The forecast performance of alternative models of inflation

By C.J. Pretorius and T.N. Janse van Rensburg

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Contents

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1. Introduction

Current and expected inflation have an important effect on decisions to save, invest, produce and consume. Decisions based on expected inflation rates which subsequently turn out to be totally wrong, are likely to result in a poor allocation of resources and therefore in a weaker overall economic performance. More accurate forecasts of inflation can accordingly contribute to a higher quality of decision making by economic agents and to the improvement of overall economic performance.

Alternative models, based on various theories of price formation, are often used to describe the inflation process. These models emphasise the role played by different variables in the inflation process. The question arises which one of these models can best describe the actual behaviour of prices in South Africa and should therefore be recommended for forecasting purposes.

Econometric models differ not only in their specification, but also in the quality of the information available. Although a large number of explanatory variables in theory-based models will improve the goodness-of-fit of the equations, they do not necessarily enhance the predictive power of the models.

This study attempts to compare the forecasting accuracy of a number of inflation models. The following theory-based models were applied to the available statistical data and the results were compared:

- The expectations-augmented Phillips curve model;
- a traditional monetarist model; and
- a price equation based on money demand views of inflation.

In addition to these theory-based models of the inflation process, a simple autoregressive model was also developed. This model use only historical inflation data to forecast future inflation and no additional explanatory variables are included in the analysis. Theoretically based models, on the other hand, make use of movements in a set of explanatory variables to define the inflation forecast.

Measures used to evaluate in-sample forecast performance are often poor indicators of a model's forecast ability. It is therefore also desirable to examine a model's out-of-sample simulation performance when evaluating its forecasting ability. The approach followed in this study was to estimate the price equations over a common period and to compare dynamic simulations with the models by projections over future periods.

1 The views expressed in this study are those of the authors and do not necessarily represent those of the South African Reserve Bank.

2. Macro-economic inflation forecasting models

This section provides a brief description of the theory underlying the structural models of the inflation process and the price equations estimated in this study.

2.1 The expectations-augmented Phillips curve model

One popular macro-economic model used in the description of the inflation process is the so-called Phillips curve. The original Phillips curve depicted the negative correlation of the rate of change in money wages in the United Kingdom with the unemployment rate. Over time this empirical relationship has also been applied to price inflation and aggregate output.

The Phillips curve model generally assumes prices are set as a mark-up over labour costs. Labour costs, in turn, are predominantly determined by expected inflation and the degree of demand pressure. In order to describe the concept of demand pressure, it is necessary to define the concepts of potential output and the natural rate of unemployment. The potential output is the hypothetical volume of output that the economy could generate if it produced at full capacity and is sometimes also referred to as the full employment level of output. The natural rate of unemployment is the rate of unemployment that persists in a period of full employment output. The Phillips curve suggests that an unemployment rate persistently lower than the natural rate of employment, is associated with a rising inflation rate. Similarly, a growth rate in real gross domestic product that exceeds that of potential output, can also be associated with an increasing inflation rate.

If the economy grows at a faster rate than the potential output, firms face production capacity constraints that force them to hire additional workers, to utilise capital more intensively and to increase investment. This normally results in increases in production costs, including wage costs. Eventually these increases in production cost are passed on to consumers, causing prices to rise and inflationary pressures to mount.

The difference between the economy's real potential output and the actual output is referred to as the output gap. The output gap is included in the Phillips curve model as an indicator of demand pressure. The inflation equation can be derived from separate wage and price equations. The following price and wage equations can be used to derive the expectations-augmented Phillips curve model:

$$\dot{P}_t = a_1 GAP_t + a_2 (\dot{W}_t - \dot{q}_p) + a_3 SS_{pt} \quad (1.1)$$

$$\dot{W} = b_o + b_1 GAP_t + b_2 \dot{P}_t^e + b_3 SS_{wt} \quad (1.2)$$

$$\dot{P}_t^e = \sum_{j=1}^{n} \lambda_j \dot{P}_{t-j} \quad (1.3)$$

where a dot over a variable indicates percentage change and

P_t = inflation rate in period t;
W = nominal wage growth;
q_p = trend growth rate of labour productivity;
SS_{pt} = supply shocks affecting output prices;
SS_{wt} = supply shocks affecting nominal wages;
GAP = the GDP gap variable, defined as the difference between actual real output and potential real output; and
P_t^e = the expected rate of inflation in period t.

Equation 1.1 describes price markup behaviour. Prices are marked-up over productivity-adjusted labour costs ($\dot{W} - \dot{q}_p$) and are influenced by cyclical demand (measured by the GAP variable) and exogenous price shocks (SS_p). In equation 1.2 wage inflation is assumed to be a function of cyclical demand, expected price inflation ($\dot{P}^e$) and exogenous price shocks (SS_w). The expected rate of inflation is modelled as a lag on past inflation in equation 1.3.

A combination of equations 1.1, 1.2 and 1.3 yields the following Phillips curve equation:

$$\dot{P}_t = d_o + \sum_{s=0}^{n} d_1 \dot{P}_{t-s} + d_2 GAP_t + d_3 SS_{pt} + d_4 SS_{wt} \quad (1.4)$$

where $d_0, d_1, \ldots$ are the parameters and where the other variables are defined as before.

The GAP variable can also be expressed as:

$$GAP_t = y_t - y_{pt} = Y_t - P_t - y_{pt} \quad (1.5)$$

where
Y_t = the log of nominal GDP;
y_t = the log of real GDP; and
y_p = the log of real potential GDP.

When first differences of equation 1.5 are taken and the variables are regrouped, the GAP variable can be expressed as:

$$GAP_t = y_t - y_{pt} = (y_{t-1} - y_{pt-1}) + (\dot{Y}_t - \dot{y}_{pt}) - \dot{P}_t \quad (1.6)$$

By substituting equation 1.6 into 1.4, the Phillips curve inflation equation can be expressed as:

$$\dot{P}_t = f_o + \sum_{s=0}^{n} f_1 \dot{P}_{t-s} + f_2 (y_{t-1} - y_{pt-1}) + f_2 (\dot{Y}_t - \dot{y}_{pt}) + f_3 SS_{pt} + f_4 SS_{wt} \quad (1.7)$$

This specification of the Phillips curve equation allows explicitly for the influence of nominal aggregate demand (via the term $\dot{Y}_t - \dot{y}_{pt}$) on inflation. The SS_p and SS_w terms in equation 1.7 are often captured in empirical work by changes in relative food and energy prices.

Hence, the Phillips curve equation is estimated as:

$$\dot{P}_t = g_o + g_1 (y_{t-1} - y_{pt-1}) + g_2 (\dot{Y}_t - \dot{y}_{pt}) + \sum_{s=o}^{n1} g_{3s} \dot{P}_{t-s} + \sum_{s=o}^{n2} g_{4s} R\dot{E}P_{t-s} + \sum_{s=0}^{n3} g_{5s} R\dot{F}P_{t-s} \quad (1.8)$$

where $R\dot{E}P$ and $R\dot{F}P$ represent changes in relative energy and food prices.

2.2 The traditional monetarist model

The traditional monetarist approach assumes that observations of past growth in the money supply predict the long-run inflation rate. The monetarist inflation model suggests the following relationship:

$$\dot{P} = f(M_t, \Delta M_t, \Delta M_{t-1}, \ldots\ldots\ldots \Delta M_{t-i}), \quad (2;0)$$

where
$\dot{P}$ = inflation rate in period t;
ΔM = money growth rate in period t;

According to this theory, inflation is therefore a function of current and past money growth. Empirical estimations of monetarist forecasting models depend largely on the choice of the monetary aggregate used to measure the growth in money supply as well as the number of lagged observations in this growth. The choice of the appropriate monetary measure and the length of the lag structure are not prescribed by economic theory, but can have a significant affect on the forecast performance of the model.

Later versions of the monetarist model also include a fiscal policy variable which can either be defined as the budget deficit as a percentage of gross domestic product or the change in the expenditure by general government. The relative prices of food and energy are included in some monetarist models to account for shifts in aggregate supply that may temporarily influence the rate of inflation. The general form of the model can then be described as:

$$\dot{P}_t = g_o + \sum_{s=o}^{n} g_1 \dot{M}_{t-s} + \sum_{s=o}^{m} g_2\dot{G}_{t-s} + \sum_{s=o}^{k} g_3 SS_{t-s} \qquad (2.1)$$

In equation 2.1 inflation is determined by current and past values of the growth rates in money supply (M), government expenditure (G) and supply shocks (SS), which can be captured by changes in relative food prices.

2.3 The money demand model

The price equation in the money demand model is based on the view that inflation is caused by growth in money supply in excess of growth in real money demand. The following equation can be used to illustrate this relationship:

$$P_t = \frac{M_t}{md_t} \qquad (3.1)$$

where P_t = the price level;
M_t = actual level of money balances; and
md_t = the public's demand for real money.

It is assumed that the actual level of money balances are exogenously determined by the monetary authorities. The price level will adjust to equate the public's demand for real money balances to the nominal money balances. In equation 3.1 an increase in nominal money stock, given real money demand, causes the price level to rise. On the other hand, a rise in the public's real money demand, given the fixed money stock, will cause the price level to fall.

The public's demand for real money balances can be expressed by the following equation:

$$\ln md_t = a + b \ln y_t - c\,(RL\text{-}RD)_t \qquad (3.2)$$

where
y_t = real income;
RL = an interest rate reflecting the opportunity cost of holding money; and
RD = an interest rate reflecting the yield on interest bearing deposits.

Equation 3.2 assumes that the public's demand for real balances depends positively on real income and is inversely related to an opportunity cost variable, defined as the difference between the rate on a money substitute and the interest rate on money balances. If equation 3.1 is transformed into natural logarithms and equation 3.2 is then substituted into the logarithmic version, the following price equation can be derived:

$$\ln P_t = -a + \ln M_t - b \ln y_t + c\,(RL - RD)_t \qquad (3.3)$$

Thus, the price level depends on the actual money stock, real income and an opportunity cost variable. According to equation 3.3 a rise in real income depresses the price level if all other variables remained unchanged. An increase in real income will raise the public's demand for real money balances. Given an exogenous money stock, the price level would have to fall to equate the rise in real money demand with the real money supply.

Similarly, a rise in the opportunity cost of holding money raises the price level. It would reduce the public's demand for real money balances, and the price level would have to rise to equate the reduced demand for real money balances given the predetermined nominal money stock.

Since there are lags involved in the adjustment of the price level to changes in the determinants of the price level, an inflation equation describing the money demand model can be expressed as:

$$\dot{P}_t = h_o + \sum_{s=o}^{n1} h_{1s} \dot{M}_{t-s} - \sum_{s=o}^{n2} h_{2s} \dot{y}_{t-s} + \sum_{s=o}^{n3} h_{3s}\,(RL \dot{-} RD)_{t-s} \qquad (3.4)$$

The monetary aggregate used in equation 3.4 should comply with the following two conditions:

- it should have a well-defined function to explain movements in real demand; and
- the interest rate on this aggregate should be fixed below its free-market value.

2.4 The time-series model

In contrast to the theory-based models of the inflation process, a univariate statistical time-series model needs no other variable than inflation in order to produce an inflation forecast. More weight is usually placed on the most recent observations and on the estimate of the recent trend rather than the trend over the entire estimation period. The autoregressive model of inflation is a function of past inflation data and can be expressed in the following way:

$$\dot{P}_t = k_o + \sum_{s=o}^{n} k_{1s} \dot{P}_{t-s}$$

3. Statistical estimation of inflation forecasting models

The inflation equations distinguished above, were estimated using quarterly data. The price index used as the dependant variable in the equations, is the derived deflator for private consumption expenditure.

The price equations associated with the inflation models were estimated by means of the ordinary least squares technique and the t-values of the estimated coefficients and the following summary statistics are tabulated:

$\bar{R}^2$ = Adjusted coefficient of determination;
D-W = Durbin-Watson d-statistic;
RHO = Autocorrelation coefficient.

The period of estimation is stated below the summary statistics for each equation. The real variables used in the estimation of the equations were measured in constant 1990 prices.

The traditional monetarist model and the demand for money equations were estimated over the period from the first quarter of 1990 to the fourth quarter of 1994 to ensure that a uniform monetary policy regime applied over the entire estimation period. The Phillips curve model was estimated over an extended period, from 1982 to 1994 in order to increase the degrees of freedom.

3.1 The Phillips curve model

Although the analysis were carried out with different lag structures, a three-quarter lag on previous inflation turned out to be the best approximation of the expectations-formation process. The coefficients of the lagged variables in the equation were determined by means of an Almon lag distribution where the best results were obtained when the coefficients of the lagged variables were constrained to follow a second degree polynomial with the end point restricted to zero. The following explanatory variables were included in the equation:

- the output gap, expressed as the difference between the real gross domestic product and the potential real gross domestic product[2] ($y_t - y_{pt-1}$);
- the difference between the growth rate in the nominal gross domestic product and the growth rate of the potential real gross domestic product ($\dot{Y}_t - \dot{y}_{pt}$);
- the inflation rate in the previous period ($\dot{P}_{t-1}$);
- the relative price of energy, calculated as the relative price of energy in the consumer price index (defined as the weight of fuel and power and transport running cost, petrol and oil) to the price index excluding energy ($R\dot{E}P$); and
- the relative price of food, calculated as the relative price of food in the consumer price index to the price index excluding food ($R\dot{F}P$).

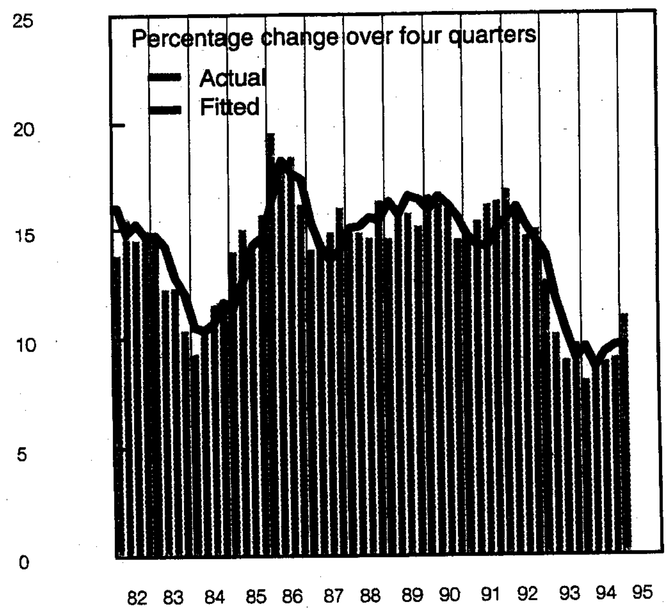
The Phillips curve inflation rate estimation is as follows:

$$\dot{P}_t = a_o + a_1 (y_{t-2} - y_{pt-2})$$

$$= + a_2 (\dot{Y}_{t-1} - \dot{y}_{pt-1}) + \sum_{s=1}^{3} a_{3s} \dot{P}_{t-s} + \sum_{s=o}^{2} a_{4s} R\dot{E}P_{t-s} + \sum_{s=o}^{2} a_{5s} R\dot{F}P_{t-s}$$

2 For a description of the calculation of the potential gross domestic product, see De Jager, B.L. and Smal, M.M.: *"The potential gross domestic product of South Africa."*, Quarterly Bulletin of the South African Reserve Bank, December 1984.

Graph 1: Actual and fitted values of the Phillips curve model



Coefficient	Estimate	T-Statistic
a_0	3.057	1.95
a_1	-0.0003	2.85
a_2	0.141	2.48
a_{31}	0.553	9.47
a_{32}	0.158	9.47
a_{33}	0.079	9.47
a_{40}	0.041	2.76
a_{41}	0.054	2.76
a_{42}	0.041	2.76
a_{50}	0.044	2.14
a_{51}	0.058	2.14
a_{52}	0.044	2.14

$\bar{R}^2$ = 0.785
D-W = 1.48
RHO = 0.22

Estimation period: 1982.1 to 1995.1

The actual and fitted values of the equation of the Phillips curve model of inflation are compared in Graph 1.

3.2 The traditional monetarist model

As already indicated, economic theory provides no guidance as to which monetary aggregate should be used and as to the choice of the lag lengths of the monetary and fiscal variables. The M3 money supply turned out to be the best monetary aggregate to use in terms of goodness-of-fit and statistical significance of individual parameters. The best results were obtained with fairly long lags on M3 money supply - up to twelve-quarter lags were employed starting with a fourth-quarter lag. The budget deficit as a percentage of gross domestic product was not statistical significant as an indicator of fiscal policy and the change in expenditure by general government was used instead. Up to five-quarter lags of the growth rate in expenditure by general government were used as an indicator of fiscal policy. The coefficients of the lagged variables in the equation were determined by means of an Almon lag distribution, and the best results were obtained when the coefficients were constrained to follow a second degree polynomial with both end points restricted to zero. The following explanatory variables are included in the equation:

- the growth rate in the M3 money supply ($\dot{M}_t$);
- the growth rate in consumption expenditure by general government ($\dot{G}_t$); and
- the relative price of food, calculated as the relative price of food in the consumer price index to the price index excluding food ($R\dot{F}P$).

The traditional monetarist model of inflation estimation is of the following form:

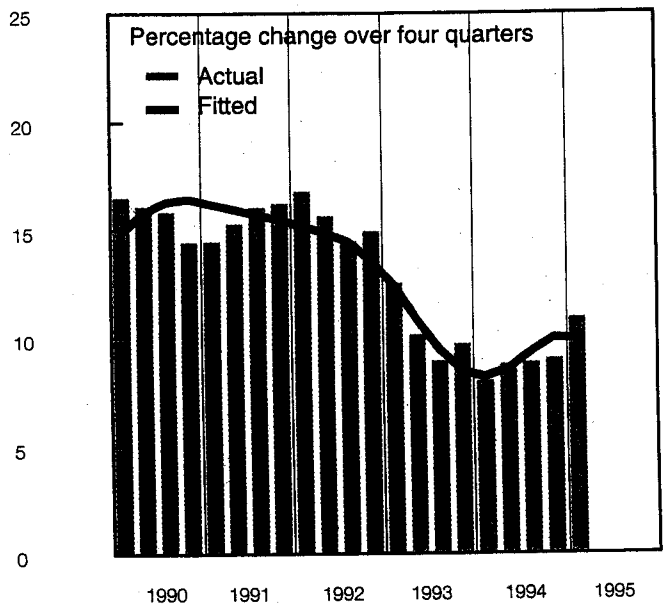
$$\dot{P}_t = g_o + \sum_{s=4}^{12} g_{1s}\dot{M}_{t-s} + \sum_{s=0}^{5} g_{2s}\dot{G}_{t-s} + \sum_{s=0}^{2} g_{3s}R\dot{F}P_{t-s}$$

Coefficient	Estimate	T-Statistic
g_0	1.682	1.75
g_{14}	0.020	6.36
g_{15}	0.036	6.36
g_{16}	0.047	6.36
g_{17}	0.053	6.36
g_{18}	0.057	6.36
g_{19}	0.053	6.36
g_{110}	0.047	6.36
g_{111}	0.036	6.36
g_{112}	0.020	6.36
g_{20}	0.035	2.79
g_{21}	0.059	2.79
g_{22}	0.070	2.79
g_{23}	0.070	2.79
g_{24}	0.059	2.79
g_{25}	0.035	2.79
g_{30}	0.013	3.75
g_{31}	0.018	3.75
g_{32}	0.013	3.75

$\bar{R}^2$ = 0.871
D-W = 1.10
RHO = 0.42

Estimation period: 1990.1 to 1995.1

Graph 2: Actual and fitted values of the traditional monetarist model



The actual and fitted values of the equation of the traditional monetarist inflation model are compared in Graph 2.

3.3 The money demand model

Judging by the goodness-of-fit and the statistical significance of estimated coefficients in a number of specifications, the M3 money supply also turned out to be the best monetary aggregate to use in the case of the money demand model. A two-period lag structure on the money supply and a six-period distributed lag structure on the gross domestic product provided the statistically most significant results. The coefficients of the lagged variables in the equation were determined by means of an Almon lag distribution with the coefficients constrained to follow a second degree polynomial and both end points were restricted to zero.

The following explanatory variables are included in the equation:

- the growth rate over four quarters in the M3 money supply in previous periods ($\dot{M}_t$);
- the growth rate over four quarters in real gross domestic product ($\dot{y}_t$); and
- the difference between the prime overdraft rate and the own rate of money (a combined weighted deposit rate) (RL - RD).

The estimated money demand model of inflation is of the following form:

$$\dot{P}_t = b_0 + \sum_{s=0}^{2} b_{1s}\,\dot{M}_{t-s} - \sum_{s=1}^{6} b_{2s}\,\dot{y}_{t-s} + \sum_{s=0}^{2} b_{3s}\,\Delta\,(RL - RD)_{t-s}$$

Coefficient	Estimate	T-Statistic
b_0	1.682	1.75
b_{10}	0.270	10.28
b_{11}	0.360	10.28
b_{12}	0.270	10.28
b_{21}	-0.234	8.18
b_{22}	-0.390	8.18
b_{23}	-0.468	8.18
b_{24}	-0.468	8.18
b_{25}	-0.390	8.18
b_{26}	-0.234	8.18
b_{30}	0.008	1.92
b_{31}	0.011	1.92
b_{32}	0.008	1.92

$\bar{R}^2$ = 0.902
D-W = 1.38
RHO = 0.28
Estimation period: 1990.1 to 1995.1

The actual and fitted values of the equation of the money demand inflation model are compared in Graph 3.

3.4 A time-series model of inflation

A time series ARIMA model was estimated, using the Box-Jenkins methodology in which inflation was assumed to be a weighted function of its own past values. The inflation process was identified as an ARIMA (0,1,1) model which implies:

- that no autoregressive structure was applicable;
- a differencing factor of one; and
- a moving average factor (ma), with a four-period lag.

The calculated coefficients of the ARIMA model can be summarised as:

$\dot{P}_t$ = ma - 0.5075*ma_{-4}
(3,3)

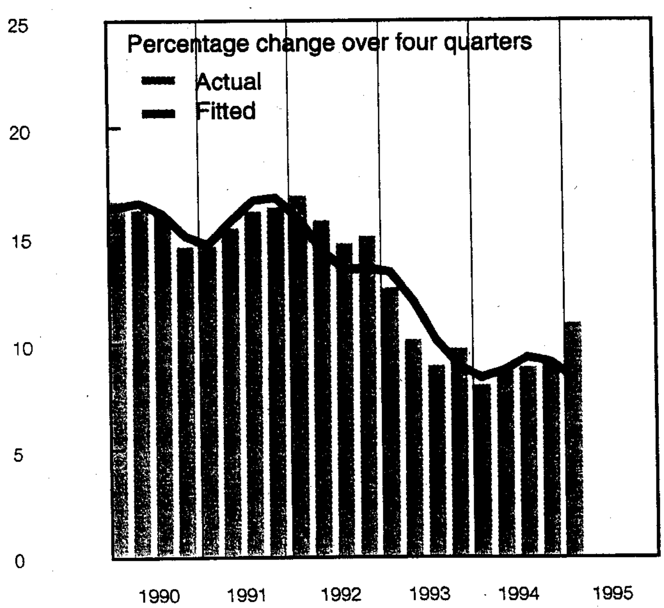
$\bar{R}^2$ = 0.81
Estimation period: 1985.1 to 1995.1

The actual and fitted values of the equation of the ARIMA time series model are compared in Graph 4.

4. Summary of results

Apart from a summary of the regression results, the in-sample forecast performance of the various models are compared in this section as well as the models' out-of-sample simulation performances.

Graph 3: Actual and fitted values of the money demand model



Graph 4: Actual and fitted values of the ARIMA time-series model

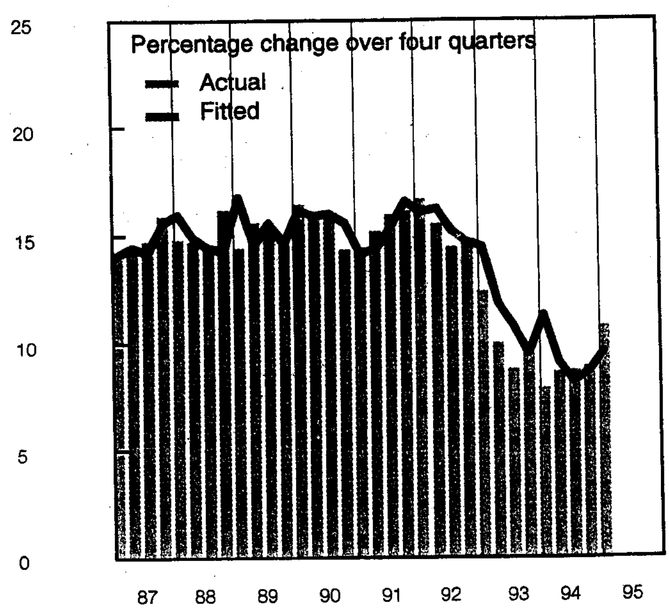


Table 1.
Summary of regression results

Inflation models	$\bar{R}^2$	D-W
Phillips curve model	0,79	1,5
Traditional monetarist model	0,87	1,1
Money demand model	0,90	1,4
ARIMA model	0,81	-

4.1 Goodness-of-fit of the models

In Table 1 the regression results of the various inflation forecasting models are compared. The results indicate that the inflation model based on the demand for money has the highest adjusted coefficient of determination R^2. However, the adjusted coefficients of determination of the different models are more or less of the same magnitude and this statistic is thus not a sufficient criterium to differentiate between the various models.

4.2 The in-sample forecast performance of the models

An eight-quarter dynamic inflation forecast was generated with the various inflation models over the period from the first quarter of 1993 (1993q1) to the fourth quarter of 1994 (1994q4), using actual observations on the exogenous variables in the equation.

Although it is difficult to distinguish between the price equations on the basis of goodness-of-fit (the regression results in Table 1), a clear ranking of the models emerges when the root mean squared errors (RMSE) and the mean absolute errors (MAE) are compared over the forecast interval. The average RMSE and MAE over the forecast period are tabulated in Table 2. It is quite evident that the theory-based models of inflation outperformed the time series model (ARIMA model) fairly decisively. The best in-sample forecasting accuracy was obtained by the money demand model of inflation according to both above-mentioned criteria. However, the choice of the sample period might have played a role in the forecast accuracy of the models. Over the chosen period, the inflation rate declined from more than 12 per cent in the first quarter of 1993 to about 9 per cent in the fourth quarter of 1994. The ARIMA model overestimated inflation consistently during the forecasting period, because future inflation is defined only as a moving average of its past values.

4.3 The out-of-sample forecast performance of the models

The in-sample forecast performance of the models is often a poor indication of the forecasting ability of the models, therefore various out-of-sample performances were conducted with the estimated models. The coefficients of the various models were re-estimated using quarterly data from the first quarter of 1985 to the fourth quarter of 1990. Firstly, an eight-quarter inflation forecast was performed over the period 1991q1 to 1992q4 for each model. This process was repeated by re-estimating the coefficients of the various models by extending the sample period by four quarters to 1991q4 and using these coefficients for dynamic forecasts over the subsequent eight quarters, starting in 1992q1. The estimation sample was updated until 1993q4, the model re-estimated and the forecasting period extended to 1995q3. The simulation results over the four different forecasting periods are tabulated in Tables 3 to 6.

The time series model (ARIMA model) outperformed the theory-based models of inflation during the first period of the out-of-sample forecasts, using the RMSE and MAE criteria (see Table 3). The high forecast accuracy of the ARIMA model is not surprising because the inflation rate was relatively stable throughout the forecast period and the immediate preceding period. The money demand model outperformed the other theory-based models with a relatively small margin. The forecast errors of the traditional monetarist model were higher than that of the other models over this period. The model used long lags on the money growth which exhibited fairly high volatility over the preceding periods. The inflation rate was fairly stable over this period and therefore the monetarist model registered large forecast errors.

During the second out-of-sample forecast period, the inflation rate started to decline from a high of more than sixteen per cent in the first quarter of 1992 to just

Table 2.
Summary of the in-sample forecast performance of the models: 1993q1 to 1994q4

Inflation models	RMSE	MAE
Phillips curve model	0,85	0,74
Traditional monetarist model	0,89	0,79
Money demand model	0,79	0,65
ARIMA model	3,99	3,69

Table 3.
Summary of the out-of-sample forecast performance of the models: 1991q1 to 1992q4

Inflation models	RMSE	MAE
Phillips curve model	0,87	0,83
Traditional monetarist model	1,11	0,93
Money demand model	0,76	0,65
ARIMA model	0,72	0,61

Table 4.
Summary of the out-of-sample forecast performance of the models: 1992q1 to 1993q4

Inflation models	RMSE	MAE
Phillips curve model	2,06	1,72
Traditional monetarist model	2,30	1,88
Money demand model	4,43	3,30
ARIMA model	3,86	2,80

below nine per cent in the fourth quarter of 1993. The results in Table 4 indicate that the forecast accuracy of the Phillips curve model surpassed that of the other models in the period 1992q1 to 1993q4. The traditional monetarist model also performed relatively well but both the money demand model and the ARIMA model were unable to predict the deceleration in the inflation rate.

All four models failed to predict with an acceptable degree of accuracy the slowdown in inflation over the period 1993q1 to 1994q4. The relatively high RMSE and MAE values in Table 5 can be contributed to the inability to predict the structural slowdown in the inflation rate since the third quarter of 1993. The Phillips curve model again performed better than the other models. The ARIMA model's inability to predict a turning point can be seen as the main reason for its poor forecasting ability over this period.

The theory-based models were all able to predict fairly accurately the lower inflation rate over the forecasting period 1994q1 to 1995q3 (see Table 6), while the ARIMA model again overestimated the inflation rate over this period by a considerable margin. The Phillips curve model again produced the best results.

In order to get some idea of which model performed better in the out-of-sample forecasts, the average RMSE and MAE were calculated over all the forecasting periods. The results are summarised in Table 7. The forecasting accuracy of the Phillips curve model is superior to that of the other models, and the other theory-based models were also more accurate in predicting future inflation than the time-series model.

Table 5.
Summary of the out-of-sample forecast performance of the models: 1993q1 to 1994q4

Inflation models	RMSE	MAE
Phillips curve model	2,95	2,86
Traditional monetarist model	3,48	3,31
Money demand model	5,75	5,60
ARIMA model	6,34	6,20

Table 6.
Summary of the out-of-sample forecast performance of the models: 1994q1 to 1995q3

Inflation models	RMSE	MAE
Phillips curve model	0,89	0,64
Traditional monetarist model	1,129	0,80
Money demand model	0,98	0,88
ARIMA model	4,35	3,99

Table 7.
Summary of the average out-of-sample forecast performance of the models: 1991q1 to 1995q3

Inflation models	RMSE	MAE
Phillips curve model	1,69	1,51
Traditional monetarist model	2,00	1,73
Money demand model	2,98	2,61
ARIMA model	3,82	3,40

5. Conclusion

A comparison of the forecasting ability of various forecasting models indicates that the theory-based models are better equipped to describe the inflation process and to forecast future inflation than time-series models. The time series model (ARIMA) is quite useful to predict the inflation rate when the inflation rate is relatively stable, but is unable to predict a turning point or a change in volatility of the inflation rate.

All the theory-based models track actual inflation reasonably well and both the root mean squared error and the mean absolute error remain within an acceptable range. The values of the RMSEs and MAEs of the theory-based models compare favourably with similar studies of forecasting in the United States of America. All the models encountered difficulties in predicting the slowdown of prices during 1993, but were able to predict the inflation rate in the ensuing period fairly accurately.

The Phillips curve model conclusively performed better than the traditional monetarist model and the money demand model over the forecasting period. The explanation for this is that the widening gap between the actual and potential GDP over this period provides an explanation for the decelerating prices. The high volatility of money growth did not coincide with similar movements in the inflation pattern and consequently failed to detect beforehand the decline in the inflation rate.

Although the rate of change in money wages is not explicitly included in the reduced form Phillips curve equation, it was shown that it has a direct influence on the inflation rate. If the rate of change in wages exceeds the increase in productivity, the inflation rate is set to rise. The important role of inflation expectations is also emphasised in the Phillips curve equation. Because inflation expectations depend in part on inflation recorded in the past, the current relatively low inflation rate may have a positive influence on inflation expectations and on the rate of change in wages.

The visible success in reducing inflation recently might be an indication that economic participants are to some extent convinced that the monetary authorities are succeeding in lowering inflation. This confirms the importance of applying monetary policy in a consistent manner in order to be perceived as credible. Consistency in the application of monetary policy is a reliable way of influencing inflation expectations in the desired direction.

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