Development Discussion Papers

Controlling Inflation During Structural Adjustment: The Case of Zambia

Per-Åke Andersson and Boo Sjöö

Development Discussion Paper No. 754
February 2000

Harvard Institute for
International Development
HARVARD UNIVERSITY

Controlling Inflation During Structural Adjustment: The Case of Zambia

Per-Åke Andersson and Boo Sjöö

Abstract

This paper analyses the relation between money and inflation during the structural adjustment program (SAP) in Zambia, 1987-1993. In contrast to many other studies of inflation in developing countries, this study focuses on a sample period relevant for SAPs and does not include pre-SAP monetary regimes. The results suggest that prices were driven by money, and that the authorities were able to reduce inflation by restricting the money supply process during the program.

Keywords: cointegration, inflation, structural adjustment

JEL codes: C32, E50, E65

Per-Åke Andersson is project associate of the Harvard Institute for International Development. He is working in Mozambique at the Capacity Building in Economic Decision-Making Project. He holds a Ph.D. in Economics from Göteborg University, Sweden.

Boo Sjöö is an Associate Professor in Finance and Econometrics at University of Skövde and Göteborg University, Sweden. He has been involved in the joint MBA program in economics organised by A.E.R.C. This paper was written while he was a Visiting Assistant Professor at McGill University.

The authors would like to thank Steve Kayizzi-Mugerwa and Tom Willet for helpful comments and suggestions. Remaining errors are our responsibility.

Controlling Inflation During Structural Adjustment: The Case of Zambia

1. Introduction

Economic structural adjustment programs (ESAPs), both in less developed countries and in emerging market economies, have become associated with high rates of inflation. The programs aim at strengthening the institutions of the market economy and increasing the flexibility of relative prices. If prices on individual markets are allowed to adjust freely, resources will be allocated more efficiently, and a necessary foundation for sustained long-run economic growth is created. However, ESAPs are often introduced in situations of repressed inflation and over-valued foreign exchange rates. When prices and exchange markets are liberalised, the result is not only relative price changes but also inflation.

High rates of inflation can be assumed to increase the costs of adjusting the economy. Inflation makes it more difficult to establish and observe new relative prices. This delays the transfer of resources into the expanding sectors of the economy. The situation is worsened if state owned firms and credit institutions are allowed to operate without binding budget constraints. An additional negative factor is if political pressure groups succeed in getting compensation for loss of income and higher prices are caused by changes in relative prices. Many adjustment programs have been terminated, or substantially reduced, due to the economic and political instability caused by high inflation.

The question is whether high and sustained inflation is unavoidable because the money supply process always passively accommodates changes in prices and exchange rates, or if the inflationary process can be controlled through monetary policy. Zambia is an example, where the implementation of a relatively firm ESAP in the early 90s, together with what was considered a tight credit policy, resulted in near hyper-inflation followed by a stabilisation of the inflationary process. In this paper, we use time series techniques to analyse the relationship between inflation and the supply money during the ESAP in Zambia 1987-1993.

The major problem with studies of inflation during ESAPs is that the programs are likely to change the parameters of interest.[1] We reduce this problem by limiting the sample to a period that is relevant for the implementation of the ESAPs in Zambia. Our results show that causality runs from money to prices and there is a long-run link between prices, money and foreign prices in domestic currency. The latter seems to suggest an important empirical relationship between the money stock and the real exchange rate during ESAPs.

Zambia has a long history of structural adjustment programs. In 1987, a program launched by the International Monetary Fund (IMF) collapsed. It was replaced by an another program named "growth from own resources". This program emphasised government control; exchange rates and interest rates were again fixed. Various measures for controlling prices were introduced, but they could not prevent prices from raising. With distorted factor and goods prices, the program was not sustainable. Thus, in 1989 the program terminated and was replaced

[1] Adam (1995) shows that a structural break occurs in money demand for Zambia during 1987.

with a more orthodox IMF supported ESAP.[2] This program was implemented more firmly than the previous ones, but the rate of inflation continued to rise. In early 1992, the inflation culminated close to hyperinflation and slowed thereafter. [3]

Inflation in sub-Saharan Africa has been investigated in a number of studies; Abebayehym (1989), Chibber *et. al.* (1989), London (1989), Canetti and Greene (1991), Chibber (1991), Aron and Elbadawi (1992), Ndung'u (1993), Sowa and Kwakye (1993). Many studies reject excess money supply as a single cause for inflation in favour of synthesised models, which include cost-push factors as well. Foreign exchange rate depreciation and real income are found important factors for explaining inflation. These results, however, are often based on heterogeneous sample periods, which span over different monetary and exchange regimes. Furthermore, many results can be questioned, because the authors did not take into account the statistical problems related to expectations and integrated time series.

This paper is organised as follows; the next section presents the data and discusses the tested hypotheses. The results of the Granger causality tests, based on both single and multivariate cointegration models are presented in section three. Finally, in section four we discuss the results.

2. Model and Data

This section presents a brief theoretical background and a discussion of the data. For an economy like Zambia's, with a soft monetary regime and underdeveloped financial markets, the relationship between money stock and the price level is best described by a Cagan money demand function,

$$\frac{M_t}{P_{d,t}} = \gamma\, Y_{d,t} \exp(-\theta D \log P^e_{d,t}), \qquad (1)$$

where M_t is the nominal money stock, P_t the domestic price level, $Y_{d,t}$ is real domestic income, $D = d/dt$ and $D\log P^e_{d,t}$ is the expected future rate of inflation at time t. The simplicity of this model, and the fact that the alternative cost of holding money is captured by expected inflation make it a good choice for describing money market equilibrium in a high inflation economy with poorly developed financial markets. Taking logs and solving for the price level lead to a first order linear expectation difference equation,

$$p_{d,t} = (1-b)(m_t - \gamma - y_{d,t}) + bE(p_{d,t+1}; I_t) \qquad (2)$$

where $b = \theta/(1 + \theta)$ and I_t is the information set held by the agents at time t.

The success of an ESAP in terms of avoiding inflation depends critically on the credibility of the program, which is a function of expectations concerning the future monetary policy. If

[2] The credibility of this program was never complete though, as discussed by Andersson and Ndulu (1992) and (1994).

[3] As a consequence of the program government expenditure fell from 23% of GDP to 12% between 1991 and 1993, and the real value of credits to the private sector fell by 20\% during the first six months of 1993.

individuals form rational expectations about the future price level and |b|< 1, repeated substitution leads to,

$$p_{d,t} = (1-b)\sum_{i=0}^{\infty} b^i E\left(m_{t+1} - \gamma - y_{d,t+1}; I_t\right), \qquad (3)$$

The solution suggests that the current price level is the sum of infinite conditional expectations of the money supply and the demand for real balances. An assumed linear stochastic process that could generate the realised price level, as the sum of expected and unpredictable shocks is therefore the following reduced system,

$$\mathbf{x_t} = \mathbf{A(L)x_{t-1}} + \mu + \varepsilon_{\mathbf{t}} \qquad (4)$$

where $\boldsymbol{x}$ $=\{p_{d,t}, m_t, y_{d,t}, \boldsymbol{z_t}\}$ and $\boldsymbol{z}_t$ a vector of other variables in the information set I_t, $\boldsymbol{\mu}$ is a vector of constants and ε_t a vector white noise process.

The solution to the expectation equation also shows that it is difficult to make clear statements about the causal ordering of the variables in bivariate model. As an example, suppose inflation causes the exchange rate to depreciate, this lead to higher prices of imports. If higher import prices are continuously accommodated by the money supply process, the outcome is persistent inflation. In the context of expectations it is therefore possible to find that the rate of depreciation Granger causes inflation, not because of structural cost-push factors, but because depreciation raises expectations about an increase in the money supply. A way to reduce these problems is to expand the information set, and perform tests of causality in a multivariate model.

Based on the vector autoregressive model (4), we focus on two hypotheses about the relationship between money and prices in the Zambian economy. First, for money to effect prices, it is necessary that the lagged money variable in (4) predicts changes in the price level. Second, for monetary policy to be an effective tool for controlling inflation during an ESAP, when money Granger causes the price level, it is also necessary that the money supply process is not accommodating historical inflation or foreign exchange depreciation. If the authorities cannot control the money supply process, inflation will feed it self through an automatic expansion of money stock. If the money supply process is not under control, the outcome is hyperinflation and a possible collapse of the monetary regime. The weaker the links from past inflation and depreciation on future supply of money, the more effective is a price stabilisation program based on a tight money supply.

The implementation of structural adjustment programs is likely to change the parameters of interest in any study of the functioning of the money market. It is therefore necessary to restrict the analysis to a period relevant for the program, in order to understand the meaning of the estimated parameters. Because of this, we use limited the study to monthly data from 1987 to 1993. The limitation with monthly data is the lack of an accurate measure of aggregate income. There are three ways of approaching this problem for the Zambian economy. First, if the real income series is a stationary process it will not enter the cointegrating relation(s). In this case, it cannot effect the tests concerning the long-run relations between the money supply and the prices in this study. The assumption of a stationary level of real income is perhaps unrealistic for Zambia during the sample period. Some studies indicate a real income drop by 20 per cent. A second alternative is to use copper prices as a proxy for income. This approach is used in Aron and Elbadawi (1992), but is not an ideal solution for studies of inflation. Unsterilized earnings from copper are part of the money supply process, which complicates the understanding of any significant correlation between money and copper prices.[4]

Finally, a third approach is to assume that real income is a function of the real exchange rate, $y_{d,t} = f(S_t P_{f,t} / P_{d,t})$, where S_t represents the nominal spot foreign exchange rate, $P_{f,t}$ and $P_{d,t}$ are foreign and domestic prices, respectively. This way of dealing with the unobserved real income is motivated by the fact that the economy is highly open and export oriented, therefore one can expect real income to be driven by the real exchange rate.

The domestic price series, used in this study, is the low-income household consumer price index, Figure 1. The peak in January 1989 is due to a reduction in the maize meal subsidy. In mid 1989 most prices were decontrolled and a second peak approaching 30% occurs. The large increase in mid 1990 is a consequence of increases in wages and housing allowances, while the early 1991 saw a price increase in oil products. With multi-party elections coming up in late 1991, the Zambian government decided on an expansive fiscal policy, with large wage increases for civil servants that resulted in the raise in inflation during 1992.

Controlling the monetary base is not sufficient if credit expansion turns out to be highly elastic with respect to price increases. Therefore, the relevant money stock in the context of an ESAP is some broad measure like M1 or M2. The graphs in Figure 1 show log levels and first differences of the nominal and the real money (M2) stocks. The real money supply is stationary from 1987 until January 1989, and declines thereafter.

The kwacha/dollar exchange rate is shown in the lower part of Figure 1.[5] The exchange rate regime changes during the period; from a fixed regime in 1987, to a flexible regime in August 1988 and finally to a floating regime after June 1990. The graph suggests that the exchange rate can be viewed as fixed up to August 1988 and 'non-fixed' there after. August 1988. There are two purchasing power parity relations (or real exchange rate measures) of relevance for a study of Zambia. The role of South Africa as a trading partner motivates testing PPP towards South Africa. The second relation is based on US wholesale prices, motivated by the high export (copper) orientation of the Zambian economy. The central bank might have targeted the real US exchange rate to reduce the variability in income from copper exports determined in US dollars.

Data on prices in South Africa and the US are taken from IMF's International Financial Statistics and Main Indicators by the Bank of Zambia. All series used in the regressions are seasonally unadjusted because the sample is too short to estimate any seasonal effects. Judging from graphs and regression estimates there is a July effect in the data. Dummy variables for the months of July are included when significant. These July dummies are probably caused by government actions, especially the presentation of the coming budget. In addition, a dummy variable for 1992:12 takes care of the peak in the rate of depreciation. Finally, a step dummy beginning in 1990:07 takes account of the change in the foreign exchange regime.

---

[4] When the foreign exchange rate became flexible it depreciated fast and consequently, the copper producing company's profits rose drastically.

[5] The series is the official rate for 1987:01-1990:06, the market rate for 1990:07-1991:06, the retention rate for 1991:07-19992:09, and the market rate for 1992:10-1993:07

3 Empirical Results

In this section, we ask whether monetary policy in Zambia contributed to controlling and reducing the inflationary process, or if it was mainly accommodating historical inflation and foreign exchange depreciation. Based on a well-defined statistical model, questions about causality can be addressed based on the principle of Granger non-causality. The important problems of empirical GNC-tests originate from the fact that macroeconomic variables are dependent and integrated stochastic processes. The dependence among the variables makes the test sensitive to the variables not included in the information set, and the integrated properties of the variables result in non-standard distributed test statistics. Given the limited number of variables available on a monthly basis, the latter issue is difficult to deal with, beyond careful testing for misspecification. The problems related to the modelling of integrated data series are approached by testing for unit roots and cointegration and using simulated empirical distributions were appropriate.

3.1 Tests of the order of integration and cointegration.

The order of integration, *I*(2) or (1), is determined based on augmented Dickey-Fuller tests for unit roots. Given the high inflation rate in the sample, integrated processes of order two cannot be ruled out a priori. Engle and Granger's two-step procedure and Johansen's vector autoregressive method are used to test for cointegration. The outcome of these tests is used to formulate GNC tests such that the test statistics follow standard distributions.

The hypotheses of second order integration (two unit roots) are clearly rejected for all variables in Table 1.[6] Thus, the variables are at most be integrated of order one. The hypothesis of one unit root, against the alternative of a deterministic trend or stationarity, cannot be rejected for most variables in Table 2. The exceptions are the nominal US dollar copper price series and the kwacha/rand foreign exchange rate. Cointegration is first tested with Granger and Engle's two-step procedure and then with Johansen's VAR technique. The limitations of the two-step procedure are that it's limiting distribution is not well-known, and that the test cannot discriminate between several cointegrating relationships when applied to more than two variables.[7] The VAR approach is superior to the two-step procedure, especially when there are more than one cointegrating relation among the variables in the process. The limitation of the approach lies in its assumption of a Gaussian error structure, needed for a full information maximum likelihood estimation, and for which only the asymptotic distributions are known. In small samples, FIML estimates are sensitive to the specification of the statistical model; general misspecification, the choice of the lag length and dummy variables etc. Furthermore, all types of cointegration tests are sensitive to structural breaks.[8] For Zambia, the firm implementation of the ESAP during 1990, and the change of exchange regime, motivate the inclusion of a shift dummy (*DUM1*) for the period 1990:07 to 1993:07. An alternative would be to use only the period after

[6] For the foreign exchange rate series, these tests are performed for the period of non-fixed rates, 1988:08 to 1993:07.

[7] To avoid 'trivial' co-integration, regress a stationary variable against one non-stationary variable, or simply include another non-stationary variable in an OLS that already is cointegrating, it is necessary to build logical chains of tests and examine all bivariate relations before testing trivariate relations.

[8] The effect of structural breaks are discussed in Perron (1989). Structural breaks tend to bias the estimates towards the unit root hypothesis, the alternative might be segmented (deterministic) trends. A step dummy for the floating exchange rate regime was included in all tests without changing any of the conclusions.

1990:06, but that would reduce the number of observations and severely reduce the efficiency of the estimated models.

The single equation tests of cointegration are presented in Tables 3 and 4. The first set of tests concerns the relation between the two money stocks M1 and M2. Since cointegration cannot be rejected between M1 and M2, we conclude that the money stocks are driven by a common stochastic trend. Thus, the additional credit creation included in M2 does not grow in a different way from M1. This result allows us to focus the cointegration tests on the broader M2 measure, without losing any important long-run information in M1.

The second set of tests concerns the existence purchasing power parity (PPP), or a stationary real exchange rate relationship. Among these relations, the PPP vector based on US wholesale prices cannot be rejected. This vector is therefore included in the GNC tests below. The parameters of this estimated cointegrating vector ($ecm1_t$) are $ecm1_t = p_{d,t} - 4.44 - 0.90\ s_{us,t} - 6.92\ p_{d,f} + DUM1$.

The remaining tests in Table 3 search for money market relations. The first model establishes a long-run stationary relation between the price level ($p_{d,t}$) and the money stock variable ($m2_t$). The stationary error correction term is $ecm2_t = p_{d,t} + 16.01 - 1.39 m2_t - 0.15\ DUM1$. This result is conditional on the inclusion of a constant term, representing a deterministic (negative) trend in real money balances. The linear trend might be understood as the result of a gradual tightening of credit and money during the program.[9] If real income happens to be stationary during the period, this cointegrating vector would be sufficient for describing long-run money market equilibrium, since a stationary income variable is not affecting the long-run solution of the model. In the following GNC-tests, this vector ($ecm2_t$) is used as an error correction mechanism to test how prices and the money supply interact in the long run.

The alternative here is to use copper prices as a proxy for income. According to the unit root test in Table 2, the real copper price is a borderline variable between $I(1)$ and $I(0)$. The tests relating domestic prices with the exchange rate and/or the copper price reject the hypothesis of no cointegration.[10] The error correction term, representing the long-run money market equation, includes nominal copper prices expressed in kwacha, $ecm3_t = m2_t - 9.48 - 0.76\ s_{us,t} - 0.99 cop_t + 0.08 DUM1$. This vector is not easy to identify. It can be understood as a proxy for a nominal money demand equation, or as a supply function for money. In the latter case, unsterilized copper income leads to an expansion of the money stock.

3.2 Single equation GNC-tests.

The results above are used to set up Granger non-causality tests that involve both long-run and short-run effects. The exclusion of relevant variables in the data generating process might affect the test. In a limited data set, however, including more variables lead to loss of efficiency. For these reasons, we estimate both bivariate and multivariate models, and test the models for misspecifications.

The first two models test for bivariate causality between money and prices based on the error correction term ($ecm2_t$), in Table 4. The misspecification tests, except the RESET test for the inflation equation, suggest that the models are well specified. The GNC tests show that

[9] The t-value of the constant term in the co-integrating vector is -39.03, the value of the dummy variable 2.86. These results indicate that a deterministic trend could explain the divergence between the money supply and the price level. For a discussion about the distribution of the constant term see Banerjee et. al. (1993) p 170 ff..

[10] The estimated co-integration vector is $p_{d,t} = -3.24 + 1.44\ cop_t + 1.05\ s_{us,t} + 0.06\ DUM1$.

money predict prices, while prices do not predict money. The sign of the error correction variable is negative, predicting that an increase in money is followed by an increase in inflation. Hence, monetary policy had effects on the price level, even during this limited sample period.

The models in Table 4 represent the simplest specification of the GNC test. The following models, Table 5 and 6, mainly prove that these results are robust against various respecifications of the models, in terms of conditioning on more information. The cointegration analysis suggested a stationary real exchange rate based on US wholesale prices and Zambian CPI. In Table 5, this PPP vector and its variables in first differences are added to the model. This extension does not change the conclusion from above that money Granger causes Zambian prices during the ESAP. There are no short-run links from foreign inflation or the rate of depreciation. The real exchange rate vector is significant in the inflation equation with the expected sign, suggesting that the domestic Zambian price level is affected by foreign prices.[11]

The single equation tests above did not reject the hypothesis of a long-run stationary relation between copper prices in kwacha and money. In Table 5, the equation for money shows that copper prices and the foreign exchange rate have no predictability on the growth in money. At the10 per cent risk level, the only significant variable is the first lag of money growth.

The two final models, Table 6, analyse the relation between money and the US dollar /kwacha exchange rate. In the inflation equation, the significant PPP vector suggests a long-run link from the rate of depreciation to the rate of inflation. For monetary policy to be effective in controlling inflation, it should not accommodate the relative price changes that follow from the depreciation of the currency. The results reject that the money supply process is driven by the rate of depreciation, and that depreciation is driven by the money supply. Thus, the results reject all causal links between the money stock and the foreign exchange rate, suggesting that the tight monetary policy worked during the program.

3.3 Causality in the multivariate model.

An other way of testing for Granger causality among integrated time series is to identify the long-run cointegrating relations within a multivariate model, and then test for causality in the vector error correction representation of the system. If the reduced system (4) is written as a vector error correction model we get,

$$\Delta\mathbf{x_t} = \sum_{i=1}^{n} \Gamma_i \Delta\mathbf{x_{t-i}} + \Pi\mathbf{x}_{t-k} + \Psi\mathbf{D_t} + \varepsilon_\mathbf{t} \qquad (5)$$

where $\Gamma_i = (I + \sum_J \mathbf{A}_J)$, and $\Pi = -(I + \sum_{J=1} \mathbf{A}_J) = -\mathbf{A}(1)$. $\mathbf{D_t}$ is a vector of deterministic dummy variables including the constants of each equation, such that if left unrestricted these terms include both the constant terms in the cointegrating vector(s), and the possible deterministic growth rates in $\mathbf{x_t}$. Finally, the residual vector is assumed to be $\varepsilon_\mathbf{t}$ ~ NID(0, Ω).

Johansen (1988, 1991) shows that the Π -matrix must be of reduced rank if the integrated variables in $\mathbf{x_t}$ are cointegrating, forming long-run stationary relations. If the dimension of $\mathbf{x_t}$ is *n*, there can at most be *n* - 1 = *r* stationary (cointegrating) relations among the variables. This is

[11] The PPP vector remains significant if the model is estimated over the non-fixed exchange rate regime, 1988:08-1993:05, suggesting that the more flexible exchange rate did not insulate the domestic prices from foreign prices or the effects of exchange rate changes.

so because r is the largest possible number of linearly independent rows in the Π-matrix. The rank of Π is determined by the number of significant eigenvalues in the estimated matrix. The distribution of the eigenvalues is only known asymptotically and for a closed system estimated under the assumption of normally distributed white noise residuals. Given that there are $r < n$ significant eigenvalues, we can write $\Pi \mathbf{x_t} = \alpha\beta'\mathbf{x_t}$ where $\beta'\mathbf{x_t}$ represents the long-run relations, and α is a matrix of adjustment coefficients measuring the strength by which each cointegrating vector affects an element in $\Delta\mathbf{x_t}$.

The variables in the system are CPI ($p_{d,t}$), money ($m2_t$), the kwacha/US exchange rate ($s_{us,t}$) and U.S. whole sale prices ($p_{f,t}$).[12] The estimation period starts from the beginning of the non-flexible exchange rate period (1988:08). By starting at this date, we avoid the deterministic (fixed) part of the exchange rate regime. The residual process is constructed as an empirical white noise using five dummy variables; four impulse dummies for the dates 1989:07, 1990:07, 1991:07, 1992:12, and one step dummy for the firm ESAP period during 1990:06-1993:05.[13] With two lags on the stochastic variables in the system, the residual test statistics suggest that the model is acceptable.

The shift dummy effects the asymptotic distribution of the test statistic, compared with the already tabulated values. The appropriate critical values are therefore simulated under the assumption that the deterministic growth term shifts during the sample. The test statistics indicate one significant cointegrating vector among the variables, in Table 7. Johansen's $I(2)$-test is then applied to test for processes integrated of order 2, but the hypothesis of an $I(2)$ relation is rejected.[14] In addition, we reject the assumptions that each variable is stationary $I(0)$, against the alternative of an $I(1)$ process.

The estimated parameters of the adjustment (α) parameters indicates that the cointegrating vector is predicting the inflation rate ($\Delta p_{d,t}$) only. The cointegration test tells us that a cointegrating vector exists, but not whether all variables need to be included to have a stationary relationship. It remains to identify the expression in economic terms. If the vector is normalised around CPI, we get the cointegrating vector: $p_{d,t} = \beta_0 + 0.95\, m2_t + 0.31\, s_{us,t} + 1.43\, p_{f,t}$.

If money is excluded from the vector it becomes a PPP relationship. If the exchange rate and the foreign price level are excluded, the vector would represent a stationary relation between money and domestic prices. In Table 10, we test if each individual variable can be excluded from the cointegrating vector. The only variable that might be excluded, is the US price level, according to the test statistic for one cointegrating vector (r =1). However, judged against the criterion of an economic meaningful relation, we decide not accept the hypothesis that US prices should be excluded. If foreign prices are the only variable excluded, it would be more difficult to

[12] Copper prices were found not to be an integrated process, they should therefore not enter any co-integrating vector is this system. If copper prices are included in this VAR, however, the test statistics reject the model and the estimates cannot be given any economic meaning.

[13] The sample is too short for estimating monthly seasonal effects. Judging from the graph of the data series there is a 'July-effect' in CPI. The inclusion of a step dummy implies a shift in the deterministic trend, which affects the distribution of the eigenvalues. Under the assumption that the real income is a stationary process, its exclusion will not affect the conclusions regarding the long-run relations among the three integrated variables.

[14] The $I(2)$ test is a reduced rank test on the matrix of short-run relations, conditionally on the number of significant eigenvalues in Π. For a given value of r, read the left most column from left to right using the same critical values as before. Since all values are clearly higher than the critical values, the hypothesis of reduced rank in the Γ-matrix is rejected.

understand the role of the foreign exchange rate, and including a non-significant variable will not harm the statistical tests.[15]

In contrast to the single equation tests above, we find that money and prices on the one hand, and the variables making up the real exchange rate on the other, are not stationary. It is only when joined together that a stationary long-run relation is established. The result suggests an interaction between the real money stock ($m2_t - p_{d,t}$) and the real exchange rate ($s_{us,t} + p_{f,t} - p_{d,t}$) during the implementation of an ESAP. This estimated vector could be understood as a long-run money market equilibrium, if the real exchange rate is seen as a substitute for real income in the Zambian economy. It is, however, difficult to test for the exact nature of such a relationship. We can impose the restrictions of a real money stock and that of a real exchange rate separately, but not test both in the same model.[16] The hypothesis of a real money stock within the estimated vector is not rejected, while that of a real exchange rate is rejected.

It remains to determine which variables in the system are changing as a result of deviations from the long-run steady state described by the cointegrating vector. This Granger causality test is performed by testing for the significance variables in the $\alpha-$vector. The cointegrating vector cannot predict or 'cause' a variable if the associated alpha parameter of that equation is zeros. This long-run GNC test is performed conditionally on all variables in the model, including the short-run dynamics and the deterministic variables. Like all GNC tests, this test is sensitive to the information set chosen, and can change if the information set is extended. The only significant long-run adjustment parameter is the one in the equation of the domestic inflation rate. Thus, the cointegrating vector is controlling the domestic price level. The short-run causality in the model is analysed through the estimated short-run parameters of the model, in the Γ-matrix. The only significant short-run variable is the lagged inflation rate, no other short-run variable is predicting the inflation rate, Table 9. In the multivariate model, the only causal relations among the variables are those associated with the cointegrating vector, which only affects the inflation rate.

The money stock, the foreign price level, and the exchange rate are exogenous with respect to the parameters in the long-run relation. The Zambian price level is Granger caused by a combination of the money supply and the exchange rate. The fact that there is only one long-run relation predicting the inflation rate, without any feed back to the other variables in the system, mean that monetary policy in combination with the exchange rate were an effective tool for controlling inflationary impulses following from the introduction of the ESAP.

4. Summary and Conclusions

This paper is inspired by the fact that the inflationary process is a critical aspect of structural adjustment programs. Many programs are terminated because of the destabilising effects of high inflation. We use the experience of Zambia to investigate the role of the money supply process during the implementation of an ESAP. Since these programs are likely to change the parameters of interest for this type of study, we focus on a sample period relevant for the ESAP.

---

[15] Copper prices were found not to be an integrated process, they should therefore not enter any co-integrating vector is this system. If copper prices are included in this VAR, however, the test statistics reject the model and the estimates cannot be given any economic meaning.

[16] The $\chi^2(2)$ distributed test for the nul of a real money stock and the same coefficient on the exchange rate and the foreign price level 0.25. For the hypothesis of a real exchange rate relation the test statistic is $\chi^2(2) = 7.21$.

Our results, based on different approaches, show a causal link from money growth to inflation. In a cointegrating VAR model, this causality is only visible if the foreign exchange rate is a part of the system. This result suggests that a combination of money and foreign exchange markets reactions determine inflation. As expected from theories of open economies, monetary policy cannot be judged independently of the foreign exchange regime. Based on the experience from Zambia, we conclude that ESAPs increase the money supply and cause inflation, but if the money process is not allowed to accommodate historical price increases, a tight monetary policy will contribute to reduce inflation and stabilise prices after some period.

References

Abebayehu, Tegene (1989), The Monetarist Explanation of Inflation: The Experience of Six African Countries. *Journal of African Studies* 16, 5-18.

Adam, Christopher (1995), Fiscal Adjustment, Financial Liberalization, and the Dynamics of Inflation: Some Evidence from Zambia. *World Development* 23, 735-750.

Andersson, Per-Åke and M. Ndulu (1992), Structural Adjustment Inflation and Political Commitment in Zambia: A Short Analysis of the New Economic Programme of 1989. Macroeconomic Studies 28/92, SIDA, Stockholm.

Andersson, Per-Åke and M. Ndulu (1994), Hyper-inflation, Stabilization and the New Economic Recovery Program in Zambia. Macroeconomic Studies 51/94, SIDA, Stockholm.

Aron, J. and I. Elbadawi (1992), Parallel Markets, the Foreign Exchange Auction, and Exchange Rate Unification in Zambia. World Bank Working papers, Washington.

Banerjee, A, J. Dolado, J. Galbraith and D. Hendry (1993), Co-Integration, Error Correction, and the Econometric Analysis of Non-stationary Data. Data. Oxford: Oxford University Press.

Blanchard, Oliver Jean and Stanley Fischer (1990), *Lectures on Macroeconomics*. Cambridge Massachusetts: MIT Press.

Canneti, E. and J. Green (1991), Monetary Growth and Exchange Rate Depreciation as Causes of Inflation in African Countries: An Empirical Analysis. IMF Working Paper.

Chibber, A. (1991), Africa's Rising Inflation: Causes, Consequences and Cures. World Bank Working Paper No 577.

Chibber, A., J. Cottani, R. Firuzabini, and M. Walton (1989), Inflation, Price Controls and Fiscal Adjustment in Zimbabwe. World Bank Working Paper Series, No 192.

Hendry, David H. and Adrian J. Neale (1990*), PC-NAIVE - An Interactive Program for Monte Carlo Experimentation in Econometrics*, Institute of Economics and Statistics. Oxford: University of Oxford.

Johansen, Sören (1988), Statistical Analysis of Cointegrating Vectors. *Journal of Economic Dynamics and Control*, 12, 231-254.

Johansen, Sören (1991), Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models. *Econometrica* 59: 1551-1581.

Johansen, Sören (1992), A Statistical Analysis of Autoregressive Processes Integrated of Order 2. *Econometric Theory* 8, 188-202.

Johansen, Sören (1995), *Likelihood-Based Inference in Cointegrated Vector Autoregressive Models*, Oxford University Press.

Johansen, Sören and Bent G. Nielsen (1994), Asymptotics for Tests for Cointegrating Rank in the Presence of Intervention Dummies: Manual for the Simulation Program DisCo, Discussion paper, University of Copenhagen.

Juselius, Katarina (1994), On the Duality Between Long-run Relations and Common Trends in the I(1) versus I(2) Model. An Application to Aggregate Money Holdings. *Econometric Reviews* 13, 157-178.

Kelfalla, M.K. (1993), An Economic Analysis of Inflation in Sierra Leone. *Journal of African Economics* 3, 200-211.

London, A. (1989), Money Inflation and Adjustment Policy in Africa: Some Further Evidence. *African Development Review* 1, 87-111.

Lütkepol, H. (1994), Interpretation of cointegrating relations. *Econometric Reviews* 13, 391-394.

Ndungu, Njuguna (1993), Dynamics of the Inflationary Process in Kenya. Ekonomiska Studier No 47, Department of Economics, School of Economics and Commercial Law, University of Gothenburg.

Osterwald-Lenum, Michael (1992), A Note with Quantiles of the Asymptotic Distribution of the Maximum Likelihood Cointegrating Rank Test Statistics. *Oxford Bulletin of Economics and Statistics* 54, 461-471.

Perron, Pierre (1989), The Great Crash, the Oil Price Shock, and the Unit Root Hypothesis. *Econometrica* 57, 1361-1401.

Sjöö, Boo (1996), Inflation and Money Growth in Zambia - A Common Trends Approach, memo, Department of Economics, University of Gothenburg.

Sowa, N. and Kwakye, J. K. (1993), Inflationary Trends and Control in Ghana. AERC Research Paper 22, Nairobi.

Table 1. Dickey-Fuller Tests for Two Unit Roots[a]

Variable		Lag number						
		0	1	2	3	4	5	6
m2	ADF-value	-10.92	-6.34	-5.15	-4.00	-4.32	-3.83	-3.22
	p-value	-	0.80	0.77	0.50	0.12	0.89	0.67
m1	ADF-value	-8.20	-5.83	-4.95	-4.15	-4.04	-4.08	-3.60
	p-value	-	0.95	0.69	0.89	0.43	0.29	0.97
$p_{d,t}$	ADF-value	-5.90	-3.92	-3.43	-2.95	-2.84	-2.41	-2.12
	p-value	-	0.14	0.83	0.67	0.75	0.54	0.61
$p_{SA,t}$	ADF-value	-13.10	-5.85	-5.31	-4.45	-3.67	-2.67	-2.54
	p-value	-	0.30	0.27	0.92	0.68	0.09	0.85
$p_{us,t}$	ADF-value	-13.96	-9.79	-7.93	-6.79	-6.02	-5.43	-4.96
	p-value	-	0.01	0.04	0.12	0.19	0.29	0.37
cop_t	ADF-value	-5.04	-4.85	-5.14	-4.23	-3.69	-4.49	-3.62
	p-value	-	0.40	0.10	0.56	0.66	0.01	0.28
$s_{us,t}$[b]	ADF-value	-7.97	-4.88	-4.23	-3.94	-3.70	-3.41	-3.26
	p-value	-	0.26	0.86	0.68	0.69	0.89	0.20
$s_{RA,t}$[b]	ADF-value	-7.67	-5.20	-4.16	-4.02	-3.69	-3.41	-3.33
	p-value	-	0.63	0.74	0.48	0.85	0.92	0.34

[a] The estimated models include a constant but no deterministic trend. The sample period is 1987:01-1995:05.
The sample period is the period of non-fixed exchange rate 1988:08-1993:05.
*** indicate that the variable is significant at the 1% level, ** indicate significance at the 10% level, and * 1% significance level.
'p-value' refer s to the probability value associated with the final lag in each augmented model.
$P_{d,t}$ = Zambia consumer price index.
p_{SA} = South Africa consumer price index.
$P_{us,t}$ = U.S. wholesale price index.
cop_t = copper prices in U.S. dollars.
$s_{us,t}$ = Kwacha/U.S. dollar rate.
s_{RA} = Kwacha/Rand.

Table 2. Dickey-Fuller Tests for One Unit Root[a]

Variable		Lag number						
		0	1	2	3	4	5	6
$m2_t$	ADF-value	-1.66	-1.04	-0.95	-0.66	-0.73	-0.00	-0.33
	p-value	-	0.03***	0.90	0.34	0.74	0.03***	0.30
$m1_t$	ADF-value	-1.19	-1.15	-1.05	-0.83	-0.81	0.40	0.09
	p-value	-	0.99	0.86	0.44	0.94	0.24	0.10*
$p_{d,t}$	ADF-value	-0.49	-0.94	-1.00	-0.94	-0.91	-0.77	-0.78
	p-value	-	0.06*	0.33	0.83	0.99	0.49	0.89
$(m2/ p_d)_t$	ADF-value	-2.85	-2.77	-3.02	-2.72	-2.60	-2.41	-2.40
	p-value	-	0.79	0.21	0.73	0.95	0.70	0.83
$p_{SA,t}$	ADF-value	-2.56	-1.32	-1.58	-1.13	-1.15	-1.42	-2.30
	p-value	-	0.00***	0.19	0.56	0.75	0.35	0.02***
$p_{us,t}$	ADF-value	-1.87	-1.97	-1.82	-1.79	-1.85	-1.43	-1.35
	p-value	-	0.46	0.55	0.92	0.58	0.02**	0.52
cop_t	ADF-value	-4.29	-4.39	-4.25	-4.17	-4.14	-4.11	-4.33
	p-value	-	0.00***	0.65	0.11	0.81	0.82	0.00***
$(copp_{us}/p_d)$b	ADF-value	-2.79	-3.36	-3.61	-3.46	-2.84	-2.86	-2.40
	p-value	-	0.05	0.21	0.68	0.30	0.58	0.30
$s_{RA,t}$	ADF-value	-7.93	-4.83	-4.21	-3.92	-3.70	-3.41	-3.28
	p-value	-	0.24	0.84	0.65	0.66	0.89	0.32
$s_{us,t}$	ADF-value	-3.33	-3.43	-3.55	-3.65	-3.18	-2.83	-2.52
	p-value	-	0.38	0.34	0.33	0.74	0.59	0.27

[a] The estimated models include a constant and a deterministic trend. The sample period is 1987:01-1995:05.
The sample period is the period of non-fixed exchange rate 1988:08-1993:05.
'p-value' refer s to the probability value associated with the final lag in each augmented model.
$(cop\ s_{us}/p_d)$ = real copper prices in domestic currency.
*** indicate that the variable is significant at the 1% level, ** indicate significance at the 10% level, and * 1% significance level.

Table 3. Engle and Granger Cointegration Tests[a]

Vector	Lag number						
	0	1	2	3	4	R^2	DW
($m2$, $m1$)							
ADF-value	-4.68	-3.85	-3.53	-3.79	-3.98	0.996	0.93
p-value	-	0.60	0.91	0.18	0.22		
(p_d, s_{US})							
ADF-value	-2.39	-2.33	-2.29	-2.28	-2.28	0.955	0.31
p-value	-	0.94	0.81	0.79	0.57		
(p_d, p_{us})							
ADF-value	-0.57	-0.96	1.47	-1.70	-1.34	0.860	0.11
p-value	-	0.12	0.07*	0.34	0.40		
(p_d, p_{us}, s_{us})							
ADF-value	-3.85	-3.75	-3.91	-3.64	-3.55	0.989	1.16
p-value	-	0.69	0.26	0.77	0.62		
(p_d, s_{RA}, p_{SA})							
ADF-value	-2.42	-2.36	-2.33	-2.31	-2.30	0.926	0.27
p-value	-	0.99	0.96	0.98	0.95		
(p_d, p_{SA})							
ADF-value	-0.37	-0.35	-0.86	-0.70	-0.79	0.981	0.10
p-value	-	0.99	0.01***	0.74	0.59		
(p_d, p_{SA}, s_{RA})							
ADF-value	-2.34	-2.06	-2.08	-2.20	-2.32	0.994	0.63
p-value	-	0.70	0.70	0.47	0.44		
(p_d, cop)							
ADF-value	-1.10	-1.25	-1.33	-1.40	-1.42	0.755	0.16
p-value	-	0.49	0.63	0.64	0.77		
(p_d, cop, s_{us})							
ADF-value	-3.08	-3.66	-4.22	-4.02	-3.44	0.985	1.09
p-value	-	0.04***	0.05**	0.58	0.73		
(s_{us}, cop)							
ADF-value	-1.30	-1.31	-1.38	-1.40	-1.42	0.759	0.23
p-value	-	0.77	0.67	0.75	0.74		

Table 3 cont.

Vector	Lag number 0	1	2	3	4	R2	DW
(*m2*, *cop*)							
ADF-value	-1.08	-1.09	-1.11	-1.13	-1.14	0.740	0.17
p-value	-	0.83	0.80	0.79	0.84		
(*m2*, *cop*, s_{us})							
ADF-value	-4.11	-4.51	-5.14	-4.84	-3.31	0.984	1.25
p-value	-	0.09	0.03	0.38	0.08*		
(p_d, *m2*, s_{us})							
ADF-value	-3.21	-3.03	-3.16	-2.92	-3.33	0.995	0.61
p-value	-	0.91	0.36	0.99	0.11		
(p_d, *m2*)							
ADF-value	-3.33	-3.13	-3.37	-3.14	-3.14	0.993	0.54
p-value	-	0.88	0.22	0.93	0.56		

[a] The models include a constant, and a dummy for floating exchange rate period, but no deterministic trend.
'p-value' refer s to the probability value associated with the final lag in each augmented model.
The R^2 figures indicate the bias in the estimated cointegrating vectors in the two step procedure.
Critical values for 0-4 lags in augmented model and 70 observations simulated with PC-NAIVE:

Critical values	0	1	2	3	4	DW
2 variables	-3.45	-3.40	-3.32	-3.29	-3.19	0.54
3 variables	-3.86	-3.80	-3.65	-3.64	-3.51	0.67

*** indicate that the variable is significant at the 1% level, ** indicate significance at the 10% level, and * 1% significance level.

Table 4. Bivariate GNC Tests Between CPI and Money.[a]

Dependent Variable	$\Delta p_{d,t}$		$\Delta m2_t$	
	Estimate	t-value	Estimate	t-value
Constant	0.0017**	1.97	0.043***	3.26
$\Delta p_{d,t-1}$	0.256***	3.19	-0.128	-1.01
$\Delta p_{d,t-2}$	0.276***	3.38	-0.004	-0.03
$\Delta m2_{t-1}$	0.037	0.45	-0.001	-0.01
$\Delta m2_{t-2}$	0.035	0.48	0.039	0.35
$ecm2_{t-1}$	-0.136***	-3.59	0.056	0.97
DUM89:7	0.200***	6.54	-	-
DUM90:7	0.126***	4.06	-	-
DUM92:7	-0.064**	-2.02	-	-
DUM1	0.018**	2.28	0.022*	1.80
DUM87:9/10	-	-	0.182***	4.99
R^2	0.657		0.370	
Q	F(10,62) 13.61		F(7,65) 5.45	
AR	F(5,59) 0.69		F(5,60) 0.07	
ARCH	F(5,54) 0.57		F(5,55) 0.46	
Normality	χ^2 (2) 3.20		χ^2 (2) 2.00	
RESET	F(1,63) 6.50		F(1,64) 1.41	
GNC-tests	probability-value		GNC-tests	probability-value
$\Sigma\Delta p_{d,t-i}$	0.0000***		$\Sigma\Delta p_{d,t-i}$	0.5756
$\Sigma\Delta p_{d,t-i} + ecm2_{t-1}$	0.0000***		$\Sigma\Delta p_{d,t-i} + ecm2_{t-1}$	0.5897
$\Sigma\Delta m2_{t-i}$	0.8624		$\Sigma\Delta m2_{t-i}$	0.9274
$\Sigma\Delta m2_{t-i} + ecm2_{t-1}$	0.0002***		$\Sigma\Delta m2_{t-i} + ecm2_{t-1}$	0.7319

[a]*DUM1* captures the period of non-fixed exchange rate. The sample period is 1987:6-1993:7.
*** indicate that the variable is significant at the 1% level, ** indicate significance at the 10% level, and * 1% significance level.

Table 5. GNC Tests in a Multivariate Reduced Models of CPI and Money.

Dependent Variable	$\Delta p_{d,t}$		$\Delta m2_t$	
	Estimate	t-value	Estimate	t-value
Constant	0.013	1.40	0.038^{**}	2.65
$\Delta p_{d,t-1}$	0.255^{***}	2.84	-0.171	-1.22
$\Delta p_{d,t-2}$	0.353^{***}	3.90	0.084	0.61
$\Delta m2_{t-1}$	0.060	0.71	-0.010	-0.07
$\Delta m2_{t-2}$	0.058	0.76	0.090	0.75
$ecm1_{t-1}$	-0.082^{**}	-2.20	-	-
$ecm2_{t-1}$	-0.130^{***}	-3.41	-	-
$ecm3_{t-1}$		-	-0.102	-1.06
$\Delta s_{us,t-1}$	-0.006	-0.19	0.044	0.86
$\Delta s_{us,t-2}$	-0.023	-0.91	-0.020	-0.51
$\Delta p_{us,t-1}$	-0.219	-0.44	-	
$\Delta p_{us,t-2}$	-0.178	-0.36	-	
Δcop_{t-1}	-	-	0.067	0.42
Δcop_{t-2}	-	-	0.101	0.61
DUM89:7	0.209^{***}	6.79	-	-
DUM90:7	0.124^{***}	3.87	-	-
DUM92:7	-0.066^{**}	-2.06	-	-
DUM1	0.015^{*}	1.86	0.002	1.45
DUM87:9/10	-	-	0.173^{***}	4.56
R^2	0.688		0.411	
Q	F(10,62) 9.14		F(11,61) 3.88	
AR	F(5,53) 0.50		F(5,56) 0.86	
ARCH	F(5,48) 0.61		F(5,51) 0.35	
Normality	χ^2 (2) 3.87		χ^2 (2) 1.37	
RESET	F(1,57) 3.70		F(1,60) 4.19	
GNC-tests	probability-value		GNC-tests	probabilty-value
$\Sigma\Delta p_{d,t-i}$	0.0000^{***}		$\Sigma\Delta p_{d,t-i}$	0.4567
$\Sigma\Delta p_{d,t-i} + ecm1_{t-1}$	0.0000^{***}		$\Sigma\Delta p_{d,t-i} + ecm3_{t-1}$	0.5897
$\Sigma\Delta p_{d,t-i} + ecm2_{t-1}$	0.0000^{***}			
$\Sigma\Delta p_{d,t-i} + ecm1_{t-1} + ecm2_{t-1}$	0.0000^{***}			
$\Sigma\Delta m2_{t-i}$	0.6895		$\Sigma\Delta m2_{t-i}$	0.6774
$\Sigma\Delta m2_{t-i} + ecm2_{t-1}$	0.0002^{***}			
$ecm1_{t-1} + ecm2_{t-1}$	0.0004^{***}			
$\Sigma\Delta s_{us,t-i}$	0.6388		$\Sigma\Delta s_{us,t-i}$	0.4090
$\Sigma\Delta s_{us,t-1} + ecm1_{t-i}$	0.1666		$\Sigma\Delta s_{us,t-i} + ecm3_{t-i}$	0.3594
$\Sigma\Delta p_{us,t-i}$	0.8510		$\Sigma\Delta cop_{t-i}$	0.5616
$\Sigma\Delta p_{us,t-i} + ecm1_{t-p}$	0.1968			
$\Sigma\Delta s_{us,t-i} + \Sigma\Delta p_{us,t-i} + ecm1_{t-1}$	0.3968		$\Sigma\Delta p_{d,t-i} + \Sigma\Delta s_{us,t-i} + \Sigma\Delta cop_{t-1}$	0.7119
$\Sigma\Delta p_{d,t-i} + \Sigma\Delta s_{us,t-i} + \Sigma\Delta p_{us,t-i}$	0.0001^{***}		$\Sigma\Delta p_{d,i} + \Sigma\Delta s_{us} + \Sigma\Delta m2 + \Sigma\Delta cop_{t-i} + ecm3_{t-1}$	0.6776

*** indicate that the variable is significant at the 1% level, ** indicate significance at the 10% level, and * 1% significance level.

Table 6. GNC Tests in Multivariate Models for Money and Foreign Exchange Rate[a].

Dependent Variable	$\Delta m2_t$		Δs_{us}		
	Estimate	t-value	Estimate	t-value	
Constant	0.050**	2.85	0.039*	1.76	
$\Delta p_{d,t-1}$	-0.151	-0.97	-0.013	-0.07	
$\Delta p_{d,t-2}$	0.071	0.44	-0.061	-0.31	
$\Delta m2_{t-1}$	-0.096	-0.07	-0.197	-1.00	
$\Delta m2_{t-2}$	-0.021	-0.15	0.102	0.54	
$ecm2_{t-1}$	-0005	-0.08	0.122	1.30	
$ecm3_{t-1}$	-	-	0.001	0.06	
$\Delta s_{us,t-1}$	-0.008	-0.09	0.072	0.11	
$\Delta s_{us,t-2}$	0.018	-0.21	0.136	1.31	
DUM89:7	-	-	0.328***	5.30	
DUM91:7	-	-	0.186***	3.10	
DUM1	0.022	1.57	0.020	1.12	
R^2	0.082		0.663		
Q-test	F(8,49) 0.54		F(12,46) 7.56		
AR	F(4,56) 1.00		F(4,42) 1.23		
ARCH	F(4,38) 0.39		F(4,38) 0.61		
Normality	χ^2 (2) 3.32		χ^2 (2) 7.17		
RESET	F(1,43) 0.35		F(1,60) 0.04		
GNC-tests	probability-value		GNC-tests	probability-value	
$\Sigma\Delta p_{d,t-1}$	0.9461		$\Sigma\Delta p_{d,t-i}$	0.5998	
$\Sigma\Delta p_{d,t-1} + ecm2_{t-1}$	0.6066		$\Sigma\Delta p_{d,t-i} + ecm2_{t-1}$	0.7804	
$\Sigma\Delta m2_{t-i}$	0.4280		$\Sigma\Delta m2_{t-i}$	0.7983	
$\Sigma\Delta m2_{t-i} + ecm3_{t-1}$	0.6207		-	-	
$\Sigma\Delta s_{us,t-i}$	0.3950		$\Sigma\Delta s_{us},_{t-i}$	0.9689	
$\Sigma\Delta s_{us,.t-1} + ecm3_{t-i}$	0.4991		$\Sigma\Delta s_{us},_{t-i} + ecm3_{t-i}$	0.9942	

[a] Sample period 1988:08-1993:06.
*** indicate that the variable is significant at the 1% level, ** indicate significance at the 10% level, and * 1% significance level.

Table 7. Test Statistics of the Model $\Delta x_t = \Sigma_{i=1} \Gamma_i \Delta x_{t-i} + \Pi x_{t-k} + \Psi D_t + \mu + \varepsilon_t$.

Eigenvalues of Π-matrix				
Eigenvalues	0.427	0.263	0.070	0.003
Trace test	52.52**	21.33	4.22	0.15
Critical value 5%	46.62	26.73	9.44	5.96[a]
Critical values 10%	43.19	23.93	7.74	4.62[a]

Residual misspecification tests					
	Q-test (12)	ARCH	Skewness	Excess kurtosis	J-B Normality
$\Delta p_{d,t}$	5.372	0.402	0.763	0.029	5.438
$\Delta m2_t$	10.750	0.910	-0.109	0.593	0.932
$\Delta s_{us,t}$	11.958	0.161	0.858	1.835	14.722***
$\Delta p_{us,,t}$	6.797	4.019	0.314	-0.104	0.945

*** indicate that the variable is significant at the 1% level, ** indicate significance at the 10% level, and * 1% significance level.

Table 8. Test Statistics for *I(2)* processes.

D.g.f.							
p - r	*r*	T(*r*,*s*)				Trace test	Critical val.[a]
4	0	192.13	118.96	65.49	29.91	52.52	46.62
3	1		137.79	65.67	28.94	21.33	26.73
2	2			64.84	13.34	4.22	9.44
1	3				15.12	0.15	5.96
Critical val.[a]		46.62	26.73	9.44	5.96		

[a] Simulated for a process with a shift in the deterministic growth of Δx_t occurring after 40% of the sample period.

Table 9. Estimated Parameters of the Model $\Delta x_t = \Sigma_{i=1} \Gamma_i \Delta x_{t-i} + \alpha\beta' x_{t-k} + \Psi D_t + \mu + \varepsilon_t$.

Short-run dynamics: Γ-matrix			
$\Delta p_{d,t-1}$	$\Delta m2_{t-1}$	$\Delta s_{us,t-1}$	$\Delta p_{us,,t-1}$
0.354***	-0.033	-0.050	0.303
-0.119	-0.057	-0.008	0.262
0.085	-0.110	-0.025	-0.578
-0.023	0.036	0.011	0.022
t-values			
3.6	0.3	0.9	0.5
0.7	0.3	0.1	0.3
0.4	0.5	0.2	0.5
0.9	1.2	0.8	0.1

Deterministic variables: ψ-matrix						
Constant[a]	*DUM1*[b]	*DUM89:7*	*DUM90:7*	*DUM91:7*	*DUM92:7*	*DUM92:12*
-4.289***	0.046***	0.173***	0.130***	-0.043	-0.069**	0.076**
0.244	0.015	-0.047	-0.032	-0.026	-0.015	0.012
0.797	0.018	0.312***	-0.020	0.196***	-0.040	0.371***
0.461*	-0.008*	0.001	-0.004	-0.001	-0.013	-0.001
t-values						
4.5	2.9	5.2	3.9	1.3	2.0	2.3
0.2	0.6	0.9	0.6	0.5	0.3	0.2
0.4	0.6	4.9	0.3	3.1	0.6	5.8
1.8	1.9	0.1	0.5	0.1	1.4	0.1

The α-matrix					**The β-matrix**			
0.019	0.006	0.002	0.000		-13.657	2.420	-1.182	5.677
-0.001	0.020	-0.006	0.000		13.086	-6.021	9.838	4.489
-0.003	0.006	-0.001	0.003		4.216	3.045	-4.671	-7.643
-0.002	0.002	0.001	0.000		19.488	-44.479	-66.194	13.625

[a] The model includes an unrestricted constant term.
[b] *Dum1* is a step dummy for the period 1991:07-1995:05
*** indicate that the variable is significant at the 1% level, ** indicate significance at the 10% level, and * 1% significance level.

Table 10. Testing Stationarity, Exclusion and, Weak Exogeneity w.r.t β in

$$\Delta x_t = \Sigma_{i=1} \Gamma_i \Delta x_{t-i} + \alpha\beta' x_{t-k} + \Psi D_t + \mu + \varepsilon_t.$$

LR test of stationarity χ^2						
d.g.f.	Test statistics				Critical values	
p - r	$p_{d,t}$	$m2_t$	$s_{us,t}$	$p_{us,t}$	χ^2 5%	χ^2 10%
3	20.60**	19.79**	18.54**	26.31**	7.81	6.25
2	8.02**	8.15**	6.52**	14.79**	5.99	4.61
1	3.16	3.38	2.72	1.79	3.84	2.71

LR test of exclusion χ^2						
d.g.f.	Test statistics				Critical values	
r	$p_{d,t}$	$m2_t$	$s_{us,t}$	$p_{us,t}$	χ^2 5%	χ^2 10%
1	13.64**	10.93**	5.22**	1.38	3.84	2.71
2	26.12**	17.48**	7.54**	5.85*	5.99	4.61
3	27.05**	20.89**	8.70**	9.63**	7.81	6.25

LR test of exogeneity χ^2						
d.g.f.	Test statistics				Critical values	
r	$p_{d,t}$	$m2_t$	$s_{us,t}$	$p_{us,t}$	χ^2 5%	χ^2 10%
1	11.53**	0.01	0.21	2.80*	3.84	2.71
2	22.78**	9.48**	0.84	7.37**	5.99	4.61
3	25.63**	13.21**	0.85	11.17**	7.81	6.25

** indicate significance at the 10% level, and * 1% significance level.

Figure 1. Variables in Log Levels and First Differences.