, and proceeds from the sale of assets by nonresidents were placed in blocked rand accounts, which made the repatriation of capital difficult. In 1976 the system was modified to allow for the transfer of assets between nonresidents.

Greater flexibility was introduced in 1979 with a dual-currency exchange rate system, following the recommendations of the interim De Kock Commission (De Kock, 1978). An official ("commercial") exchange rate was announced on a daily basis in line with market forces. The second, "financial" exchange rate applied to most nonresident portfolio and direct investment transactions, with all other transactions channeled through the commercial rand market. The intended impact of the dual system was to break the direct link between domestic and foreign interest rates, as well as to insulate the capital account from certain categories of capital flows.

In 1983 the commercial rate was set free to be determined in the market, subject to direct intervention by the SARB, and the dual rates were unified as recommended by the De Kock Commission (De Kock, 1978, 1985). Controls on nonresident capital movements were removed, and although those on residents remained, a more lenient attitude was taken to applications by residents to make direct investments abroad.

The unified currency remained stable for a few months but then, following the gold price decline in 1983, began a sharp descent. In 1985, following a prolonged period of political upheaval, U.S. banks recalled their loans, precipitating a debt crisis, followed by a debt

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clarified using empirical models of extended Taylor rules (Aron and Muellbauer, forthcoming).

standstill, and subsequently a series of debt rescheduling agreements. The unified rand fell even further, and eventually the financial rand was reintroduced and capital controls on residents were tightened. The dual-currency system remained in existence until its unification a decade later, in March 1995, under a managed float.

Starting in 1979, the SARB intervened in both spot and forward foreign exchange markets, although constrained by low reserves. Kahn (1992) suggests that during 1979-88, exchange rate intervention smoothed the real rand price of gold faced by producers despite large fluctuations in the dollar price of gold. After August 1989, under a new governor, the SARB appeared to be stabilizing the real effective exchange rate, partly out of concern for the competitiveness of manufacturing exports. There was, however, no explicit official policy to stabilize the real exchange rate. Intervention was less successful at stabilizing the exchange rate in the uncertain atmosphere before the elections of April 1994, when huge capital outflows occurred. After the elections, there appeared to be a pattern of periodic temporary targeting of the nominal exchange rate, with periodic currency crises (Aron and Elbadawi, 1999). Under inflation targeting, however, such exchange rate management is expected to have a fairly low priority.

4.3 Trade policy regimes

An important consideration for output in South Africa is changing trade policy and openness to competition. Particularly from the mid-1980s, pressures on the capital account from protracted capital outflows due to foreign disinvestment and sanctions required an adjustment in the economy to maintain current account surpluses in excess of required foreign debt repayments. This was partly achieved through trade policy, with big increases in tariffs and import surcharges relative to imports of goods and services. Trade barriers began to be dismantled in 1990, and especially after 1994, which put downward pressure on inflation.

One might expect the degree of openness to affect the influence of the real exchange rate on growth, via the impact on the leakage of demand into imports and the demand for exports (see equation 2.5). Unfortunately we do not have an index of effective protection combining the effects of surcharges, tariffs and quotas (these last are dominant in South African trade policy until the early-1980s); nor can we directly capture the effects of trade

[2] See Aron, Elbadawi, and Kahn (2000).

sanctions. Instead we use a proxy for openness, which is derived from a model for the share of manufactured imports in home demand for manufactured goods, where the latter is defined as domestic production plus imports, less exports, for which we have annual data. We do not employ the import share itself to measure openness, because it depends on other factors, such as fluctuations in domestic demand and relative prices of imports or the exchange rate. However, our model for the log of the import share controls for these influences.

The model includes a measure of import tariffs and surcharges, which is one (negative) component of openness. The unmeasured component of quotas and the effect of sanctions are captured in our model by an I(2) stochastic trend, using a stochastic trend model of the type discussed above, estimated in STAMP (Koopman et al,2000).

To capture demand side influences (other than home demand for manufactured goods as defined above), the model includes the growth rate of real GDP, the log of the real exchange rate and a lag in the log of the terms-of-trade, heavily influenced by the price of gold. The latter might reflect sectoral differences in GDP growth, relevant for imports, as well as the relaxation of balance of payments constraints when gold prices are high.

The results, estimated on annual data, are shown in Table 3, column 1 (the model was also estimated over shorter samples to demonstrate robustness of the parameters, see columns 2 and 3). The variables are defined in Table 2, where some statistics are presented. The hypothesis could be accepted that the coefficient on the lagged (log) level of the import share was zero. As shown in Table 2, the tariff measure, the real exchange rate and the import share are all I(1) variables, and are expected to be cointegrated. The log terms-of-trade and GDP growth are I(0).

The influences of openness operate both through the measured effects of import tariffs and surcharges (RTARIF), and through the stochastic trend. We therefore define our openness indicator as the fitted stochastic trend plus the fitted effect of *RTARIF (-4.30 x RTARIF (-1))*.[3] The openness indicator is shown in Figure 1, where a rise indicates trade liberalisation (the other two variables in the figure are discussed in section 5.3).

4.4 Productivity trends

[3] We convert to a quarterly measure by taking the moving average of the step-function implied by the annual data, and make a plausible guess as to the trend before 1970.

In Figure 2, series for non-agricultural and manufacturing labour and total factor productivity are shown, together with the respective stochastic I(2) trends generated by regressions on lagged productivity, a drought dummy for 1992, and a distributed lag of capacity utilisation (to remove cyclical effects). Total factor productivity is measured by the $\log Y_t - \alpha \log L_t - (1-\alpha)\log K_t$, with α=0.67. The trends are adjusted by dividing by 1 minus the coefficient on the lagged dependent productivity variable, and thus represent the trend of the long run solution.

There was a trend rise in labour productivity in the 1970s corresponding to a rising capital to labour ratio. The ratio of total private investment (excluding housing) to GDP trended upwards until 1976, the year of the Soweto riots, whereafter the average trend, though fluctuating, was downwards. Generally speaking there appears to be a considerable correlation between the openness indicator shown in Figure 1 and productivity trends. The effects of the 1973 and 1979 oil price shocks are seen in the tapering off of the productivity trends, more pronounced for the broader non-agricultural measure. This was mitigated by the gold price shock**,** which brought renewed investment until about 1982. The 1980s saw slower productivity growth. Partly this resulted from South Africa's increasing isolation - for example, the inefficient production of petrol from coal, under trade sanctions which constrained oil imports. After the substantial sovereign debt crisis of late 1985, labour productivity fell according to both measures, though more sharply in manufacturing. Capital inflows were severely restricted to expensive short-term trade finance, and trade policy tightened sharply. A positive shock to gold prices beginning in 1987, was followed by a recovery in real investment. The sharp upward trend in labour productivity in the 1990s, is due in large part to the shedding of labour in a more competitive environment generated by rapid trade liberalisation. To the extent that real wages and other labour costs increased, this provided a further incentive to firms to cut employment. The trend is steeper after 1995, with the more open capital account and increased inflows, which promoted investment through cheap and available finance, and introduced new technology. It is notable that total factor productivity in the whole economy (excluding agriculture) actually fell from the early 1970s to the late 1980s. In addition to the factors mentioned above, there was a large shift of employment towards the government sector, where real and/or measured productivity is low. The improvements in the 1990s are nonetheless remarkable.

Although labour productivity growth in the 1990s will overstate the underlying growth in the economy's capacity to produce, this discussion should lead one to expect a slight deceleration of capacity growth in the mid-1970s, a bigger slowdown in the 1980s and an improvement after 1990. The correlation of our openness indicator and both productivity growth measures is evident.

5. Output Forecasts in South Africa

Output is modelled using an extended version of stochastic trend models discussed above**,** estimated using STAMP (Koopman et al, 2000). We derive a four-quarter-ahead forecasting model for the rate of growth of real output, and build in allowances for the influences discussed in section 2. A smooth stochastic trend represents the underlying capacity of the economy. By incorporating important regime shifts in the model, output growth forecasts should be fairly immune to the Lucas critique.

5.1 Model specification

In section 2, a theoretical model was motivated which emphasised a range of factors for forecasting output, including oil prices and the terms of trade, exchange rates and the current account, supply/demand imbalances, interest rates, asset prices and wealth effects, volatility and uncertainty measures, credit availability, yield gaps and corporate to government bond spreads, government debt, and measures of foreign demand.

In the context of South Africa, a number of these mechanisms cannot be investigated in a data set that spans historical experience from the 1960s. The corporate bond market has really only become significant in the 1990s, and even the government bond market lacked depth until the mid-1980s. The role of oil prices will have been affected by special contracts, which buffered South Africa from the oil shocks of the 1970s, and trade sanctions, which applied from the 1980s. In any case, the relevant prices paid for oil will be part of the inclusive measure of the terms of trade, which are also sensitive to minerals prices, given the importance of minerals in exports.

Further, the difference in the structure and openness of the South African economy gives a different emphasis to variables found to matter for the U.S. economy (Muellbauer and Nunziata, 2001).

The output gap ($\ln TY_{t-1}$ - $\ln Y_{t-1}$) in equation 2.5 is likely to be measured as the deviation of log GDP from a non-linear trend. The trade deficit to GDP ratio, TDEF, may provide additional information on the output gap, although it is also very sensitive to variations in the terms of trade. Lags in TDEF may therefore reflect persistence in TDEF, which both helps forecast TDEF and plays an indirect role via its contribution to measuring the output gap.

The single equation model has the following form where Y is real GDP[4]:

$$\Delta_4 \log Y_{t+4} = \gamma(\alpha_0 + \mu_t + \sum_{i=1}^{n} \alpha_i X_{it} - \log Y_t) + \sum_{i=1}^{n} \sum_{s=0}^{k} \beta_{i,s} \Delta X_{i,t-s} + \varepsilon_t \qquad (5.1)$$

where ε_t is white noise plus, possibly, a moving average error component, and μ_t is a smooth stochastic trend reflecting the underlying capacity of the economy to produce.

Standard augmented Dickey-Fuller tests suggest that over 1963-2000, log Y_t is I(1), implying that Δlog Y_t is a stationary variable (Table 2). This would imply that the stochastic trend, μ, the X_i's and log Y are cointegrated. The fact that μ is an I(2) variable, is, at first sight, problematic. However, a low variance stochastic trend closely resembles a segmented linear trend so that $(\mu + \sum_{i=1}^{n} \alpha_i X_i - \log Y)$ can easily be I(0) over the relevant samples.

The key X variables are the level of real interest rates, changes in nominal short-term interest rates, the trade surplus to GDP ratio, the government surplus to GDP ratio, the log real exchange rate interacted with an indicator of the openness of the economy to trade, a real share price index, the log terms of trade, and a dummy for the drought of 1992/3. However, a wide range of other influences were investigated including volatility measures of inflation and share prices, broader measures of household wealth, the rate of growth of real private credit, private investment to GDP and capital-to-labour ratios to reflect supply side shifts, the spread

[4] In Muellbauer and Nunziata (2001), GDP is scaled by working age population so that the stochastic trend picks up productivity growth. But high unemployment and poor data on population in South Africa argues against this.

between South African and U.S. bond yields as a proxy for uncertainty, the change in U.S. short term interest rates, world industrial production, and net capital inflows.

The variables are defined in Table 2, where statistics are also given. These variables explain the deviation in income from a smooth stochastic trend, which does not impose changes in trend *a priori* but allows them to be estimated flexibly. Parameter shifts in the income-forecasting relationships appear to take place at broadly the dates suggested by prior information about policy regimes, and in the direction predicted by theory.

We have emphasised four types of regime shifts. The first is captured by the stochastic trend, shown in Figure 3. Note that the general shape of the trend reflects the discussion on productivity growth in the previous section, including the slowdown in the 1980s and increase in the 1990s.

The second type of parameter shift reflects changes in monetary policy, capturing the changing sensitivity of output growth to interest rates as the monetary policy regime changed. From 1983-84 there was a move away from quantitative controls via liquidity ratios and other mechanisms towards more market-oriented methods of control via interest rates. It is important, therefore, to investigate systematically the effects of these changes on the monetary transmission mechanism. We construct a dummy indicator from the changing prescribed liquid asset requirements for commercial banks in the 1980s (see Table 2) which we cross with nominal and real interest rates. As far as fiscal policy is concerned, the major change is likely to have been the new emphasis on fiscal discipline from 1995 under the GEAR strategy. In principle, this would be expected to increase the positive effect of government surpluses on future growth, as the private sector would then expect lower taxes and/or more government spending.

The third shift is financial liberalisation in consumer credit markets from the 1980s. Proxying this by the ratio of debt to income, as in Bayoumi (1993a, 1993b) and Sarno and Taylor (1998), is not ideal because this ratio responds with a lag to deregulation and depends too on income expectations, asset levels, uncertainty, and interest rates. Bandiera et al (2000) propose the technique of principal components to summarize the composite information in a set of dummy variables reflecting different facets of financial liberalization. However, the weights do not reflect the behavioural impact of financial liberalization. A flexible technique linking institutional information with behavioural responses is needed.

In Aron and Muellbauer (2000b,c), our innovation is to treat financial liberalization as an unobservable indicator entering both household debt and consumption equations. The indicator, FLIB, is proxied by a linear spline function, and the parameters of this function are estimated jointly with the consumption and debt equations (subject to cross-equation restrictions on the coefficients in the spline function)[5]. The estimated parameters for FLIB in the model reflect the key institutional changes in credit markets. Our estimated indicator shows strong rises in 1984, 1988, and 1995, with more moderate increases in 1989, 1990, and 1996 (Figure 4).

The last shift reflects the evolving trade policy across the period and is captured in our measure of openness, described above (Figure 1). This would be expected to shift the influence of the real exchange rate on growth. The direct effect of increased openness on productivity and hence capacity growth will be buried in the estimated stochastic trend, μ_t, in equation 5.1.

5.2 Results of estimations for the basic regression

A general-to-specific testing procedure on quarterly data for 1963:1-2000:2 (forecasting to 2001:2) was applied to a version of equation (5.1) with a set of variables available for the whole period.[6] For lags longer than four, we restrict the dynamics to fourth-differences or four-quarter moving averages, to prevent over-parameterisation. This gives the parsimonious equation shown in the first column of Table 4. In the process of simplification from the general forms, the data suggested several transformations, in particular, moving average versions of some of the key regressors. Figure 2 shows real output and the stochastic trend generated from the equation in column 1 of Table 4. Several other forecasting equations are reported in columns 2-6 for different samples to demonstrate parameter stability, given that Chow tests are unavailable in STAMP.

In the parsimonious equations reported, the only I(1) variable is the real interest rate, which is expected to form a cointegrating vector with the deviation of log output from the stochastic trend. Note, however, that the current account and government surplus to GDP ratio are borderline I(0), so potentially could also be part of a cointegrating vector.

[5] We define FLIB using a linear spline function. The "knots" in the spline function occur in the first quarter of each year (i.e. it can shift shape in the first quarter of each year). Under the constraint that the parameters be non-negative (i.e. that there is no reversal in financial liberalization), in practice only six parameters are needed to define FLIB.

[6] For example, our openness indicator and the real exchange rate are accurately defined only from 1970. Private sector credit growth data begin in 1967. Liquidity ratios presented by the SARB begin in 1965.

Turning to the parameter estimates in Table 4, nominal rises in interest rates and the level of the real rate both have strong negative effects on subsequent growth. The real interest rate also enters as a lagged four-quarter moving average, suggesting its effect on output is relatively persistent. The long duration probably results from the effect on investment and therefore on the capital stock of high real rates. However, the shift towards more market-oriented monetary policy in the 1980s appears to have somewhat weakened their influence. The shift is picked up by interacting Δ_4(PRIME) and RPRIMA with the prescribed liquid asset ratio measure, where PRIME is the prime rate of interest for borrowing from banks. Before the shift, high liquidity ratios and other quantitative methods of controlling credit growth were correlated with changes in nominal rates, exaggerating the apparent influence of interest rates on growth. After the shift, firms and households could also refinance more easily, meaning that higher nominal interest rates had a weaker effect on expenditures. However, although most of the effect of changes in nominal interest rates disappears, the greater volatility of interest rates in the market regime means that the proportion of the variance of growth explained by interest rates remains high. The high and rising level of real interest rates in the 1990s explains much of the poor performance of output. Financial liberalisation enters as a first difference, suggesting only a short-run effect in boosting output.

The positive government surplus effect enters through a three-year moving average, suggesting that government deficits have persistent negative effects on subsequent income growth.[7] These effects could reflect typical concerns for budget deficits followed by higher taxes or lower government expenditures; but these deficits may also signal political shocks. In the past, political unrest was often followed by higher social or military expenditures, which thus may serve as a proxy for a direct negative effect on growth through falling investment. Note that government surpluses also reflect positive terms of trade shocks, since these are associated with higher tax revenue from mining companies. There is no evidence of an increased coefficient after 1994 associated with the shift in fiscal policy discussed above.

The positive effect expected from the trade surplus to GDP ratio is also confirmed, another channel for the terms of trade. There is an additional, positive effect (though weak) from the (three year) change in the terms-of-trade (including gold), as one might expect in a

[7] In contrast, in the U.S. (Muellbauer, 1996), there is some evidence that before the heightened concern with government deficits in the 1980s, there was a negative "Keynesian" response of output to the government surplus.

mineral dependent economy. Finally, given the importance of agriculture in South Africa output, the drought dummy for 1992 produces the expected negative effect.

In Figures 4-6, we provide a visual display of the size of the impact of different variables or combinations of variables on output. The dependent variable is defined as Δ_4 log GDP_{t+4} + 1.14 log GDP_t - μ_t , which is a close approximation to the output gap defined as the deviation of log GDP_{t+4} from the trend scaled by 1.14.

Figure 4 plots this dependent variable against the regression-weighted combination of the five different interest rate effects minus their respective means, and similarly for the change in the indicator of financial liberalisation. This confirms the very important role of interest rates in the recent weakness of economic growth in S.A.

Figure 5 shows the contribution of current and government account surpluses relative to GDP, which, as noted above, incorporate large indirect terms of trade effects. This suggests at current levels the two surpluses, particularly the improved fiscal position of the government, promise a more positive growth outlook. Figure 6 shows the small direct effect of the terms of trade.

To test for parameter stability, various sample breaks were chosen. The first begins in the 1970s (column 2). The second, until the second quarter of 1989, covers the period prior to the new monetary regime of Governor Stals and an increased momentum of political change under the new President de Klerk, initiated by the release of political prisoner, Nelson Mandela (column 3). The third, until the first quarter of 1994, covers the period prior to the transition to a democratic government (column 4). Finally, in columns 5, we show estimates for the period of the floating exchange rate and the reign of Governor Stals.

The parameter estimates from the shorter samples are close to those of the full period suggesting that once structural change has been accounted for as described above, the remaining parameters are fairly stable. There is no evidence of autocorrelated residuals. Tests for normality and heteroscedasticity are also satisfactory.

5.3 Results of estimations with additional variables

Although this basic model seems fairly robust, it is noteworthy that the standard error of the residuals is clearly higher in the pre-1970 period. This may well reflect omitted variables, such as the real exchange rate, which is likely to have been affected by higher inflation in South Africa in the mid 1960s and by the U.K.'s devaluation in 1967.

In Table 5 we show a series of specifications estimated from the first quarter of 1970 with a wider set of variables as follows.[8] Prescribed short-term liquid assets ratio (a monetary policy tool frequently used before 1985 to restrict bank lending) is expected to have a negative effect on output growth. The change in short-term U.S. interest rates is also expected to have a negative effect, given the evidence in Aron and Muellbauer (forthcoming), that South African interest rates tend to follow U.S. rates. Stock market volatility, an indicator of uncertainty, and the moving average of the log of the real JSE all-share index, an indicator of the cost of capital and of wealth, are expected to have negative and positive effects on output, respectively. The rate of growth of real private sector credit is expected to have a positive effect on growth, reflecting some combination of credit availability and a positive investment outlook. The interaction of our openness proxy with the deviation from the mean of the four-quarter moving average of the log of the real exchange rate is expected to have a negative effect: the more open the economy, the more positive for growth should be an increase in competitiveness (a fall in the real exchange rate as measured). Long-term capital inflows relative to GDP is an indicator of access to international capital flows, which were greatly restricted from the mid-1980s to the early 1990s, and it should have a positive effect on output.

An alternative measure of a wealth effect is the ratio of personal sector wealth to personal sector non-property income (constructed in Aron and Muellbauer, 1999), which we find to have a strong significant effect on consumer spending in South Africa in Aron and Muellbauer (2000). Via spending, it would be expected to have a positive effect on output growth. Another risk measure is the South African government's long bond yield less the U.S. ten-year government bond yield. A higher spread can reflect both the perception of a bigger risk of government default and of a fall in the rand relative to the dollar. The former, at least, would damage the growth outlook. The latter effect may be ambiguous: it could indicate both political risk (and therefore a poor growth outlook) and a fall in the nominal exchange rate - which with sticky prices, would increase competitiveness temporarily and so be more positive for growth. Finally, we include the moving average of the log ratio of fixed capital formation (excluding residential housing) to GDP. In principle, this effect too is ambiguous.

[8] We also tested a number of other variables that failed to have any significant influence. These included a measure of inflation volatility, another aspect of uncertainty; the log ratio of capital to employment, reflecting capital deepening; the log of real U.S. GDP and the log of world industrial production, to measure the global economic environment; and finally, the domestic debt to GDP ratio, to proxy constraints on fiscal policy.

As a proxy for a young capital stock as a result of recent investment, it should capture an aspect of the capacity to produce not fully reflected in the stochastic trend. However, if recent additions to the capital stock have been high, firms have less need to expand capacity and may have depleted financial reserves. In the near term, investment expenditure might then be expected to fall, reducing near term growth.

As Table 5 shows, all these variables operate in the direction suggested by *a priori* economic considerations (given the proviso of the ambiguous effects just discussed). Credit growth enters as a two-year growth rate.[9] In Table 5, column 1, shows a fairly general specification, while column 2 eliminates four statistically less significant effects. Interestingly, one of these eliminated variables is the interaction of the current moving average of the real interest rate with the dummy measuring the 1983-5 shift in the monetary policy regime, NRPRIME. Column 2 thus suggests that the real interest effect is stable over the entire period, so that from 1985 only the overall effect of the change in the nominal interest rates is sharply lower. Columns 3 and 4 show the specification from column 2 over different samples, as a check on robustness. Column 5 shows results with the private sector wealth to income ratio, although the t-ratio is only 1.4. Column 6 includes the South African.-U.S. bond spread, which, perhaps not surprisingly, weakens the effect of capital flows, as it is capturing similar phenomena. Finally, column 7 confirms the second of the two possible interpretations of the investment to GDP ratio, with a negative coefficient on the variable.

For most specifications, the SARB's liquidity ratio, real credit growth, the real exchange rate-openness interaction and long-term net capital inflows to GDP, remain significant. Of these, we must highlight the role of the real exchange rate-openness interaction, which is the only significant, clearly I(1) variable in Table 5. First, note that the post-1994 data are critical in estimating its coefficient – see Table 5, column 4, where the effect is quite insignificant estimating up to 1994. Since there has been a trend decline of the real exchange rate since 1994, see Figure 1, it is difficult to distinguish this effect from a shift in the stochastic trend reflecting the underlying capacity of the economy to produce, or any other trending variable which has had a positive effect on output growth since 1994. In other words, though the effect works in the direction one would expect, its size is unlikely to be robust. Secondly, the Table 5 results are sensitive to the inclusion of this variable: if it

[9] In our inflation forecasting work we find credit growth to be insignificant over a four quarter horizon, but significant over an eight quarter horizon. The channel of transmission from credit growth to inflation may well

excluded, the other variables become individually and jointly less significant and, after successive simplification, the model reverts to the Table 4 specification. Perhaps this kind of difficulty is inevitable in an economy which has been through structural changes as deep as those which have faced South Africa.[10]

In Figure 3, we show the stochastic trend implied by Table 5, column 2, and compare it to that implied by Table 4, column 1. Note that in the mid-1980s the trend from the Table 5 regression shows less of a slowdown, since this is accounted for in the model by the drying up of foreign capital. It grows much less after 1994, since the real exchange rate-openness interaction has such a positive effect in this period.

5.4 Implications for construction of alternative measures of the output gap

One application of the output model is in the construction of measures of the output gap. This is important in the context of inflation targeting, where some weight is placed on the output gap in interest rate rules (Batini and Haldane, 1999). South Africa does not publish measures of the output gap, and has used the production function method for calculating the output gap.

We contrast three alternative approaches to measuring the output gap, all using a smooth trend estimated in STAMP (Koopman et al, 2000). The first, method A, uses no data other than log of real GDP itself. Here

$$\begin{aligned}\log Y_t &= \mu_t + \alpha_1 \log Y_{t-1} + trigonometric.stochastic.cyclical.component \\ &+ stochastic.seasonal + \varepsilon_t\end{aligned} \qquad (5.2)$$

where Y_t is real GDP and μ_t is a smooth stochastic trend reflecting the underlying capacity of the economy to produce, defined by $\Delta^2\mu_t = \eta_t$ where η_t is white noise. Then, $\log Y_t - \mu_t /(1-\alpha_1)$ defines the output gap.

The second approach, method B, adds more economic content by replacing the trigonometric stochastic cyclical component by log of capacity utilisation in manufacturing.

operate via the output gap on a four quarter ahead horizon (which we show influences inflation four quarters later).

[10] With good measures of openness and the real exchange rate before 1970, the robustness of these results could probably be improved.

The third, method C, takes an output-forecasting model for $\log Y_{t+4}$ of the type discussed in this paper. If we write this in the form,

$$\log Y_{t+4} = \mu_t + \alpha_1 \log Y_t + \sum_j \beta_j X_{jt} + \varepsilon_t \tag{5.3}$$

then $\log Y_t - \mu_{t-4}/(1-\alpha_1)$ is the output gap.

For this method to make sense, it is important that none of the X_{jt} variables have I(1) components, which is the case for the specifications in Table 4, but not for those in Table 5. Nevertheless, the deviation from trend can be more persistent in method C than in methods A and B. Furthermore, this model would typically imply that after a period of high real interest rates, the output gap is likely to be negative.

In Aron and Muellbauer (2000a), we compare the performance of constructed output gap measures by methods B[11] and C in an inflation forecasting equation. Both measures have significant coefficients in levels and changes, though those for measure C are somewhat larger and more significant. The principal differences between the two occur in the aftermath of the 1980/81 gold price shock and the smaller price shock in 1987, when OUTGAP-C indicates lower excess capacity in the economy; and after 1994, when OUTGAP-C indicates a higher excess capacity. The main economic reason is the inclusion of the real interest rate amongst the economic variables. Though this variable is I(0), it nevertheless displays considerable persistence, and in the 1990s, rose strongly, depressing output, in part through contracting capital accumulation. Conceptually, therefore, OUTGAP-C differs from OUTGAP-B.

6. Monetary Policy Implications and Discussion

This paper has employed multi-step forecasting techniques in estimations with stochastic trends to predict output growth in South Africa, one year ahead. Underlying the model for forecasting real GDP is an income-expenditure approach with partial adjustment of output to expenditure, and to a long-run trend, reflecting the capacity of the economy to produce. The model also builds in allowances for diminished trade and finance related to periodic political crises, monetary policy regime shifts in the 1980s and financial liberalisation. We find that

[11] In this application, changes rather than levels of capacity utilisation are used, and lagged changes in the terms of trade were also introduced.

changes in nominal interest rates as well as levels of real rates, with quite long lags, have a negative effect on future output. However, these effects have been altered by changes in the monetary policy regime, particularly in 1983-85, see discussion below.

Mineral dependency is reflected through the terms-of-trade. It addition to its small, direct role in our model, it has large indirect effects via the trade surplus to GDP ratio, and a moving average of the government surplus to GDP ratio. A smooth stochastic trend satisfactorily represents long-run changes in productivity and capacity growth of the kind one expects in an economy subject to these regime changes. The stochastic trend approach also proves very helpful in deriving plausible measures of the output gap.

The model offers important insights on monetary policy transmission with policy implications. Note that this model, even in combination with our inflation forecasting model, Aron and Muellbauer (2000a), do not constitute a full system and hence do not make possible policy experiments of the type discussed by Cunningham and Haldane (1999), where different monetary policy feedback rules can be compared. Nevertheless, our models suggest which variables should be included in such a system.

Our output forecasting model contains important evidence on the influence of interest rates on output, and suggests the effects persist for up to three years, even without feedback effects via the other explanatory variables. However, a one percentage point rise in the prime rate now has a smaller effect on output than before the shift in monetary policy in the early 1980s, when policy emphasised liquidity ratios, credit directives and other quantitative controls on credit expansion. One reason for the reduced coefficient is that such controls are excluded from our model yet are likely to be positively correlated with interest rates, implying that the interest rate effects are probably overstated pre-1983. A second reason is that with more liberal credit markets, borrowers found it easier to refinance when nominal rates rose, so reducing the impact of interest rates, especially changes in nominal rates, on output.

One surprising finding of our research is that though we can find positive wealth effects on output growth one year ahead, these are never very significant, though they are clearly important for explaining current consumption. This is in sharp contrast to the sizeable and highly significant stock market price effects which Muellbauer and Nunziata (2001) find in forecasting U.S. GDP. More than one explanation is likely to be involved. The stock market in South Africa is less liquid than that in the U.S. and less important for raising new capital. It tends to be strongly linked to movements on Wall Street and in metals prices. The former may be less relevant for growth in South Africa and the terms of trade effects already enter the model through several other routes. Finally, it is possible that our interest rate effects are effectively capturing the asset channel as well as more direct interest rate transmission channels, leaving only a small role for asset prices.

We find evidence over a 1970-2000 sample, where we have a more complete data set, that South Africa has become more responsive to the real exchange rate as its economy became more open during the 1990s, especially after 1994. During the 1970-2000 period, there is also evidence that international capital flows and the growth of real domestic credit improve the one year ahead growth outlook. However, the sample is, as yet, too short to be sure of the robustness of the size of the real exchange rate effect, though its direction is surely correct.

Economic forecasting for an extended horizon is likely to prove a hazardous undertaking when structural changes are important. Regrettably, the AIDS-HIV pandemic, the economic effects of which are likely to peak in the coming decade, see Lewis (2001), is clouding the outlook in South Africa. The robustness of forecasts over a one-year horizon is likely to be enhanced by the stochastic trend incorporated in our models, and the next few years are unlikely to be an exception.

Perhaps even more important than good forecasts are the economic policy lessons of this model for output and our parallel model for inflation. For example, the model suggests that there are significant potential growth benefits from the fiscal discipline South Africa has exercised in recent years. At the same time, because of the serious growth consequences of high real interest rates, and the perverse short-term inflationary effects of higher interest rates - in part because of the mortgage cost element in the consumer price index[12] - policy responses such as the rise in prime rate to 25 percent in the emerging markets crisis of 1998, should be avoided. Moreover, our research on interest rate rules in South Africa (Aron and Muellbauer, forthcoming) suggests that a major reason for the rise in real interest rates in the 1990s was a response to the liberalisation of consumer credit and mortgage markets. This also accounts for much of the decline in private saving (Aron and Muellbauer, 2000c). Somewhat stronger prudential regulation in this area could well have growth benefits.

[12] The mortgage cost component in the CPI has unfortunate policy implications, as well as a weak conceptual basis in the context of liberalised mortgage markets. Increases in the real prime interest rate, and in our proxy for the mortgage cost component in the CPI index, both raise inflation in the following year (Aron and Muellbauer, 2000a). The first, and weaker effect, captures the increased costs for businesses with debt. The second effect operates via the mortgage cost component of the CPI feeding into labour costs.

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Table 1: Monetary Policy Regimes

Years	Monetary Policy Regime
1960-1981	Liquid asset ratio-based system with quantitative controls on interest rates and credit
1981-1985	Mixed system during transition
1986-1998	Cost of cash reserves-based system with pre-announced monetary targets (M3)
1998-1999	Daily tenders of liquidity through repurchase transactions (repo system), plus pre-announced M3 targets and targets for core inflation
2000-	Repo system with inflation targeting (CPI-X)

SOURCE: Aron and Muellbauer (forthcoming).

Table 2: Statistics and Variable Definitions

Variable	*Definition of Variable*	*Mean*	*Standard Deviation*	*I(1)*[a,b]	*I(2)*[a,b]
1963q1-2000q2	**Output Forecasting Equation**				
Δ_4 log (Y)	Annualised real GDP growth rate (seas. adj.)	0.0279	0.0278	-	-
log (Y)	Log of real GDP (seas. adj.)	13.0	0.276	-2.95*	-4.87**
RPRIMA	Real prime interest rate/100 (four-quarter MA)	0.0445	0.0429	-4.65**	-
Δ_4 PRIME	Annual change of prime interest rate/100	0.00243	0.0293	-3.67*	7.13**
RCASUR	Ratio to current GDP of current account surplus	-0.00769	0.0385	-4.16**	-
RGSUR	Gov. surplus to GDP ratio (three-year MA)	-0.0390	0.013	-6.49**	-
Δ_{12} log (TOT)	Three-year change in the log terms-of-trade	0.00880	0.123	-2.59	15.22**
DFLIB	First difference in FLIB, financial liberalisation measure – see text	0.00429	0.0115	-	-
Monetary regime shift dummy	Dummy progressing from 0 to 1 in 1983:2-1985:4 , derived from short term liquid asset requirements	-	-	-	-
ND4PRIME	Shift dummy x Δ_4 PRIME	-0.000657	0.0242	-	-
NRPRIMA	Shift dummy x RPRIMA	0.0314	0.0466	-	-
DUM92	Drought dummy=1 for 1991:3-92:2, or =0	-	-	-	-
	Additional variables				
STLA	Level of short-term liquid asset ratios from 1965 onwards	0.323	0.209	-	-
DUS60C	First difference in US treasury bill rate/100	0.000198	0.00833	-2.62	-3.91**
VSTOCK	Absolute value of a 3-month MA of the monthly growth in JSE all-share index less average growth over the previous three years, converted to quarterly data.	0.0428	0.0250	-4.25**	-
Log (RJSE)	Log of the JSE all-share index deflated by the consumer price deflator (four-quarter MA)	5.29	0.209	-4.461**	-
DUMOPEN	The saved stochastic trend from the share of import demand equation in Table 3, column	-	-	-	-

Variable	*Definition of Variable*	*Mean*	*Standard Deviation*	*I(1)*[a,b]	*I(2)*[a,b]
	1, minus (4.30 x RTARIF(-1)).				
DUMOPEN* log (REER)	DUMOPEN interacted with the log of the real effective exchange rate less 4.65.	-0.0134	0.0194	4.74	-6.89**
Δ_8 log (RPSCRED)	Two-year change in private sector credit deflated by consumer price deflator.	0.0868	0.0799	-3.57*	-4.09**
log (RLTFLOW)	Log ratio of net long-term capital inflows (old definition) to current GDP (four-quarter MA). Extended after 1998 using a regression (see text).	0.00294	0.00515	-6.03**	-
WEALTH	Wealth measure from Aron and Muellbauer (1997): sum of equity, housing and pension wealth components, with housing entering only from early 1980s (four-quarter MA)	1.63	0.671	2.82	8.20**
USSPREAD	Spread between SA gov. long bond rate and US gov. 10 year bond rate	0.0409	0.0374	-2.68	10.35**
log (RINVEST)	Ratio of private investment, excluding housing, to current GDP (four-quarter MA)	-3.06	0.208	-2.52	4.85**
1971-1998	**Import-Demand Equation**				
log (IMPDEM)	Log share of imports in home demand	3.07	1.29E-1	-0.53	-4.85**
Log (TOT)	Log terms-of-trade (including gold)	4.64	7.55E-2	-5.74**	-
RTARIF	Ratio of customs plus import surcharges to merchandise imports	2.36E-2	6.47E-3		
Log (REER)	Log of the SARB's real effective exchange rate	4.60	1.06E-1	-1.53	-4.40**
Δ log (Y)	Annualised real GDP growth rate (seas. adj.)	5.95E-1	5.72E4	-3.63*	-

a. For a variable X, the augmented Dickey-Fuller (1981) statistic is the t ratio on π from the regression: $\Delta X_t = \pi X_{t-1} + \Sigma_{i=1,k} \theta_i \Delta X_{t-i} + \psi_0 + \psi_1 t + \varepsilon_t$, where k is the number of lags on the dependent variable, ψ_0 is a constant term, and t is a trend. The kth-order augmented Dickey-Fuller statistic is reported, where k is the last significant lag of the 5 lags employed. The trend is included only if significant. For null order I(2), ΔX replaces X in the equation above. Critical values are obtained from MacKinnon (1991). Asterisks * and ** denote rejection at 5% and 1% critical values.

b. Stationarity tests are performed for the variables in levels before time-transformation i.e. before taking moving averages and changes.

Table 3: Equation for share of imports in home demand with a stochastic trend

Dependent Variable: log (IMPDEM)	1. 1971 – 1998	2. 1971 – 1990	3. 1971 – 1986
Regressors:			
Log (TOT) (-1)	0.48 (3.70)	0.48 (3.18)	0.55 (3.17)
RTARIF (-1)	-4.30 (2.44)	-3.93 (1.76)	-2.55 (0.95)
Log (REER) (-1)	-0.34 (1.97)	-0.35 (1.86)	-0.45 (1.34)
Δ log (Y)	1.34 (4.50)	1.29 (3.31)	1.14 (2.61)
Diagnostics:			
Eq. Standard Error	0.0407	0.0417	0.0434
r(1)	-0.348	-0.384	-0.706
R_D^2	0.745	0.754	0.756
Durbin-Watson Statistic	2.17	2.18	2.36

(Absolute values of asymptotic t-ratios in parentheses)

a. The equation includes an I(2) stochastic trend.

b. r(1) is first-order residual autocorrelation; R_D^2 is R-squared computed for first differences of the dependent variable.

c. The variable, DUMOPEN, is defined as the saved stochastic trend from the share of import demand equation in Table 3, column 1, minus (4.30 x RTARIF(-1)).

Table 4: Forecasting equations for real output with a stochastic trend

Dependent variable: $\Delta_4 \log (Y)$	**1** **1963 (1) to 2000 (2)**	**2** **1970 (1) – 2000 (2)**	**3** **1963 (1) to 1989 (2)**	**4** **1963 (1) to 1994 (1)**	**5** **1979 (2) – 2000 (2)**
Regressors					
Log (Y)	-1.12 [15]	-1.18 [15]	-1.14 [13]	-1.10 [13]	-1.13 [11]
RPRIMA	-0.318 [3.2]	-0.325 [3.1]	-0.330 [3.5]	-0.322 [3.0]	-0.286 [2.2]
RPRIMA (-4)	-0.321 [4.3]	-0.294 [3.9]	-0.350 [4.0]	-0.337 [3.6]	-0.223 [2.8]
Δ_4 PRIME	-0.318 [4.2]	-0.268 [3.8]	-0.327 [3.9]	-0.327 [4.0]	-0.294 [3.7]
ND4PRIME	0.263 [3.0]	0.226 [2.7]	0.252 [2.4]	0.270 [2.3]	0.285 [3.1]
NRPRIMA	0.327 [2.6]	0.343 [2.7]	0.344 [2.7]	0.334 [2.3]	0.279 [1.8]
RGSUR	0.694 [2.8]	0.918 [3.8]	1.06 [3.6]	0.740 [2.6]	0.670 [2.5]
$\Delta_{12} \log$ (TOT)	0.0244 [2.0]	0.0215 [1.9]	0.0251 [2.0]	0.0241 [1.8]	0.00853 [0.68]
DFLIB	0.177 [2.0]	0.187 [2.5]	0.203 [1.9]	0.146 [1.4]	0.173 [2.6]
DUM92	-0.0186 [3.4]	-0.0166 [3.5]	-	-0.0195 [3.3]	-0.0135 [3.2]
RCASUR (-1)	0.0742 [2.3]	0.0690 [2.3]	0.0698 [1.8]	0.0785 [2.2]	0.0512 [1.9]
RCASUR (-2)	0.108 [3.5]	0.131 [4.4]	0.116 [3.1]	0.106 [3.1]	0.137 [4.7]
RCASUR (-3)	0.124 [4.2]	0.112 [4.0]	0.130 [3.8]	0.127 [3.9]	0.0895 [3.2]
Diagnostics					
Eq. Std error	0.00888	0.00730	0.00921	0.00940	0.00592
Normality	2.53	1.15	2.72	1.23	2.27
H(48)	0.329	0.376	0.311	0.360	0.312
R(1)	-0.0782	0.00983	-0.133	-0.0936	0.0287
DurbinWatson	2.14	1.96	2.20	2.17	1.94
Adj.R^2	0.718	0.738	0.768	0.730	0.794

(Absolute values of asymptotic t-ratios in parentheses)

a. The equations include an I(2) stochastic trend.

b. See Table 2 for definitions of the variables, some of which are defined as moving averages.

Table 5: Additional variables in the forecasting equations for real output

Dependent variable: Δ_4 **log (Y)**	**1** **1970 (1) to 2000 (2)**	**2** **1970 (1) to 2000 (2)**	**3** **1979 (2) to 2000 (2)**	**4** **1970 (1) to 1994 (1)**	**5** **1971 (2) to 1997 (4)**	**6** **1979 (1) to 2000 (2)**	**7** **1970 (1) – 2000 (2)**
Regressors							
Log (Y)	-1.19 [15]	-1.14 [15]	-1.0595 [9.9]	-1.1114 [13]	-1.201 [14]	-1.12 [10]	-1.1361 [15]
RPRIMA	-0.233 [2.3]	-0.197 [3.4]	-0.16195 [2.6]	-0.23268 [3.1]	-0.200 [3.3]	-0.134 [2.1]	-0.15212 [2.4]
RPRIMA (-4)	-0.304 [4.4]	-0.311 [4.8]	-0.29183 [4.3]	-0.29698 [3.6]	-0.349 [4.8]	-0.297 [4.7]	-0.26417 [3.6]
Δ_4 PRIME	-0.390 [5.2]	-0.368 [5.3]	-0.41693 [5.6]	-0.31110 [3.8]	-0.403 [5.3]	-0.492 [6.6]	-0.36634 [5.2]
ND4PRIME	0.328 [3.9]	0.317 [4.1]	0.37704 [4.5]	0.31324 [3.1]	0.384 [4.4]	0.445 [5.6]	0.33649 [4.3]
NRPRIMA	0.114 [0.89]	-	-	-	-	-	-
RGSUR	0.789 [3.5]	0.778 [3.6]	0.545 [2.1]	0.695 [2.5]	0.761 [3.4]	0.422 [1.6]	0.727 [3.2]
Δ_{12} log (TOT)	0.0202 [1.8]	0.0225 [2.0]	0.0130 [1.0]	0.0195 [1.5]	-	-	-
DFLIB	0.174 [2.3]	0.153 [2.1]	0.151 [2.4]	0.167 [1.9]	0.134 [1.8]	0.167 [2.7]	0.155 [2.1]
DUM92	-0.0185 [4.2]	-0.0190 [4.4]	-0.0168 [4.2]	-0.0183 [3.7]	-0.0178 [4.0]	-0.0159 [4.1]	-0.0184 [4.1]
RCASUR (-1)	0.0600 [2.0]	0.0705 [2.4]	0.0677 [2.4]	0.0973 [2.8]	0.0848 [2.7]	0.0583 [2.0]	0.0708 [2.4]
RCASUR (-2)	0.129 [4.3]	0.147 [5.2]	0.163 [5.6]	0.173 [5.0]	0.152 [4.7]	0.151 [5.1]	0.151 [5.3]
RCASUR (-3)	0.108 [3.7]	0.114 [4.2]	0.101 [3.6]	0.146 [4.3]	0.134 [4.1]	0.0994 [3.4]	0.104 [3.7]
STLA	-0.0798 [2.7]	-0.0887 [3.2]	-0.0629 [2.3]	-0.0918 [2.8]	-0.105 [3.7]	-0.0727 [2.6]	-0.0763 [2.6]
DUS60C	-0.0837 [1.3]	-	-	-	-0.109 [1.6]	-0.123 [2.0]	-
VSTOCK (-1)	-0.0277 [1.0]	-	-	-	-	-	-
Log (RJSE) (-1)	0.0124 [1.1]	-	-	-	-	0.0162 [1.5]	-
Δ_8 log (RPSCRED)	0.0667 [2.3]	0.0752 [2.9]	0.0659 [2.0]	0.0545 [1.7]	0.0974 [3.3]	0.0901 [2.7]	0.0763 [2.9]
DUMOPEN* log (REER)	-0.415 [2.8]	-0.449 [3.2]	-0.386 [2.5]	0.112 [0.27]	-0.372 [1.6]	-0.333 [2.3]	-0.493 [3.3]
Log (RLTFLOW)(-1)	0.693 [2.0]	0.829 [2.5]	0.554 [1.4]	1.41 [3.0]	1.00 [2.7]	0.389 [0.97]	1.04 [2.9]
WEALTH	-	-	-	-	0.0310 [1.4]	-	-
USSPREAD	-	-	-	-	-	-0.0801 [1.3]	-
Log (RINVEST)	-	-	-	-	-	-	-0.0733 [2.1]

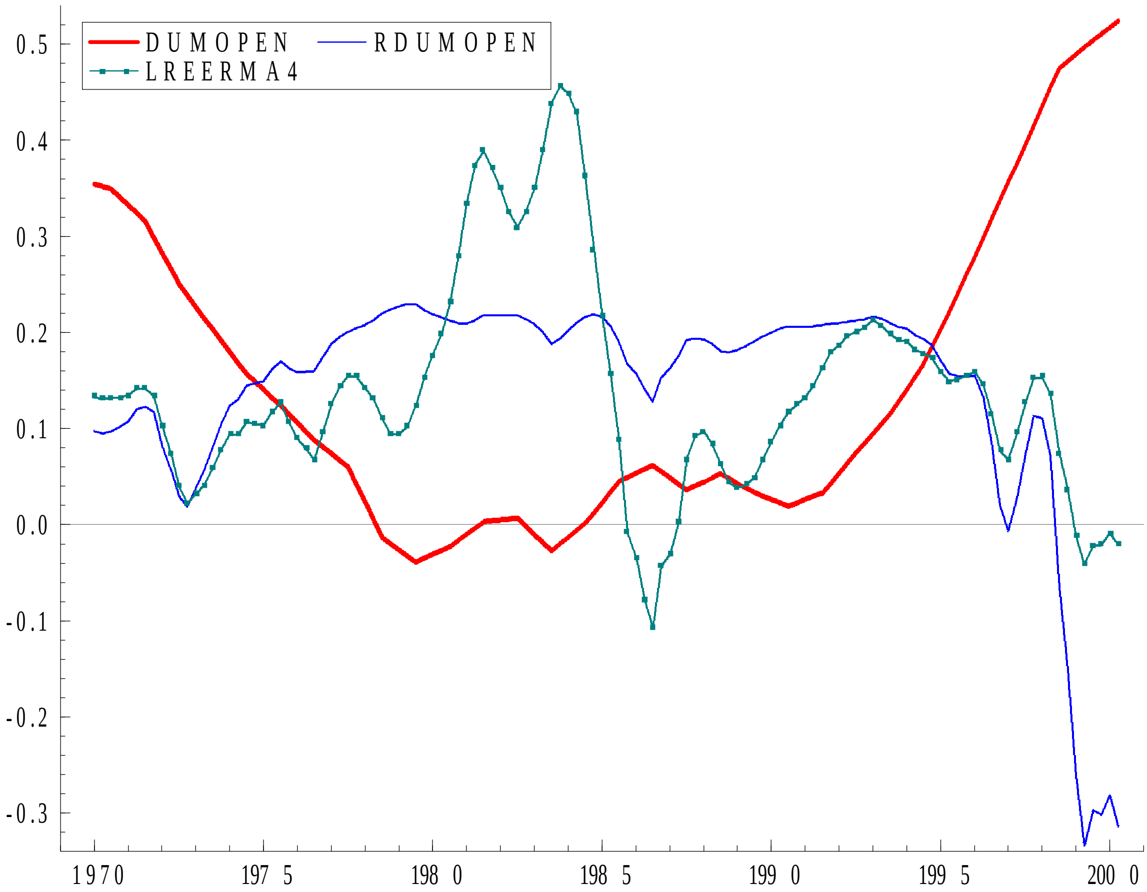
Diagnostics							
Eq. Std error	0.00672	0.00686	0.00565	0.00731	0.00680	0.00537	0.00689
Normality	0.260	0.0707	0.454	1.21	0.162	0.130	0.811
H(48)	0.355	0.346	0.248	0.547	0.433	0.288	0.345
R(1)	-0.0337	0.00765	0.0333	-0.0263	-0.0347	-0.0537	-0.00249
DurbinWatson	2.02	1.93	1.92	2.01	2.05	2.10	1.95
Adj.R^2	0.793	0.784	0.812	0.797	0.790	0.830	0.782

(Absolute values of asymptotic t-ratios in parentheses)

a. The equations include an I(2) stochastic trend.

b. See Table 2 for definitions of the variables, some of which are defined as moving averages.

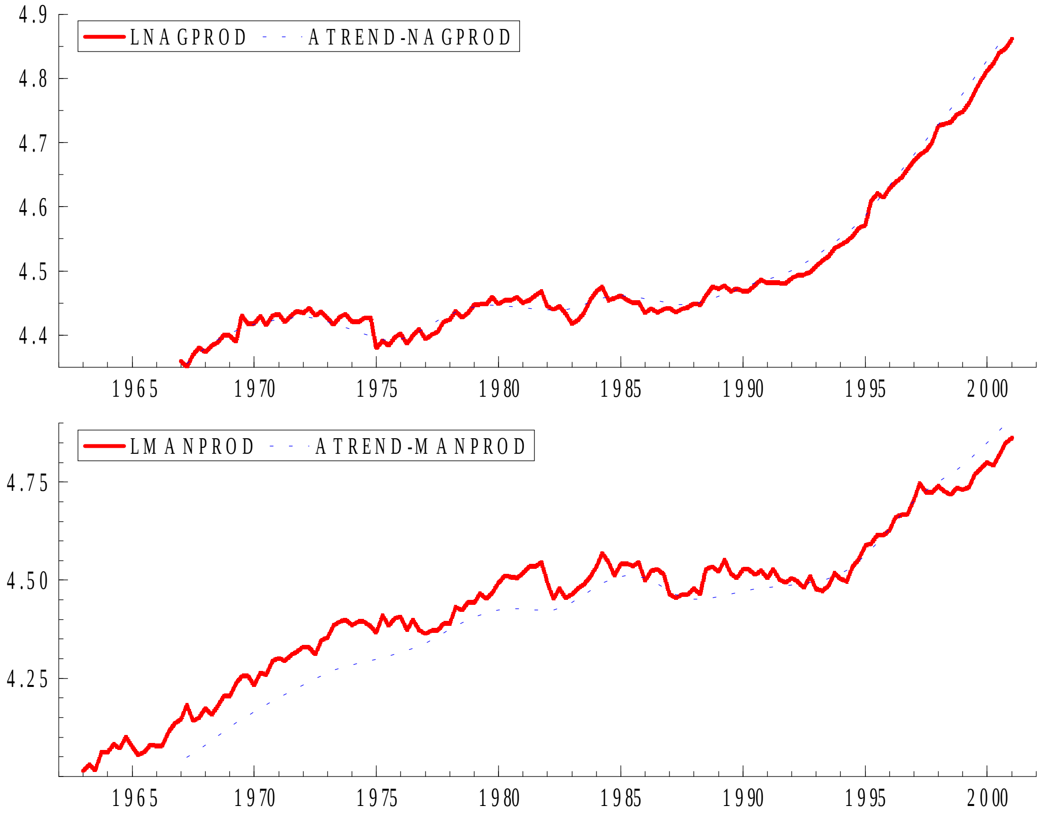
Figure 1: The openness indicator for South Africa



Note 1. The variable, DUMOPEN, is defined as the saved stochastic trend from the share of import demand equation in Table 3, column 1, minus (4.30 x RTARIF(-1)).

Figure 2: Non-agricultural and manufacturing labour and capital productivity measures, with stochastic trend after removing cyclical influences.

A. <u>Labour productivity</u>



B. <u>Total factor productivity</u>

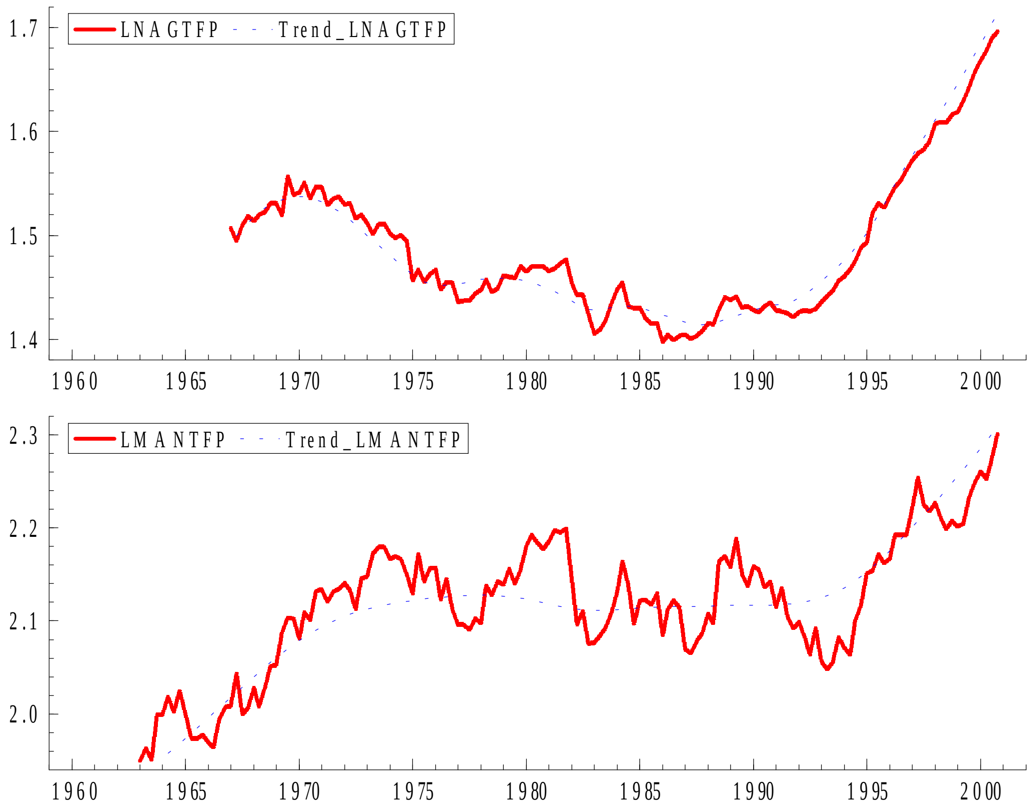
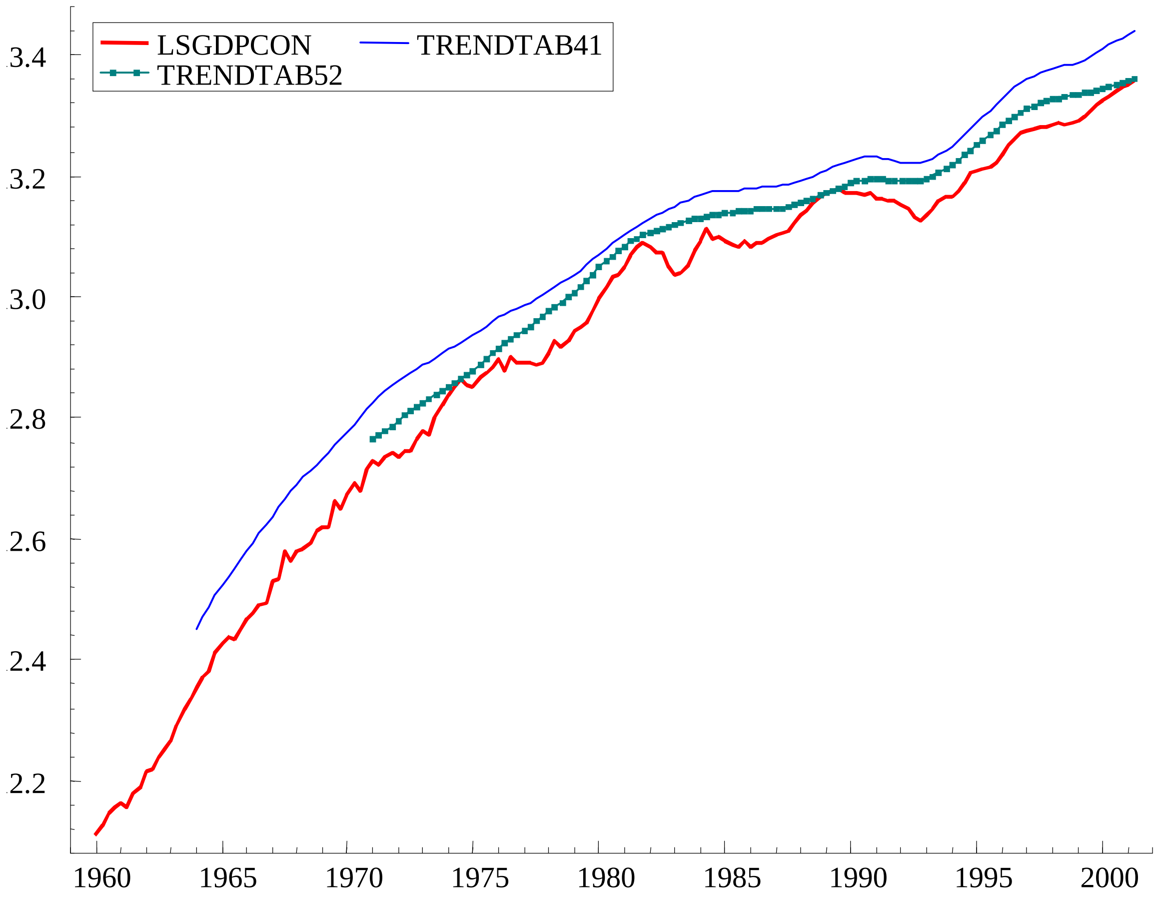
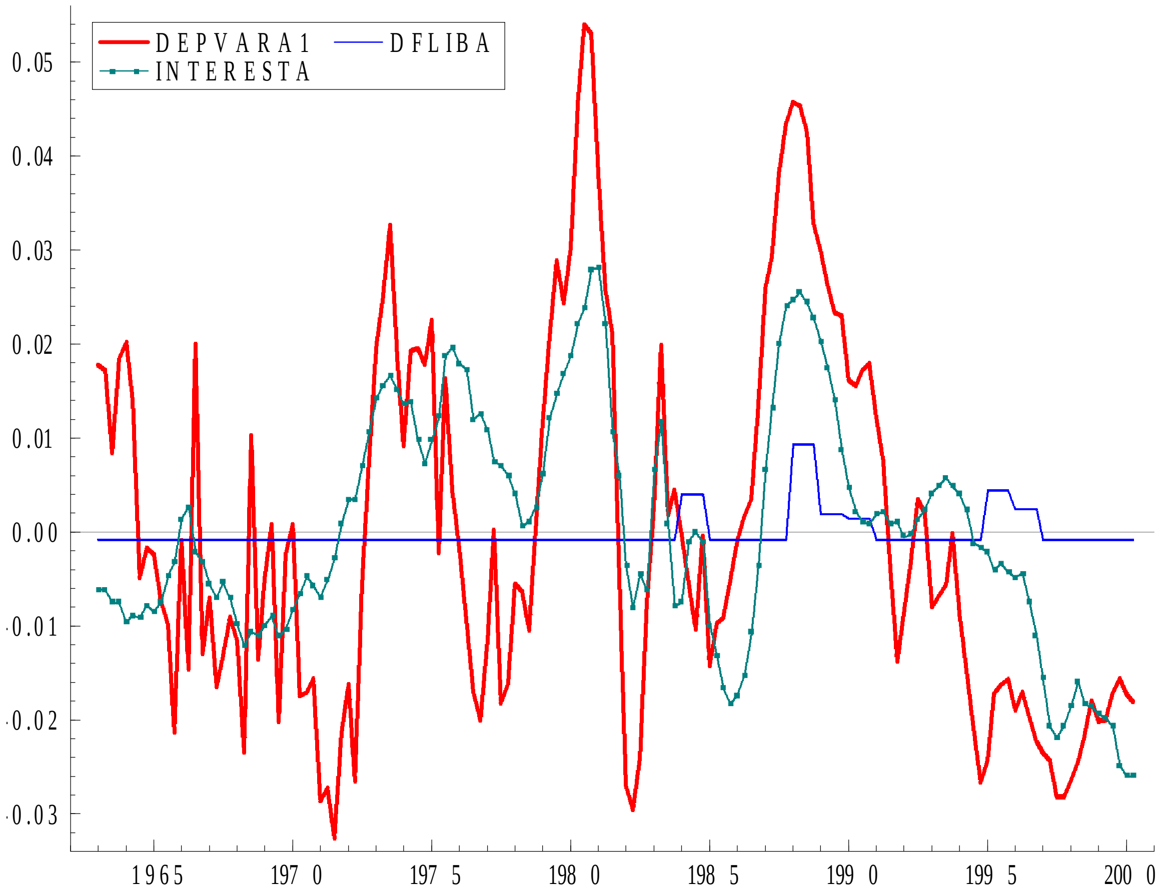


Figure 3: Real output and the stochastic trend



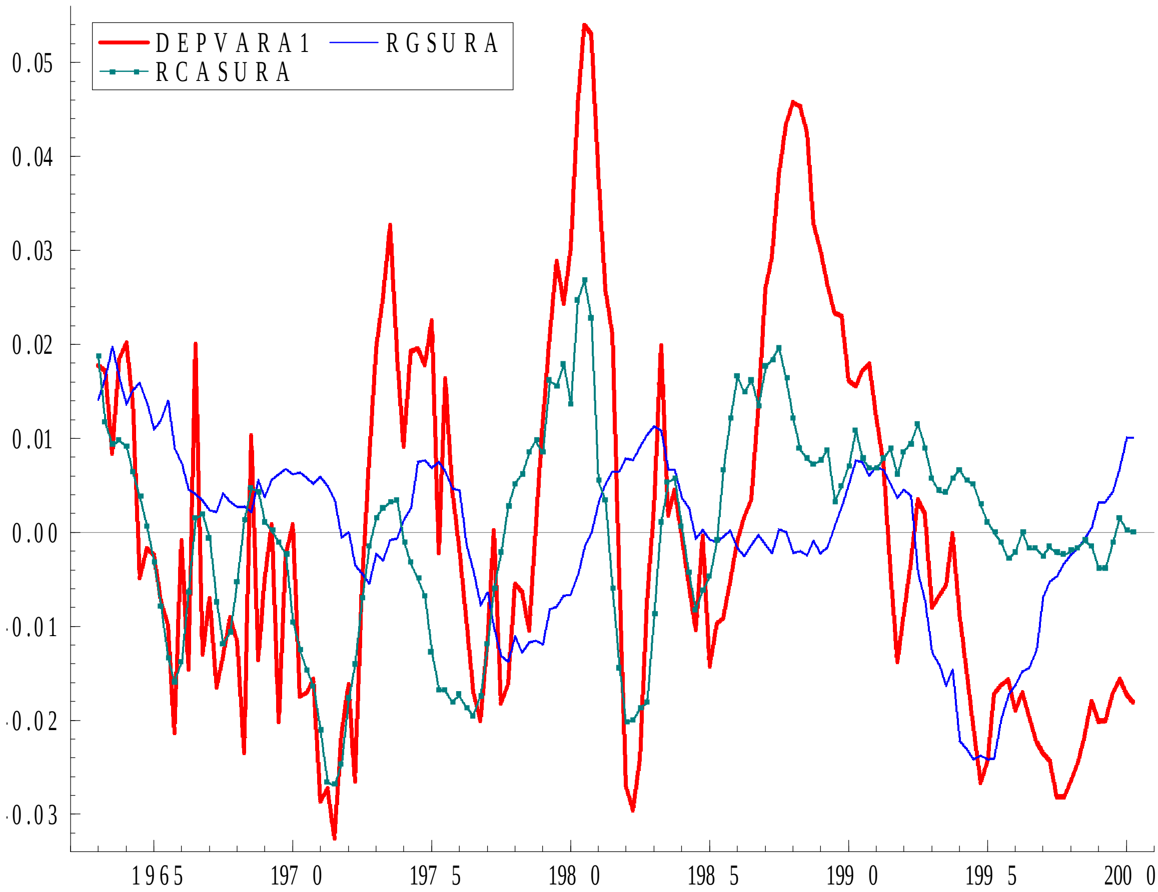
Note 1. The stochastic trends are from the equations in Table 4, column 1, and Table 5, column 2.

Figure 4: The contribution to the output forecast of financial liberalisation and the composite interest rate effect.



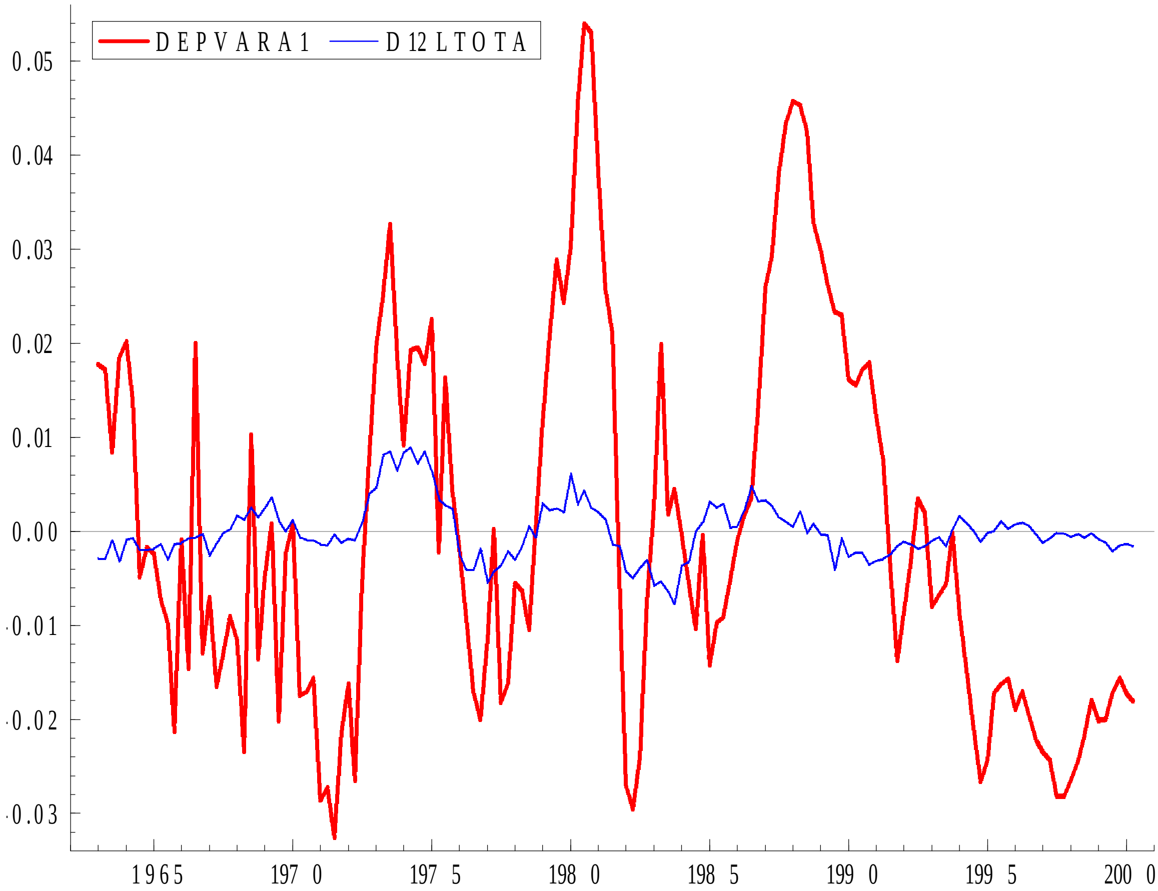
Note 1. DEPVARA1 is the dependent variable minus the level of real GDP multiplied by its regression coefficient minus the stochastic trend, from the equation in column 1, Table 4, and is mean-adjusted.
Note 2. The right-hand side variables are shown weighted by their regression coefficients (Table 4, column 1), and are mean-adjusted.
Note 3. The weighted interest rate effect is defined as: -0.318*(RPRIMA-0.0445)-0.321*(RPRIMA(-4)-0.0445)-0.318*(D4PRIME-0.00243)+0.263*(ND4PRIME+0.000657)+0.327*(NRPRIMA-0.0314).

Figure 5: The contribution to the output forecast of the current account and government surpluses to GDP.



Note 1. DEPVARA1 is the dependent variable minus the level of real GDP multiplied by its regression coefficient minus the stochastic trend, from the equation in column 1, Table 4, and is mean-adjusted.
Note 2. The right-hand side variables are shown weighted by their regression coefficients (Table 4, column 1), and are mean-adjusted.

Figure 6: The contribution to the output forecast of the terms-of-trade.



Note 1. DEPVARA1 is the dependent variable minus the level of real GDP multiplied by its regression coefficient minus the stochastic trend, from the equation in column 1, Table 4, and is mean-adjusted.
Note 2. The right-hand side variables are shown weighted by their regression coefficients (Table 4, column 1), and are mean-adjusted.