A Dynamic Model of Inflation for Kenya 1974 - 1996

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Abstract

This paper develops an error correction model with the aim of analysing the behaviour of prices in Kenya during 1974 –1996. In estimating the model, we first test for cointegration in the money and foreign exchange markets, using the Johansen procedure. The cointegrating vectors are then included in an autoregressive distributed-lag model, and a general-to-specific procedure is applied to obtain a parsimonious, empirically constant, error correction model. We find that in the long run inflation emanates from movements in the exchange rate, foreign prices, and terms of trade. The error correction term for the monetary sector does not enter the model, but money supply and the interest rate influence inflation in the short run. Inflation inertia is found to be an important determinant of inflation up until 1993, when about 40% of the current inflation is carried over to the next quarter. After 1993, inertia drops to about 10%. The dynamics of inflation are also influenced by food supply constraints, proxied by maize-price inflation. These findings indicate that the exchange rate is likely to be a more efficient nominal anchor than money supply, and that inflation could be made more stable by policies that secure the supply of maize during droughts.

Key Words: Kenya, Inflation, Inertia, Money demand, Food supply, Real exchange rate, Terms of Trade, Cointegration, Error Correction Model.

JEL-Codes: E31, F41, O55.

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1. Introduction

The objective of this paper is to model and explain inflation in Kenya over the period 1974 to 1996. To achieve this goal, we develop a single-equation error correction model. The period of study encompasses a number of policy changes and external shocks that are likely to have affected inflation. Import substitution, the development strategy prevalent in the 1970s, was partially dismantled during the 1980s as several structural adjustment programs were implemented, and in the beginning of the 1990s there was a large-scale liberalisation of the economy. This entailed deregulation of the financial sector, removal of controls on retail and producer prices, and liberalisation of the current and capital accounts of the balance of payments. Exchange rate policy also changed; in 1982 a crawling peg replaced the adjustable peg, and in 1993 the Kenyan Shilling started to float. In addition, several external shocks such as the oil-price shocks in the 1970s, coffee booms in 1976/77, 1986 and 1993, and donors' foreign aid embargo in 1991/92 hit the economy. Hence, finding an empirically stable and parsimonious model that describes the evolution of Kenya's inflation constitutes a major challenge.

A review of the literature on inflation in Kenya reveals a variety of conclusions drawn. Killick (1984), for instance, states that no single factor could be taken as the major cause of inflation in Kenya. On the other hand, Killick and Mwega (1989) conclude, "despite variations in model tests, all studies in Kenya are unanimous in finding monetary expansion among the most important variables explaining inflation". Ndung'u (1994) and Adam et al (1996) also obtain results which indicate that money supply drives inflation. However, according to Ndung'u there is only a short-run relationship between these variables; deviations from equilibrium in the money market do not enter the model and thus money does not determine the price level in the long run. Another result is obtained by Ryan and Milne (1994) who find that exchange rate movements and changes in oil prices are the most important factors determining inflation, while the contribution from monetary variables is small. There are also diverging results about the degree of inflation inertia. Killick and Mwega (1989) and Mwega (1990) do not find evidence of inertia, i.e., lagged inflation does not enter their models. On the other hand, both Ndung'u (1994) and Isaksson (1997) find a degree of inertia of about 0.30. This is similar to what has been found for Brazil when experiencing chronic inflation, and inflation inertia was considered to be very high (Durevall 1998).

This paper attempts to improve upon these past studies in several respects. First, we include terms of trade and maize-price inflation in our model, which, to our knowledge, has not bee done previously. Second, our sample includes data up to 1996, and thus extends over a period of when rapid liberalisation of the Kenyan economy was undertaken. Other recent studies have concentrated on periods ending in the 1980s or early 1990s. When extending the sample, we have allowed inflationary inertia to shift since both the removal of price controls and changes in policies should have reduced it in the 1990s. Third, a major shortcoming of most studies is that explicit attention was not paid to the non-stationarity of the data, exemptions are Ndung'u (1993,1994, 1996), Adam et al. (1996), and Isaksson (1997). Using recent developments in time series econometrics, we are able to distinguish between long and short-term effects. Fourth, we develop a model that is empirically stable; in earlier work stability has usually been ignored. Two exceptions are Ndung'u (1994), who estimated a purely monetarist model on data ending in 1990, and Isaksson (1997), whose model breaks down in 1992.

In order to model inflation in Kenya we start by specifying long-run equilibria in the monetary and foreign sectors, from which inflation is usually assumed to originate in an open economy. These are also of interest because either money supply or the exchange rate can serve as a nominal anchor. Then we develop an empirically constant, error correction model (ECM), with the aim of analysing the dynamics of inflation. In estimating the model, we first test for (and find) cointegrating vectors using the Johansen maximum likelihood procedure (Johansen 1988). The cointegration vectors are then included in a general error correction model, which is tested in order to make sure that the assumptions regarding its stochastic properties are fulfilled. Next, the overparameterized model is reduced in order to obtain a parsimonious representation. Finally, the stability of the model is investigated using recursive estimation, and diagnostic tests are applied on omitted variables. Our main findings are that the exchange rate, foreign prices, and terms of trade determine inflation in the long run, inflationary inertia was high until 1993 when it declined sharply, and growth in money supply and maize-price inflation affect inflation in the short run.

The paper is organised as follows: The following sub-section provides a brief background to the Kenyan economy. Section 3 provides a theoretical background to the empirical model. In Section 4, the data is briefly reviewed and in Section 5 integration and cointegration tests are provided. The error-correction model of inflation is developed and analysed in Section 6, and its statistical properties are evaluated in Section 7. Section 8 summarises and draws some conclusions.

2. Background

One particular turn of events in the 1990s is the slowdown in economic growth, the rapid rise in inflation, money growth and interest rates, and the spectacular depreciation of the currency. The 1990s thus contrast sharply with the first decade of Kenya's independence, the 1960s, when inflation averaged 3% and the exchange rate was fixed. Inflation was thus not a policy problem in this period. In the 1970s, with the first oil price shocks and balance of payments problems, the rate of inflation began to increase. This increase was accompanied by devaluations and changes in the exchange rate peg from the Sterling pound to the U.S. dollar, and then to the SDR. Expansionary fiscal and monetary policies, along with accompanying balance of payments crises, then led to an economic crisis in the mid-1970s.

In response to the balance of payments crisis, the policy makers in Kenya chose to introduce instruments of control rather than liberalise the economy. These included; selective controls on bank lending, licensing of foreign exchange transactions, quota restrictions on most imports, direct price controls on goods and control on interest rates. The restrictions on domestic credit were later lifted but controls on foreign exchange transactions, imports, domestic prices and interest rates were modified and made more restrictive every year. These produced major distortions and the discretionary powers gave room to pervasive rent-seeking activities in the public sector, which has been difficult to reverse. Moreover, the reaction to the crises prevented policy makers from formulating and adopting stabilisation and adjustment measures that could re-orient the economy in the phase of severe internal and external shocks.

In 1976-77, there was a commodity boom in the major export crops, coffee and tea. This boom eased some of the economic difficulties experienced in the early 1970s and postponed the pressure for adjustment. However, the management of this boom is partly responsible for the economic difficulties experienced after it subsided. The boom led to an appreciation of the exchange rate, a tremendous expansion of the domestic credit and the money supply, fiscal expansion and an expansion of the Non-bank Financial Institutions. Even during the boom, the country's level of indebtedness was rising, and so was the level of fiscal deficit. Thus, the 1980s opened up with macroeconomic disequilibrium calling for remedial policy options, and by 1982 it was clear that the macroeconomic policies pursued were not sustainable and needed drastic change. The first policy change was to shift from a fixed exchange rate to a crawling peg, a real exchange rate rule in effect. Moreover, various policy measures were put in place after the exchange regime shift, including an interest rate adjustment and a reduction in fiscal deficit. These measures helped to stabilise the balance of payments, reduce the excess liquidity generated by the coffee boom, and slow down inflation.

In the 1990s, inflation and monetary expansion rose rapidly, indebtedness increased, and so did the speed of nominal exchange rate depreciations. In this period, the exchange rate regime had changed to a dual system in that there was an official exchange rate and a "market" rate, which was operated on the basis of Foreign Exchange Bearer Certificates[1]. Moreover, by 1992 there were foreign exchange retention accounts in commercial banks. This meant relaxation of

[1] The Forex-Cs provided a significant relief to the foreign exchange since possessing them entitled one to some amount of foreign exchange without having to go through the long delays of foreign exchange licensing process. Forex-Cs were purchased at the official rate from the Central Bank in foreign exchange without having to declare the source of foreign exchange. These certificates attracted an interest rate and could thus be marketed as any other paper asset.

controls in foreign exchange transactions. These policies were implemented at a time when there was excess money supply in the circulation, a severe shortage of foreign exchange, price decontrol in the presence of inadequate supply of essential commodities, and increased spending (electoral greasing) in the run-up to the 1992 elections. Hence, one outcome was to raise inflation.

Besides all these factors, money supply expansion was also being influenced by the aid embargo at the time; the escalating fiscal deficit had to be financed from money printing. In an attempt to mop up the excess liquidity, the Treasury bills discount rate shot up, pushing the rate of inflation with it and the exchange rate depreciated markedly. This was followed by massive private capital inflows, which led to a build up of foreign exchange reserves and thus appreciating the exchange rate. The Treasury bills discount rate gradually came down and the rate of inflation started to follow suit. The appreciation of the shilling thus partly reflected substantial inflows, which were a result of liberalisation of foreign exchange transactions and high yields on domestic Treasury bills.

The beginning of the 1990s was characterised by a shift in attention away from the real economy to one in which trade in financial assets dominates, with rates on secure government paper earning excess premium, and lending for investment or importing inputs was seen as unattractive. Exporters were benefiting from currency depreciation but domestic demand was depressed. By the end of 1993, the official exchange rate was abolished, and further liberalisation allowed individuals to hold foreign exchange. These liberalisation efforts, together with a shadow program negotiated by the World Bank and IMF, created credibility and assured traders of commitments to a more market driven policy. As a result, there was improved stability of macro-prices in 1994-96 period and a gradual decline of inflation from the high levels of 1993.

3. Theoretical Framework

Although a number of studies on inflation exists, there is no consensus on which theory is the most adequate. In general, earlier work on inflation in Kenya has either been a-theoretical, in the sense that a set of variables has been analysed using Granger non-causality tests or vector-autoregressive models, or based on monetarist models (see for instance, Killick and Mwega 1989, Mwega 1990, Cannetti and Greene 1992, Ndung'u, 1993; 1994, Ryan and Milne 1994, and Adam et al. 1996). We base our analysis on two dominant theories for price formation in an open economy, which act through money demand and purchasing power parity. More specifically, following Juselius (1991) we postulate that changes in the domestic price level are generated by deviations from the long-run equilibrium in the foreign sector and the money market. The long-run relations are specified as,

$$m - p = \gamma_0 + \gamma_1 y + \gamma_2 \Re \tag{1}$$

$$p = e + p^f + \tau \tag{2}$$

where m is the log of the money stock, p is the log of the domestic price level, y is the log of real output, $\Re$ is a vector of rates of returns on various assets, e is the log of the exchange rate, p^f is the log of foreign prices, τ is the log of the trend in the real exchange rate.

Equilibrium in the monetary sector is spelled out in (1). Demand for real money is assumed to be increasing in *y*, where $\gamma_1 = 1$ for the quantity theory. The rates of returns of interest are the deposit interest rate, i.e., the own interest rate, Treasury bills discount rate, inflation, and the returns on holdings of foreign assets. The inclusion of the return on foreign assets is primarily motivated by the liberalisation of the foreign exchange market in the beginning of the 1990s. Nevertheless, we do not preclude that it has influenced money demand before the 1990s even though domestic agents were prohibited from holding foreign currency balances and the parallel market for foreign exchange was of a limited scale (see Adam 1992).

Equation (2) gives long-run equilibrium in the market for foreign exchange. The inclusion of a trend term is motivated by the fact that the real exchange rate $(p\text{-}e\text{-}p^f)$ in Kenya is nonstationary and that the standard formulation of purchasing power parity (PPP) thus does not hold (De Grot 1991, Elbadawi and Soto 1997). Moreover, there is no theoretical reason to assume that inflation and the level of the real exchange rate are related over long time spans; the real exchange rate is a relative price that ultimately is determined by fundamental factors affecting the demand and supply of foreign exchange. In our empirical analysis we use the development of terms of trade to represent τ. This is in accordance with the dependent economy model which predicts that changes the relative price between exportables and importables should lead to an adjustment in the real exchange rate, i.e., the relative price between non-traded and traded goods (see Dornbusch 1980, Chap. 6). The fact is that terms of trade turn out to fully account for the long-run movements in the real exchange rate.

Ideally, we would analyse ($p, m, y, \mathfrak{R}, e, p^f, \tau$) as a single system and proceed from there.

However, because of the small sample, we adopt an alternative strategy. We first estimate the equations above separately via cointegration analysis. Then, to examine the relative importance of these relationships in determining Kenyan prices, we develop a single-equation ECM for inflation that incorporates feedback from both relationships. The ECM is thus of the form:

$$\Delta p_t = \pi_0 + \sum_{i-1}^{k-1} \pi_{1i} \Delta p_{t-i} + \sum_{i=0}^{k-1} \pi_{2i} \Delta m_{t-i} + \sum_{i=0}^{k-1} \pi_{3i} \Delta y_{t-i} + \sum_{i=0}^{k-1} \pi_{4i} \Delta \mathfrak{R}_{t-i} + \sum_{i=0}^{k-1} \pi_{5i} \Delta e_{t-i} + \sum_{i=0}^{k-1} \pi_{6i} \Delta p^f{}_{t-i}$$
$$+ \sum_{i=0}^{k-1} \pi_{7i} \Delta pm_{t-i} + \alpha_1 (m - p - \gamma_1 y - \gamma_2 \mathfrak{R})_{t-1} + \alpha_2 (p - e - p^f - \tau)_{t-1} + \sum_{i=1}^{3} \pi_{8i} S_{it} + \pi_9 D_t + v_t, \qquad (3)$$

where Δ is the first difference operator, ν_t is a white noise process, D_t is a vector of deterministic variables such as constant, centred seasonal dummies, and impulse dummies, and an interaction dummy for the changes in inflationary inertia. We have also included maize-price inflation, Δpm_t, to capture short-run effects from officially determined changes in the price of maize, i.e., of the staple food of Kenya.

Equation (3) has both a short and a long run part. The long run part of the model is given by the two error correction terms, which allow discrepancies between the log-level of the price and its determinants to impact on inflation the following period. Their coefficients, α_1 and α_2, show the amount of disequilibrium (or strength of adjustment) transmitted in each period into the rate of inflation. The short-run part of the model is accounted for by the inclusion of variables in first differences. Since Equation (3) can be solved so to get p_t on the left-hand side it determines both the log-level of the price, as well the rate of inflation.

It is possible to view (3) as a general model that embeds other models of inflation. An important one is the monetarist model of Harberger (1963). It has been used to analyse inflation in developing countries on a number of occasions (see Vogel 1974, London 1989, Ndung'u 1994). In this model excess money supply drives inflation and prices. In the pure monetarist version, only variables entering the money-demand relation should be significant, while other versions would predict that imported inflation also influences domestic inflation, or that the law of one price holds for goods that are tradables (Hanson 1985; Moser 1995). In any case, a reasonable requirement for the monetarist model to be valid empirically is that the error-correction term for money demand enters significantly in (3).

An alternative interpretation is that inflation occurs when the relative price between non-tradable and tradable goods deviates from equilibrium. For example, an increase in terms of trade requires either the nominal exchange rate to appreciate, or the price of non-tradables to increase, for equilibrium to be restored, while a decrease in terms of trade requires a depreciation of the nominal exchange rate or a decline in non-tradable prices. It is quite possible that consumer prices rise in both cases; the nominal exchange rate is not allowed to appreciate enough when terms of trade improve, and devaluations push up prices through feedback effects when terms of trade deteriorate. Money supply would in these cases be demand determined, or solely influence domestic prices through its effects on their proximate determinants (see Dornbusch 1980, Chap. 6, Liviatan and Piterman 1986, Kamin 1996).

Another issue of interest is the degree of inflation inertia, usually interpreted as measuring the effects of indexation or inflation expectations. When there is no inertia, as claimed by Killick and Mwega (1989) and Mwega (1990), and implied by the model of Ryan and Milne (1994), the parameters on lagged inflation should be zero. In the other extreme, when the level of inflation is only determined by inertia, the parameters on lagged inflation should sum to unity. In Kenya explicit indexation has not been common but government-administered price setting based on increased costs was widespread before liberalisation, and it probably worked as a form of indexation. Hence, we should expect there to some inertia. However, the decontrol of prices in the 1990s and the change in policy at the end of 1993 are likely to have reduced it considerably. To test for this an interaction dummy for lagged inflation is included in Equation (3).

4. A Look at the Data

In this section we use graphs to show the character of the data, and give some intuition why cointegration holds.[2] The data used are quarterly and they span the period 1972 - 1996. Details are given in Appendix.

Inflation, the variable of major interest, is plotted in Figure 1. It is defined as the quarterly rate of change of the logarithm of the weighted consumer price index. During the 1970s, and the first half of the 1980s, average inflation was fairly stable, although there were large fluctuations between the quarters. Around 1986 a change occurred when both its level and variance decreased markedly. Inflation then slowly rose again, and in the beginning of the 1990s it was

2 All the graphs and numerical results were obtained with PCGIVE and PCFIML.

back at its pre-1986 level. During 1992 inflation was hit by several shocks raising it to over 30% per year. But in the beginning of 1994 it declined abruptly, and there was actually period of deflation.

It is not obvious what measure of money should be employed for estimating Equation (1). We have therefore plotted two commonly used series in Figure 2; the logarithms of M1 and M1 plus quasi money (denoted M2), deflated by the consumer price index. Both series exhibit the same short-run pattern, but in the long run they differ markedly; real M2 grows over time while real M1 appears to be stationary. Since GDP has grown by more than 5% per year on average since the beginning of the 1970s, M1 does not seem to be related to transactions demand. Real M2 on, the other hand, appears to grow along with output as shown by Figure 3, where the quarterly series of output was obtained through interpolation of GDP at constant 1990 prices.

There is some controversy about the status of the Treasury bills discount rate. In Adam (1992) it is interpreted as the own rate of return on money in the long run, while it enters as an alternative interest rate in Ndung'u (1994). We use a three-month deposit rate, R^D, as the own interest rate and the three-month Treasury bills rate, R, as the alternative interest rate. These are depicted in Figure 4 (upper panel). The two series follow each other closely over time, although it is clear that R^D is not market determined before the 1990s.

To measure returns on foreign assets we used the official exchange rate instead of the parallel market rate. This is because the variable is primarily assumed to be relevant for the period after relaxation of controls on the capital account in the 1990s, when the parallel currency market is negligible. However, the parallel exchange rate would better capture currency substitution. In practice our results are not dependent on the choice of exchange rate, presumably because the parallel market rate remained relatively close to the official exchange rate during the 1970s and 1980s, with an average premium of about 15% (Adam 1992).[3] [4] Figure 4 (lower panel) plots the three-month deposit rate, R^D, and the three-month eurodollar interest rate adjusted for changes in the exchange rate, R^f. Uncovered interest rate parity ($R^D = \Delta e + R^f$) does not hold most of the time, creating an incentive to bypass the controls on capital outflows. However, removal of controls changed this situation, and at the end of the sample there are periods when returns on domestic assets are much higher than on foreign assets.

Figure 5 depicts the logarithm of the consumer price index minus the nominal exchange rate (*p-e*), calculated as a weighted average of the bilateral exchanges rates of Kenya's main trading partners, and the foreign price level p^f, calculated as the weighted average of the wholesale prices of the same trading partners. The two series, plotted with matched means, follow each other over time fairly closely. This indicates that although PPP may not hold, the price level, the exchange rate, or both adjust a great deal to reduce temporary deviations between *p-e* and p^f.

The real exchange rate ($p–e-p^f$) and terms of trade (*tot*), interpolated from annual data, are graphed in Figure 6. It shows that PPP does not hold since the real exchange depreciates during

[3] Results from cointegration tests with the parallel exchange rate can be obtained from the authors.
[4] During the crawling peg regime, it has been argued that even though the parallel market was illegal, the central bank took into account the parallel market rate in determining the crawl. This is consistent with backward indexation arguments of the official exchange rate to the parallel market rate (see Ndung'u 1998).

a large part of the sample period. However, this long-run decline, and several of the short-run increases, appears to be related to changes in terms of trade.

One variable that is likely to affect the dynamics of inflation, although it does not enter the theoretical models, is maize-price inflation. The reason is that maize is the staple crop in Kenya, out of which maize meal is produced, and its price was determined by the authorities until liberalisation of maize marketing and decontrol on inter-district movements in the 1990s. Moreover, changes in maize prices are likely to reflect supply shortages in the food sector, especially after deregulation. Figure 7 plots maize-price inflation (*pm*) together with inflation. It illustrates clearly the erratic character of maize prices.

5. Integration and Cointegration Analysis

In testing for the level of integration and for cointegration, we first carry out unit root tests for the variables of interest. We then proceed to use Johansen's (1988) procedure for the non-stationary variables to determine the cointegration rank and the associated cointegrating vectors. The purpose of the cointegration analysis is to find out if the data support the models outlined in Equations (1) and (2).

Before carrying out the cointegration analysis it can be useful to test for unit roots with univariate methods. To do this we used the Augmented Dickey-Fuller test (ADF), where the null hypotheses is that the variable tested is integrated of order one, denoted I(1). Later we will do unit root tests in a multivariate framework with the Johansen procedure where the null is that the variable is stationary, i.e., I(0).

In Table 1 ADF statistics and estimated roots are reported. All variables appear to have at least one unit root since nonstationarity is not rejected for any variable in levels, and the estimated roots are close to one. To test for a second unit root we re-did the tests on the first differences of the variables. Now all the ADF test statistics are significant. We thus proceed under the assumption that no variable contains more than one unit root and that the first difference of each series is stationary.

Results from the application of Johansen's maximum likelihood procedure for finite order vector autoregressions for the monetary sector are summarised in Table 2.[5] The VAR consists of six lags on $m, p, y, R^D\text{-}R^f$ each, a constant, centred seasonal dummies, and six impulse dummies that capture serious outliers.[6] Six lags were used to remove the autocorrelation in the output equation. The interest-rate spread was entered directly because of the deterministic character of R^D during a large part of the sample. Moreover, to limit the number of variables in the analysis $R^D\text{-}R$ was not included since it is a stationary relation; as reported in Table 1, nonstationarity is clearly rejected by the unit root test.[7]

The first row in Table 2 lists the estimated eigenvalues. Two of these are clearly larger than zero, indicating that there are two cointegrating vectors. Evidence of two long-run relations in the data

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[5] See Johansen (1995) for details about cointegration analysis and tests implemented in this section.

[6] The following impulse dummies were used: devaluations, 1981:1, 1983:1 and 1993:2; price instability related to price decontrol, electoral greasing and aid embargo 1992:1 and 1992:4; a sharp increase in output, 1979:2.

[7] Results from cointegration tests showing that $R^D\text{-}R$ form a stationary vector can be obtained from the authors.

is also given by the maximal eigenvalue and trace eigenvalue statistics (λ_{max} and λ_{trace}), which both reject the null of no cointegrating vector at the 99% level, and the null of one vector at the 95% and 99% levels, respectively. Neither of these two vectors is made up of only one variable, as indicated by the multivariate tests for stationarity. Moreover, tests for exclusion from the cointegrating space show that all variables enter in at least one stationary vector, and tests for weak exogeneity indicate that no variable is weakly exogenous.

Table 2 also reports the standardized eigenvectors, β, and the adjustment coefficients α. The first two rows of β and first two columns of α show the estimated cointegrating vectors and their adjustment coefficients, respectively. The first vector has β coefficients that are broadly consistent with Equation (1) and a correctly signed α for *m*, indicating that 23% of a deviation from the long-run relation is removed each quarter by adjustment in the money stock.

To identify the cointegrating vectors several hypotheses about the long-run structure were tested by imposing restrictions on the β's. Some of these are reported in Table 3. In the first test we have imposed price homogeneity and set the coefficient on *y* to -0.5 in the first vector, and excluded *m* and *p* in the second. This hypothesis was accepted. Then we tested if m-p-0.5y form a stationary relation without the interest rates; it was rejected. Finally we repeated the first test but changed the coefficient on *y* to -1. This hypothesis was also accepted. Thus we have two cointegrating vectors that look like money demand relations, $m-p-0.5y + 4.71(R^D-R^f)$, and $m-p-y +16.19(R^D-R^f)$, where the coefficients on the interest-rate spread should be divided by four to get yearly values. The second cointegrating vector, (R^D-R^f) -0.044y in the first test, is obviously sample specific and probably arises because (R^D-R^f) is close to being tend stationary and the interpolated GDP series contains a strong deterministic trend.

Figure 8 graphs the three cointegrating vectors defined above. Not surprisingly, the two money demand relations are quite similar. Since there are no theoretical reasons to prefer one before the other we will test both when developing the ECM for inflation in Section 6.

Results from the cointegration analysis for the foreign sector are reported in Table 4. Five lags of the real exchange rate and terms of trade, a constant, centred seasonal dummies, and a dummy for the sharp depreciation in 1993:2 were included in the VAR. The test statistics reject the null hypothesis of no cointegration, i.e., r = 0, so we conclude there is one cointegrating vector. It is depicted in Figure 9 (upper panel) together with its components (lower panel). Our estimates of the deviations from real exchange rate equilibrium are fairly similar to the ones calculated by Elbadawi and Soto (1997) with annual data for the period 1972-1993. It is also noteworthy that our estimated coefficient for *tot*, 0.36, is close to theirs, 0.32.

Test statistics for significance and stationarity, which are the same in the bivariate case, confirm that both variables enter the cointegrating vector and that neither is stationary. Moreover, tests for weak exogeneity indicate that *tot* is weakly exogenous while ((p–e-p^f) is endogenous. However, this test is not invariant to the inclusion of stationary variables. Likewise, weak exogeneity in the full system ($p, m, y, R^D, R, R^f, e, p^f, \tau$) may differ from weak exogeneity in the two subsystems examined.

6. Developing an Error Correction Model of Inflation

This section reports on the development of a single-equation ECM for inflation in Kenya. First a general model is estimated, and the general-to-specific modelling strategy is used to obtain an empirically constant parsimonious model. Then the economic and statistical properties of the preferred model are described.[8]

The general model was estimated with five lags of each variable in first differences, three error correction terms defined as $EC1 = [p – e - p^f – 0.36tot]$, $EC2 = [m - p - 0.5y + 4.71(R^D - R^f)]$, and $R^D - R$, a constant, centred seasonal dummies, and three impulse dummies.[9] We also included an interaction dummy for lagged inflation defined as $D^* \Delta p_{t-1}$ where D is zero until 1993.4 and one thereafter. Output and terms of trade were not included in the short-run part of the model since the series were obtained by interpolation from annual data and thus are unlikely to contain relevant information about the dynamics of inflation. This is confirmed by tests presented in Section 7. Table 5 reports the estimated coefficients and diagnostic test statistics. Statistically the ECM appears well specified; there is no evidence of serial correlation (AR test), autoregressive heteroscedasticity (ARCH test), non-normal errors (Normality test) and regression mis-specification (RESET test). See Hendry (1995) on these tests.

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[8] Ericsson, Campos and Tran (1990) give a good description of the general-to-specific methodology.

[9] The three impulse dummies are motivated as follows: *D2* (1990:4), the effects of the Gulf crisis resulted in increases in several government-controlled prices during last quarter of 1990 (Economic Survey pp.47-48, 1991). *D3* (1992:2), price decontrol of 72 items out of which several entered the basket of consumer goods (Economic Survey pp. 64-65, 1993). *D4* (1993:1-93:2), disturbances related to the floating of the Kenya Shilling, which led to a 50% depreciation, and the subsequent reversal of the decision to float the Shilling in March (Economic Survey p. 65, 1993).

The reduction of the general model was carried out by removing the longest lag of each variable with low t-values, and then using F-tests and the Schwartz criterion to check the validity of the simplification. The F-statistics generated in every step of the reduction process and the Schwartz criteria are reported in Table 6. None of the F-statistics, comparing the initial, intermediate and final models is significant, and the Schwartz criterion becomes more and more negative for each model. Moreover, standard error declined from 0.0107 to 0.0104 when going from the general to the parsimonious model. Hence, our simplification seems statistically valid.

Table 7 reports the parsimonious model. Out of the three error correction terms, only the one for the foreign sector (*EC1*) remains; the test statistic for excluding long-run money demand (*EC2)* is F(1,76) = 0.69, and for excluding both *EC2* and R^D-R it is F(2,75) = 0.761. The test statistic for the other error correction term for the money market, [m - p – y + 16.19(R^D-R^f)], is F(1,76) = 0.11. Hence, money does not seem to determine prices in the long run in our model.

Nevertheless, two of the variables in the money demand relation affect the dynamics of inflation; money growth and the change in the Treasury bill rate both have a positive effect on inflation. Our results are thus in accordance with a multitude of other studies on inflation claiming to have found support for the Harberger model. However, in general these models have been formulated in rates of change, following Harberger's own work, ignoring the long-run information in the data.[10]

[10] The reason Harberger (1963) estimated his model in rates of change was that he thought it was too easy to get a high R^2 using log-levels.

Lagged inflation enters with a coefficient as large as 0.42, showing a substantial degree of inflation inertia. However, the interaction dummy for lagged inflation, *D1*, is significant and its coefficient is -0.31. Thus, inertia appears to have decreased to about 0.1 after 1993. Finally we have maize-price inflation, which enter both contemporaneously and lagged two and four quarters. The sum of the estimated parameters is 0.04, which indicates that supply shocks related to weather conditions affect the rate of inflation. However, most of the impact of maize price inflation falls on the rate of change of inflation.

An error correction model can be interpreted as capturing feedback from disequilibria. In our model adjustment to disequilibria is slow, i.e., only about 6% per quarter. This can be seen in Equation (4), which is the autoregressive distributed lag representation of the model reported in Table 7 where constant, seasonals and dummies are left out for simplicity,

$$p_t = 0.94p_{t-1} - 0.06e_{t-1} + 0.06p^f_{t-1} + 0.02tot_{t-1}. \tag{4}$$

The coefficient on the lagged price level is high, 0.94, and the ones on the other variables are low, indicating that, for instance, an increase in p^f would raise the domestic price level gradually over several years. This result is consistent with those of Kamin (1996), de Brouwer and Ericsson (1998), and Durevall (1998) who also found similar results for the speed of adjustment in models of inflation in Mexico, Australia, and Brazil respectively.

7. Diagnostic Tests

To evaluate the statistical properties of the model, a battery of tests were implemented. Table 7 reports test statistics on the residual and for parameter constancy over last ten quarters; none of these are significant, indicating that the model is well specified and tentatively reflect the data used. By estimating the model recursively from 1980 to 1996 its empirical constancy was assessed. The output from this exercise is summarised in graphs. Figure 10 plots of the recursive estimates of the coefficients and their respective ±2 estimated standard errors. All of the parameters are quite stable with the exception of the one for ΔR_{t-3}, which becomes significant first during the 1990s, probably as a result of relaxation of controls prevailing in financial and foreign currency markets. Figure 10 also graphs the one-step residuals and their ±2 standard errors; since all the estimates are within the standard error region there is no indication of outliers. Lastly, sequences of one-step and break-point Chow test statistics, scaled such that the straight line matches the 5% significance level, are reported. There is only one Chow test statistic that is significant at the 5% level, the p-value is 0.033, out of the close to 70 one-period-ahead Chow statistics. Hence, we conclude that the stability of the model is satisfactory.

Finally, we calculated omitted-variable tests for different subsets of variables. Table 8 first reports F-tests for the two cointegrating vectors not included in the ECM. Both tests were insignificant. Since the definition of money might be of importance for the results, we tested for adding the log of either high-powered money (*hpm*) or M1 (*m1*). Instead of going through the Johansen approach again, we entered the variables directly into our preferred model together with p, y, R^D, R and R^f. The F-tests were insignificant in both cases. Next we included *m* and the other variables used in the analysis of the monetary sector to check whether invalid restrictions were responsible for the lack of significance of the error correction terms for the money market. Also in this case was the F-test insignificant. Then we tested whether adding impulse dummies from 1994:2 to 1995:1 to cater for the large swing in the money demand relation (see Figure 8) would rescue the monetarist model. This test was also insignificant. After that we tested the money demand specification of Adam (1992) by replacing foreign returns with the rate of change of the log of the parallel exchange rate. Moreover, we added four lags of the second difference of the parallel exchange rate and excluded the deposit rate. However, this did not make the F-test significant. We then tested for the inclusion of the first difference of the two interpolated variables, *y* and *tot*, and of petrol prices, *pp.* The latter variable was considered because during most of the sample period government controlled energy prices, and it is sometimes argued that intermittent price rises increased inflation (see Ryan and Milne 1994 and Central Bank of Kenya 1997). Five lags of each variable were added to the preferred model, but neither of the F-tests was significant. As a final check of the model, the validity of the restrictions imposed on the error correction term [$p – e - p^f – 0.37tot$] were tested by re-estimating the parsimonious model with e_{t-1}, p^f_{t-1} and tot_{t-1} entering as separate variables. The null hypothesis was not rejected.

8. Conclusion

The objective of this study was to analyse the dynamics of inflation in Kenya using a single-equation error correction model. The resulting model is highly parsimonious and empirically stable, though with the help of some dummy variables. However, it should not be viewed as a final product but as part of what Hendry (1995, p. 550) calls a progressive research strategy where new models improve and encompass old ones. Nevertheless, it does provide some interesting information.

Our key findings are as follows: The proximate determinants of prices in the long run are the exchange rate, the foreign price level and terms of trade. This result is consistent with the predictions of the dependent economy model where changes in terms of trade affect demand for non-traded goods. The adjustment of inflation to disequilibria is slow, and typically lasts several years, a finding also made in studies on consumer price inflation in other countries (see Kamin 1996, de Brouwer and Ericsson 1998, and Durevall 1998).

We failed to find evidence that excess money supply affect inflation in the long run in the way implied by monetarist models. Neither of the error-correction terms formulated for the money market entered the model significantly. This implies that prices are not determined in the money market as often argued.

Supply and demand for money does affect the dynamics of inflation, however. Money growth and changes in the Treasury bills rate have positive and significant coefficients, although the latter only become important at the end of the sample, probably as a consequence of financial and foreign exchange market liberalisation. These results are in accordance with many other studies on inflation in the Harberger (1963) tradition. But in general these models have been formulated in rates of change, even though the theoretical model is in log-levels, ignoring the long-run information in the data.

Inertia, measured as the size of the estimated coefficient on lagged inflation, was found to be as high as 0.42 up until 1993, when it declined to about 0.10. One explanation for the high degree of inertia in the 1970s and 1980s could be that we do not consider wage inflation (quarterly data are not available). Yet, Isaksson (1997) finds almost as high inertia in a model based on annual data for the period 1971 –1991 that includes wage inflation. Thus, our results suggest that either expectations or price controls, or both, generated the high degree of inertia prior to the 1990s. Moreover, the shift in exchange rate policy from a fixed rate to a crawling peg in the early 1980s probably also contributed (see Mwega and Ndung'u 1996). From this follows that the sharp drop in inertia in 1994 is likely to be due to the removal of price controls and the floating of the Shilling, in connection with a decline in inflation expectations.

According to our model money supply is not likely to be an efficient nominal anchor since it does not directly affect the level of prices in the long run. The exchange rate would probably be a better anchor. Yet, it may not be particularly effective because of the slow rate of adjustment back to equilibrium. Hence, it appears to be difficult to maintain stable prices in the presence of shocks irrespective of the anchor used. To maintain stability, it is thus important for policy makers to try to reduce the number and sizes of domestic shocks and to monitor external shocks.

One important source of shocks according to our results is maize-price inflation. Domestic supply constraints raise inflation in the short-run, and this brings into focus the management of drought crisis. Kenya has been gripped with droughts on average every two to three years, and the solution has almost always been the same, expensive imports to cover domestic food supply shortfalls. Re-thinking of this policy is thus required. A straightforward strategy is to accumulate stocks to ride over supply constraints in the drought periods; a policy goal formulated already in 1981 in the Sessional Paper Number 4 on National Food Policy.

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Appendix: Data Definitions

Consumer price Index, *P*, is the weighted average of the indices for lower, middle, and upper income groups. The source is the Central Bureau of Statistics.

Money, *HPM, M1* and *M2*, are taken from the International Financial Statistics (IFS) data base of the IMF. *M2* is M1 plus quasi money.

Output, *Y*, is the yearly GDP in 1990 prices from the IFS data base, interpolated to a quarterly series using a RATS procedure for interpolation.

Interest rate *R*, is the three-month treasury bill discount rate from the IFS data base.

Exchange rate, *E,* is the weighted exchange rate, where the weights are based on the trade shares for each year of the following countries; Belgium, France, Germany, Italy, Japan, the Netherlands, Sweden, Switzerland, United Kingdom, and the U.S., and for oil imports. For oil imports the U.S. dollar exchange rate was used. The sources are the IFS data base, and World Trade Yearbook, various issues.

Parallel exchange rate, *PE*, was kindly supplied by Chris Adam. The original source is World Currency Yearbook, various issues.

Foreign Price Level, P^f, is the weighted whole sale price index, using the same weights as for the exchange rate, and the consumer price indices for each country. For oil imports the oil price was used.

Maize Price, *PM*, supplied by Central Bureau of Statistics, Kenya

Petroleum Price, *PP*, supplied by Central Bureau of Statistics, Kenya

Table 1. ADF Statistics for Testing for a Unit Root

Variable	ADF t-value	Estimated root	Null Order	Number of lags
p	-2.27	0.96	I(1)	6
m	-0.65	0.98	I(1)	6
y	-1.79	0.99	I(1)	6
R^D	-2.21	0.94	I(1)	1
R	-1.76	0.91	I(1)	5
R^f	-2.85	0.72	I(1)	4
e	-1.68	0.94	I(1)	6
p^f	-2.70	0.93	I(1)	3
pm	-2.67	0.86	I(1)	0
tot	-2.39	0.95	I(1)	1
Δp	-3.05*	0.63	I(2)	6
Δm	-5.43**	0.21	I(2)	1
Δy	-3.03*	0.92	I(2)	5
ΔR^D	-6.01**	0.41	I(2)	0
ΔR	-5.72**	-0.98	I(2)	7
ΔR^f	-10.01**	-0.52	I(2)	3
Δe	-3.53**	0.00	I(2)	6
Δp^f	-4.95**	0.35	I(2)	2
Δpm	-7.67**	-0.11	I(2)	1
Δtot	-4.64**	0.57	I(2)	1
R^D-R	-4.17**	0.48	I(1)	4

Notes:

1. The ADF is the augmented Dickey Fuller test. The null hypothesis is that the series tested contains a unit root. The number of lags was determined by including eight lags and then removing the insignificant ones.

2. The asterisks * and ** denote rejection at the 5% and 1% critical values.

3. The sample period is 1974:1 to 1996:4.

Table 2: Cointegration Analysis of the Monetary Sector

Eigenvalue	0.479	0.228	0.107	0.022
Null hypothesis	r=0	r≤1	r≤2	r≤3
λ_{max}	59.96**	23.75*	10.43	2.12
95% critical value	27.10	21.00	14.10	3.80
λ_{trace}	96.26**	36.30**	12.55	2.12
95% critical value	47.20	29.70	15.40	3.80
	Standardised eigenvectors β'			
Variable	*m*	*p*	*y*	R^D-R^f
	1.00	-1.01	-0.37	1.98
	0.48	1.00	-4.86	32.57
	0.11	-0.62	1.00	-5.48
	0.58	-0.18	-1.50	1.00
	Standardised adjustment coefficients α			
m	-0.231	-0.009	-0.017	-0.064
p	0.078	-0.001	0.030	-0.008
y	-0.010	0.001	0.001	0.000
R^D-R^f	-0.076	-0.013	0.018	0.002
Statistics for testing for the significance of a given variable				
	m	*p*	*y*	R^D-R^f
$\chi^2(2)$	49.05**	46.07**	10.44**	16.17**
Multivariate statistics for testing stationarity				
	m	*p*	*y*	R^D-R^f
$\chi^2(2)$	10.12**	10.38**	11.38**	8.75*
Weak exogeneity test statistics				
	m	*p*	*y*	R^D-R^f
$\chi^2(2)$	10.36**	8.44*	26.21**	15.71**

Note: The estimation period is 1974:1 - 1996.4. The vector autoregression includes six lags on each variable, a constant, centred seasonal dummies, and six impulse dummies. The impulse dummies take a value of unity in 1979:2, 1981:1, 1983:1, 1992:1, 1992:4 and 1993:2. Critical values are from Osterwald-Lenum (1992). '*' and '**' indicate significance at the 5% and 1% level respectively.

Table 3. Testing stationarity hypotheses about the cointegration space

Variable	*m*	*p*	*y*	R^D - R^f	LR statistic
1) Null hypothesis	1	-1	-0.5	0	$\chi^2(2) = 17.05$**
	0	0	x	x	
2) Null hypothesis	1	-1	-0.5	x	$\chi^2(2) = 4.78$
	0	0	x	x	
3) Null hypothesis	1	-1	-1	x	$\chi^2(2) = 4.78$
	0	0	x	x	

Note: An ‘x’ indicates that no restriction was imposed on the parameter.

Table 4: Cointegration Analysis of the Foreign Sector

Eigenvalue	0.201	0.023
Null hypothesis	r=0	r≤1
λ_{max}	20.66**	2.16
95% critical value	14.1	3.8
λ_{trace}	22.82**	2.15
95% critical value	15.4	3.8
Standardized eigenvectors β'		
Variable	*p-e-p^f^*	*tot*
	1.00	-0.36
	-0.60	1.00
Standardized adjustment coefficients α		
*p-e-p^f^*	-0.408	-0.004
Tot	-0.010	-0.019
Statistics for testing for significance and stationarity		
	*p-e-p^f^*	*tot*
$\chi^2(1)$	17.71**	9.00**
Weak exogeneity test statistics		
	*p-e-p^f^*	*tot*
$\chi^2(1)$	18.32**	0.08

Note: The estimation period is 1974:1 - 1996.4. The vector autoregression includes five lags on each variable, a constant, centred seasonal dummies, and one impulse dummy for 1993:2. Critical values are from Osterwald-Lenum (1992). '*' and '**' indicate significance at the 5% and 1% level respectively.

Table 5. General Error Correction Model

Variable	0	1	2	3	4	5
Δp_{t-i}	-1	0.365	-0.036	-0.101	0.042	-0.175
	(-)	(0.117)	(0.113)	(0.118)	(0.116)	(0.106)
Δm_{t-i}	-0.012	0.147	0.052	-0.014	0.060	0.005
	(0.043)	(0.049)	(0.057)	(0.053)	(0.050)	(0.053)
ΔR_{t-i}	0.453	0.681	0.385	1.421	1.117	0.687
	(0.402)	(0.614)	(0.567)	(0.530)	(0.550)	(0.468)
ΔR^{D}_{t-i}	-0.160	0.473	-0.321	0.404	-1.034	-0.744
	(1.160)	(1.155)	(1.152)	(1.017)	(0.941)	(0.724)
ΔR^{f}_{t-i}	0.510	-0.309	-0.243	-0.058	-0.116	-0.082
	(0.613)	(0.641)	(0.156)	(0.155)	(0.144)	(0.127)
Δe_{t-i}	-0.156	0.038	0.048	-0.028	0.154	-0.061
	(0.156)	(0.159)	(0.067)	(0.070)	(0.162)	(0.159)
Δp^{f}_{t-i}	0.035	-0.014	-0.038	-0.008	0.096	0.032
	(0.040)	(0.047)	(0.043)	(0.044)	(0.043)	(0.044)
Δmp_{t-i}	-0.004	-0.038	-0.010	0.014	0.037	0.006
	(0.015)	(0.014)	(0.013)	(0.013)	(0.016)	(0.017)
$EC1_{t-i}$		-0.087				
		(0.036)				
$EC2_{t-i}$		-0.039				
		(0.028)				
$(R-R^{D})t_{-i}$		-0.286				
		(0.444)				
D1		-0.687				
		(0.345)				
D2	0.034					
	(0.014)					
D3	0.060					
	(0.014)					
D4	0.057					
	(0.018)					
S_{it}	0.178	0.005	0.008	0.006		
	(0.221)	(0.005)	(0.006)	(0.005)		

T = 92 [1974:1-1996:6] R^2 = 0.947 Stand error = 0.0107

AR 1-5: F(5. 29) = 1.58 [0.197] ARCH 4: F(4.26) = 0.04 [0.997]

Normality: • ^{2}(2) = 3.63 [0.163] RESET: F(1. 33) = 1.03 [0.317]

Notes: The dependent variable is Δp_t and the estimation period is 1974:1 – 1996:4. The error correction terms are defined as $EC1 = p - e - p^* - 0.37tot$. and $EC2 = m - p -0.5\, y + 3.47(R^D - R^f)$. The variable D1 is an interaction dummy for Δp_{t-1} with zeros for 1974:1 - 1993:4. and D2. D3. and D4 are impulse dummies with ones in 1990:4. 1992:2. and 1993:1 and 1993:2, respectively. The constant term is S_{0t}. and S_{1t} S_{2t} S_{3t} are centred seasonal dummies.

Table 6: *F* Statistics and Schwartz Criteria for Sequential Reduction of the General Error Correction Model to a Parsimonious Model.

Null hypothesis			Maintained Hypothesis						
Model	k	*SC*	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
1	58	-7.22	-						
↓									
2	50	-7.40	0.98 (8,34) [0.46]						
3	43	-7.56	1.12 (15,34) [0.38]	1.27 (7,42) [0.28]					
↓									
4	36	-7.76	1.13 (22,34) [0.36]	1.21 (14,42) [0.30]	1.11 (7,49) [0.37]				
↓									
5	28	-8.07	0.98 (30,34) [0.51]	0.99 (22,42) [0.50]	0.82 (15,49) [0.65]	0.54 (8,56) [0.82]			
↓									
6	23	-8.28	0.92 (35,34) [0.59]	0.91 (27,42) [0.60]	0.75 (20,49) [0.76]	0.53 (13,56) [0.89]	0.56 (5,64) [0.73]		
↓									
7	17	-8.49	0.92 (41,34) [0.60]	0.91 (33,42) [0.60]	0.78 (26,49) [0.75]	0.65 (19,56) [0.85]	0.77 (11,64) [0.67]	0.98 (6,69) [0.44]	
↓									
8	15	-8.57	0.92 (43,34) [0.61]	0.90 (35,42) [0.62]	0.78 (28,49) [0.76]	0.66 (21,56) [0.86]	0.76 (13,64) [0.69]	0.92 (8,69) [0.50]	0.76 (2,76) [0.47]

Notes:

1. The first three columns report the model number, the number of unrestricted parameters, *k*, and the Schwarz criterion, *SC*. The three entries within a given block of numbers in the last 8 columns are: the F -statistic for testing the null hypothesis against the maintained hypothesis, the degrees of freedom for the F-statistic (in parentheses) and the tail probability of the F-statistic (in square brackets).

2. Model 1 is the general model reported in Table 2. It contains 5 lags of each variable in first differences, two error correction terms, the interest rate spread lagged one period, a constant term, centred seasonal dummies, three impulse dummies and an interaction dummy for Δp_{t-1}. Model 2 is Model 1 excluding the fifth lag of each variable. Model 3 is Model 2 excluding the forth lag of each variable except maize-price inflation, Δmp_{t-4}. Model 4 is Model 3 excluding the third lag of all variables except $\Delta R_{t-3.}$ Model 5 is Model 4 excluding the second lag of all variables. Model 6 is Model 5 excluding the first lag except Δp_{t-1} $\Delta m_{t-1,}$ Δmp_{t-1}, and the error correction terms. Model 7 is Model 6 excluding all the contemporaneous variables except for Δmp_t. Model 8 is Model 7 excluding the error correction term for the monetary sector $EC2_{t-1,}$ and $(R^D\text{-}R^f)_{t-1.}$

Table 7: Parsimonious Error Correction Model. 1974:1 -1996:4

Variable	Coefficient	Standard Error	t-value
Δp_{t-1}	0.416	0.053	7.862
Δm_{t-1}	0.054	0.028	1.918
ΔR_{t-3}	0.862	0.130	6.631
Δmp_t	0.022	0.008	2.670
Δmp_{t-1}	-0.028	0.008	-3.303
Δmp_{t-4}	0.031	0.008	3.822
$[p-e-p^f-0.37tot]_{t-1}$	-0.058	0.014	-4.154
D1	-0.310	0.084	-3.686
D2	0.041	0.011	3.820
D3	0.069	0.011	6.144
D4	0.075	0.008	9.394
Constant	-0.081	0.022	-3.623
S_{1t}	0.010	0.003	3.163
S_{2t}	0.011	0.003	3.303
S_{3t}	0.004	0.003	1.061

R^2 = 0.884 standard error = 0.0104 DW = 2.00 AR 1- 5: F(5. 72) = 0.780 [0.567]
ARCH 4: F(4.69) = 0.689 [0.602] Normality: $\chi^2(2)$ = 5.327 [0.070]
Heteroscedasticity: F(24.52) = 0.869 [0.638] RESET: F(1.76) = 0.105 [0.746]
Tests of parameter constancy over 1994 (3) to 1996 (4): Forecast $\chi^2(10)$ = 13.853 [0.180] Chow F(10. 67) = 0.970 [0.477]

Table 8. Diagnostic Tests for Omitted Variables

Variables						F-tests
$m\text{-}p\text{-}y + 16.19(R^D\text{-}R^f)$,						F(1,76) = 0.26 [0.61]
$R^D\text{-}R^f$ -0.044y						F(1,76) = 0.12 [0.74]
hpm_{t-1}	p_{t-1}	Y_{t-1}	R^D_{t-1}	R^f_{t-1}	R_{t-1}	F(6,71) = 0.78 [0.59]
$m1_{t-1}$	p_{t-1}	Y_{t-1}	R^D_{t-1}	R^f_{t-1}	R_{t-1}	F(6,71) = 0.96 [0.46]
m_{t-1}	p_{t-1}	y_{t-1}	R^D_{t-1}	R^f_{t-1}	R_{t-1}	F(6,71) = 0.79 [0.58]
$[m - p - 0.5y + 4.71(R^D - R^f)]$,			$R^D\text{-}R$,			F(2,71) = 1.00 [0.37][a]
$m\text{-}p_{t-1}$	y_{t-1}	R_{t-1}	Δpe_{t-1}	$\Delta^2 pe_t$	$\Delta^2 pe_{t-1}$	
$\Delta^2 pe_{t-2}$	$\Delta^2 pe_{t-3}$	$\Delta^2 pe_{t-4}$				F(10,65) = 1.08 [0.39][b]
Δy_t	Δy_{t-1}	Δy_{t-2}	Δy_{t-3}	Δy_{t-4}	Δy_{t-5}	F(6,71) = 0.60 [0.73]
Δtot_t	Δtot_{t-1}	Δtot_{t-2}	Δtot_{t-3}	Δtot_{t-4}	Δtot_{t-5}	F(6,71) = 0.78 [0.59]
Δpp_t	Δpp_{t-1}	Δpp_{t-2}	Δpp_{t-3}	Δpp_{t-4}	Δpp_{t-5}	F(6,71) = 1.19 [0.32]
e_{t-1}	p^f_{t-1}	tot_{t-1}				F(3,74) = 1.18 [0.32]

Note: The p-values are given in square brackets. *hpm* is high-powered money, *pp* is the price of petroleum and *pe* is the parallel exchange rate.

[a] Impulse dummies for the 1994:2 to 1995:1 were included in the model.
[b] The sample period for the test with the parallel exchange rate is 1974:3 – 1996:4.

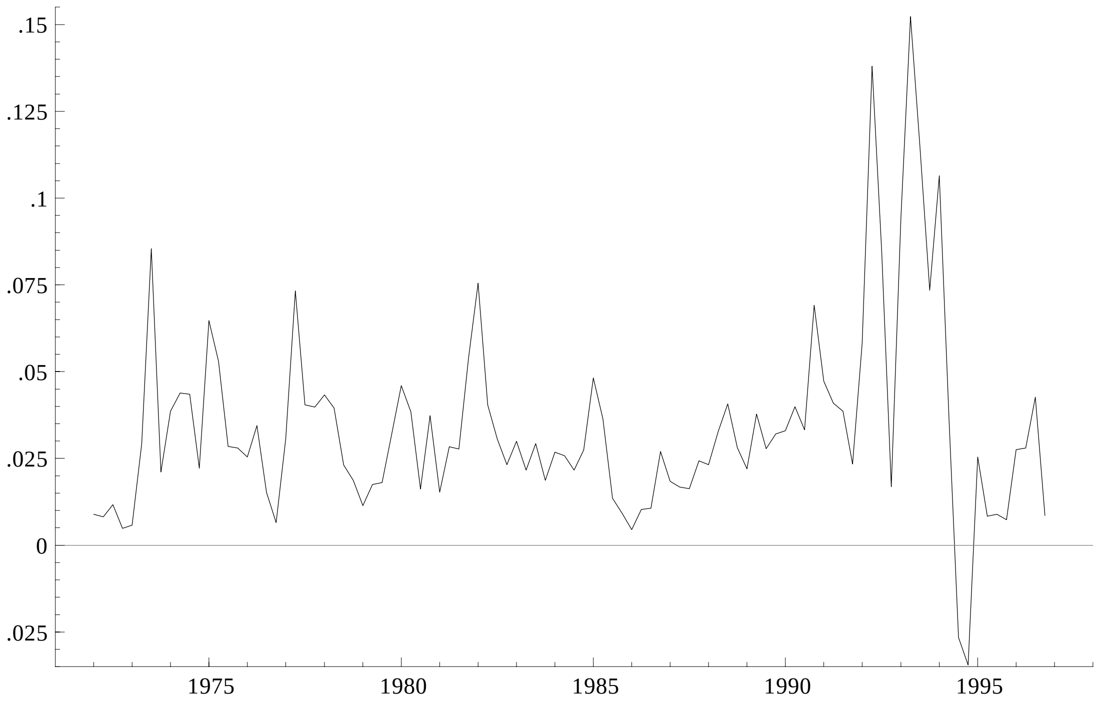

Figure 1. The rate of inflation 1972-1996.

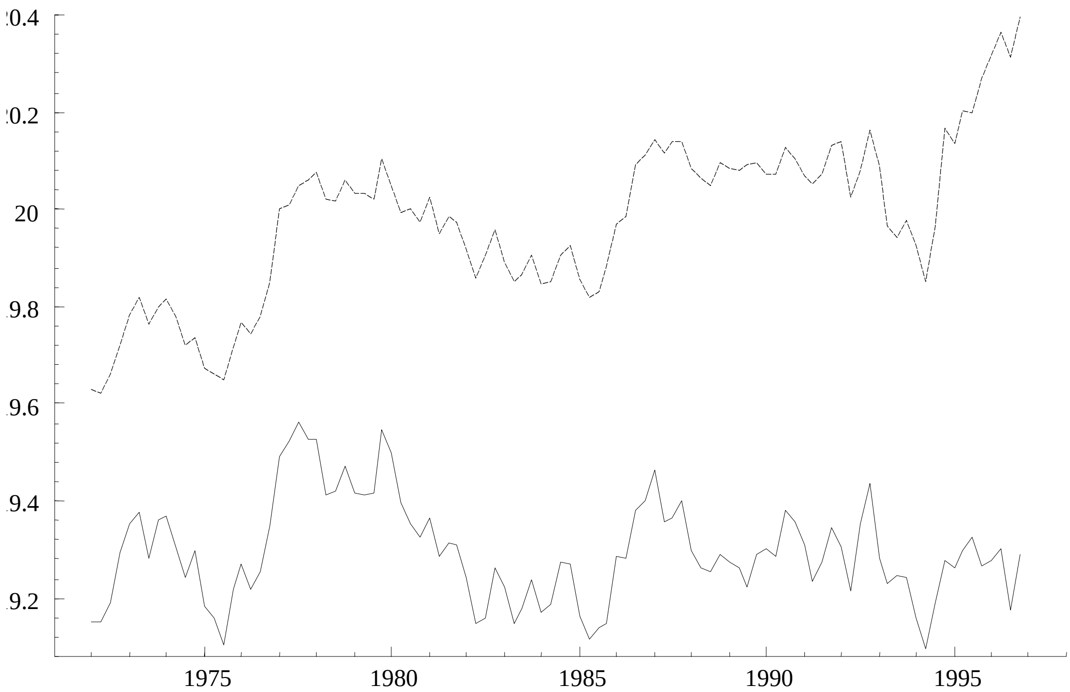

Figure 2. The log of real M1(—) and real M2 (---).

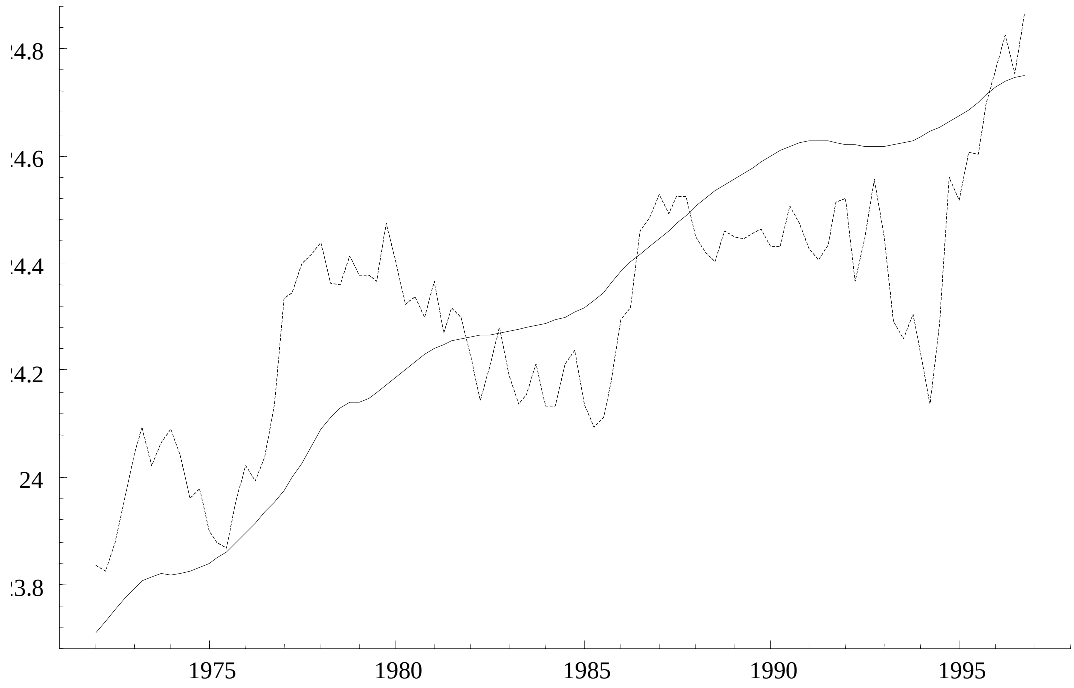

Figure 3. The log of real GDP interpolated from yearly observations (—) and the log of real M2 (---) (mean and variance adjusted).

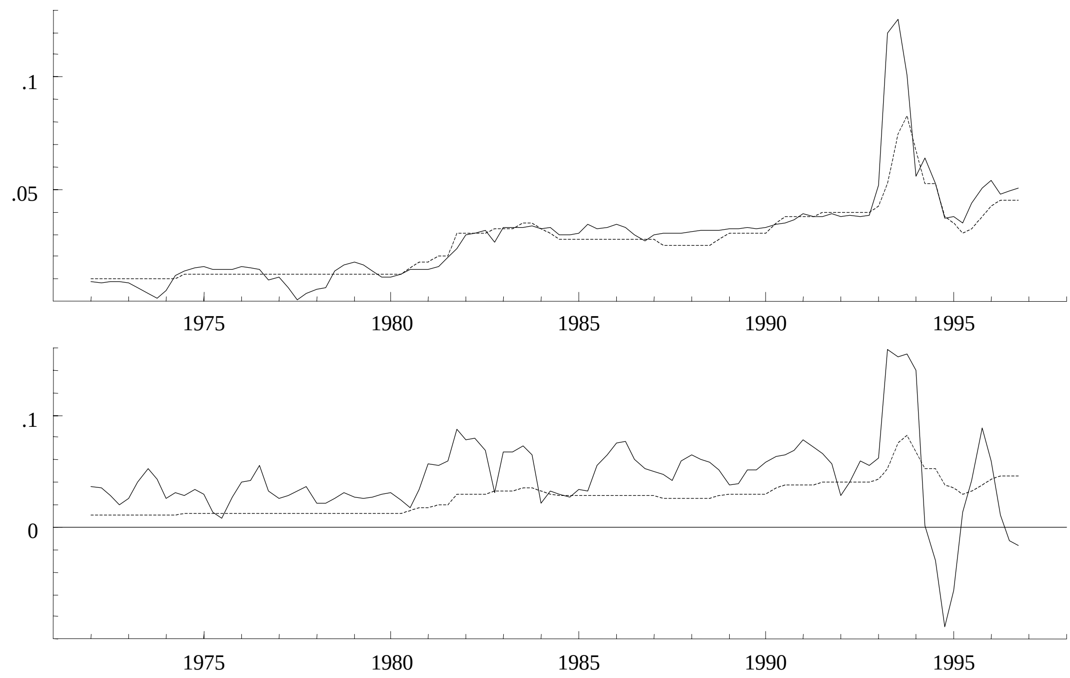

Figure 4. Three-months Treasury bill discount rate (—) and three-months deposit rate (---) (upper panel). Returns on three-months eurodollar (—) and three-months deposits (---) (lower panel).

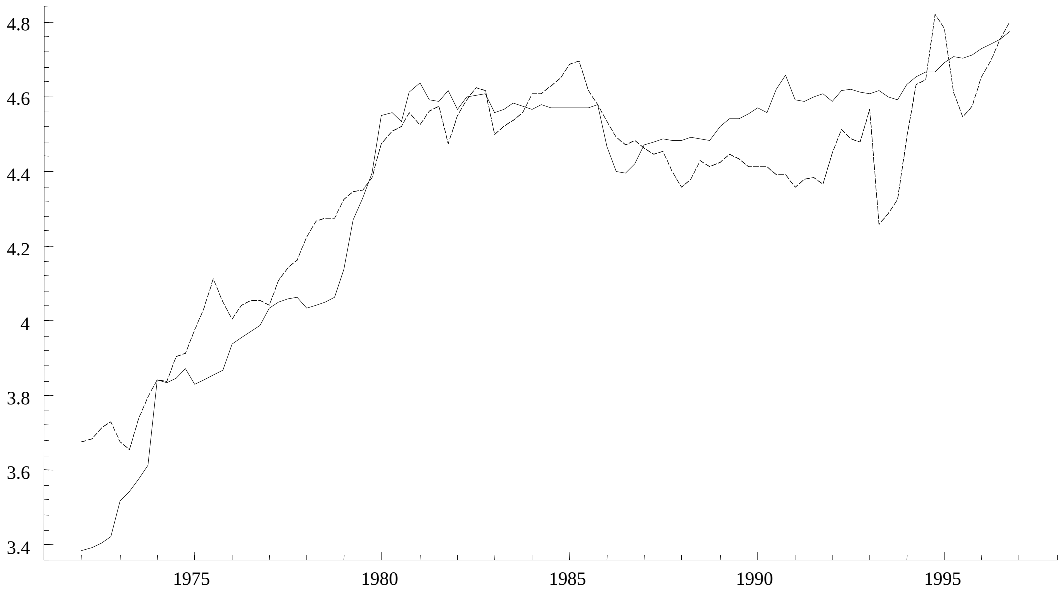

Figure 5. The log of foreign price level (—) and the mean adjusted log of the consumer price minus the log of the exchange rate (---).

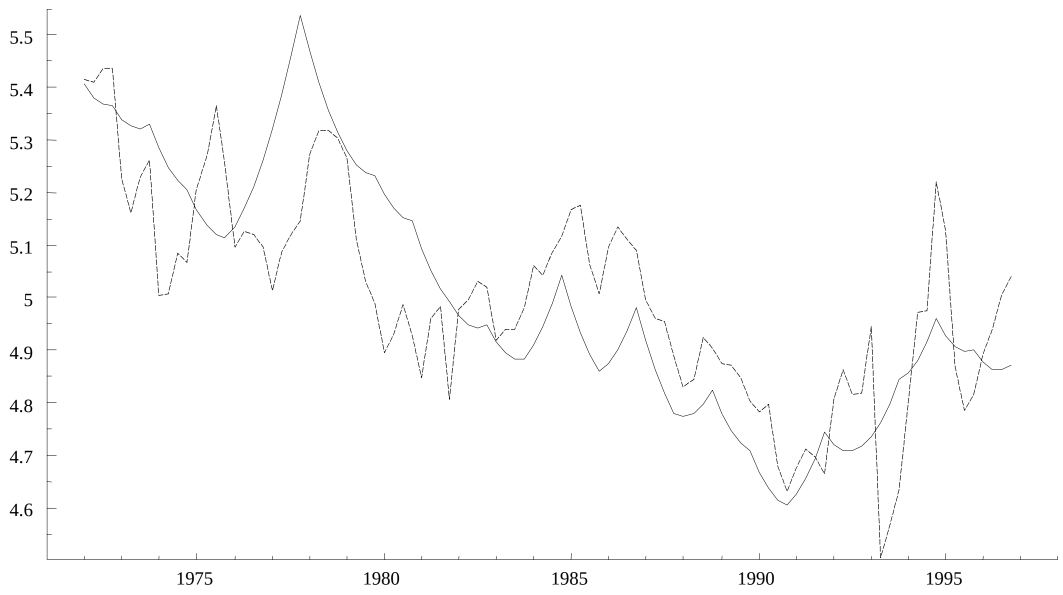

Figure 6. The log of terms of trade (—) and the the real exchange rate *p-e-p*^{f} (---).

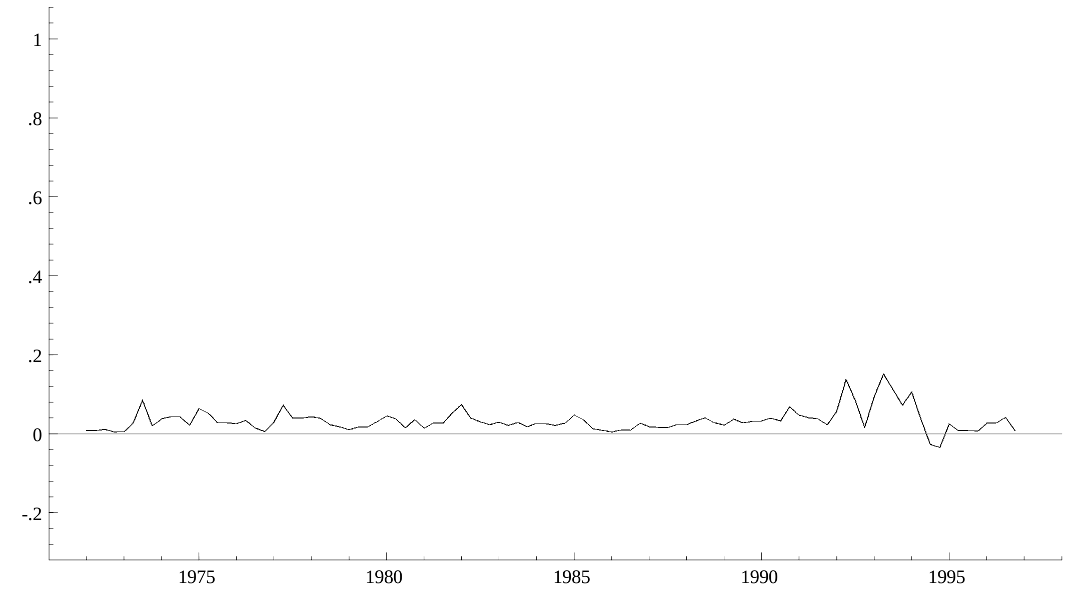

Figure 7. Consumer-price inflation trade (—) and maize-price inflation (---).

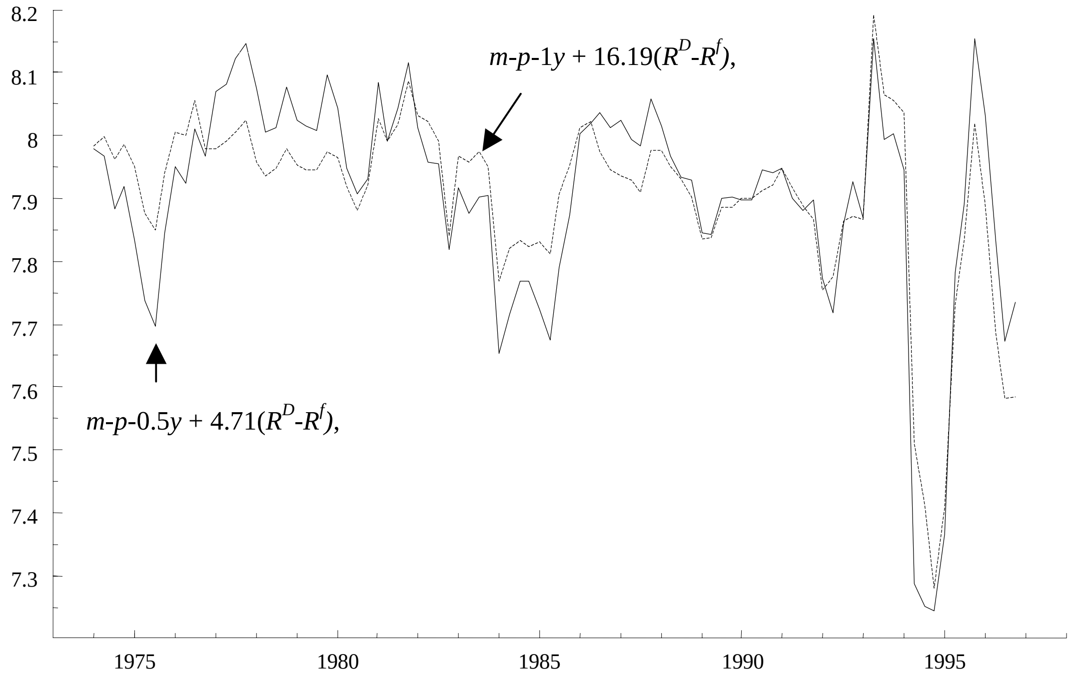

Figure 8. Restricted cointegration vectors for the monetary sector, mean and variance adjusted.

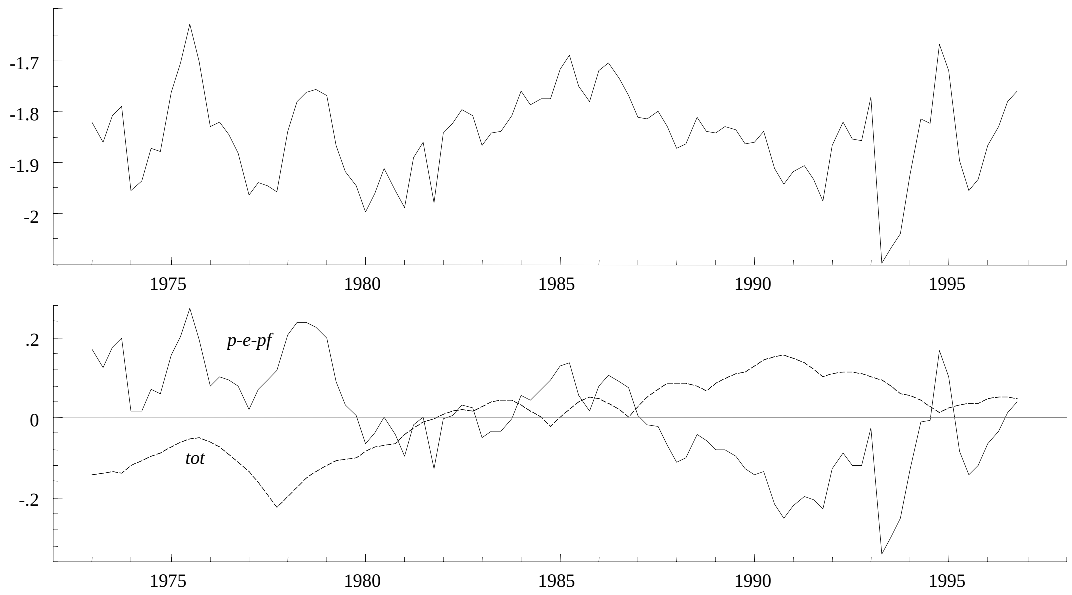

Figure 9. Cointegrating vector for the foreign sector (upper panel) and its components (lower panel).

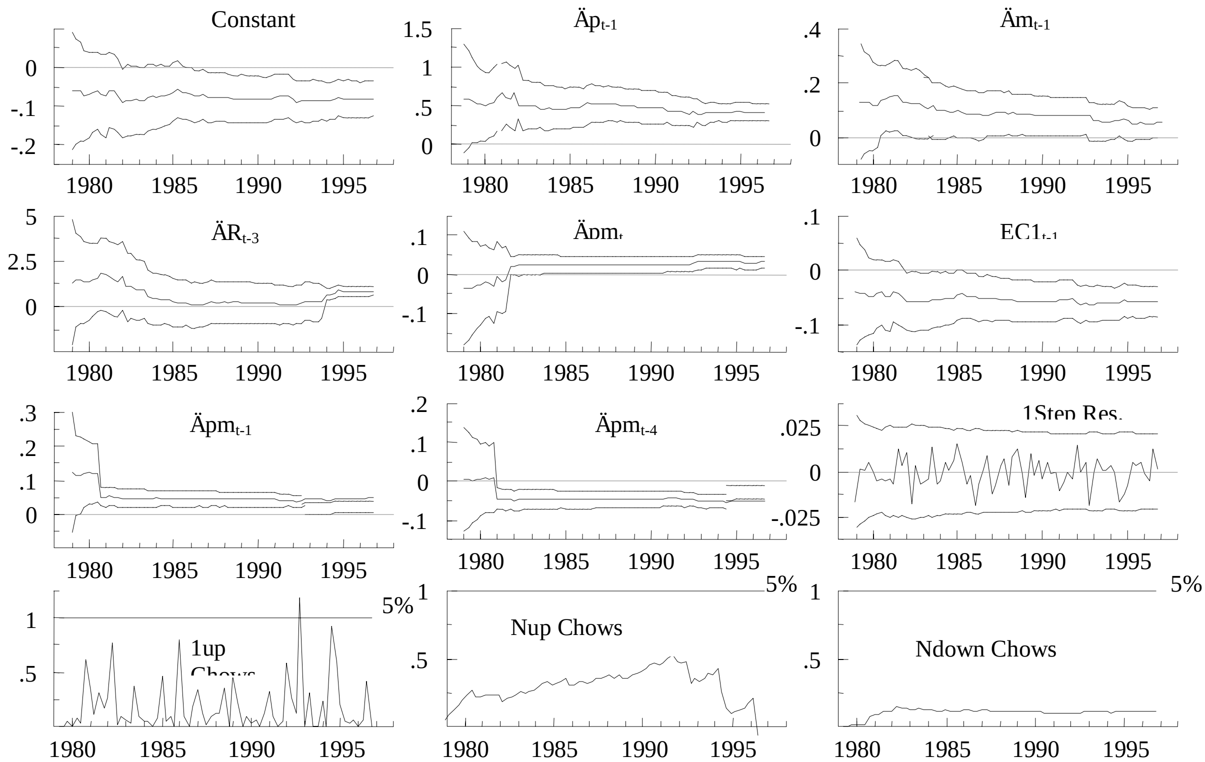

Figure 10. Recursive estimates and Chow tests over 1980 – 1996. In the first 9 graphs the recursively estimates parameter values, and the one-step-ahead residuals, are plotted with their ±2 estimated standard errors. The last three graphs plot Chow test statistics. The significance level used for the tests is 5%. It is indicated by the straight line thorugh unity.