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ABSTRACT

Interest Rate Effects on Output: Evidence from a GDP Forecasting Model for South Africa*

Forecasting models for output are presented to throw light on monetary transmission. 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, appropriate for measuring interest rate effects. A stochastic trend measures underlying shifts in productivity and other supply side trends. The inclusion of important monetary policy regime shifts, which altered the output response to interest rates, and the control for other structural changes (e.g. trade liberalization), address the Lucas critique in forecasting output growth. There are important and persistent effects of high real interest rates, which significantly constrained growth in the 1990s, and significant potential growth benefits from fiscal discipline. South African growth appears to have become more responsive to the exchange rate with increasing trade openness in the 1990s.

JEL Classification: C22, C53, E32, E37 and E52
Keywords: growth, monetary policy transmission, multi-step forecasting and structural breaks

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In small, fairly open economies with deep financial markets, the current central bank view of monetary transmission emphasises the output gap and the exchange rate, a view confirmed for South Africa by Aron and Muellbauer (2000a). The conventional wisdom is that a rise in interest rates affects output with a lag of several quarters. In this paper we measure the effect for South Africa focusing on the lag at a four-quarter horizon, and we use novel techniques appropriate for economies that have experienced important regime shifts.

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 force of circumstance has compelled a move away from these ideas. The shift to inflation targeting from 2000 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 shared understanding with the private sector of the effectiveness of monetary policy for inflation and output (Leiderman and Svensson, 1995).

Forecasts of output and inflation are usually made from large quarterly "structural" or "policy" econometric models, or from vector autoregressive (VAR) models usually containing fewer than ten variables, often below five.[1] The macromodel of the South African Reserve Bank (SARB) has recently undergone wholesale revision but has not yet been published. The previous vintage of the SARB's models omitted important interest rate transmission channels, via wealth effects and hence asset prices (except for the exchange rate), and via expectations. Further, these models gave insufficient attention to the consequences of regime shifts. Consequently, it has

[1] See Jonsson (1999) for a small VAR model of prices, broad money, real income, interest rates, and the exchange rate for South Africa.

been difficult to arrive at a well informed view of the size and dynamics of the effects of monetary policy.

While structural macromodels may be misspecified, reduced-form VAR models are frequently prone to forecast failure from omitted structural breaks, key variables, and lags. Clements and Hendry (1999) show that intercept-equivalent structural breaks are the single most serious cause of forecast failure. Yet such breaks are commonly neglected in VAR studies[2] (see, for example, Hendry and Mizon (2000) for a critique of VAR methodology and the resulting impulse response functions).

More generally, a VAR system with n variables and k lags uses ($nk + 1$) parameters per equation.[3] 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 tradeoff 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 is of little help where data are highly persistent, as is mostly the case with macroeconomic time series.[4]

In this paper we address some of these disadvantages in forecasting output for South Africa, adapting a third approach, multistep single equation forecasting (see Stock and Watson, 1999, and 2001; Forni and Reichlin, 1998; and for neural networks approaches, Tkacz, 2001). The dependent variable is, for example, the four-quarter ahead rate of growth or inflation. Methodologically, these models can be regarded as single equation, reduced forms of the related

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[2] For example, Britton and Whitley (1997) neglect the financial liberalisation in U.K. consumer credit markets in the 1980s and the shift in the fiscal and monetary policy regimes around 1979–80.

[3] 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 misspecified.

VAR system. Recent research suggests that where VAR models suffer from specification errors, such as omitted moving average error components or structural breaks – both important in South Africa – single-equation, multistep models 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. We pay careful attention to testing for structural breaks and, where necessary, model them; use a stochastic trend to capture shifts in underlying capacity trends; employ "general-to-specific" model selection procedures from a rich class of models (Hoover and Perez, 1999; Hendry and Krolzig, 1999) subject to strong sign priors derived from economic theory; and are able to test for long lags without loss of parsimony by restricting the nature of longer lags.

The multistep forecasting single equation models developed here have the advantage of simplicity over a full VAR system and, it turns out, of economic interpretability. South Africa experienced considerable political schisms from the 1960s onwards, and while the economic effects were profound (e.g., on productivity growth), the impact of such breaks is usually difficult to model. However, our model contains a smooth nonlinear stochastic trend to help deal with these changes – effectively the Kalman filter applied to a time-varying intercept – while VAR models generally do not.[5]

I. Theoretical Background

[4] Other routes to reduce overparameterisation in VARs using Bayesian priors, as in the Minnesota VAR, see Doan, Litterman, and Sims (1984). 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).

[5] In some VAR studies, the Hodrick-Prescott filter is used to detrend output and other variables in advance of estimation. 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.

Following Muellbauer (1996) and Muellbauer and Nunziata (2001), output growth is captured in a dual adjustment process: firstly, output adjusts to equilibrium output, given by an income-expenditure model; and secondly, output adjusts to trend output, 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 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. The component of output growth due to the income-expenditure adjustment is shown in Muellbauer (1996) to be approximately proportional to:

$$A_t / Y_{t-1} - GSUR_t + TSUR_t \ , \qquad (2.1)$$

where *A* is autonomous expenditure, *Y* is real GDP, and *GSUR* and *TSUR* are respectively, the ratios to GDP of the government and trade surpluses. Adding adjustment to the lagged output gap to the income-expenditure adjustment gives:

$$\Delta \ln Y_t = b_0 + b_1 (A_t / Y_{t-1} - GSUR_t + TSUR_t) + b_2 (\ln TY_{t-1} - \ln Y_{t-1}), \qquad (2.2)$$

where *TY* is trend output.

To convert this expression into a one-period ahead forecasting model effectively involves forecasting autonomous expenditure and the government and trade surplus ratios. Embedded in the autonomous term, A_t, are credit, asset, uncertainty, expectations, and terms of trade variables that influence consumption and investment. Important proxies for these variables arise in the context of empirical work on the monetary transmission mechanism,[6] including the "credit channel",[7] Bernanke and Blinder (1992), Bernanke and Gertler (1995), or the "financial accelerator", Bernanke, Gertler, and Gilchrist (1996, 1999).

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. 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, for example, real oil price effects have been studied in the U.S. by Hamilton (1983).

Clear sign priors exist on the autonomous demand forecasting variables (see section III). The (positive) sign prior on a lagged trade surplus[8] is also clear, given the well known persistence of this variable, its reflection of positive terms of trade shocks and its potential role in reflecting excess capacity. The sign prior on a lagged government surplus is less certain. Depending on the fiscal policy feedback rule and the effect on private sector expectations, a

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[6] Studies examining effects of short-term interest rates or other monetary policy indicators on subsequent output growth using VARs include Sims (1980), Bernanke (1990) and Todd (1990).

[7] Credit conditions have been proxied using spreads between corporate and government bonds as one proxy for such credit terms, see Gertler and Lown (1999); others have interpreted such spreads as a proxy for uncertainty.

surplus will predict lower taxes and/or higher future spending, with a positive growth effect. This may well dominate the short-term persistence of a conventional negative "Keynesian" effect.

The forecasting equation will implicitly incorporate both monetary and fiscal feedback rules and is therefore subject to the Lucas critique (Lucas, 1976). It is important therefore to build in parameter shifts reflecting such regime changes and to test for parameter stability.

II. South African Policy Regime Changes

During the 1980s, there were significant regime changes with the move to new operating procedures for monetary policy and domestic financial liberalization. Macroeconomic management was 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). 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.

Monetary Policy Regimes and Financial Liberalisation

Broadly speaking, there have been three monetary policy regimes since the 1960s (Table 1). The first regime was based on liquid asset ratios with quantitative controls on interest rates and credit,

[8] Below we use instead the lagged current account surplus to include service flows also relevant for domestic

and limited importance was attached to the interest rate as a corrective tool. Considerable disintermediation occurred in the late 1970s, and increasing dissatisfaction with the system led to a range of reforms from the early 1980s (see Aron and Muellbauer, 2002).

A cash reserves-based system was introduced following the recommendations of the De Kock Commission (De Kock, 1978, 1985), and direct controls were gradually removed. There were technical changes to asset requirements over a few years, and the role of the central bank's discount rate was redefined. The regime was in full operation by mid-1985, with pre-announced, flexible monetary targets used from 1986. The discount rate was used to influence the cost of overnight collateralised lending and hence market interest rates.

Financial liberalization began in the early 1980s, rapidly expanding credit growth, and with a more open capital account in the 1990s, any usefulness of monetary targets was diminished. In later years the targets were supplemented by a broader set of indicators (see SARB *Quarterly Bulletin*, October 1997), though it is likely that such indicators played a role in previous years too.[9]

Under a third system of monetary accommodation introduced in 1998, the repurchase interest rate is determined at auction. 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 *SARB Quarterly Bulletin*, June 1999). In practice there has been little difference in interest rate behavior between the current and previous regime, and the commercial banks collectively have remained heavily influenced by SARB-directed preferences for the level of the interest rate. From early 2000, an inflation targeting regime was instituted.

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spending.

[9] Extended Taylor rules have been used to examine empirically which factors influenced monetary policy in the second monetary policy regime (Aron and Muellbauer, 2002).

Exchange Rate Policy Regimes[10]

Various exchange rate policy regimes are shown in Table 1. Until 1979 the rand was pegged to either the U.S. dollar or the pound sterling. 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.

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). A "commercial" exchange rate was announced on a daily basis in line with market forces. A "financial" exchange rate applied to most non-resident 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 non-resident capital movements were removed, and while those on residents remained they were treated more leniently.

The unified currency remained stable for a few months, but following the gold price decline in 1983, it 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 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

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

March 1995, under a managed float.

Under inflation targeting, however, the exchange rate is officially fully floating.

Trade Policy Regimes

From the mid-1980s, 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 large increases in tariffs and introducing import surcharges. 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 demand for exports and leakage of demand into imports, see equation (2.2). 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 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 a smooth non-linear stochastic trend, estimated in *STAMP* (Koopman, and others, 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. Variables are defined in Table 2, where some statistics are presented.

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

The influences of openness operate both through the measured effects of import tariffs and surcharges (*RTARIF*), and through the unobservable effects captured in 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)).[11] The openness indicator is shown in Figure 1, where a rise indicates trade liberalisation.

Productivity Trends

[11] 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 and after 1998, with a slower pace of tariff reductions.

In Figure 2, series for nonagricultural and manufacturing labor 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). 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. Generally speaking there appears to be a considerable correlation between the openness indicator shown in Figure 1 and productivity trends.

There was a trend rise in labor productivity in the 1970s corresponding to a rising capital to labor 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. The oil price shocks of 1973 and 1979 levelled the productivity trends, and this is more pronounced for the broader nonagricultural measure. A gold price shock beginning in 1980 brought renewed investment until about 1982, but the 1980s as a whole saw slower productivity growth. South Africa’s increasing isolation was partly responsible for this, but there was also a large shift of employment towards the government sector, where real and/or measured productivity is low. After the substantial sovereign debt crisis of late 1985, labor productivity fell, 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 has been due in large part to the shedding of labor in a more competitive environment generated by rapid trade liberalisation. To the extent that real wages and other labor costs increased, this provided a further incentive to firms to cut employment. The trend is steeper after 1995 with an open capital account, when increased inflows promoted investment through cheap and available finance and introduced new technology.

III. Output Forecasts for South Africa

We now discuss how the theory represented in equation (2.2) is implemented in practice, using South African data.

Model Specification

The single equation equilibrium correction model where Y is real GDP[12] is:

$$\Delta_4 \log Y_{t+4} = \gamma(\alpha_0 + \mu_t + \sum_{i=1}^{n} \alpha_i X_{it} - \log Y_t) + \sum_{i=1}^{n}\sum_{s=0}^{k} \beta_{i,s} \Delta X_{i,t-s} + \varepsilon_t, \qquad (4.1)$$

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.

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

$$\begin{aligned} \mu_t &= \mu_{t-1} + \gamma_t + \eta_{1t} \\ \gamma_t &= \gamma_{t-1} + \eta_{2t} \end{aligned} \qquad (4.2)$$

where η_{it} are white noise errors. When the variance, var $\eta_{2t} = 0$, μ_t is an $I(1)$ trend with drift. When the variance, var $\eta_{1t} = 0$, μ_t is a smooth $I(2)$ trend, and this is the type we use to capture the

[12] 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.

evolution of the supply side. These non-linear trends can be estimated, via the Kalman filter, in the *STAMP* package (Koopman, and others, 2000).

Standard Dickey-Fuller tests suggest that over 1963–2000, log Y_t is $I(1)$, implying that Δ log Y_t is a stationary variable (Table 2). This would imply that the stochastic trend, μ, the X_i variables, 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 investigated in the base model (sign priors are in parentheses) are the level of real interest rates (–) and changes in nominal short-term interest rates (–), with interaction effects discussed below, respectively reflecting theoretical predictions of effects on consumption and investment; the trade surplus to GDP ratio (+) and government surplus to GDP ratio (?), discussed above; a real share price index (+) reflecting wealth and costs of capital effects on consumption and investment; the log terms of trade (+), which affects real domestic spending power; our financial liberalisation indicator (+); and a dummy for the drought of 1992/3 (–).

A wider range of other influences was investigated for a shorter sample, including the prescribed short-term liquid assets ratio (–), a monetary policy tool frequently used before 1985 to restrict bank lending; and the log real exchange rate interacted with an indicator of the openness of the economy to trade (–) (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). Volatility measures of inflation and share prices (–) and the spread between South African and U.S. bond yields (–) proxy uncertainty and are expected to reduce consumption and investment when firms face downward sloping demand curves. Broader measures of household wealth (+)–ratios of liquid and illiquid personal sector wealth to personal sector nonproperty income, constructed in Muellbauer and Aron (1999)–should raise consumption and so GDP; as should the rate of growth of real private credit (+), reflecting a mix of credit availability and a positive investment outlook. Other factors include the change in U.S. short-term interest rates (–), which is a predictor of South African interest rates; world industrial production (+); and net capital inflows (+), indicating access to international capital inflows.

Supply side shifts due to investment are represented by the private investment to GDP (?) and capital-to-labor ratios (+), the former entering as the moving average of the log ratio of fixed capital formation (excluding residential housing) to GDP. In principle, this effect is ambiguous. 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. If recent additions to the capital stock have been high, however, firms have less need to expand capacity and may have depleted financial reserves. In the near term, investment expenditure might be expected to fall, reducing growth.

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. Thus, the output gap ($\ln TY_{t-1} - \ln Y_{t-1}$) in equation (2.2) is measured as the deviation of log GDP from a nonlinear trend. 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 the changing sensitivity of output growth to interest rates as the monetary policy regime changed in the 1980s. 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. We investigate systematically the effects of these changes on the monetary transmission mechanism by constructing 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.

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 it depends also on income expectations, asset levels, uncertainty, and interest rates. Bandiera and others, (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 behavioral impact of financial liberalization. A flexible technique linking institutional information with behavioral 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).[13] The estimated parameters for *FLIB* reflect the key institutional changes in credit markets. Our 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 and is captured in our measure of openness, described above (see Figure 1). This would be expected to shift the influence of the real exchange rate on growth, while the direct effect of increased openness on productivity and hence capacity growth will be buried in the estimated stochastic trend, μ_t.

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 (4.1) with a set of variables available for the whole period.[14] We use a device to save on degrees of freedom while permitting the examination of longer lags than is possible in a conventional VAR model. For lags longer than four, the lag structure is restricted to fourth changes or four-quarter moving averages to prevent overparameterization. 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. 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*. Figure 2 shows real output and the stochastic trend generated from the equation in column 1, Table 4.

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[13] 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 nonnegative (i.e., that there is no reversal in financial liberalization), in practice only six parameters are needed to define FLIB.

[14] 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.

In the parsimonious equations reported, all explanatory variables are $I(0)$ as is 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.

Turning to the parameter estimates in Table 4, all sign priors are supported by the data. 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 $\Delta_4(PRIME)$ 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. Although most of the effect of changes in nominal interest rates disappears, however, the greater volatility of interest rates in the new monetary 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 government surplus effect enters through a three-year moving average, suggesting that government deficits have persistent negative effects on subsequent income growth.[15] 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 current account surplus to GDP ratio, *RCASUR*, is also confirmed, another channel for the terms of trade. It may also provide additional information on the output gap. Lags in *RCASUR* may therefore reflect persistence in *RCASUR*, which both helps forecast the trade balance and plays an indirect role via its contribution to measuring the output gap. 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 mineral dependent economy. Finally, given the importance of agriculture in South African 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 $\Delta_4 \log GDP_{t+4} + 1.14 \log GDP_t - \mu_t$, 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.

[15] In the U.S. (Muellbauer, 1996), there is some evidence that before the heightened concern with government

Figure 4 (above) 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 South Africa. 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. 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 central bank 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 column 5, we show estimates for the period of the floating exchange rate.

Though a formal *F*-test of parameter stability is not possible given the stochastic trend, 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 quite stable. This is evidence that the model is robust to the Lucas critique. There is no evidence of autocorrelated residuals. Tests for normality and heteroscedasticity are also satisfactory.[16]

Results of Estimations with Additional Variables

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deficits in the 1980s, there was a negative “Keynesian” response of output to the government surplus.

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.[17]

As Table 5 shows, all these variables operate in the direction suggested by *a priori* economic considerations (given the proviso of the ambiguous effects discussed above). Credit growth enters as a two-year growth rate.[18] 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, *NRPRIMA*. 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 personal 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,

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[16] The current version of *STAMP* makes recursive forecasting and thus rigorous out-of-sample performance evaluation infeasible.

[17] 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.

[18] 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 operate via the output gap on a four quarter-ahead horizon, which influences inflation four quarters later.

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 prescribed 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 that has had a positive effect on output growth since 1994. In other words, though the effect works in the direction one would expect, its estimated size is unlikely to be robust. Secondly, the Table 5 results are sensitive to the inclusion of this variable: if it is excluded, the other additional 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 that has been through structural changes as deep as those that have faced South Africa.[19] Note that taking the coefficient for the interactive effect of –0.33 from Table 5, column 6, a sustained fall in the real exchange rate of 10 percent translates into a 1.5 percent higher level of output. Given that such a fall also improves the current account surplus, the full effect should be even larger.

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.

IV. Monetary Policy Implications and Discussion

We have employed multistep forecasting techniques in estimations with stochastic trends to predict output growth in South Africa, one year ahead. The model builds in allowances for diminished trade and finance related to periodic political crises, monetary policy regime shifts in the 1980s, and financial liberalisation, so addressing the Lucas critique. A smooth stochastic trend satisfactorily represents long-run changes in productivity and capacity growth given these regime changes. Other innovative features are the use of comprehensive sign priors based on economic theory and restrictions in the form of longer lags–rather than their omission–in reducing the model from a general to a parsimonious form.

The models offer important insights on monetary policy transmission.[20] Levels of real rates influence output, and the effects persist for up to three years, even without feedback effects via the other explanatory variables. However, Table 5 implies the effects of changes in nominal interest rates have been reduced by changes in the monetary policy regime, particularly in 1983–85: a one percentage point rise in the prime rate now has a smaller direct effect on output than before the shift in monetary policy in the early 1980s, when policy emphasised liquidity ratios,

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[19] If there were measures of openness and the real exchange rate before 1970, the robustness of these results could probably be improved.

[20] Note that this model, even in combination with our inflation forecasting model, Aron and Muellbauer (2000a), does not constitute a full system and hence does not make possible policy experiments of the type discussed by Cunningham and Haldane (2002), where different monetary policy feedback rules can be compared. Nevertheless, our models suggest which variables and structural breaks should be included in such a system. Clearly, the system is required fully to trace through effects of different types of shocks over different horizons.

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 pre-1983 interest rate effects are probably overstated. 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.

When central banks follow systematic policy rules, as in the Taylor (1995) rule linking short-term interest rates to the output gap and inflation, it can be difficult to identify interest rate effects in a reduced form forecasting equation or in the impulse response function from a VAR (Rotemberg and Woodford, 1997). There are two reasons why this is not a problem in our study: our equations embody theory-derived sign restrictions; and interest rates in South Africa have, at times, been subject to large exogenous shocks (Aron and Muellbauer, 2002).

A surprising finding is that, while we can find positive wealth effects on output growth a year ahead, these are never very significant, yet they are important for explaining current consumption (Aron and Muellbauer, 2000b, c). This is in sharp contrast to the sizeable and highly significant stock market price effects in forecasting U.S. GDP (Muellbauer and Nunziata, 2001). 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. 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 (with a more complete data set) that South Africa became more responsive to the real exchange rate as its economy became more open during the 1990s, especially after 1994. During 1970–2000, 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 too short to be sure of the robustness of the size of the real exchange rate effect, though its direction is surely correct.

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[21] – 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 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). Stronger prudential regulation in this area could have had considerable growth benefits. Under the new inflation targeting regime, the large output costs of high real interest rates should focus attention on other policies that could bring down inflation, including competition policy, labor market policies, and improved measurement of housing costs in the consumer price index.

The robustness of forecasts over a one-year horizon is likely to be enhanced by the stochastic trend incorporated in our models, which evolves with changing circumstances, and the next few years are unlikely to be an exception. 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. It will affect productivity growth and the government surplus, and probably the current account and long-term capital flows, all shown to affect the one-year ahead growth outlook.

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[21] Homeowner housing costs are measured using the mortgage interest rate in the CPI, which apart from having unfortunate policy implications, has a weak conceptual basis in the context of liberalised mortgage markets.

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Table 1. Monetary Policy and Exchange Rate Policy Regimes

Years	**Monetary Policy Regimes**
1960–81	Liquid asset ratio-based system with quantitative controls on interest rates and credit
1981–85	Mixed system during transition
1986–98	Cost of cash reserves-based system with pre-announced monetary targets (M3)
1998–99	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)
Years	**Exchange Rate Policy Regimes**
1961q1–1971q2	Pegged to fixed pound sterling
1971q3–1974q2	Pegged in episodes to floating U.S. dollar/pound sterling
1974q3–1975q2	"Controlled Independent Float": devaluations every few weeks
1975q3–1979q1	Fixed regime: pegged to the U.S. dollar
1979q2–1982q4	Dual foreign exchange system: controlled floating commercial rand and floating financial rand
1983q1–1985q3	Unification to a controlled floating rand
1985q4–1995q1	Return to a dual system
1995q1–	Unification to a controlled floating rand

SOURCE: Aron and Muellbauer (2002) and Aron, Elbadawi and Kahn (2000).

Table 2. Statistics and Variable Definitions

Variable	Definition of Variable	Mean	Standard Deviation	$I(1)^{1,2}$	$I(2)^{1,2}$
1963q1–2000q2	**Output Forecasting Equation**				
$\Delta_4 \log(Y)$	Annualised real GDP growth rate (seasonally adjusted)	0.0279	0.0278	-	-
$\log(Y)$	Log of real GDP (seasonally adjusted)	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**	-
RGSURMA12	Government surplus to GDP ratio (three-year MA)	–0.0390	0.013	–6.49**	-
$\Delta_{12} \log(TOT)$	Three-year change in the log terms-of-trade	0.00880	0.123	–2.59	–15.22**
Δ*FLIB*	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	-	-	-	-
$N\Delta_4$*PRIME*	Shift dummy x Δ_4 *PRIME*	–0.000657	0.0242	-	-
NRPRIMA	Shift dummy x *RPRIMA*	0.0314	0.0466	-	-
*DUM*92	Drought dummy = 1 for 1991:3–1992:2, otherwise = 0	-	-	-	-
	Additional variables				
STLA	Level of short-term liquid asset ratios from 1965 onwards	0.323	0.209	-	-
Δ*USTBILL*	First difference in U.S. treasury bill rate/100	0.000198	0.00833	–2.62	–3.91**

Table 2. Statistics and Variable Definitions (contd.)

Variable	Definition of Variable	Mean	Standard Deviation	*I*(1)[1,2]	*I*(2)[1,2]
	Additional variables contd.				
VSTOCK	The 3-month MA of the absolute value of monthly change in the JSE all-share index less the average change over previous three years divided by 36. (Converted to quarterly data.)	0.0428	0.0250	–4.25**	-
log (*RJSEMA*)	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 1, minus (4.30 x *RTARIF*(–1)). Interpolated back to 1970 and forward to 2000.	-	-	-	-
*DUMOPEN** log (*REERMA*)	*DUMOPEN* interacted with the log of the four-quarter moving average of the real effective exchange rate, less approximate log mean of 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 (*RLTFLOWMA*)	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**	-
WEALTHMA	Wealth measure from Muellbauer and Aron (1999): 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**

Table 2. Statistics and Variable Definitions (contd.)

Variable	Definition of Variable	Mean	Standard Deviation	$I(1)$[1,2]	$I(2)$[1,2]
	Additional variables contd.				
USSPREAD	Spread between South African government long bond rate and U.S. government 10 year bond rate	0.0409	0.0374	–2.68	–10.35**
log (*RINVESTMA*)	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 (seasonally adjusted)	5.95E-1	5.72E4	–3.63*	-

1. 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), Δ*X* replaces *X* in the equation above. Critical values are obtained from MacKinnon (1991). Asterisks * and ** denote rejection at 5 percent and 1 percent critical values.
2. Stationarity tests are performed for the variables in levels before time-transformation, that is, before taking moving averages and changes.

Table 3. Equation for Share of Manufactured 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)

1. The equation includes an *I*(2) stochastic trend.
2. *r*(1) is first-order residual autocorrelation; R_D^2 is *R*-squared computed for first differences of the dependent variable.
3. The equation standard error and t ratios in *STAMP* are not adjusted for degrees of freedom.

Table 4. Forecasting Equations for Real Output with a Stochastic Trend

Dependent variable: $\Delta_4 \log(Y)$ (+4)	**1** **1963 (1) – 2000 (2)**	**2** **1970 (1) – 2000 (2)**	**3** **1963 (1) – 1989 (2)**	**4** **1963 (1) – 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]
$N\Delta_4$*PRIME*	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]
RGSURMA12	0.694 [2.8]	0.918 [3.8]	1.06 [3.6]	0.740 [2.6]	0.670 [2.5]
Δ_{12} log (*TOT*)	0.0244 [2.0]	0.0215 [1.9]	0.0251 [2.0]	0.0241 [1.8]	0.00853 [0.68]
Δ*FLIB*	0.177 [2.0]	0.187 [2.5]	0.203 [1.9]	0.146 [1.4]	0.173 [2.6]
*DUM*92	–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					
Equation Standard 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
Adjusted R^2	0.718	0.738	0.768	0.730	0.794

(Absolute values of asymptotic *t*-ratios in parentheses)

1. The equations include an *I*(2) stochastic trend.
2. See Table 2 for definitions of the variables, some of which are defined as moving averages.
3. The equation standard error and *t* ratios in *STAMP* are not adjusted for degrees of freedom.

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

Dependent variable: Δ_4 **log (Y) (+4)**	**1** **1970 (1) – 2000 (2)**	**2** **1970 (1) – 2000 (2)**	**3** **1979 (2) – 2000 (2)**	**4** **1970 (1) – 1994 (1)**	**5** **1971 (2) – 1997 (4)**	**6** **1979 (1) – 2000 (2)**	**7** **1970 (1) – 2000 (2)**
Regressors							
log (*Y*)	–1.19 [15]	–1.14 [15]	–1.06 [9.9]	–1.11 [13]	–1.20 [14]	–1.12 [10]	–1.14 [15]
RPRIMA	–0.233 [2.3]	–0.197 [3.4]	–0.162 [2.6]	–0.233 [3.1]	–0.200 [3.3]	–0.134 [2.1]	–0.152 [2.4]
RPRIMA (-4)	–0.304 [4.4]	–0.311 [4.8]	–0.292 [4.3]	–0.297 [3.6]	–0.349 [4.8]	–0.297 [4.7]	–0.264 [3.6]
Δ_4 *PRIME*	–0.390 [5.2]	–0.368 [5.3]	–0.417 [5.6]	–0.311 [3.8]	–0.403 [5.3]	–0.492 [6.6]	–0.366 [5.2]
$N\Delta_4PRIME$	0.328 [3.9]	0.317 [4.1]	0.377 [4.5]	0.313 [3.1]	0.384 [4.4]	0.445 [5.6]	0.337 [4.3]
NRPRIMA	0.114 [0.89]	-	-	-	-	-	-
RGSURMA12	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]	-	-	-
Δ*FLIB*	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]
*DUM*92	–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]

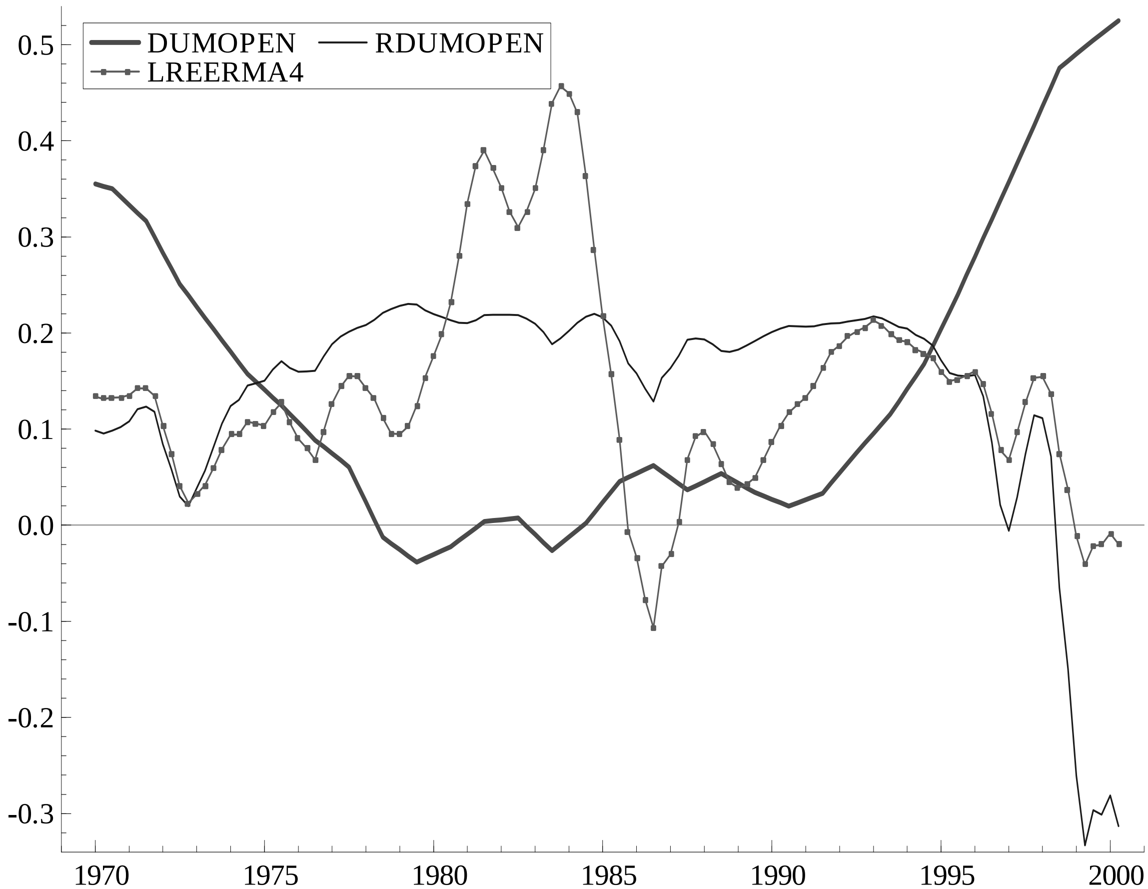
Table 5. Additional variables in the forecasting equations for real output (contd.)

Dependent variable: Δ_4 log (Y) (+4)	**1** **1970 (1) – 2000 (2)**	**2** **1970 (1) – 2000 (2)**	**3** **1979 (2) – 2000 (2)**	**4** **1970 (1) – 1994 (1)**	**5** **1971 (2) – 1997 (4)**	**6** **1979 (1) – 2000 (2)**	**7** **1970 (1) – 2000 (2)**
Regressors							
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]
Δ*USTBILL*	–0.0837 [1.3]	-	-	-	–0.109 [1.6]	–0.123 [2.0]	-
VSTOCK (–1)	–0.0277 [1.0]	-	-	-	-	-	-
log (*RJSEMA*) (–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 (*REERMA*)	–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 (*RLTFLOWMA*)(–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]
WEALTHMA	-	-	-	-	0.0310 [1.4]	-	-
USSPREAD	-	-	-	-	-	–0.0801 [1.3]	-
log (*RINVESTMA*)	-	-	-	-	-	-	–0.0733 [2.1]
Diagnostics							
Equation Standard 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
Adjusted R^2	0.793	0.784	0.812	0.797	0.790	0.830	0.782

(Absolute values of asymptotic *t*-ratios in parentheses)

1. The equations include an *I*(2) stochastic trend.
2. See Table 2 for definitions of the variables, some of which are defined as moving averages.
3. The equation standard error and *t* ratios in *STAMP* are not adjusted for degrees of freedom.

Figure 1: The Openness Indicator for South Africa



Note 1: The variable, *DUMOPEN*, is defined as the saved stochastic trend from the equation for the share of imports in home demand in Table 3, column 1, minus (4.30 x *RTARIF*(–1)). *RDUMOPEN* = *DUMOPEN***LREERMA4*, where *LREERMA4* is the four quarter moving average of the log of the real effective exchange rate, less its approximate log mean.

Figure 2. Nonagricultural and Manufacturing Labor Productivity Measures with Stochastic Trend After Removing Cyclical Influences.

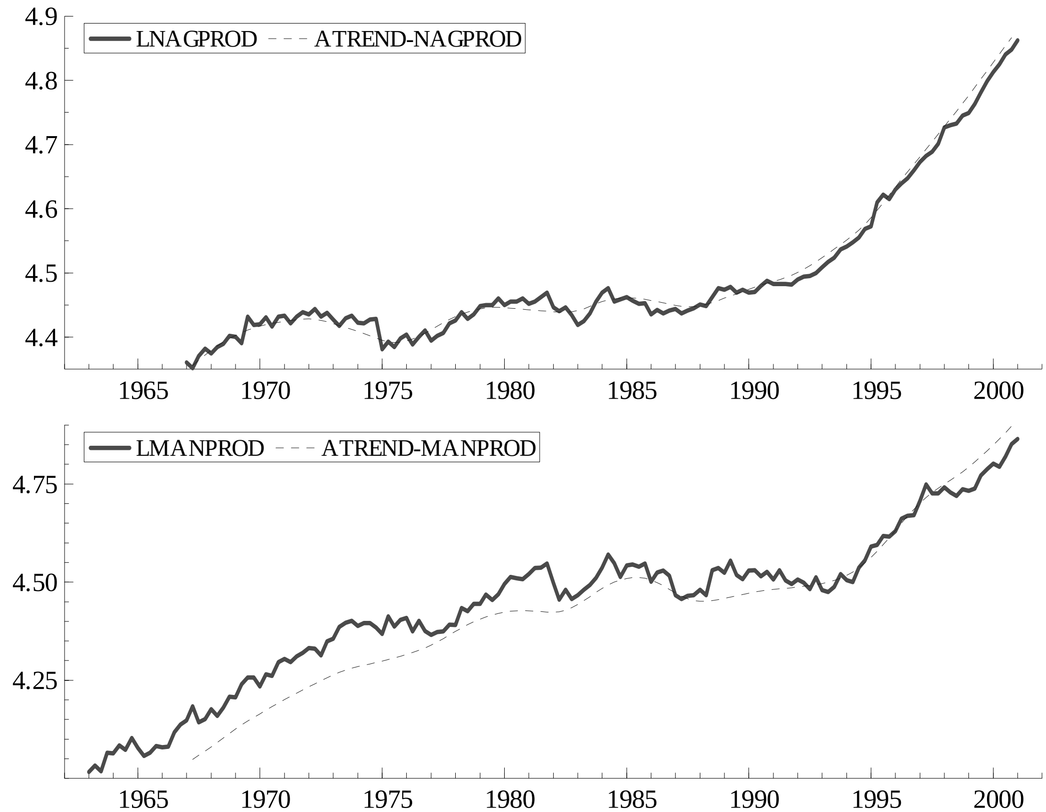
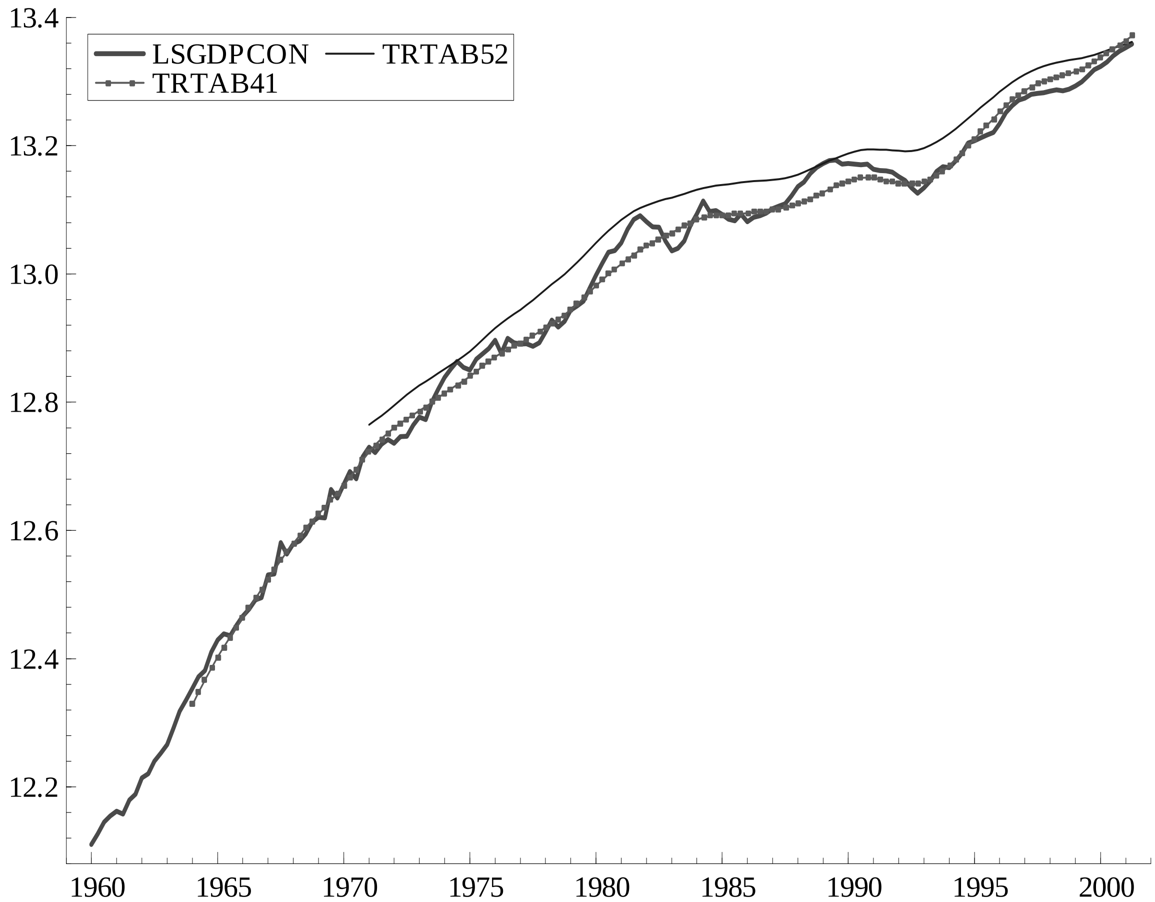
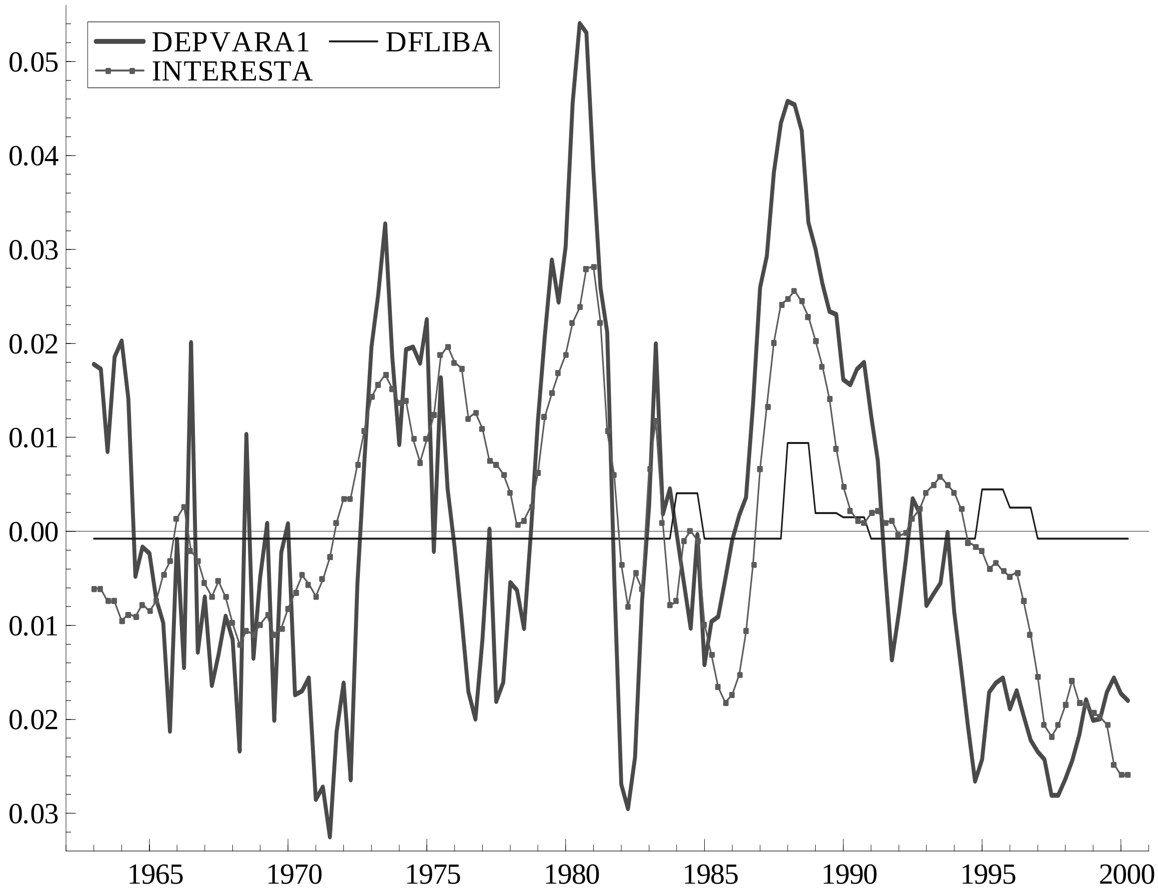


Figure 3. Real Output and the Stochastic Trend



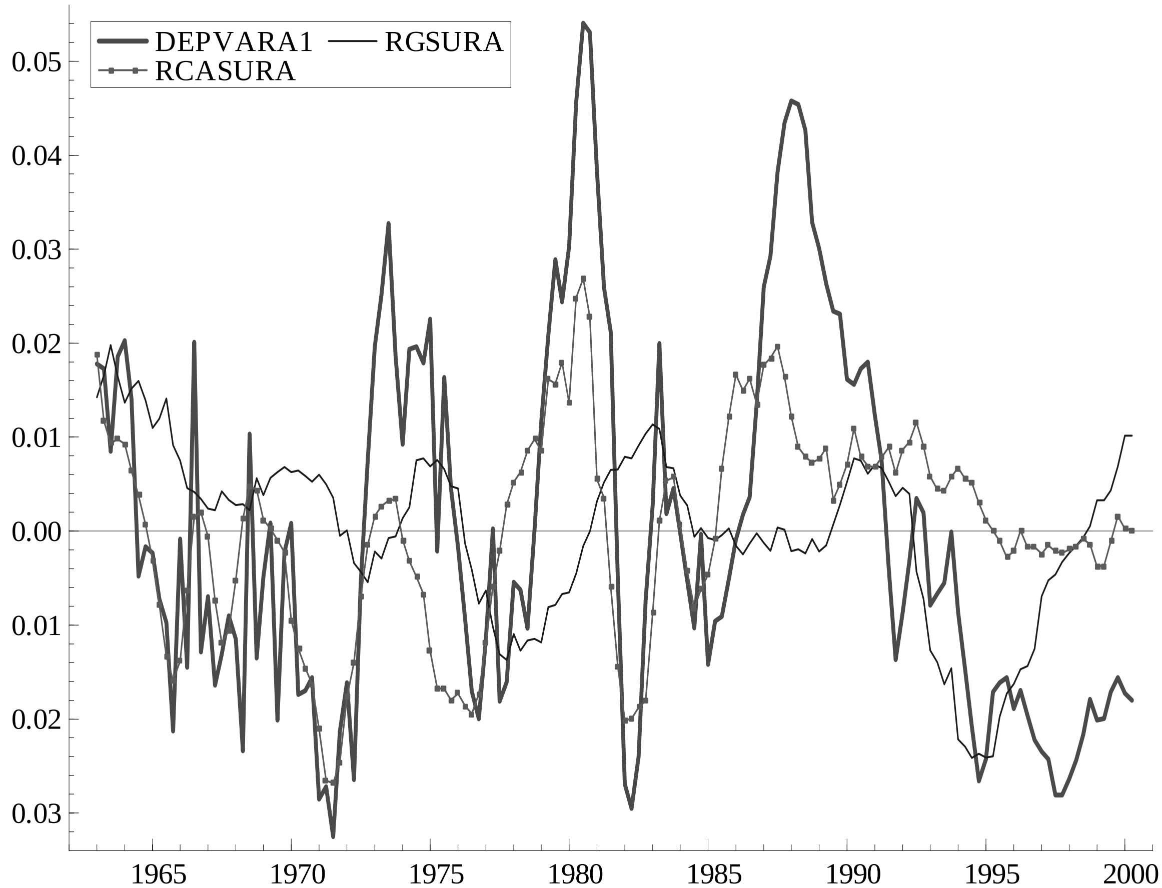
Note: The stochastic trends are from the equations in Table 4, column 1, and Table 5, column 2. They are defined as $\mu_{t-4}/1.12$ and $\mu_{t-4}/1.14$, respectively; the fact that *TRTAB52* lies above the log *Y* line reflects the inclusion of the additional regressors in Table 5, column 2, which have non-zero means.

Figure 4. The Contribution to the Output Forecast of Financial Liberalisation and the Composite Interest Rate Effect.



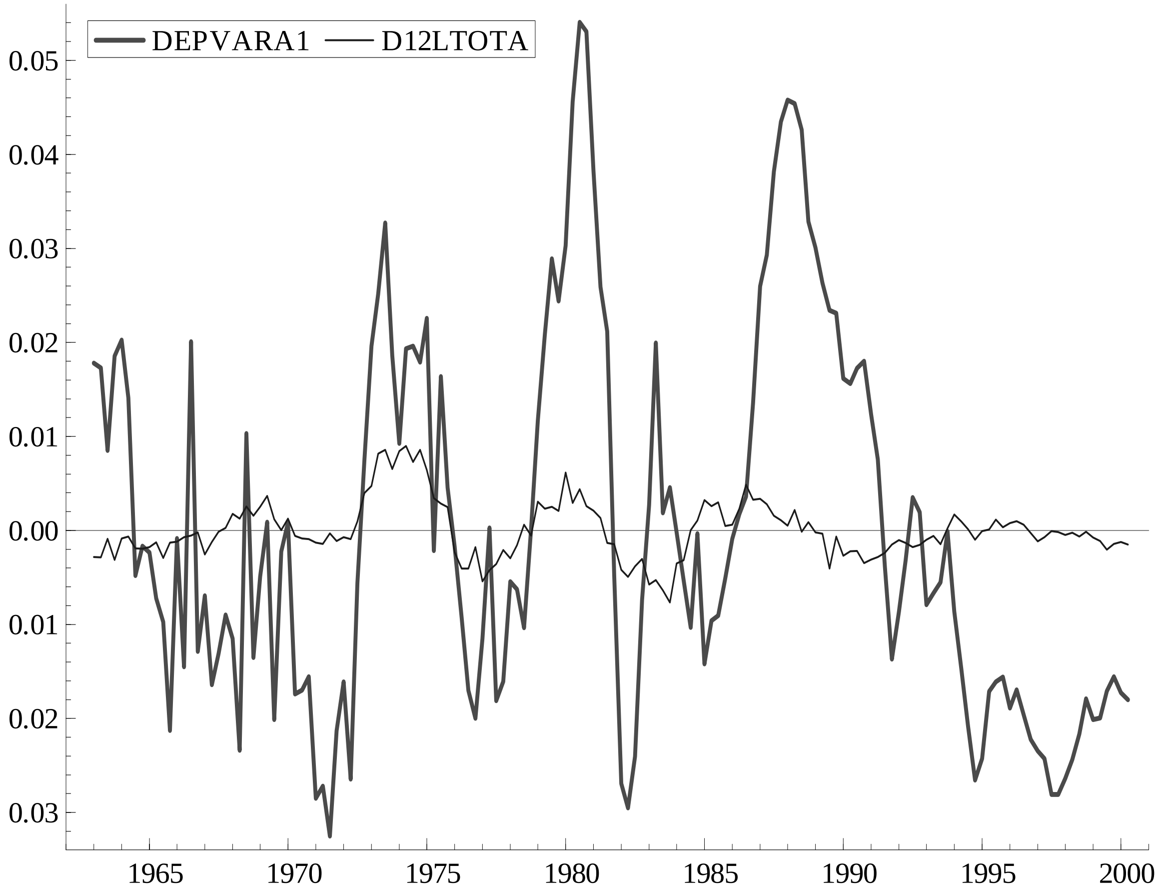
Note: *DEPVARA1* is the dependent variable minus the level of real GDP multiplied by its regression coefficient minus the stochastic trend, from the equation in column 1, Table 4, and is mean adjusted; the right-hand side variable, Δ*FLIB*, is shown weighted by its regression coefficient (Table 4, column 1), and is mean adjusted (*DFLIBA*); the weighted interest rate effect, *INTERESTA*, is defined as: –0.318*(*RPRIMA*–0.0445) – 0.321*(*RPRIMA*(–4) – 0.0445) –0.318*(Δ_4*PRIME*–0.00243)+0.263*(*N*Δ_4*PRIME*+0.000657)+0.327*(*NRPRIMA*–0.0314), and is mean adjusted.

Figure 5. The Contribution to the Output Forecast of the Current Account and Government Surpluses to GDP.



Note: *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; the right-hand side variables, *RCASUR* and *RGSUR*, are shown weighted by their regression coefficients (Table 4, column 1), and are mean adjusted (*RCASURA* and *RGSURA*).

Figure 6. The Contribution to the Output Forecast of the Terms of Trade.



Note: *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; the right-hand side variable, Δ_{12} log (*TOT*) is shown weighted by its regression coefficient (Table 4, column 1), and is mean adjusted (*D*12*LTOTA*).