Inflation and Output Forecasting for South Africa: Monetary Transmission Implications*

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Abstract: *South Africa's recent adoption of inflation targeting increases the need for good forecasting models of inflation and models for understanding the monetary transmission mechanism. This paper presents multi-step models for inflation and output, four-quarters ahead. The inflation model has an equilibrium correction form, which clarifies medium- or longer-run influences on inflation, including opening the economy to foreign imports. The model confirms the importance of the output gap and the exchange rate for forecasting inflation; and the influence from recent changes in the current account surplus to GDP ratio, which is also sensitive to short-term interest rates. However, a rise in interest rates can also raise inflation in the short-run, via a rise in mortgage interest payments (a component of the consumer price index). The unfortunate policy implications for South Africa are discussed. The output model uses a stochastic trend to measure long-run changes in the capacity to produce. On the demand side there are important negative interest rate effects, though these have been altered by changes in the monetary policy regime. The trade surplus and government surplus to GDP ratios, which also respond to interest rate changes, and improvements in the terms-of-trade, all have a positive effect on future output.*

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1. Introduction

Monetary policy in South Africa is going through a rapid transition. In earlier years, an old-fashioned, partly "monetarist" view assumed a simple connection between money supply and inflation. Accumulated international evidence does not support this, and in South Africa too, force of circumstance has seen a move away from these ideas (see Tables 1 and 2). The shift to inflation targeting from late 1999[1] demands good forecasting models of inflation, as well as a shared understanding with the private sector of the effectiveness of monetary policy for inflation (e.g. Leiderman and Svennson, 1995). In principle, there are several channels of transmission of monetary policy to inflation, see Taylor (1995) for a simple summary. In an open economy, domestic sources of inflation which are likely to be responsive to short-term interest rates include the output gap (the deviation of output from capacity) and the exchange rate. There is thus a need for robust empirical evidence on the effects of these variables on inflation, and the effects of interest rates, in turn, on the output gap and on the exchange rate. This paper provides some of this evidence for South Africa.

The South African Reserve Bank's quarterly econometric macro-model has recently been undergoing wholesale revision. In the previous version of the inflation sector, see Smal and Pretorius (1994), a fairly conventional, multi-sectoral Phillips curve specification was adopted in which wages and import prices feed into final goods prices; and wage inflation depends, among other things, on the output gap. A simple expectations proxy in the wage inflation equation is based on lagged inflation and the change in the money supply. Long-run influences on inflation are absent, such as the increased openness of the economy to import competition and the gradual adjustment of relative prices.

As far as the determination of aggregate expenditure and output is concerned, the previous vintage of the Bank's models appear to omit two of the most important interest rate transmission channels: via wealth effects, and so asset prices (except for the exchange rate); and via expectations. Consequently, it is difficult to take a well-informed view of the size and dynamics of the effects of monetary policy. Further, these models give 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, see Lucas (1976). Such defects in earlier U.K. models played a major role in the costly macroeconomic policy failures of the late 1980s and early 1990s.

One alternative to forecasting with a large, quarterly, structural macro-econometric model (which may be mis-specified), is to develop reduced-form forecasting models with plausible long-run properties, and to subject these models to extensive econometric testing. This could be done in the context of a quarterly vector autoregressive model (VAR) (e.g. see Jonsson (1999b) for a small VAR model of prices, money and the exchange rate for South Africa). However, in this paper we forecast the consumer price level and real GDP, four quarters ahead, using a single-equation, multi-step forecasting approach. For VAR models suffering from certain specification errors e.g. omitted moving average error components or structural breaks, multi-step forecasts can provide more robust forecasts (Weiss, 1991; Clements and Hendry, 1996, 1998). Multi-step forecasting models have the further advantage of transparency and ease of use.

Section 3 presents a model for forecasting the change in the log consumer expenditure deflator four quarters ahead. The model has an 'error or equilibrium correction' form, which clarifies medium- or longer-run influences on inflation, including opening the economy to

[1] The feasibility of an inflation targeting system in South Africa has been discussed by Kahn (1998), Casteleijn (1999) and Jonsson (1999a).

foreign imports. The model confirms the importance of the output gap and the exchange rate for forecasting inflation; and the influence from recent changes in the current account surplus to GDP ratio, which is also sensitive to short-term interest rates. However, a rise in interest rates can also *raise* inflation in the short-run, via a rise in mortgage interest payments (a component of the consumer price index).

We also present an alternative version of the model incorporating a stochastic trend, see Harvey and Jaeger (1993). The latter promises to offer a practical method for dealing with shifts in long-run inflationary expectations, such as those which might arise from the adoption of inflation targeting, or from other slowly evolving structural changes in the economy. The stochastic trend approach also proves very helpful in deriving plausible measures of the output gap.

Section 4 derives a 4-quarter-ahead forecasting model for the rate of growth of real GDP. During the 1980s in South Africa, there were significant regime changes with the move to new operating procedures for monetary policy and financial liberalization. Periodically, serious political crises entailed the increasing international isolation of South Africa, reflected in diminished trade and finance. Its mineral dependency as a primary exporter gives an important role to terms-of-trade shocks in determining output growth. Our model builds in allowances for these features, as well for an income-expenditure approach for analysing the deviations of output from trend. A smooth stochastic trend satisfactorily represents long-run changes in productivity growth of the kind one might expect in an economy subject to such regime changes.

The model has important implications for modelling the transmission of interest changes onto output. We find that changes in nominal interest rates as well as levels of real rates, with quite long lags, have a negative effect on future output. These effects have, however, been somewhat altered by changes in the monetary policy regime. The trade surplus and government surplus to GDP ratios, which also respond to interest rate changes, and improvements in the terms-of-trade, all have a positive effect on future output.

Section 5 draws out the implications for the monetary transmission process of both models and concludes.

2. Multi-step forecasting models

Structural models in open economies of inflation, as exemplified by typical, large quarterly models, examine the inter-relationship of consumer prices, wages, wholesale or output prices, import prices and the exchange rate (see Bank of England, 1999; and Pretorius and Smal, 1994[2]). In principle, VAR models of inflation are concerned with the same set of variables, and the lagged relationships between them.

Methodologically, the models presented in this paper for forecasting inflation or output four quarters ahead can be regarded as single equation, reduced-forms of the related VAR systems. These models have the advantage over a full VAR model of simplicity, and, it turns out, of economic interpretability. Note that VAR models used for forecasting with five endogenous variables will need fairly short lags for parsimony. Moreover, while a single equation of a conventional VAR model can forecast one quarter ahead, forecasting further into the future using recursive substitution requires, in general, all the remaining equations of the VAR system. Treating the dynamics in our model, for lags longer than four, the lag

[2] The inflation sector in the South African Reserve Bank's quarterly econometric model is the most comprehensive inflation model published to date for South Africa.

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 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 inflation rate, which has a three-quarter overlap with its lagged value. Thus, estimated t-ratios and standard errors may require some adjustment.

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; Chevillon, 2000). These features have relevance for modelling both the inflation process and 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, a consequence for instance of periods of large and very persistent capital outflows (later, after democratic elections, inflows), and attendant currency crises. Yet the impact of such breaks is difficult to model.

An example of the moving average error problem occurs with a managed float of the exchange rate in the presence of significant capital flows. Exchange rates are notoriously difficult to model, partly because of the variable success of intervention by the central bank. With large capital outflows, for instance, the central bank may temporarily be able to stabilize the nominal exchange rate to avoid exchange rate depreciation feeding into domestic prices (and similarly, if the source of the shock is higher domestic inflation and so deteriorating international competiveness). But eventually it is likely to be overwhelmed by the macro-economic fundamentals and forced to allow the nominal exchange rate to depreciate. In the error term, this policy reversal manifests itself as negative auto-correlation. A forecast horizon longer than one quarter ahead, such as four or eight quarters ahead, may thus have the advantage that the fundamentals are more likely to have overcome the difficult-to-predict policy interventions of the central bank. This can partially compensate for the inevitable information loss that comes from forecasting over the longer horizon, and give more robust forecasts than a mis-specified VAR.

Similarly, it can be argued that a four-quarter-ahead forecast horizon for output allows more fundamental forces to reveal themselves than are often apparent in quarterly VAR models, particularly those with lag lengths restricted to avoid over-parameterization. The background for the output model follows Muellbauer (1996), which forecasts income growth for the U.S.. We adapt the approach below, using a stochastic trend to measure underlying shifts in productivity and other supply-side trends in the South African economy.

3. An Inflation Forecasting Model for South Africa

3.1 Background

The persistence of inflation in South Africa has been widely commented on. Figure 1 shows annual inflation four-quarters ahead against a long (five-year) moving average of inflation. A partial explanation is given by overlapping contracts with relative wage objectives (e.g. Fuhrer and Moore, 1995), and also by an element of backward-looking expectations, reflected in the practice of capturing the last year's price increases in the current year's wage increase – rather than using formal indexation.

Further, while unions for black workers were legalised only in 1980, they were increasingly effective from the early 1970s in raising real wages. Note, however, that the ratio of the unit labour cost to the consumer price deflator is without trend during 1982-1998, and in practice it does not prove useful in consumer price inflation forecasts[3].

This upward persistence was reinforced by changes in the openness to competition, which has been subject to major evolutionary changes over long periods: international trade sanctions from the late 1970s, coupled with raised domestic tariffs and import surcharges, left domestic companies with increased market power. However, as trade barriers began to be dismantled in the early 1990s, especially after 1994, there was a steady downward pressure on inflation (Figure 1).

3.2 Theoretical motivation

The theoretical background to the model is an extended version of the Phillips curve model, which implies a temporary trade-off between inflation and unemployment (see Phillips, 1958). A simple expectations-augmented form of the Phillips curve (Friedman, 1968; Phelps, 1968) with excess demand expressed in terms of an output gap, rather than an unemployment gap is given by:

$$\pi_t = \pi_t^e - \theta(y_t - y_t^*) \tag{3.1}$$

where π_t and π_t^e are actual and expected inflation, y_t and y_t^* are, respectively, actual and desired output, and θ captures the impact of inflation on the output gap. The difference between y_t and y_t^* is termed the “output gap”, and in practice is a measure of the deviation of output from capacity or trend output.

An extended version of the Phillips curve model (e.g. Bank of England, 1999) typically takes account of the fact that the adjustment of inflation to demand shocks may be protracted, by contrast with equation (3.1), where the adjustment is immediate. Inflation inertia, for instance from backward-looking expectations or overlapping wage contracts, may be introduced by including lagged inflation.

On the supply-side, variables can be added to take account of supply shocks which will affect the output gap: such as changes in oil prices, or the terms-of-trade; or in the wedge between prices faced by employers and employees, due to factors such as taxes or trade policy - see Bank of England (1999), p.81, for an extended dynamic specification. Such a structural equation will be part of a small model system, including at least, equations for the determination of the output gap and the exchange rate, both typically incorporating a monetary policy variable such as the short-term interest rate, and an equation for the monetary policy feedback rule.

In this paper, however, we are concerned with the reduced-form of such a system: to be precise, in the multi-step (four-quarter-ahead) forecasting equation for inflation it implies. This is given by

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[3] There are two possible reasons for this surprising finding. First, earnings increases typically arise from backward-indexation to the Consumer Price Index (CPI) plus a productivity component, already included in the unit labour cost measure. Secondly, the unit labour cost measure uses current output per head to proxy the productivity level, which is volatile in the short-run, so that the variable is noisy as well as trendless.

$$\sum_{i=1}^{4}\pi_{t+i} = G_1(L)(y_t - y_t^*) + G_2(L)\pi_t + \sum_{j=3}^{k} G_j(L)V_{jt} \quad (3.2)$$

where π_t is quarterly inflation, so that the dependent variable in equation (3.2) is the four-quarter-ahead inflation rate; $G_j(L)$ is a polynomial in the lag operator for j = 1,…,k; and V_t is a vector of variables entering the complete system, including factors relevant for determining the exchange rate and the output gap in the coming year, such as the real exchange rate, the current account, import prices, unit labour costs, the terms-of-trade, taxes, trade policy, an explicit wedge between producer and employee prices such as the producer price to consumer price ratio, and supply and demand shocks.

Although the extended Phillips curve has a fairly general formulation, one can argue that it does not focus sufficiently on the fact that one of the factors behind consumer price inflation is the gradual adjustment of relative prices. In this view, an equation for inflation should incorporate a long-run solution for relative prices, which is missing from equation (3.1). Thus, if consumer prices deviate strongly relative to wholesale prices, import prices or unit labour costs, a dynamic adjustment occurs bringing price relatives back towards their equilibrium paths. Note that these paths themselves may depend on economic forces such as the degree of openness of the economy, long-run productivity growth, the real exchange rate and trade-union strength. Our reduced-form formulation is general enough to encompass such a mechanism.

3.3 Empirical forecasting model

The model forecasts inflation four quarters ahead, measured by the log change in the consumer expenditure deflator[4], given information at time t (see also the 12-month ahead inflation model of Stock and Watson, 1999). We estimate both a constant parameter model and an extended version of stochastic trend models of the type recommended by Harvey (1993) and Harvey and Jaeger (1993), using the STAMP programme of Koopman et al (1995).

The reduced-form single equation VAR model has the following general representation:

$$\Delta_4 \log P_{t+4} = \gamma(\alpha_0 + \alpha_1\mu_t + \sum_{i=2}^{n}\alpha_i X_{it} - \log P_t) + \sum_{j=1}^{n}\sum_{s=0}^{k}\beta_{j,s}\Delta X_{j,t-s} + \varepsilon_t \quad (3.3)$$

where $\Delta_4 \log P_{t+4}$ is the four-quarter-ahead inflation rate; the X_i include a range of potential inflation determinants detailed below, and ε_t is white noise. Lagged inflation, $\Delta \log P_{t-s}$, is included as the $\Delta X_{1,t-s}$ term. The stochastic trend, μ_t, has the following properties (Koopman et al, 1995):

$$\mu_t = \mu_{t-1} + \delta_{t-1}$$
$$\delta_t = \delta_{t-1} + \zeta_t$$
$$\zeta_t \sim NID(0,\sigma^2_\zeta) \quad (3.4)$$

[4] The consumer expenditure deflator is preferred to the CPI as the dependent variable because it excludes mortgage interest payments.

Thus, the stochastic trend is defined as a moving average of a moving average of random shocks, and requires twice-differencing to give a stationary series. The technique is to be preferred to the widely-used Hodrick-Prescott filter, because it does not rely on arbitrary calibration of the variance of the underlying shocks: instead, all the parameters of the model are estimated from the data (see Harvey and Jaeger, 1993, for discussion).

For the period 1970 to 1998, annual inflation in South Africa (measured on quarterly data) appears to be an I(1) process, which, superficially, presents a problem for the 'equilibrium-correction' formulation in equation (3.3). Our two model representations (section 3.6) hypothesize, respectively, that annual inflation corrected for openness or for a stochastic trend, is I(0), and that $(\alpha_1\mu_t + \sum_{i=2}^{n}\alpha_i X_{it} - \log P_t)$ is I(0), so that the components in this expression are cointegrated. However, quarterly inflation is I(0) on the same tests Table 3), and it can be argued that this is the "cleaner "test, since it avoids the positive autocorrelation induced in the four-quarter-ahead inflation measure. Either way, equation (3.3) has a satisfactory equilibrium-correction interpretation.

The economics of the long-run solution, $\log P = \alpha_0 + \alpha_1\mu + \sum_{i=2}^{n}\alpha_i X_i$, is now explained in more detail. In the long-run, we expect the consumer expenditure deflator, P, to be a linearly homogeneous function of wholesale prices (WPI), unit labour costs (ULC), and the foreign wholesale price index (WPI*), translated at the nominal trade-weighted exchange rate (NEER). In turn, we might expect unit labour costs to be influenced by the Consumer Price Index (CPI), which, unlike the consumer expenditure deflator, includes a mortgage interest payment (MIP) component to reflect part of homeowners' housing costs. If ULC does not appear directly in the long-run solution, then MIP should take its place.[5]

In a log-linear formulation, we thus have

$$\begin{aligned}\log P &= \alpha_0 + \alpha_1\mu + \alpha_2 \log WPI + \alpha_3 \log ULC \\ &\quad + \alpha_4(\log WPI^* - \log NEER) + \sum_{i=5}^{n}\alpha_i X_i\end{aligned} \tag{3.6}$$

where $\sum_{i=4}^{n}\alpha_i X_i$ represents other long-run economic influences such as the indirect tax rate and openness, and $\sum_{i=2}^{4}\alpha_i = 1$.[6] In the alternative where ULC does not appear directly,

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5 If the ULC index is linked to the CPI, and the CPI is a weighted average of MIP and the consumer expenditure deflator, then substituting into equation (3.6) results in an expression in WPI and MIP.

6 For a comparable formulation on Australian inflation, see de Brouwer and Ericsson (1998). These authors use import prices instead of foreign prices converted at the exchange rate and wholesale prices. They also include petrol prices, but exclude long-run trends; and include only the output gap in the set of X variables. In Hendry (2000), the long-run solution, for U.K. data spanning 1870-1991, incorporates unit labour costs, the exchange rate and foreign prices, commodity prices, the interest rate differential between long and short rates, and the output gap, the latter two being I(0) variables. No attempt was made to proxy the degree of openness of the economy to foreign competition.

$$\log P = \alpha'_0 + \alpha'_1 \mu + \alpha'_2 \log WPI + \alpha'_3 \log MIP + \alpha'_4 (\log WPI^* - \log NEER) + \sum_{i=5}^{n} \alpha'_i X_i \tag{3.7}$$

and $\sum_{i=2}^{4} \alpha'_i = 1$. Because of linear homogeneity (or lack of money illusion) in the long-run, we can rewrite the above as

$$\log P / WPI = \alpha'_0 + \alpha'_1 \mu + \alpha'_3 \log MIP / WPI + \alpha'_4 \log REER + \sum_{i=5}^{n} \alpha'_i X_i \tag{3.8}$$

where the real trade-weighted exchange rate, REER, is defined as WPI/(NEER.WPI*).

3.4 Measurement of openness

As indicated, an important consideration for inflation 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.

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 in the inflation model, 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 the STAMP programme of Koopman et al (1995).

To capture demand side influences (other than home demand for manufactured goods as defined above), the model includes the growth rate of real GDP 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 4, 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 3, where some statistics are presented. In this simple error correction model, the share of imports in domestic demand depends on the terms-of-trade, on a measure of tariffs and surcharges, and on the real exchange rate, while adjustment to equilibrium is affected by GDP growth. The hypothesis could be accepted that the coefficient on the lagged (log) level of the import share was 1, and hence the differenced dependent variable was redefined as the (log) level of the import share. As shown in Table 3, 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).

As noted above, the influences of openness in this model operate through the measure 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)).[7]

3.5 Measurement of the output gap

Before turning to the results of the inflation model, we briefly explain the formulation of the output gap used in the model. The output gap is constructed using an extended version of stochastic trend models of the type discussed above, estimated using the STAMP programme of Koopman et al (1995). We used several different measures of the output gap. For the first measure, the quarterly model has the following form:

$$\log Y_t = \alpha_0 + \mu_t + \alpha_1 \log Y_{t-1} + \sum_{j=1}^{n} \beta_j X_{jt} + \varepsilon_t \qquad (3.5)$$

where Y_t is real GDP and μ_t is a smooth stochastic trend reflecting the underlying capacity of the economy to produce. The X_{jt} capture cyclical factors: we use distributed lags of changes of the log of capacity utilization and changes in the log real gold price, estimating the model from 1973:1–1998:4. The resultant output gap, defined as $(\log Y_t - \alpha_0 - \mu_t)/(1-\alpha_1)$, was used to construct the first output gap measure, OUTGAP1 (Figure 1). This trend was compared in estimations with the alternatives of capturing the underlying capacity trend with a cubic function of time and with split time trends. For the specifications reported below, the output gap derived from the stochastic trend model gives a better fit than these two alternatives.

The second measure of the output gap, OUTGAP2, is also shown in Figure 1, and employs a stochastic trend from the richer model of output detailed in section 4, below.[8] The principal differences between the two measures occur in the aftermath of the 1980/81 gold price shock and the smaller price shock in 1987, when OUTGAP2 indicates lower excess capacity in the economy; and after 1994, when OUTGAP2 indicates a higher excess capacity. The main economic reason is the inclusion of the real interest rate amongst the economic variables. This variable is I(1), and in the 1990s, rose strongly, depressing output, in part through contracting capital accumulation. Conceptually, therefore, OUTGAP2 differs from OUTGAP1. In recent years, a demand boost from lower interest rates would generate more inflation using the OUTGAP1 measure. The OUTGAP2 measure effectively implies that capacity would respond to lower real interest rates so reducing the inflationary pressure.

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[7] We convert to a quarterly measure by taking the moving average of the step-function implied by the annual data.

[8] This is defined simply as current log (Y), adjusted for a constant, minus the stochastic trend, shifted back four quarters, and estimated from the specification for log $(\text{output})_{t+4}$ shown in column 1, Table 7. This means that we effectively interpret the other variables - interest rates, the current account surplus to GDP ratio, the government surplus to GDP ratio and changes in the terms of trade and in financial liberalization as purely demand-side influences, leaving the stochastic trend to pick up the supply-side influences.

3.6 Inflation results

The theoretical motivation for the variables, X_i , in the most general specification of the reduced-form model estimated, derives from the extended Phillips curve model in equation (3.3). Additionally, we emphasise the role of inflation as relative price adjustment. In other words, an essential feature of the model is its "equilibrium correction" representation, in which relative prices play a key role.

The X_i comprise nine variables, though in a general-to-specific testing procedure the data suggested the elimination or transformation of some of these. Detailed definitions of variables and statistics are given in Table 3. The variables are the log of the real exchange rate, log(REER); the real wholesale price index, log(RWPI), deflating by the consumer expenditure deflator (or –log(P/WPI) in equation (3.8)); the ratio to current GDP of the seasonally adjusted current account surplus, RCADEF; the terms-of-trade (including gold), log(TOT); the output gap, OUTGAP; the real prime interest rate, RRPRIME; a measure of the weighted mortgage interest payment component of the CPI deflated by the wholesale price index, RMIP[9]**;** a proxy for the indirect tax rate, TAXR**;** the log of unit labour costs divided by the consumer expenditure deflator, RULC; and the annual rate of change of a weighted index of foreign wholesale prices, FORINFL. These are all I(1) variables, as is the inflation rate (Table 3).

We present two types of inflation models, which differ by their treatment of long-run evolutionary effects in the economy. In the first we introduce as one of the components of the X_i's the measure of openness to international competition, derived from our import demand share model (see section 3.4), but do not include a separate stochastic trend in the model[10]. We compare this with a more general treatment of long-run evolutionary effects by including a stochastic trend in the model. For the second representation, we thus estimate the model using the STAMP programme of Koopman et al (1995).

After a sequence of steps of simplification from the general forms in equation (3.3), we obtain the parsimonious quarterly inflation forecasting model results shown in Table 5. As discussed above, a restricted lag structure was employed: for lags longer than four, we restrict the dynamics to fourth-differences or four-quarter moving averages, to prevent overparameterisation. Note that the estimation period for South African inflation, from 1979:1-1997:4, is dictated by a regime switch from a fixed exchange rate to a floating rate regime in 1979:1, expected to alter the inflation process. However, we later extend the sample back to 1975 to test for parameter stability of the equations, and also check stability over 1979:1-1994:1, before the ANC government came to power.

The results are similar for the two measures of the output gap, OUTGAP1 and OUTGAP2 (columns 1 and 4). There is little negative feedback from inflation in the previous three quarters. As expected, there are positive effects on next year's inflation rate from the

[9] The log of the real mortgage cost measure is defined as follows. Let wh_t be the weight of the mortgage cost component of the CPI. This weight was 0.0361 from May 1970, 0.034 from January 1978, 0.0947 from November 1987, 0.1151 from August 1991 and 0.1291 from January 1997. Mortgage payments can be defined as the mortgage interest rate multiplied by mortgage debt, *MDEBT*. In practice the mortgage rate moves very closely with the prime rate on borrowing. Then $\Delta \log RMIP_t = wh_t \times (\Delta \log PRIME_t + \Delta \log MDEBT_t - \Delta \log WPI_t)$: we subtract $\Delta \log WPI_t$ to obtain $\Delta \log RMIP_t$. By summing these changes over time we obtain the log level of the real mortgage cost index, $\log RMIP_t$.

[10] We can accept the hypothesis that there is no stochastic trend in the model containing openness.

real WPI as consumer prices catch up with a lag to producer prices; from the output gap (for traditional reasons); and from the foreign rate of WPI inflation, since with a given exchange rate, foreign inflation will translate to some degree into domestic inflation. The mortgage cost component of the CPI feeds into the consumer expenditure deflator with a lag. While our dependent variable excludes this component, these costs will, with a lag, feed into wages, which respond to CPI inflation. A rise in the rate of indirect taxation raises the price level, and, in the transition, the rate of inflation.

There is the expected negative effect from the real exchange rate: the more overvalued the exchange rate, the more competitive pressure acts on domestic producers to prevent price increases. The change over the previous two years in the ratio of current account to GDP, also exerts a negative effect, probably through exchange rate appreciation in the next few quarters, but also as a symptom of falling excess demand.

A rise in the terms-of-trade, via a boom following a positive gold price shock, is likely to have inflationary consequences. Finally, the real unit labour cost was insignificant, as indicated above. Experimentation with real or nominal M3 or private sector credit growth showed a lack of significant positive effects over the four-quarter horizon.[11]

The LM tests for columns 1 and 4 reported in Table 5 show little sign of residual autocorrelation, and pass CHOW and normality tests. To test for parameter stability, the model for both the measures of the output gap was run over different samples. In the first, shown in columns 2 and 5, an additional four years are added at the beginning of the sample, which little alters the parameter estimates. The second sample omits the transition to democratic government in April, 1994 and the subsequent years, and again the parameter estimates are little altered (columns 3 and 6). We also tested the model over the period 1975:1 to 1989:2, thus omitting both the period of a new monetary regime of Governor Stals and increased momentum of political change under the new President de Klerk, as well as the period of democratic government. Again, the parameter estimates are similar (not reported).

When the above specification including the openness indicator is estimated in STAMP, including a stochastic trend, the trends drops out, suggesting our openness indicator successfully captures evolutionary trends in inflation. However, for real-time forecasting, there can be advantages in using a specification where the openness indicator is replaced by a stochastic trend, since the latter can respond flexibly to other evolutionary factors potentially influencing inflation in South Africa. Such a specification is shown in Table 6, columns 1 to 3, demonstrating parameter stability over different samples.

Suppose, for example, that a new inflation targeting regime was widely regarded as credible, and supported by fiscal and other policies. If this succeeded in reducing inflationary expectations, the stochastic trend estimated by STAMP would be likely to pick up this regime shift within a few quarters. Be that as it may, the two approaches shown in Tables 5 and 6 give very similar parameter estimates and inflation forecasts over the estimation period of the model.

We can now comment on the economic significance of our findings using Table 5, column 2, since we accept parameter stability for this longer sample. In Figures 2 to 4, we show the directly-estimated contribution of each explanatory variable to inflation - to be precise, to $\Delta_4 \log (P (+4)) + 0.17 \Delta_3 \log (P)$, which incorporates the small negative feedback term into the dependent variable. It is striking how important is the decline and then improvement in the openness to imports in explaining the long-run trend in inflation, see Figure 2. This links inflation in South Africa closely to its political history. The full effects of

[11] Note that a similar approach with a two-year inflation forecasting horizon finds significant, positive money or credit growth effects.

openness are probably even greater since it is likely that it also influences the ratio of wholesale prices to the consumer expenditure deflator, as the visual correlation in Figure 2 suggests.

The coefficient of 0.37 on the log ratio of WPI to P measures the speed of price adjustment to disequilibrium in relative prices. Greater openness and the fall in the real WPI since the late 1980s thus explain the decline in South African inflation since 1990. However, Figure 3 shows that a large countervailing force came from the rise in real mortgage costs, which is part of the CPI. This was due to higher real mortgage debt, mainly the result of financial deregulation (see Aron and Muellbauer 2000) and to the rise in interest rates. To a lesser extent, the higher costs of firms, also stemming from higher real interest rates, contributed to inflation. We return to these important issues in the conclusions. Figure 4 shows the effects of the other variables, all I(0), which have been small in recent years, though important in explaining past inflation shocks.

4. Output Forecasts in South Africa

4.1 Background

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, serious political crises 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 some trade finance), and domestic policy was directed at maintaining current account surpluses through large import surcharges, exchange rate depreciation and interest rate policy. This constraint, together with South Africa's mineral dependency as a primary exporter, are expected to give an important role to terms-of-trade shocks and the current account balance in determining output growth (Figures 5 and 6).

Output is modelled using an extended version of stochastic trend models discussed above, and was estimated using the STAMP programme of Koopman et al (1995). We derive a four-quarter-ahead forecasting model for the rate of growth of real output, and build in allowances for the above features as well for a more standard income-expenditure approach. A smooth stochastic trend represents long-run changes in productivity growth. Further, an institutional measure of the shift in monetary policy in the early 1980s is crossed with the interest rates. By incorporating important regime shifts in the model, output growth forecasts should be fairly immune to the Lucas critique.

4.2 Model specification

The background for the approach, tailored for the U.S. economy, is set out in Muellbauer (1996). It is based on an income-expenditure model with partial adjustment of output to expenditure, and to a long-run trend, reflecting the capacity of the economy to produce The key variables are the change in nominal (and sometimes real) short-term interest rates, the real exchange rate (a measure of international competitiveness), the trade surplus to GDP ratio, the government surplus to GDP ratio and the change in a real share price index. These variables explain the deviation in income from trend, where the trend is represented either by a linear trend subject to changes in slope or 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, corroborated by the shifts in the estimated feedback rules, and in the direction predicted by theory.

The single equation VAR model has a similar linear reduced-form to equation (3.3), where the price level, P, is replaced in the equation by real GDP, Y:

$$\Delta_4 \log Y_{t+4} = \gamma(\alpha_0 + \alpha_1 \mu_t + \sum_{i=2}^{n} \alpha_i X_{it} - \log Y_t) + \sum_{j=1}^{n} \sum_{s=0}^{k} \beta_{j,s} \Delta X_{j,t-s} + \varepsilon_t \qquad (4.1)$$

In the case of real output, the X_j include a range of potential output determinants detailed below; ε_t is white noise 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 1966-1997, log Y_t is I(1), implying that Δlog Y_t is a stationary variable (Table 3). 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 $(\alpha_1 \mu \; + \sum_{i=2}^{n} \alpha_i X_i - \log Y)$ can easily be I(0) over the relevant samples.

4.3 Output results

The set of potential explanatory variables, X_i, included those relevant in Muellbauer (1996), namely the real and nominal interest rates, the government surplus to GDP ratio, the trade surplus to GDP ratio, the real exchange rate, a real stock market price index; but, in addition, the log terms-of-trade. Poor data precluded the inclusion of an unemployment rate as in Muellbauer (1996), but implicitly this is captured by the deviation of the dependent variable from the stochastic trend. The model also includes some institutional variables capturing financial liberalisation and monetary policy regime shifts, and a dummy for the drought of 1992/3. The variables are defined in Table 3, where statistics are also given.

A general-to-specific testing procedure on quarterly data for 1966-97 was applied to a version of equation (4.1) with a restricted lag structure, as before: for lags longer than four, we restrict the dynamics to fourth-differences or four-quarter moving averages, to prevent overparameterisation. This gives the parsimonious equation shown in the first column of Table 7. 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. Two other forecasting equations are reported for shorter samples to demonstrate parameter stability, given that Chow tests are unavailable in STAMP.[12]

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.

[12] The forecasts are based on full-sample estimates, not recursive estimates, since recursive estimation is unavailable in STAMP. However, stability tests for the equation carried out over different samples confirm parameter stability. Thus, the recursive forecasts are unlikely to differ much from those based on full-sample parameter estimates.

We have emphasised three types of regime shifts. The first is captured by the stochastic trend, shown in Figure 5. This reflects a decline in the underlying growth rate in the early 1980s partly due to the productivity losses resulting from South Africa's increasing isolation - for example, the inefficient production of petrol from coal, under trade sanctions which constrained oil imports. From the late 1980s, some improvements in the underlying growth rate are visible.

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. We construct a dummy indicator from the changing prescribed liquid asset requirements for commercial banks in the 1980s (see details in Aron and Muellbauer, forthcoming).

The third shift is financial liberalisation from the 1980s. Proxying FLIB 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 (2000), 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 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 6).

Turning to the parameter estimates, 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.[14] 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

[13] We define FLIB using a linear spline function. Define a dummy, D, which is zero up to 1983Q4 and is 1 from 1984Q1. The 4-quarter moving average, DMA84, then takes the values 0.25, 0.5, 0.75 and 1 in the 4 quarters, respectively, of 1984, and the value 1 thereafter. We define DMA85 to be the 4-quarter lag of DMA84, and define DMA86 to DMA97 to be the corresponding 8- to 48-quarter lags of DMA84. The spline function is: $FLIB = d84 \times DMA84 + d85 \times DMA85 + ... + d97 \times DMA97$, where up to 14 parameters (i.e. d84 to d97) are estimated. 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.

[14] The liquid asset measure in itself proved insignificant in the equation.

on growth. After the shift, firms and households could also refinance more easily, meaning that higher 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. Figure 6 shows the contribution of the combination of interest rate effects, weighted by their regression coefficients, to explaining the deviation of the log of GDP from trend, i.e. OUTGAP2, one year ahead. 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.[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.

The positive effect expected from the trade surplus to GDP ratio is also confirmed. There is a 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. Figure 7 demonstrates that the deterioration in the government deficit to GDP ratio and in the current account to GDP ratio contributed to the decline in GDP relative to trend in the 1990s. Finally, given the importance of agriculture in South Africa output, the drought dummy produces the expected negative effect.

To test for parameter stability, two sample breaks were chosen. The first, from the third quarter of 1989, coincides with 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. The second, from the second quarter of 1994, captures the transition to a democratic government. The parameter estimates from the shorter samples, as well as other samples not reported, are close to those of the full period suggesting that once structural change has been accounted for as described above, the remaining parameters are stable. There is no evidence of autocorrelated residuals (save for a trace at a lag of 4: $\rho_4 = -0.23$). Tests for normality and heteroscedasticity are also satisfactory.

5. Monetary Policy Implications and Discussion

This paper has employed multi-step forecasting techniques in estimations with stochastic trends to predict both inflation and output growth in South Africa, one year ahead.

The model forecasting the change in the log of the consumer expenditure deflator one year ahead has an ‘error or equilibrium correction’ form. We find that the forward inflation rate tends to fall when the openness of the economy increases, when wholesale prices are low relative to consumer prices, when the real exchange rate is high, when real mortgage payments and real interest rates are low, when the output gap is low, and when the indirect tax rate is low. Other factors reducing domestic inflation are lower foreign inflation, a rise in the two-year change in the current account surplus to GDP ratio and a fall in the output gap.

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

Figures 2 and 3 provide striking visual evidence of the importance of these factors. The measure of openness comes from a separate import demand share model; but can also be replaced by a smooth stochastic trend estimated from the data. The latter offers a useful method for dealing with shifts in long-run inflationary expectations such as might arise from the adoption of inflation targeting.

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. Mineral dependency is reflected through the terms-of-trade shocks. We find that changes in nominal interest rates as well as levels of real rates, with quite long lags, have a negative effect on future output. These effects are altered by changes in the monetary policy regime. The two-year change in the trade surplus to GDP ratio, a moving average of the government surplus to GDP ratio and improvements in the terms-of - trade have a positive effect on future output. A smooth stochastic trend satisfactorily represents long-run changes in productivity 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.

Both models offer important insights on monetary policy transmission with policy implications. Note that these models 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 variables to 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 rates rose, so reducing the impact of interest rates on output.

Forecasting inflation one year ahead, we find an effect from the output gap in common with other studies, but little evidence for money or credit growth effects (but see footnote 11). Given our evidence of interest rate effects on output, this clarifies an important monetary policy channel on inflation. We also found the two-year change in the trade surplus to GDP ratio helps to forecast inflation a year ahead. While we have not formally modelled the current account surplus to GDP ratio, it is likely that this too gives an important policy channel for interest rates. Furthermore, the exchange rate is clearly an important factor for inflation. In general, the empirical literature on exchange rates finds no stable relationship between exchange rates and short-term interest rates (e.g. survey in Isard, 1995). This can leave the authorities with a difficult policy quandary, as demonstrated with the 1996-98 exchange rate crises, when the exchange rate continued low or to fall further despite large increases in real interest rates. Indeed, if such interest rate rises cause growth prospects to deteriorate sharply, they can have a negative impact on long-term capital inflows, and a perverse effect on the exchange rate.

Furthermore, a rise in the real prime interest rate, and in our proxy for the mortgage cost component in the CPI index, both raise inflation in South Africa as measured by the consumer price deflator in the following year. 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. Moreover, the rise in the real level of mortgage debt, mainly due to financial deregulation, actually contributes to rising mortgage costs. Figure 3 shows the contribution to inflation of these factors. The mortgage cost component in the CPI has unfortunate policy implications, as well as a weak conceptual basis in the context of liberalized mortgage markets.

While inflation targeting will use the CPI-X (which excludes mortgage interest payments, similar to the U.K.'s RPI-X), wage negotiators still focus on the headline CPI (or whichever measure proves to be the higher). There is, therefore, a strong case for switching to an imputed rent measure in the CPI, as in the U.S. in 1981 and Australia in 1998. The case for this is stronger in South Africa than in the U.K., since the market-rented sector is substantially larger than the 10 percent in the U.K.. If this change in the measurement of home-owners' housing costs were to be adopted, it would be important to preserve a substantial flexible market-rented sector so that market rents would be a valid proxy for such costs. Had such a change in measurement been adopted in 1990, some of the output sacrifice in the 1990s, thought necessary to bring down inflation, could have been avoided.

The recent move to inflation targeting demands good forecasting models of inflation. The Kalman filtering or stochastic trend approach illustrated in this paper helps to control for the effects of structural changes (e.g. trade liberalisation, deregulation of markets, and a tougher government stance on unions) and offers a practical way of dealing with the Lucas critique. Indeed, the move to inflation targeting itself can shift inflationary expectations.

As far as the multi-step forecasting approach is concerned, there is little evidence of positive serial correlation in our four-quarter-ahead inflation forecasts, surprising in view of the overlapping structure of the model referred to in section 2. This suggests negatively-autocorrelated disturbances in the inflation process (implicit exchange rate forecasts being one factor). A conventional VAR model would probably fail to capture this effect since for parsimony, the lag structure is usually restrictive. Clements and Hendry (1996, 1998) suggest that multi-step forecasts may be superior in the presence of such moving average error processes and structural breaks. Our single equation, reduced-form approach with a flexible lag structure therefore has important advantages –as well as simplicity and interpretability.

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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-	Daily tenders of liquidity through repurchase transactions (repo system), plus pre-announced M3 targets and targets for core inflation

SOURCE: Aron and Muellbauer (forthcoming).

Table 2: A History of Money Growth and Inflation Targets

Year	Money Growth	Money Growth	Inflation	Inflation	Inflation	Inflation
%	*Guidelines*	*Actual*	*Core "Target"*[1]	*Total*	*Core*	*CPIX*
1986	**16-20**	**9.3**		**18.6**		
1987	**14-18**	**17.6**		**16.1**		
1988	**12-16**	**27.3**		**12.9**		
1989	**14-18**	**22.3**		**14.7**		
1990	**11-15**	**12.0**		**14.4**		
1991	**8-12**	**12.3**		**15.3**	**18.9**	
1992	**7-10**	**8.0**		**13.9**	**16.8**	
1993	**6-9**	**7.0**		**9.7**	**12.6**	
1994	**6-9**	**15.7**		**9.0**	**8.9**	
1995	**6-10**	**15.2**		**8.7**	**7.9**	
1996	**6-10**	**13.6**		**7.4**	**7.2**	
1997	**6-10**	**17.2**		**8.6**	**8.8**	
1998	**6-10**	**14.6**	**1-5**	**6.9**	**7.5**	**7.1**
1999	**6-10**	**10.2**	**1-5**	**5.2**	**7.9**	**6.9**

SOURCE: Aron and Muellbauer (forthcoming).

1. Core targets were informally announced. Core inflation is overall CPI (metropolitan and other urban areas), excluding certain food prices, interest costs, value-added tax and municipal rates. In February, 2000, a CPIX target was announced of 3-6 % for 2002, in the context of a new inflation targeting regime. CPIX inflation is overall CPI (metropolitan and other urban areas), excluding interest rates on mortgage bonds.

Table 3: Statistics and Variable Definitions

Variable	*Definition of Variable*	*Mean*	*Standard Deviation*	*I(1)*[a,b]	*I(2)*[a,b]
(1966q2-1997q4)	**Output Forecasting Equation**				
Δ_4 log (Y)	Annualised real GDP growth rate (seas. adj.)	2.48E-2	2.03E-1		
log (Y)	Log of real GDP (seas. adj.)	12.98	2.15E-1	-2.93*	-6.18**
RPRIMA	Real prime interest rate/100 (four-quarter MA)	3.65E-2	4.09E-1	-2.13	-4.58**
Δ_4 PRIME	Annual change of prime interest rate/100	4.10E-3	2.84E-2	-2.28	-6.31**
RCASURMA	Ratio to current GDP of the seas. adjusted current account surplus (four-quarter MA)	-7.38E-3	3.70E-2	-3.56**	-
GSURMA	Gov. surplus to GDP ratio (three-year MA)	-1.08E-2	3.12E-3	-6.42**	-
FLIB	Financial liberalisation measure – see text	-	-	-	-
DFLIB	First difference in FLIB	-	-	-	-
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	-	-	-	-
NRPRIMA	Shift dummy x RPRIMA	-	-	-	-
Δ_{12} log (TOT)	Three-year change in the log terms-of-trade	1.85E-2	1.30E-1	-2.42	-5.05**
DUM92	Drought dummy=1 for 1991:3-92:2, or =0	-	-	-	-
(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*	-
(1979q1-1997q4)	**Inflation Forecasting Equation**				
Δ_4 log (P) (+4)	Four-quarter-ahead annual inflation rate of the consumer expenditure deflator	1.18E-1	3.13E-2	-1.08	-5.10**
Δ_3 log (P)	Three-quarter change in the log of the consumer expenditure deflator	8.95E-2	2.39E-2	-1.08	-5.10**
log (REERMA)	Four-quarter MA of the log of the real effective exchange rate	4.62	1.01E-1	-2.60	-4.81**
log (RWPIMA)	Log ratio of the WPI (four-quarter MA) & the consumer expenditure deflator	4.69	7.70E-2	-0.30	-9.88**
Δ_8 RCASUR	Two-year change in the ratio to current GDP of the seas. adjusted current account surplus	8.89E-4	5.66E-2	-3.39*	-5.23**
Output gap 1	Deviation of real GDP from a stochastic trend	1.37E-4	1.66E-2	-3.59**	-
ΔOutput gap 1	First difference of the output gap	-1.41E-4	9.12E-3	-3.59**	-
Δ_{12} log (TOT)	Three-year change in the log terms-of-trade	-1.09E-2	1.11E-1	-3.74**	-
RRPRIME	Real prime interest rate/100, calculated using annual inflation a quarter ahead	4.33E-2	4.95E-2	-1.73	-4.79**
log (RMIP)	Log of the weighted mortgage interest payment component of the CPI, deflated by the WPI	6.37E-2	4.42E-1	-0.09	-4.62**
TAXRMA	Percentage difference between current and market price GDP (two-quarter MA)	8.62E-2	1.57E-2	-1.78	-8.87**
FORINFL	Annual foreign WPI inflation (weighted index, SARB weights)	3.68E-2	3.68E-2	-3.98**	-

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. The stationarity tests are performed for the variables in levels before time-transformation i.e. before taking moving averages and changes. For the inflation tests the sample is from 1975q1 to 1997:4.

Table 4: Equation for share of imports in home demand with a stochastic trend

Dependent Variable: **log (IMPDEM)**	**STAMP:** [a] **1971 – 1998**	**STAMP:** [a] **1971 – 1990**	**STAMP:** [a] **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 (REERMA) (-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:			
Equation 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.

Table 5: Forecasting equations for inflation using a measure of openness, and different measures of the output gap

Dependent variable: Δ_4**log (P) (+4)**	**OLS: OUTGAP1 1979q1-1997q4**	**OLS: OUTGAP1 1975q1-1997q4**	**OLS: OUTGAP1 1979q1-1994q1**	**OLS: OUTGAP2 1979q1-1997q4**	**OLS: OUTGAP2 1975q1-1997q4**	**OLS: OUTGAP2 1979q1-1994q1**
Regressors						
Intercept	-1.66 (8.1)	-1.31 (8.2)	-1.44 (3.6)	-1.61 (7.8)	-1.23 (7.6)	-1.41 (3.2)
IMPORTTREND	-0.24 (9.4)	-0.22 (9.2)	-0.13 (1.7)	-0.22 (8.8)	-0.20 (8.3)	-0.17 (2.0)
Δ_3 log (P)	-0.17 (2.5)	-0.13 (2.2)	-0.11 (1.5)	-0.18 (2.6)	-0.13 (2.1)	-0.10 (1.4)
log (REERMA)	-0.10 (5.4)	-0.12 (7.4)	-0.10 (4.3)	-0.10 (5.1)	-0.11 (7.3)	-0.10 (4.0)
log (RWPIMA)	0.43 (12.2)	0.37 (12.6)	0.40 (5.1)	0.41 (11.7)	0.35 (11.7)	0.38 (4.5)
Δ_8 RCASUR	-0.18 (6.0)	-0.16 (6.1)	-0.15 (4.5)	-0.15 (4.8)	-0.14 (4.7)	-0.15 (4.4)
Output gap	0.23 (2.4)	0.29 (3.4)	0.25 (2.4)	0.27 (3.2)	0.32 (4.0)	0.24 (2.4)
ΔOutput gap	0.53 (3.6)	0.37 (3.0)	0.44 (2.8)	0.50 (3.6)	0.35 (2.9)	0.49 (3.3)
Δ_{12} log (TOT)	0.10 (7.2)	0.08 (8.3)	0.08 (5.2)	0.10 (7.3)	0.08 (8.1)	0.08 (5.6)
RRPRIME (-2)	0.15 (4.4)	0.14 (4.4)	0.16 (4.5)	0.18 (5.9)	0.18 (5.8)	0.20 (5.9)
log (RMIP) (-3)	0.52 (4.7)	0.39 (4.2)	0.34 (2.0)	0.51 (4.7)	0.37 (4.0)	0.36 (2.1)
TAXRMA (-3)	0.46 (2.9)	0.37 (3.0)	0.58 (2.9)	0.43 (2.8)	0.34 (2.7)	0.56 (2.7)
FORINFL	0.10 (2.7)	0.13 (3.7)	0.18 (3.9)	0.08 (2.1)	0.11 (2.9)	0.14 (2.6)
Diagnostics						
Equation Standard Error	0.00735	0.00771	0.00705	0.00726	0.00771	0.00719
R^2	0.959	0.947	0.937	0.960	0.947	0.934
Adj.R^2	0.951	0.939	0.921	0.952	0.939	0.918
Durbin-Watson	2.02	1.96	2.30	2.03	1.94	2.24
LM1	0.01	0.04	1.73	0.01	0.08	1.26
LM2	0.81	0.85	3.50	0.74	0.68	1.82
LM3	3.76	6.55	6.15	4.03	5.27	5.76
LM4	10.73	17.92	11.61	12.06	14.74	8.94
CHOW	0.583 [.856]	1.578 [.114]	1.470 [.178]	0.543 [.886]	1.595 [.109]	1.704 [.104]

(Absolute values of asymptotic t-ratios in parentheses)

a. The variable, IMPORTTREND, is defined as the saved stochastic trend from the share of import demand equation in Table 5, column 1, minus (4.30 x RTARIF(-1)).

Table 6: Forecasting equations for inflation with a stochastic trend

Dependent variable: **Δ_4 log (P) 1(+4)**	**STAMP: [a] 1979q1-1997q4**	**STAMP: [a] 1975q1-1997q4**	**STAMP: [a] 1979q1-1994q1**
Regressors			
Δ_3 log (P)	-0.17 (2.0)	-0.13 (1.7)	-0.17 (2.0)
log (REERMA)	-0.07 (3.2)	-0.07 (3.5)	-0.08 (4.3)
log (RWPIMA)	0.38 (4.3)	0.38 (5.0)	0.43 (5.1)
Δ_8 RCASUR	-0.20 (6.1)	-0.16 (5.5)	-0.17 (5.0)
Output gap	0.22 (2.2)	0.17 (1.7)	0.26 (2.6)
ΔOutput gap	0.56 (3.7)	0.48 (3.7)	0.50 (3.3)
Δ_{12} log (TOT)	0.10 (6.5)	0.09 (8.0)	0.08 (5.6)
RRPRIME (-2)	0.17 (3.2)	0.16 (3.1)	0.20 (4.2)
log (RMIP) (-3)	0.48 (2.7)	0.48 (3.0)	0.29 (1.6)
TAXRMA (-3)	0.76 (3.2)	0.61 (3.8)	1.02 (4.0)
FORINFL	0.08 (1.3)	0.13 (2.6)	0.13 (2.5)
Diagnostics			
Equation standard error	0.00793	0.0089	0.00665
R_D^2	0.667	0.599	0.776
r(1)	0.010	0.007	-0.229
Durbin-Watson	1.96	1.93	2.32

(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.

Table 7: Forecasting equations for real output with a stochastic trend

***Dependent variable:* log (Y) (+4)**	**STAMP: [a] 1966q2-1997q4**	**STAMP: [a] 1966q2-1989q2**	**STAMP: [a] 1966q2-1994q1**
Regressors			
RPRIMA	-0.33 (3.4)	-0.32 (4.2)	-0.34 (3.4)
RPRIMA(-4)	-0.30 (3.6)	-0.26 (3.3)	-0.30 (3.4)
Δ_4 PRIME	-0.32 (4.0)	-0.35 (4.1)	-0.32 (4.2)
RCASURMA	0.32 (4.4)	0.33 (4.4)	0.32 (4.2)
GSURMA	0.80 (3.1)	1.15 (4.2)	0.82 (2.9)
DFLIB	0.22 (2.3)	0.25 (2.3)	0.21 (2.0)
ND4PRIME	0.30 (2.9)	0.37 (3.8)	0.30 (2.8)
NRPRIMA	0.26 (2.2)	0.27 (2.7)	0.27 (2.1)
Δ_{12} log (TOT)	0.03 (1.9)	0.02 (1.2)	0.03 (1.7)
DUM92	-0.03 (4.5)	-	-0.03 (4.4)
Diagnostics			
Equation standard error	0.00922	0.00924	0.00950
r(1)	-0.088	-0.101	-0.095
R_D^2	0.728	0.872	0.737
Durbin-Watson	2.07	2.05	2.09

(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.

Figure 1: One-year-ahead and five-year moving average inflation rates (using the consumer expenditure deflator) and output gap measures

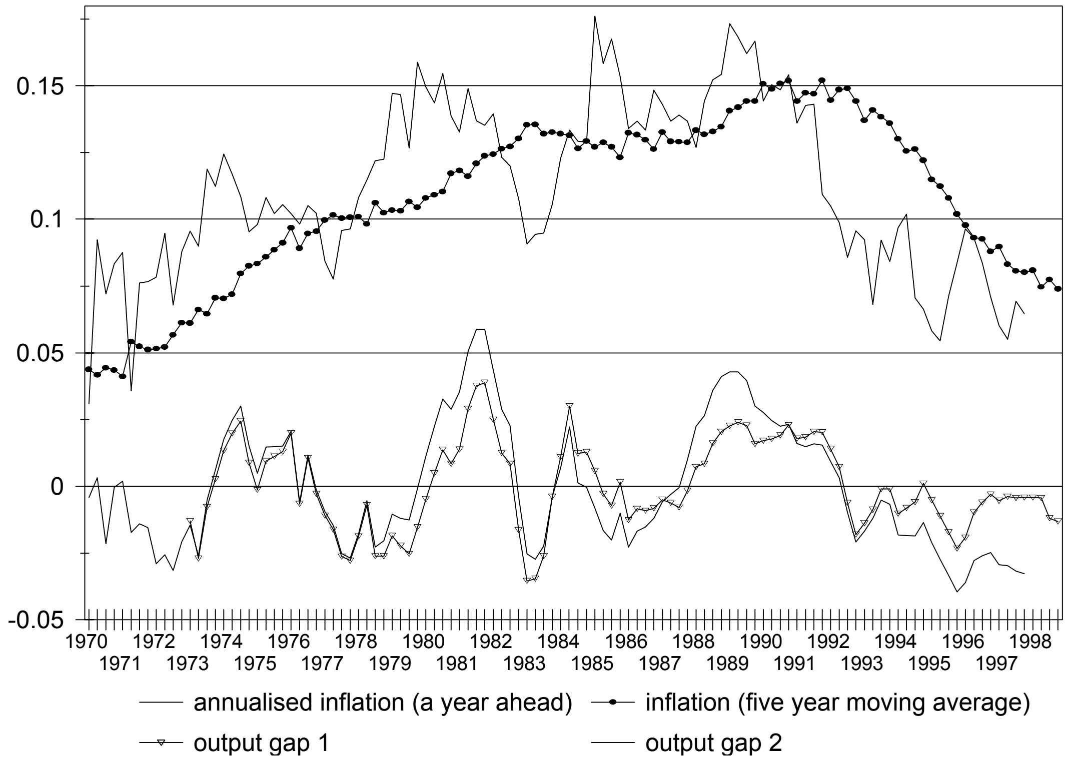
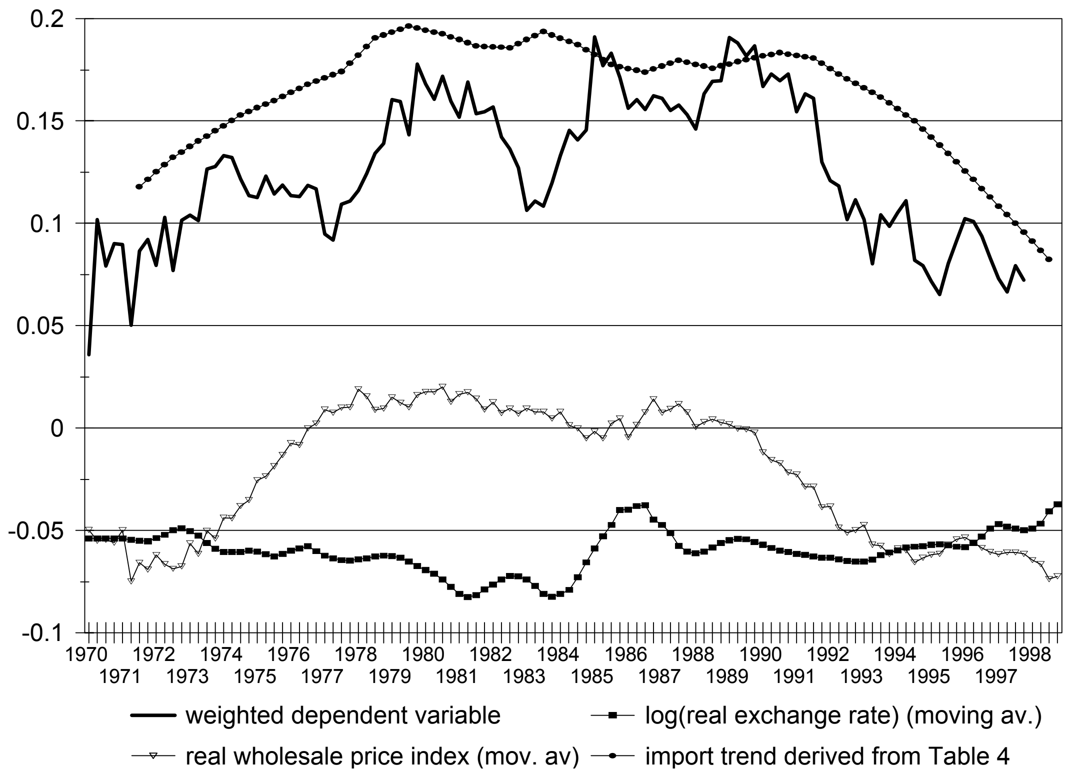
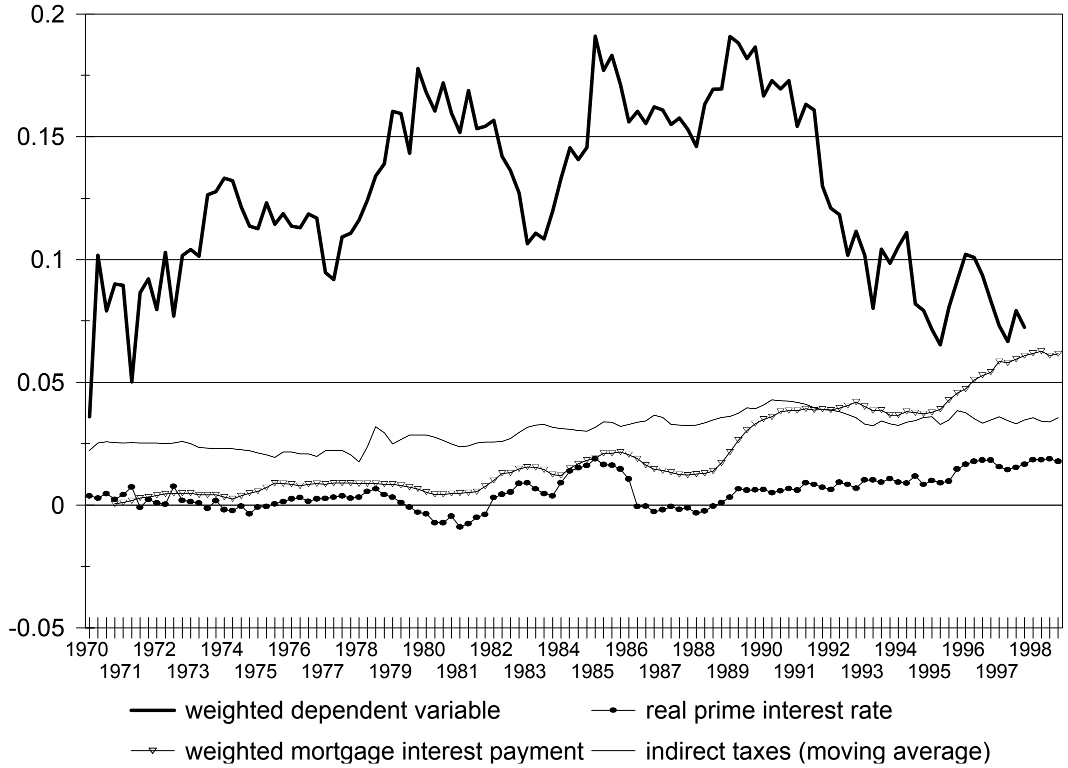


Figure 2: The contribution to the inflation forecast of the real exchange rate, real wholesale prices and the import trend



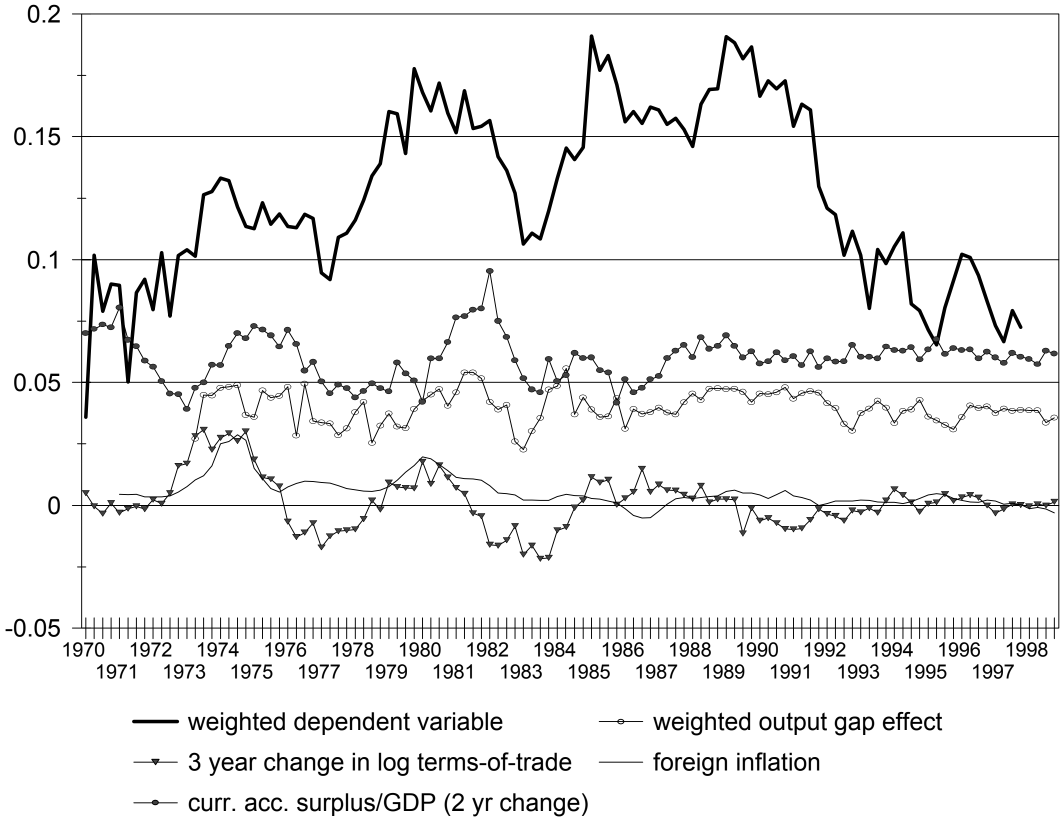
Note 1. The weighted dependent variable term is defined as: $\Delta_4 \log (P\ (+4)) + 0.17\ \Delta_3 \log (P)$.
Note 2. The right-hand side variables are shown weighted by their regression coefficients (Table 5, column 2), and are levels-adjusted relative to the dependent variable.

Figure 3: The contribution to the inflation forecast of the interest rate, mortgage interest payments and indirect taxes



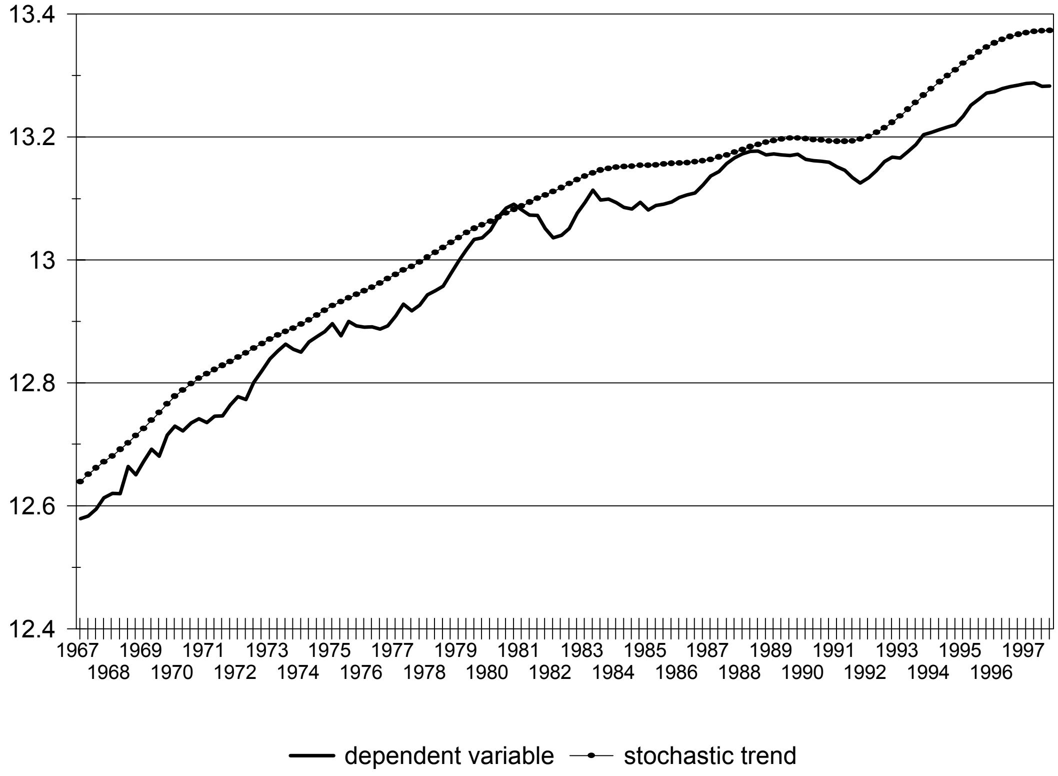
Note 1. The weighted dependent variable term is defined as: $\Delta_4 \log(P(+4)) + 0.17\, \Delta_3 \log(P)$.
Note 2. The right-hand side variables are shown weighted by their regression coefficients (Table 5, column 2), and are levels-adjusted relative to the dependent variable.

Figure 4 : The contribution to the inflation forecast of other variables



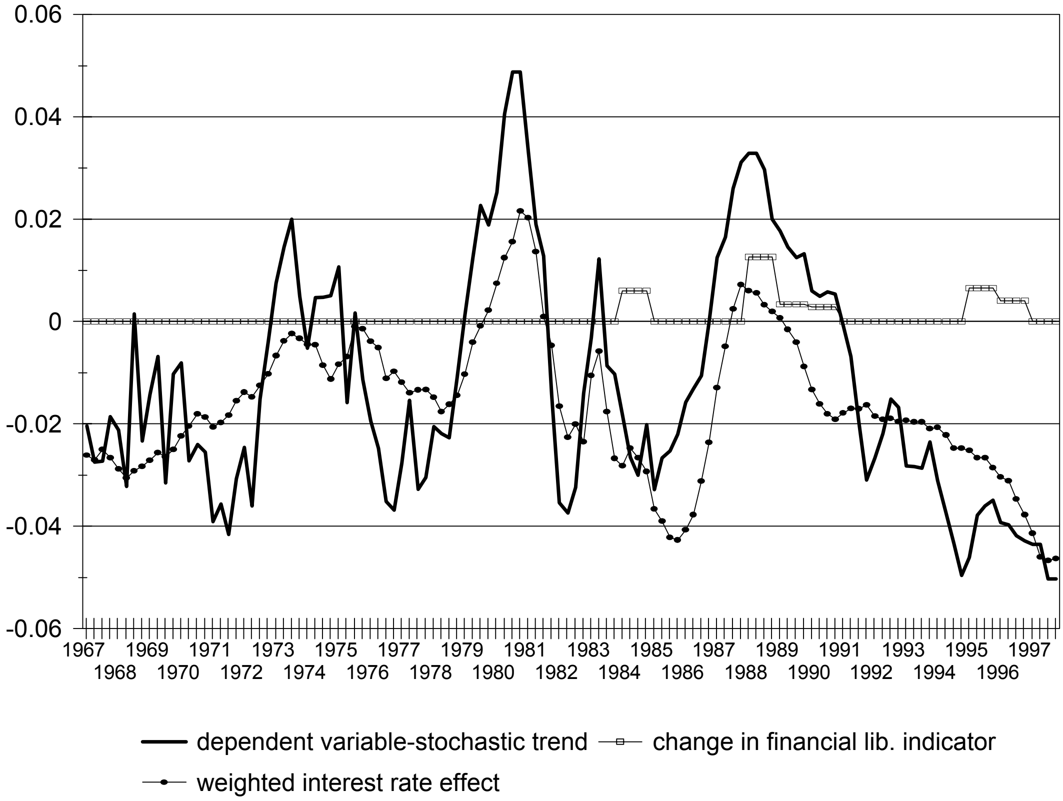
Note 1. The weighted dependent variable term is defined as: Δ_4 log (P (+4)) +0.17 Δ_3 log (P) .
Note 2. The weighted output gap effect is defined as: 0.29*OUTGAP1 + 0.37*DOUTGAP1
Note 3. The right-hand side variables are shown weighted by their regression coefficients (Table 5, column 2), and are levels-adjusted relative to the dependent variable.

Figure 5: Output growth, four quarters ahead, and the stochastic trend



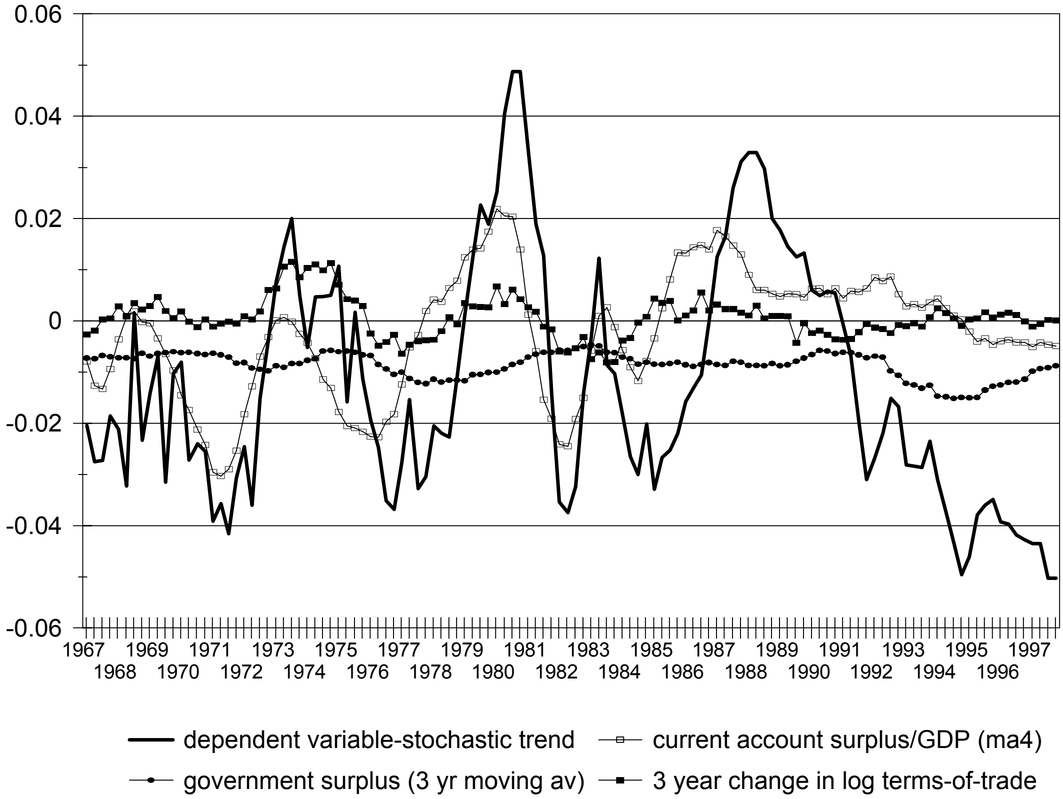
Note 1. The stochastic trend is from the equation in column 1, Table 7.

Figure 6: The contribution to the output forecast of financial liberalization and the composite interest rate effect



Note 1. The stochastic trend is from the equation in column 1, Table 7.
Note 2. The weighted interest rate effect is defined as: - 0.33*RPRIMA - 0.30*RPRIMA(-4) –0.32*D4PRIME +0.30*ND4PRIME +0.26*NRPRIMA
Note 3. The right-hand side variables are shown weighted by their regression coefficients (Table 7, column 1), and are levels-adjusted relative to the dependent variable.

Figure 7: The contribution to the output forecast of the current account and government surpluses to GDP and the terms-of-trade



Note 1. The stochastic trend is from the equation in column 1, Table 7.
Note 2. The right-hand side variables are shown weighted by their regression coefficients (Table 7, column 1), and are levels-adjusted relative to the dependent variable.