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Inflation Dynamics in Madagascar, 1971-2000

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Inflation Dynamics in Madagascar, 1971-2000

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Abstract

The paper analyzes the dynamics of inflation in Madagascar in the period 1971-2000, applying cointegration analysis and error correction modeling. The empirical results, based on quarterly data, confirm that there exists a stable money demand relationship, as well as a purchasing power relationship in the long run. The former enters the short-run dynamics of inflation and money growth, while the latter affects the short-run dynamics of the exchange rate only. We also find that an appreciation has a direct negative impact on inflation and that inflation inertia is important. In addition, we conduct FIML estimation of the system and trace the impulse responses to various shocks.

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Keywords: Madagascar, inflation, money demand, exchange rate, cointegration, error correction model

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I. Introduction

1. The objective of this paper is to model the determinants of inflation in Madagascar over the period 1971-2000, paying special attention to the relation between short-run dynamics and long-run equilibrium, and how the impacts on inflation unfold over time. For this purpose an error correction model is developed. The period under study encompasses a number of policy changes and external shocks that are likely to have affected inflation. The exchange rate peg was abandoned in 1982, and import restrictions and price controls were dismantled in the late 1980s as a series of structural adjustment programs was implemented. The banking and financial system and the exchange market were liberalized in the mid-1990s. In addition, several external shocks affected the economy, including oil-price shocks in the 1970s and early 1990s, the coffee booms in the mid 1970s and mid-1980s, and severe political disruptions that took place in the early 1990s.

2. A previous analysis of the determinants of inflation in Madagascar (see Toujas-Bernaté, 1996) has found stable long-term relationships for money demand and the real exchange rate, leading to an error correction representation of inflation. Major methodological differences of the current paper from that study include the use of the more general Johansen's procedure that allows testing for multiple cointegration relationships, instead of the Engle-Granger (1987) procedure which cannot detect the number of cointegrating vectors. In addition, tests for weak exogeneity are performed. System estimation is also carried out, permitting the impulse response to be analyzed. Similarly to the 1996 paper, we also proceed with the estimation of two long-run relationships (money demand and real exchange rate) as a step toward the analysis of the short-run dynamics; the results indicate that there exists a stable money demand type relationship among domestic prices, broad money, real income, and domestic and foreign interest rates, as well as a long-run relationship among the nominal exchange rate, domestic prices, foreign prices, and the terms of trade.

3. Unlike Jonsson (1999), because of data limitations, it was not feasible to estimate the two long-run equations simultaneously within a single vector error-correction model (VECM). Instead, we start by identifying the cointegration relations in two subsystems, and unify the two subsystems when we turn to the short-run dynamics. In the short-run analysis, in addition to estimating a single error correction equation for inflation, we also carried out a simultaneous estimation (relying on the full information maximum likelihood—FIML—methodology), using, as dependent variables, all the variables in the model, including prices, money, exchange rate, and real output. The most salient results of the short-run dynamics, and of the associated impulse response analysis, are as follows: (i) in both the inflation equation and the money growth equation the error correction term from the money demand relationship is significant, while that from the exchange rate relationship is not; (ii) the exchange rate change has, however, a significant direct impact on both inflation and money growth; (iii) there is considerable inflation inertia; (iv) positive shocks to the money supply affect immediately domestic prices, but real money balances increase; (v) inflation has a significant negative impact on nominal money growth; (vi) the change in exchange rate is not

responsive to the error correction term from the money demand relation but is responsive to the error correction term from the external sector. Moreover, an increase in the domestic deposit rate leads to an appreciation of the exchange rate.

4. The paper is organized as follows. Section II provides a brief background to the Malagasy economy. Section III presents the theoretical framework and econometric methodology. Data issues and results from cointegration tests are addressed in Section IV. Section V presents the results from estimating the single equation error correction model for inflation and evaluates its statistical properties. System estimation and impulse response analysis are conducted in Section VI. Section VII draws the main conclusions.

II. BACKGROUND

5. Madagascar benefited from relative price stability over the first two decades since its independence (Figure 1). With the currency pegged to the French franc until 1982, despite having left the franc zone in 1973, the rate of inflation remained below those of its trading partners, and broadly in line with developments in France(Figure 2). With fiscal and monetary policy insufficiently tight, and the accumulation of a monetary overhang, a first burst of high inflation occurred during the early 1980s. A second period of high inflation occurred in 1987-88, associated with a sharp depreciation of the Malagasy franc. This phase was of short duration, and low inflation was achieved in the 1989-93 period, initially as a result of the disciplined financial policies pursued during the period 1988-90 under an IMF-supported program. Starting in 1991, policies became more expansionary, but inflation remained subdued until 1993 as the nominal and real exchange rate appreciated.

6. The consumer price index (CPI) started rising rapidly at end-1993, and inflation remained high in 1994 and 1995 as three shocks affected the Malagasy economy: (i) a rapid expansion of the money supply in 1993-94 resulting from a significant increase of credit to the government and the nongovernment sectors; (ii) the January 1994 cyclone which damaged the paddy rice crop, leading to a surge in rice prices; and (iii) a large depreciation of the real exchange rate following the introduction of a free interbank foreign exchange market in May 1994 (Figure 3). On a 12-month basis, inflation rose to 61 percent at end-1994; however, it abated to 37 percent in the 12 months to end-1995, as tight financial policies were pursued in 1995, entailing an increase in the central bank base rate and in the reserve requirements, as well as a sharp reduction in the overall budgetary deficit, which led to a decline in net bank claims on the government. In 1996 inflation declined further, to 8.3 percent at end-December (year on year), as the further cut in the government deficit allowed a continued decline in net credit to government, and credit to the economy was subdued because of high lending rates. In 1997-98, inflation was broadly stable in the 5 to 6 percent range, as money growth declined further and the nominal effective exchange rate depreciated modestly; it increased, however, in 1999 to 14.4 percent on an end-year basis, as money growth reached 20 percent, spurred by an acceleration in credit to the economy and by an increase in the net foreign assets of the banking system. Money growth and inflation declined in 2000.

III. Theoretical Framework and Econometric Methodology

7. We base our analysis on the recognition that in a small open economy the price level is influenced both by money demand and by imported inflation. Therefore, the approach followed in this paper is to assume that the changes in the domestic price level are the result of deviations from the long-run equilibrium in the money market and in the purchasing power relationship. The equilibrium in the money market requires that real money supply, $(m^s - p)$, is equal to real money demand, m^d, where the latter is assumed to be positively related to real income and its own rate of return, and negatively to the opportunity costs of holding money, expressed by foreign interest rates and variables such as the expected inflation:

$$m^s - p = m^d(y, i, i^*, \Delta p^e), \qquad (1)$$

where m is the logarithm of the money stock, p the logarithm of the domestic price level, y the logarithm of real output, i the interest rate on time deposits (as a proxy of its own rate of return), and i^* the foreign interest rate. The equilibrium in the foreign sector can be expressed by the relation:

$$p = q - e + tot, \qquad (2)$$

where q is the logarithm of the foreign price level, e is the logarithm of the nominal effective exchange rate (defined as foreign currency per unit of domestic currency), and tot is the logarithm of an index of the terms of trade.
The rate of return on foreign assets is expected to be relevant in the money demand function for Madagascar, not only after the liberalization of the foreign exchange market in the early 1990s, but also before, given the close relationships of the business community with key partner countries.

8. Equation (2), which specifies the long-term equilibrium in the market for foreign exchange, contains the terms of trade, as there are indications that the real exchange rate $(e+p-q)$ is nonstationary in Madagascar, as confirmed below, so that the standard formulation of the purchasing power parity does not hold. The presence of the terms of trade in the exchange rate equilibrium relationship is consistent with the hypothesis that a change in the relative prices between exportables and importables should lead to an adjustment in the real exchange rate (see Dornbusch (1980)).

9. With the formulation of the hypothesis of the existence of two long-term relationships, the preferable way to proceed would be to include the variables $(m, p, y, i, i^*, e, q, tot)$ in a single system, with none of the variables assumed a priori to be exogenous, and to estimate a vector autoregression (VAR) model, applying cointegration tests to verify if there are any long run relationships among the variables. The next step would be to use economic theory for identification, so as to move from an empirical model to a structural VAR model, and estimate and test specific cointegrating vectors associated with the money demand and the modified PPP hypothesis. The single system approach is used, for instance, by Jonsson (1999) in his study of inflation in South Africa.

Thus, the analysis would be based on an autoregression model of the form:

$$\Delta x_t = \mu + \sum_{i=1}^{k} \Gamma_i \Delta x_{t-i} + \Pi x_{t-1} + \Phi d_t + \varepsilon_t, \qquad (3)$$

where x_t is the vector of all the variables in the model ($m_t, p_t, y_t, i_t, i_t^*, e_t, q_t, tot_t$); the parameters μ and Γ are allowed to vary without restrictions; k is the lag length of the model; d_t is a vector of deterministic variables; and ε is a vector of errors with mean zero.

10. The existence of cointegration, namely of long-term relationships among the variables of the model, is tested by analyzing the rank of the matrix Π (Fountis and Dickey, 1989; Johansen and Juselius, 1990; and Johansen, 1991). In case of a reduced rank of Π, i.e., if the rank of Π is $r < n$, where n is the number of endogenous variables, then there exists r cointegrating vectors, and the matrix Π can be written as equal to $\alpha\beta'$, where α and β are (n $\times$ r) matrices, with β containing the r cointegrating vectors, and α representing the speed of adjustment to the long run equilibria, or the coefficient of the error correction terms. In this paper we expect the rank of the matrices Π to be two.

11. In practice, it has been recognized (Juselius, 1992) that large vector autoregression models are difficult to handle, and that when many variables are included in a VAR, difficulties to interpret the cointegration space increase. For this reason, we have followed Juselius (1992), Metin (1995), Sekine (2001), and others in deriving long-run relationships from sector VARs. Thus, instead of testing the existence of cointegrating vectors from the full matrix of the system's variables Π, we divide the vector of the endogenous variables in two subsets, the first ($m_t, p_t, y_t, i_t, i_t^*$) pertaining to the monetary sector and the second (e_t, p_t, q_t, tot_t) pertaining to the foreign sector, and we then analyze the two corresponding submatrices Π_1 and Π_2 to identify cointegrating vectors. A similar approach applied to analysis of African economies has been used by Durevall and Ndung'u (1999) for Kenya, and by Nachega (2001) for Uganda.

12. The sectoral approach can be regarded as, in effect, adding certain identifying restrictions to the full system. This approach still allows the short-run dynamics to be analyzed within the context of the full system. In the second part of the paper, we have estimated a single-equation error correction equation for inflation, as well as a simultaneous system of dynamic equations, in which the dependent variable in each equation is the quarterly percentage change of all the system's variables, and explanatory variables include the error corrections terms from the two long-term relations and the lagged changes of all the variables in the system. This allows a more precise analysis of the impulse responses.

IV. Data Issues and Cointegration Analysis

Data and unit root tests

13. The empirical analysis is conducted using quarterly data from 1971:Q1 to 2000:Q4. End-of-period values are used when converting from higher-frequency data. All variables are in logarithms except the interest rates. The money supply is the sum of demand and time

deposits. As GDP is available only at an annual frequency, quarterly GDP data are obtained through an interpolation by cubic method. The money and price series display some seasonality. In order not to alter their time-series properties, centered seasonal dummy variables are used in the estimations instead of preadjusting the series for seasonality. Figure 1 plots the inflation rate and money growth. Figure 2 graphs the series of the nominal effective exchange rate, the domestic CPI, and partner-country CPI, and Figure 3 the real effective exchange rate against the terms of trade. The nominal effective exchange rate is calculated using the trade weights of the Fund's Information Notice System, which take into accounts competitiveness with third countries; the same weights are used to calculate the partner countries' CPI index. For the rate of return on monetary balances, we have used the rate on time deposits with a term of between three months and one year. For the foreign interest rate, in view of the peg with the French franc until 1982, and the close economic relations with France throughout the period, the series of the ten-year government bond yield in France has been used in the estimations. The interest rates are plotted in Figure 4.

14. Standard augmented Dickey-Fuller (ADF) unit root tests (see Table 1) suggest that all variables are nonstationary in levels, while the first differences of the variables are stationary. It is interesting to notice that the real exchange rate is nonstationary, suggesting that the strong version of purchasing power parity hypothesis is not confirmed in this sample period.

Cointegration Analysis

As data are nonstationary, and as none of the variables can a priori be considered as exogenous, we have proceeded to formulate a nonstructural VAR model, with appropriate lags, and have applied cointegration tests to assess whether any long-run relationship exists among the variables; then, as a second step, we have used economic theory, and placed restrictions to identify the long run equations. As explained above, we have proceeded with testing the existence of cointegrating vectors in two subsystems pertaining to the monetary sector and the foreign sectors. Then, for the short-run dynamics, we have estimated simultaneously dynamic equations incorporating the error correction mechanism both from the long-run money demand function and the purchasing power relation.

15. Results from Johansen's maximum likelihood procedure for VAR for the monetary sector are presented in Table 2. The VAR model consists of five lags on m, p, y, i, i^*, a constant, centered seasonal dummies, a dummy for the 1994 cyclone, $dm94q1$, and a dummy for the discontinuation of the peg with the French franc, $dm82\_00$.[2] A trend term is restricted to lie within the cointegration space.

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[2] Certain opportunity cost variables, such as past inflation and past changes in the exchange rate, which can be taken as proxies for expected inflation and expected appreciation, have not been included. They appear to be stationary and thus would not affect whether a group of nonstationary variables are cointegrated or not. In fact, the standard critical values for the

(continued...)

Table 1. Unit Root Tests

	Lags Included	ADF t-Values on Levels	Lags Included	ADF t-Values on First Differences
p	2	0152	1	-4.702**
m	0	1.653	0	-9.308**
y	5	0.651	4	-4.083**
e	0	0.389	0	-9.104**
i	0	-1.533	0	-9.875**
*i**	4	-1.137	3	-5.355**
q	1	-1.765	0	-3.268*
e+p-q	0	-1.087	0	-11.634**
tot	5	-1.087	4	-4.776**

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 starting with fivelags and then removing the insignificant ones.
2. The reported statistics are for the tests with a constant term included. Including a time trend does not alter the results qualitatively.
3. ** indicates rejecting nonstationarity at the 1% significance level. * indicates rejecting nonstationarity at the 5% significance level.

16. Results from cointegration analysis for the external sector are reported in Table 3; also in this case the VAR model includes five lags on each variable, *e, p, q, tot,* a constant, seasonal dummies, the two dummies for the 1994 cyclone and for the discontinuation of the peg.

17. Under the Johansen cointegration procedure, two tests, both based on likelihood ratio statistics, can be applied to determine the number of cointegrating vectors. The maximum eigenvalue statistic tests the null hypothesis of $r = s$ cointegrated relationships against the alternative that $r = s+1$, while the trace statistic tests the same hypothesis $r = s$ cointegrated relationships against the more general alternative of $r \geq s+1$.

18. As can be seen from Table 2, for the monetary sector there is one very large and one very small eigenvalue and three relatively small eigenvalues. On the basis of the maximum eigenvalue test, the hypothesis that there is no cointegrating vector is rejected, while the

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Johansen tests are supplied assuming that in general only nonstationary variables are included in the cointegrating vector.

hypothesis that there is one cointegrating vector is not rejected. According to the trace test, the hypothesis that there is at most one cointegrating vector is not rejected. Thus, we conclude that there appears to be exactly one cointegrating relationship.

Table 2. Cointegration Analysis of the Monetary Sector

Eigenvalue	0.263	0.163	0.115	0.098	0.034	
Null hypothesis on rank = r	$r = 0$	$r \leq 1$	$r \leq 2$	$r \leq 3$	$r \leq 4$	
λ_{max}	37.59*	21.93	15.04	12.72	4.24	
95% critical value	37.50	31.50	25.50	19.00	12.30	
λ_{trace}	91.52*	53.93	32.00	16.96	4.24	
95% critical value	87.30	63.00	42.40	25.30	12.30	
	m	p	y	i	i*	trend
Cointegrating vector	1.000	-1.045	-0.947	-0.067	0.030	-0.010
Restricted cointegrating vector	1.000	-1.000	-1.000	-0.036	0.036	-0.008
$\chi^2(2)$	1.154 [0.764]					

The estimated cointegrating vector is reported in the seventh line of Table 2. The long run relationship can be written as

$$m = 1.045p + 0.947y + 0.067i - 0.030i^* + 0.010trend. \qquad (4)$$

This equation has the properties of a money demand function. All the coefficients have the right signs suggested by a money demand function. Furthermore, the price elasticity and income elasticity are close to unity. Including the trend term in the long run relationship captures the effect of financial deepening over time.

19. If the cointegrating vector represents a demand function for real money balance, the coefficient on p could be restricted to unity, and it is appropriate to test whether the income elasticity is unity and whether the semielasticities on the two interest rates are of equal magnitude but opposite signs, as economic theory would suggest. Imposing these restrictions, we have obtained a relationship that could not be rejected, according to the chi square statistics of the likelihood ratio tests (see Table 2, last row). The restricted long-run money demand function can be written as

$$m - p = y + 0.036(i - i^*) + 0.008trend. \qquad (5)$$

Results from the cointegration analysis for the external sector are reported in Table 3.

The maximum eigenvalue test indicates that the hypothesis that there is no cointegrating vector can be rejected at the 99 percent level; the hypothesis there is only one cointegrating vector cannot be rejected at the 95 percent level. According to the trace test, we cannot reject the hypothesis that there is at most one cointegrating vector. We thus conclude that there appears to be only one such vector. The estimated cointegrating vector is reported in the seventh row of Table 3. The long-run relationship, unconstrained, can be written as follows:

$$e = -0.763p + 0.660q + 0.183tot. \qquad (6)$$

Table 3. Cointegration Analysis of the External Sector

Eigenvalue	0.230	0.092	0.037	0.008
Null hypothesis on rank = r	$r=0$	$r\leq 1$	$r\leq 2$	$r\leq 3$
λ_{max}	32.14**	11.93	4.63	1.00
95% critical value	27.10	21.00	14.10	3.80
λ_{trace}	49.69*	17.55	5.63	1.00
95% critical value	47.20	29.70	15.40	3.80
	e	p	q	tot
Cointegrating vector	1.000	0.763	-0.660	-0.183
Restricted cointegrating vector	1.000	1.000	-1.000	-0.223
$\chi^2(2)$	1.550 [0.461]			

Although the unconstrained coefficients on the prices seem not close to unity, contrary to what economic theory would predict, the hypothesis that the coefficients on p and q are equal to one cannot be rejected (see eighth row of Table 3). The restricted cointegrating vector can be written as:

$$e + p - q = 0.223tot. \qquad (7)$$

The coefficient on *tot* is 0.22, which is very close to that obtained for Kenya by Elabadawi and Soto (1997), 0.32, and by Durevall and Ndung'u (1999), 0.36.

20. In summary, in this section we have detected two cointegrating vectors through Johansen's tests, which can be interpreted as representing a long-run money demand function and a long-run real exchange rate function. Furthermore, restrictions deemed appropriate by economic theories are not rejected. The restricted cointegrating vectors are graphed in Figure 5.

V. SHORT-RUN DYNAMICS

21. A cointegrated system can be written in the error correction form of equation (3), which, employing $\Pi = \alpha\beta'$, becomes the following:

$$\Delta x_t = \mu + \sum_{i=1}^{k} \Gamma_i \Delta x_{t-i} + \alpha\beta' x_{t-1} + \Phi d_t + \varepsilon_t \qquad (8)$$

The difference between the error correction model and a simple vector autoregressive model in first differences lies in the $\beta' x_{t-1}$ term, which takes the values of the cointegrating vectors in the previous period. This term indicates how much the system deviates from the long-run equilibrium in the previous period and is called the error correction term. α represents the speed of adjustment at which the system returns to equilibrium. The error correction model assumes that the endogenous variables, such as domestic prices, not only respond to short-term changes of the variables in the system, but also are a function of their deviation in the previous period from the long-run equilibrium. When cointegration is present, fitting simple VAR models in first differences will overlook the useful information contained in the levels of the variables.

Weak Exogeneity

22. In a system of error correction equations, if the error correction term does not enter the equation for one variable, that variable is said to be weakly exogenous. Thus it is possible to test whether a variable is weakly exogenous by testing whether the coefficient on the error correction term,that is the corresponding element in α, is zero. It can be shown that, if a variable is weakly exogenous, it can be left out of the system without affecting the statistical properties of the test statistics of hypotheses about the cointegrating vector (see, for example, Ericsson 1998). The distribution of these test statistics will depend on all other variables that are not weakly exogenous, and the system must be estimated as a whole to make correct inference about the cointegrating vector. It is worth noting that estimating the equations jointly is needed only for testing hypotheses about the cointegrating vector. For making consistent estimates of the coefficients or testing hypotheses on other coefficients, estimating the equations separately is sufficient (Johansen, 1992).

23. Table 4 shows the *p*-values of the test statistics for testing whether the price, money, domestic deposit rate, French government bond rate or real output variables are weakly exogenous. The *p*-values indicate that while we can reject the hypothesis of weak exogeneity for the price, money, and domestic interest rate variables, we cannot reject the hypothesis for foreign interest rates and real income. If an external shock causes the system to deviate from its long-run path, the above test suggests that money, prices and domestic interest rate will adjust over time to restore the long-run equilibrium. This means that, if a simultaneous equation model is used, the error correction mechanism should be introduced in the equations

for money, prices, and domestic interest rates, but not in the equation for the foreign interest rate and real income.

Table 4. Monetary Sector: Tests for Weak Exogeneity

	χ^2	p-Value for the Test Statistic
p	4.800	0.029
m	8.288	0.004
i	5.894	0.015
i^*	0.254	0.614
y	2.211	0.137

24. A similar test is conducted for the external sector (Table 5).

Table 5. External Sector: Tests for Weak Exogeneity

	χ^2	p-Value for the Test Statistic
e	17.389	0.000
p	1.264	0.261
q	1.311	0.252
tot	1.204	0.272

In this case, the results suggest that we can reject the hypothesis of weak exogeneity for the exchange rate, but we cannot reject the hypothesis for domestic prices, foreign prices, and the terms of trade.

Single Equation Error Correction Model for Inflation

25. This section presents the development of a single equation for inflation in Madagascar, based on an error correction model. First, a general model is estimated, and then a modeling strategy is used to arrive at an empirically parsimonious model, in which the number of lagged variables is reduced and insignificant explanatory variables are omitted.

Table 6. Coefficient Estimates of the Error Correction Inflation Equation

Regressor	Unrestricted Coefficients	Restricted Coefficients	Regressor	Unrestricted Coefficients	Restricted Coefficients
Δp_{t-1}	-0.019 (-0.182)		Δq_{t-1}	0.390 (0.865)	
Δp_{t-2}	0.026 (0.245)		Δq_{t-2}	-0.142 (-0.264)	
Δp_{t-3}	-0.219** (-2.160)		Δq_{t-3}	-0.122 (-0.226)	
Δp_{t-4}	0.269** (2.843)	0.240** (3.145)	Δq_{t-4}	0.015 (0.031)	
Δm_{t-1}	0.045 (0.656)		Δi^*_{t-1}	-0.001 (-0.077)	
Δm_{t-2}	-0.004 (-0.063)		Δi^*_{t-2}	0.015* (1.954)	
Δm_{t-3}	0.004 (0.055)		Δi^*_{t-3}	-0.003 (-0.418)	
Δm_{t-4}	-0.012 (-0.188)		Δi^*_{t-4}	0.011 (1.482)	
Δe_{t-1}	-0.060 (-1.422)	-0.083** (-2.322)	$EC1_{t-1}$	0.054** (3.006)	0.050** (3.738)
Δe_{t-2}	-0.024 (-0.540)		$EC2_{t-1}$	-0.006 (-0.360)	
Δe_{t-3}	-0.066 (-1.423)	-0.079** (-2.200)	$dm94q1$	0.096** (4.688)	0.088** (5.914)
Δe_{t-4}	-0.055 (-1.272)		$dm82\_00$	0.048** (3.295)	0.039** (3.121)
Δi_{t-1}	0.001 (0.369)		Constant	0.184* (1.778)	0.153** (4.305)
Δi_{t-2}	-0.001 (-0.251)				
Δi_{t-3}	0.001 (0.461)				
Δi_{t-4}	-0.001 (-0.285)				

Notes:
1. t-statistics are in parentheses.
2. ** indicates significant at 5% level. * indicates significant at 10% level.
3. Diagnostic tests of the restricted model: testing for error autocorrelation from lags one to five $\chi^2(5) = 7.7916$ [0.1681]; normality $\chi^2(2) = 7.9106$ [0.0192]; autoregressive conditional heteroskedasticity (ARCH) from lags 1 to 4 $\chi^2(4) = 5.332$ [0.2549]; heteroskedastic errors $\chi^2(8) = 2.9006$ [0.9404].

26. The general model is estimated with four lags of each variable in the first differences, two error correction terms- defined as $EC1 = [m - p - y - 0.036(i - i^*)]$ and $EC2 = [e + p - q - 0.22tot]$- and the appropriate dummy variables and seasonal dummies;interpolated annual variables, y and tot, are not included.

$$\Delta p_t = \alpha + \sum_{i=1}^{4} \beta_i \Delta p_{t-i} + \sum_{i=1}^{4} \gamma_i \Delta m_{t-i} + \sum_{i=1}^{4} \delta_i \Delta e_{t-i} + \sum_{i=1}^{4} \lambda_i \Delta q_{t-i} + \sum_{i=1}^{4} \omega_i \Delta i_{t-i} + + \sum_{i=1}^{4} \theta_i \Delta i^*_{t-i} \tag{9}$$
$$+ \kappa_1 EC1_{t-1} + \kappa_2 EC2_{t-1} + \chi_1 dm94q1 + \chi_2 dm82\_00 + \phi_1 S_1 + \phi_2 S_2 + \phi_3 S_3 + \varepsilon_t .$$

The reduction from the general model is carried out by removing the variables with low t-values, and then using F tests and the Schwarz information criterion to check the appropriateness of the simplification (test results not reported). None of the F-statistics, comparing the initial, the intermediate and the final model, are significant, and the Schwarz criterion becomes more and more negative for each model. Hence, the simplification appears statistically valid.

27. Table 6 reports the estimation results. The estimated coefficient on the error term $EC1$ is 0.05. Instead, the coefficient for $EC2$ is not statistically significant. Therefore, out of the two error correction terms, only the one for the monetary sector remains in the parsimonious model. However, it is shown below that the $EC2$ relationship has an impact on the exchange rate, and the latter influences the rate of inflation; thus, indirectly, the deviation from the long-run equilibrium in the foreign sector affects inflation. The adjustment coefficient on $EC1$ suggests that, if the money stock level is 10 percent higher than the equilibrium level in one quarter, this will cause inflation to increase by 0.5 percent in the following quarter. While money growth does not have a significant direct impact on inflation, its effect is transmitted through the error correction mechanism.

28. Table 6 also shows that changes in the exchange rate have significant effects on inflation, so that a depreciation causes inflation to rise. Also, there is considerable inflation inertia, with lagged inflation entering with a coefficient of 0.24 in the restricted model.

29. Figure 6 plots the fitted inflation and the actual inflation series. It appears that the error correction model traces the movements of inflation in a satisfactory manner.

Diagnostic Tests

30. To evaluate the statistical properties of the model, a battery of tests was conducted. We present the results for the single equation parsimonious model. Several misspecification tests were performed on the residuals and are reported in the notes to Table 6. Error autocorrelation, ARCH errors, and heteroscedastic errors are rejected. However, normality can be rejected from the data. Overall, the residuals seem to be well behaved.

31. The model was estimated recursively from 1975 to 2000 to examine its stability. Figure 7, top panel, plots the one-step residuals and their ±2 standard errors. Almost all the residuals lie within the ±2 standard error band, except, as expected, for 1994, when a large

spur in inflation occurred. One-step and breakpoint Chow test statistics are presented in the middle and bottom panel of Figure 7. Almost all the Chow test statistics are not significant at the 5 percent level, except, again, for the year 1994, as could be expected. Hence, we conclude that the stability of the model is acceptable.

VI. System Estimation of the Error Correction Model and Impulse Responses

32. To utilize all the information contained in the data, we estimate via full information maximum likelihood (FIML) the full system consisting of an error-correction equation for each of the eight variables in the system. Table 7 reports the results of the FIML estimation for the variables that we are most interested in: prices, money, and the exchange rate. The explanatory variables that are not significant have been dropped from the estimation.

33. The price equation is essentially the same as in the OLS estimation, which has been discussed in the previous section. In the price equation (with Δp as the dependent variable, i.e., the rate of inflation), the coefficient of the error correction term in the monetary sector, $EC1$, is significant and equal to 0.06; this indicates that approximately 6 percent of the excess in the money supply is reabsorbed through inflation in each quarter. In addition, inflation inertia is significant, as indicated by the 0.23 coefficient on lagged inflation. The error correction term from the foreign sector is not significant, but the change in the nominal exchange rate has a direct impact on inflation.

34. The money equation (Δm, money growth, being the dependent variable) shows that broad money growth depends on lagged inflation, the lagged exchange rate change, and the error correction term, $EC1$. The interest rate terms are not significant. The previous-quarter inflation rate is significant at the 5 percent level, with a coefficient of -0.32, but the coefficients on further lags of inflation are not significant. Thus, for an increase in inflation of 10 percentage points, nominal money growth would decline by about 3.2 percentage points. This could be explained by the central bank's tightening money supply in response to an increase in inflation, or by the public's desire to hold money declining markedly when inflation increases. The error correction term from the monetary equilibrium is significant, with a coefficient of -0.07. This means that about 7 percent of any disequilibrium in the money market is absorbed in the next quarter. As for the change in the nominal exchange rate, it has a significant coefficient, equal to –0.12; this indicates that following a 10 percent depreciation the nominal money demand rises by 1.2 percent, presumably because of transaction needs.

35. The impact of an exchange rate depreciation in the price and in the money equations, that is on inflation and on nominal money growth, is broadly similar; thus, the estimate suggests that a depreciation has almost no impact on real money growth.

Table 7. FIML Estimates of the Restricted Error Correction System

Regressor	Δp_t	Δe_t	Δm_t
Δp_{t-1}		-0.478** (-2.374)	-0.321** (-2.724)
Δp_{t-3}		0.483** (2.627)	
Δp_{t-4}	0.230** (3.416)		
Δe_{t-1}	-0.069** (-2.199)		-0.117** (2.230)
Δe_{t-3}	-0.086** (-2.758)		
Δe_{t-4}		0.159* (1.847)	
Δi_{t-1}		0.013** (2.053)	
$EC1_{t-1}$	0.064** (5.050)		-0.068** (-2.979)
$EC2_{t-1}$		-0.070** (-2.944)	
Constant	0.185** (5.567)	0.286** (2.950)	-0.135** (-2.263)
$dm82\_00$	0.051** (4.287)	-0.042** (-2.751)	-0.048** (-2.336)
$dm94q1$	0.112** (7.679)	-0.159** (-4.246)	0.071** (3.052)

Notes:
1. t-statistics are in parentheses.
2. ** indicates significant at 5% level. * indicates significant at 10% level.

1. With respect to the exchange rate equation, the results reported in Table 7 show that the exchange rate change depends significantly on the past deviation from the long-run equilibrium in the external sector. If the exchange rate is below the level required by the long-run equilibrium, it will move higher to restore the equilibrium. The coefficient on the error correction mechanism is -0.07, indicating that about 7 percent of the disequilibrium is corrected every quarter. A higher domestic deposit rate tends to cause the local currency to appreciate, as local currency-denominated assets become more attractive. The exchange rate changes also display a high degree of serial correlation.

Impulse Response Analysis

2. From the FIML estimation, it is possible to analyze the short-run dynamics and the comovements among the variables through impulse response functions. Thus, we can examine the impact of different shocks on the variables in the model and analyze the lagged

structure of the responses. Impulse response functions have been generated with shocks to the p, m, i^*, e, q, y, tot, and i equations. Each initial shock is assumed to be a one-unit shock. The results are presented in Figures 8 and 9 (for the latter, cumulated responses), where we focus on the responses of three domestic variables, Δp, Δm, and Δe. Real output growth, being interpolated from annual data, appears to follow an autoregressive process only.

38. As Figures 8 and 9 show, a positive shock on domestic prices leads, as expected, to a cumulative depreciation of the nominal exchange rate. The impact of inflation on money growth, after being negative in the first few quarters, becomes positive thereafter, but the cumulative effect is only about 0.5; this suggests that, responding to a spur in inflation, money supply tightens initially but then expands, although not enough to offset the increase in prices, so that the real money growth declines.

39. A shock to the nominal money growth leads to an immediate increase in inflation; however the cumulative impact is well below unity, about 0.4 over 20 quarters. This outcomes, along with a cumulative increase in nominal money growth of 0.7 of the initial shock over 20 quarters, indicates that the growth in real money stock rises by about 0.3 over 20 quarters. As mentioned before, a shock to money growth does not affect real GDP growth, as the interpolated GDP growth series appears to follow an autoregressive process only. This result can be compared with that found by Jonsson (1999) in the case of South Africa, where a positive effect of an increase in money stock on output in the first 5 quarters vanishes in the next 10 quarters, while real money balances adjust back toward their initial level. In addition, following a positive monetary shock, the nominal exchange rate starts depreciating after about 5 quarters, and the cumulative depreciation is about 0.2 of the increase in the growth of the money stock after about 15 quarters.

40. A shock to the change of the nominal exchange rate, such as an appreciation (a positive shock), leads immediately to lower inflation, with a cumulative effect in 8 quarters of -0.2, but this impact fades out in the following quarters. The effect on money growth, although similar to that on inflation, is of a smaller magnitude in the first 15 quarters. This suggests that an appreciation of the exchange rate increases real money growth in the first 15 quarters and leaves real money balances broadly unchanged afterward.

41. Most of the impact of a rise in the domestic deposit rate on money growth and inflation is displayed in the first 10 quarters. Not surprisingly, the money growth increases and the nominal exchange rate appreciates as local-currency denominated assets become more attractive. The appreciation causes inflation to fall.

VII. Conclusions

42. The objective of this study was to examine the dynamics of inflation in Madagascar using, both a single-equation error correction model and an error correction model estimated for a complete system of variables. The single-equation model is parsimonious and empirically stable. The equation allows the evaluation of the relative impact on inflation of changes in money, the exchange rate, and lagged inflation. The adjustment of inflation to

disequilibria in the money market is relatively slow, with about 6 percent of the disequilibrium absorbed in one quarter. Inflation inertia is relatively strong, with the lagged inflation having a coefficient of 0.24.

43. The system estimation highlights the impact on prices, the money supply, the exchange rate, and real output of all the other variables in the system. Inflation is affected by money growth and the change in the exchange rate, and there is also a considerable inertia. However, the impulse response analysis indicates that the cumulative impact on prices of an increase of the money stock is significantly below unity, so that real money balances increase. Any deviation from the long-run money demand relationship takes about 16 quarters to be reabsorbed. A depreciation of the exchange rate has a broadly similar effect on inflation and nominal money growth, so that it leaves real money balances broadly unchanged. The exchange rate depends mostly on the past deviation from the long-run equilibrium between the real exchange rate and the terms of trade. Also, a rise in the domestic deposit rate has a positive effect on the exchange rate, which subsequently lowers the inflation rate.

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Figure 1. Inflation and Money Growth, 1969-2000

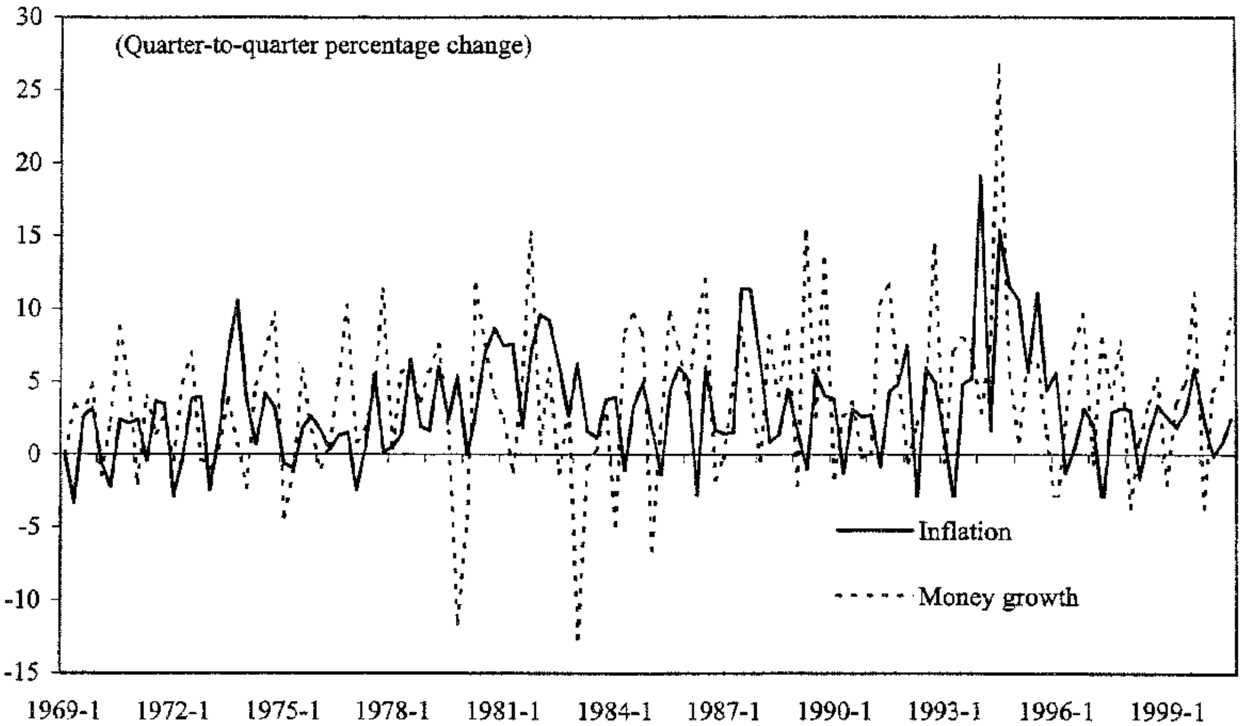


Figure 2. CPI, Exchange Rate, and Foreign Price, 1969-2000

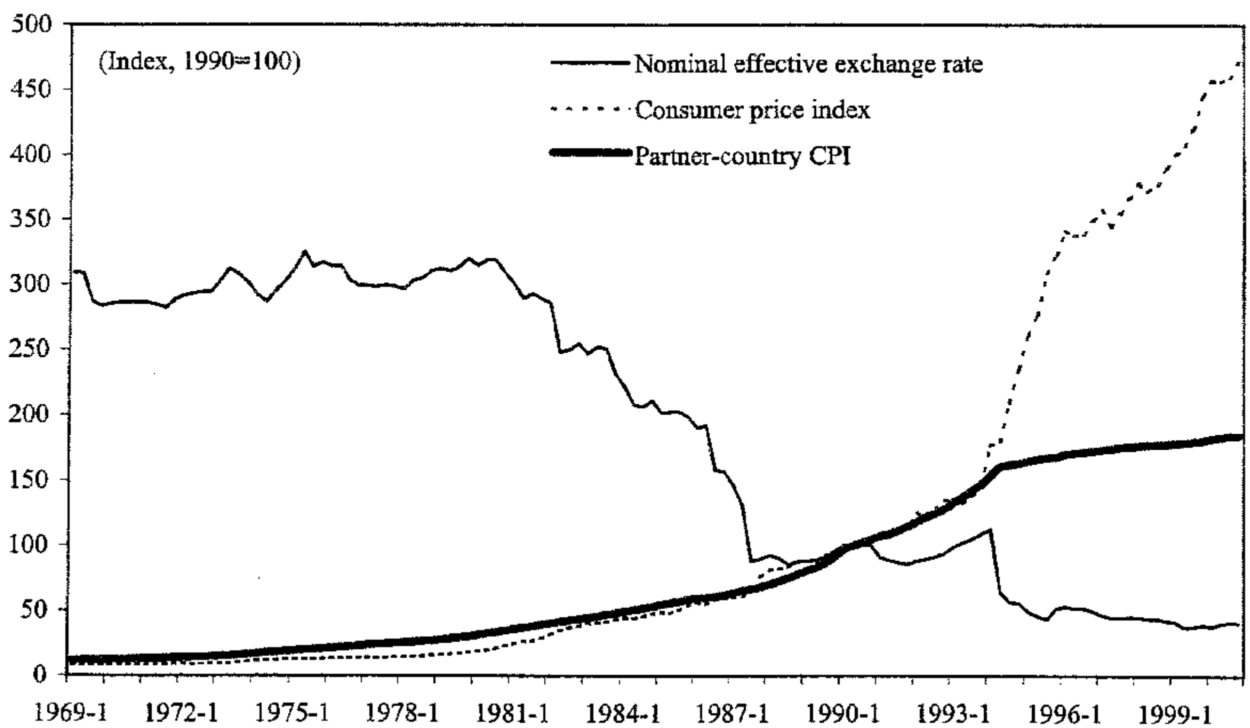


Figure 3. Real Effective Exchange Rate and Terms of Trade, 1969-2000

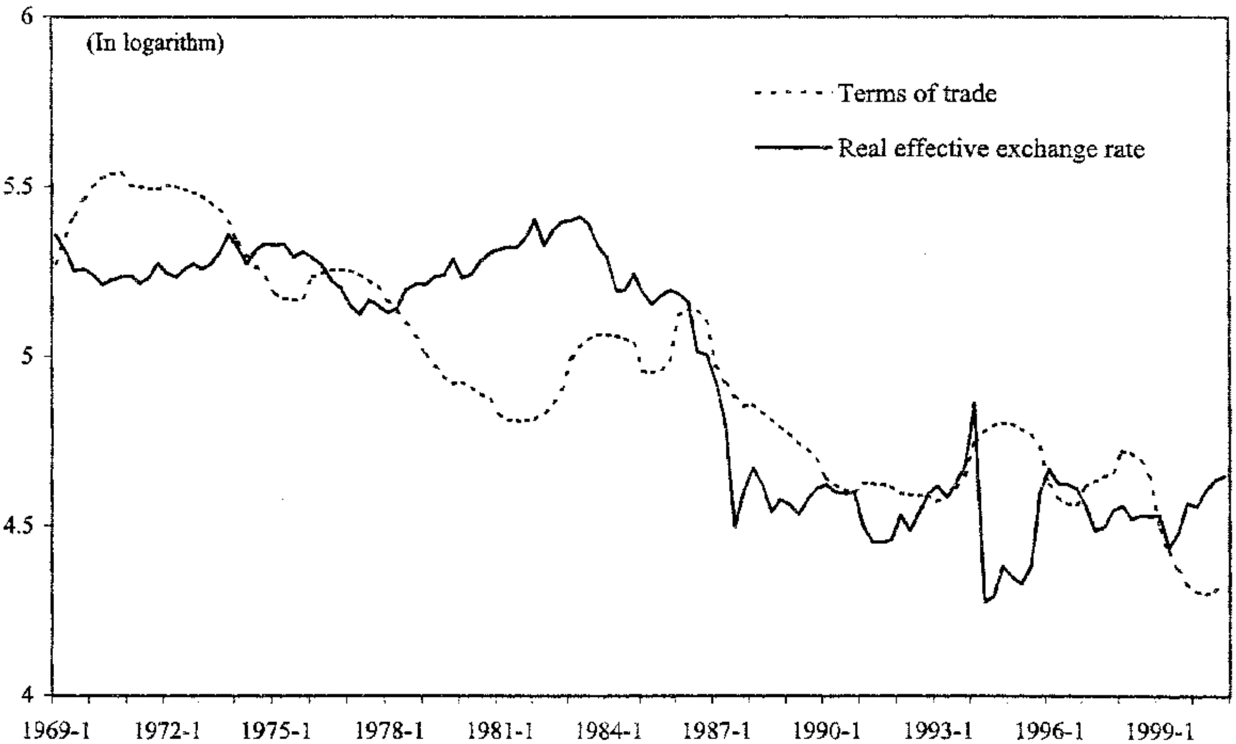


Figure 4. Domestic and Foreign Interest Rates, 1969-2000

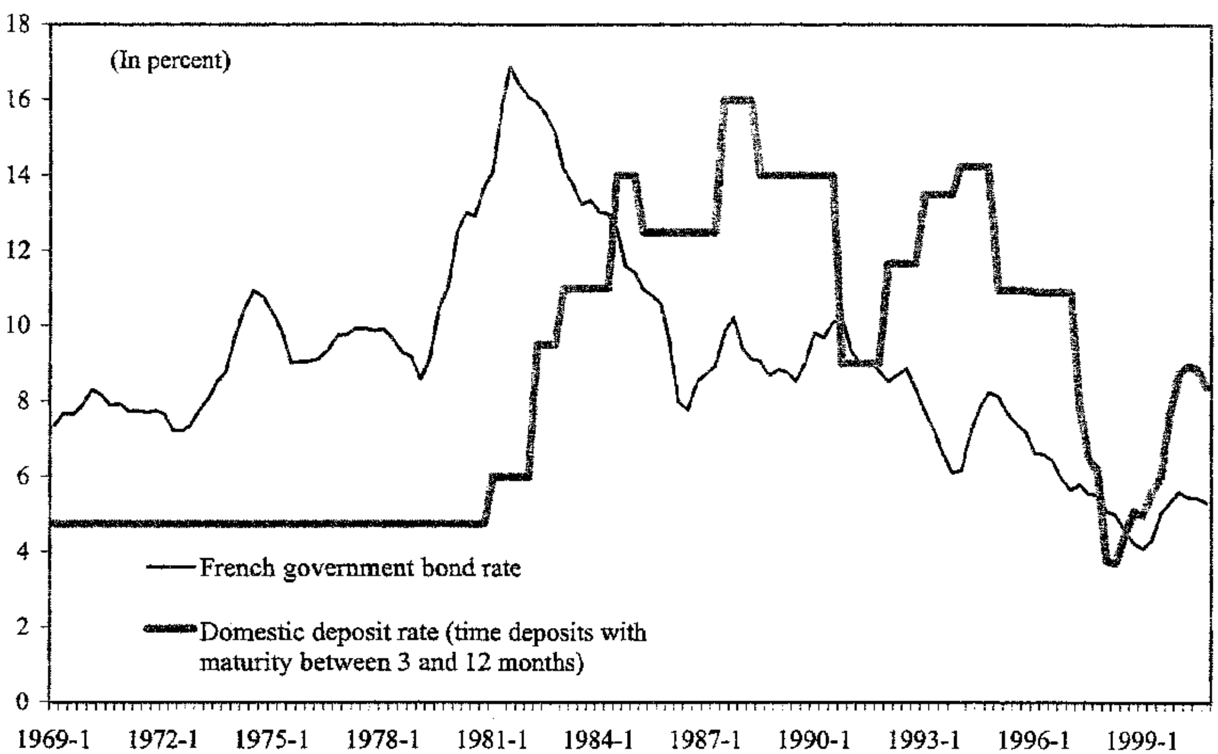


Figure 5. Restricted Cointegrating Vectors

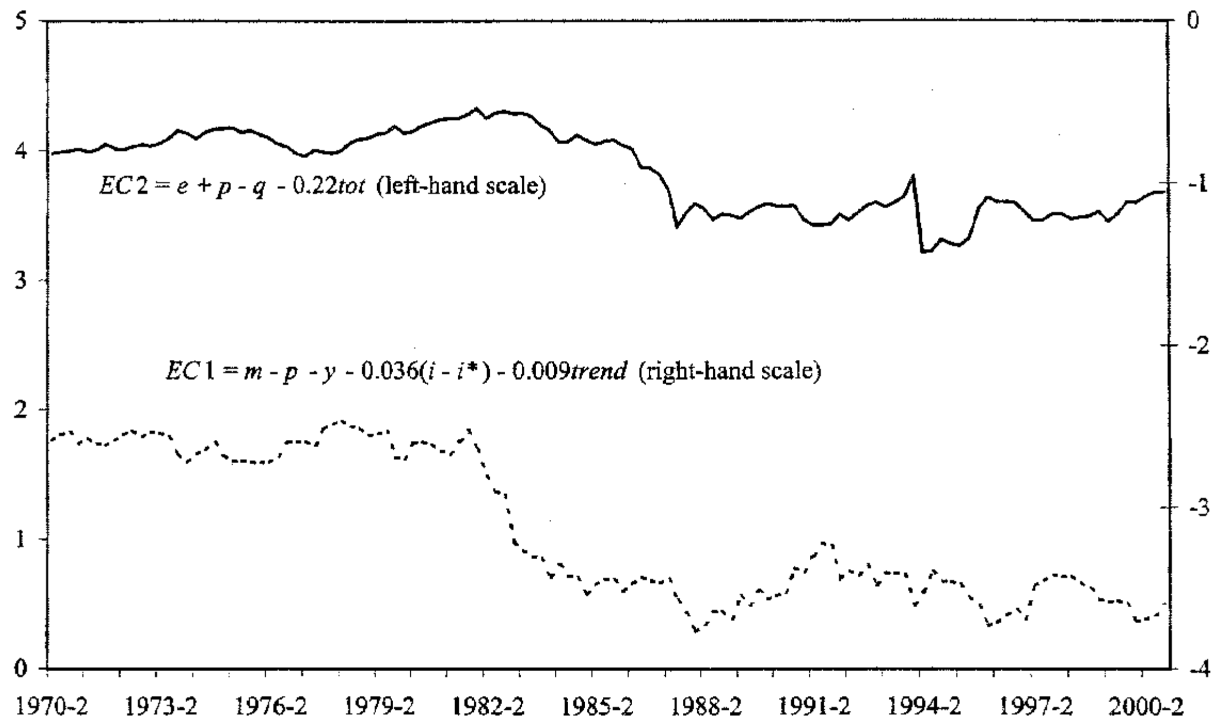


Figure 6. Fit of the Inflation Equation

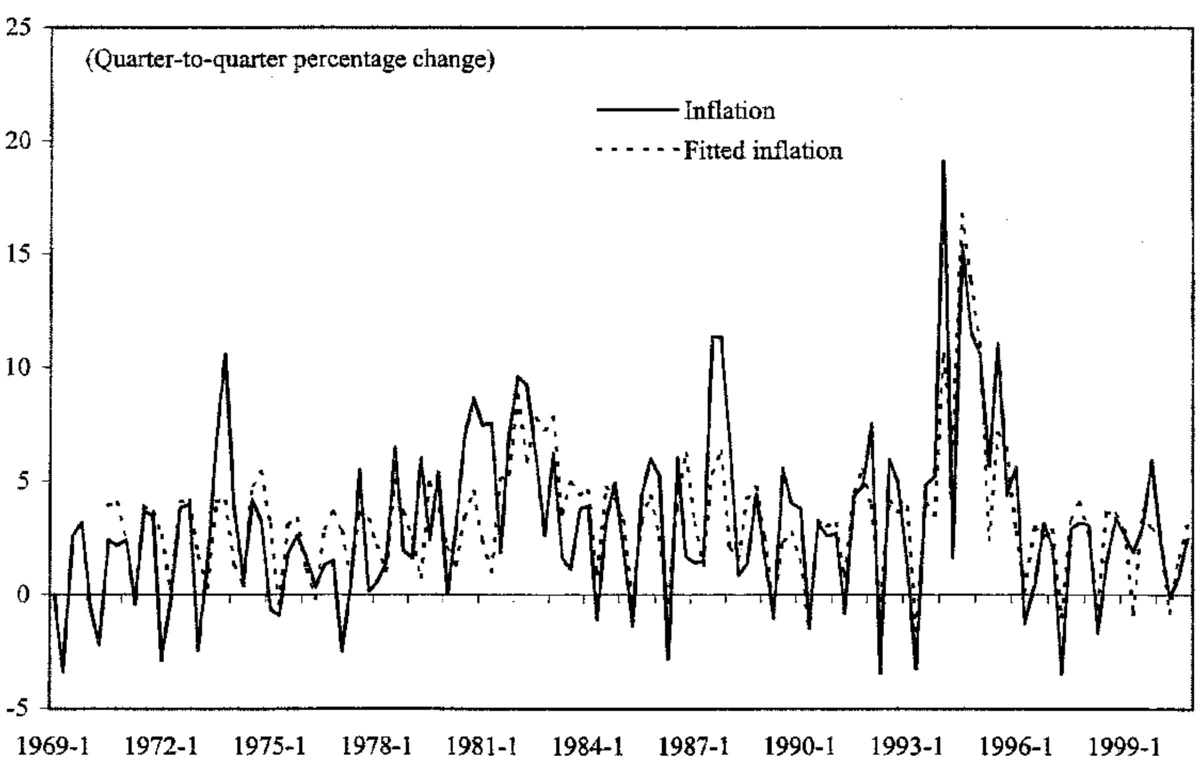


Figure 7. Stability Tests of the Restricted Inflation Equation

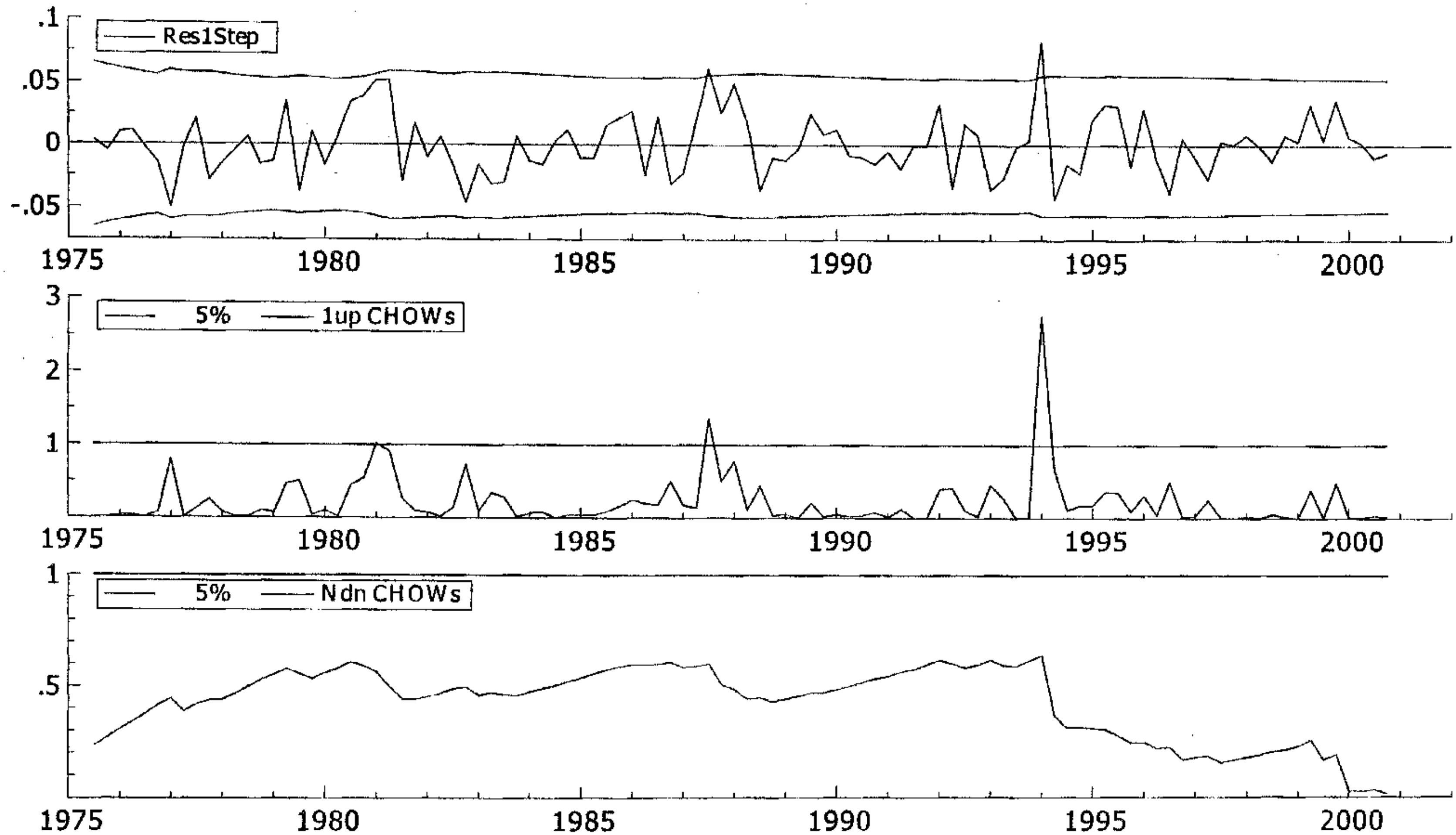
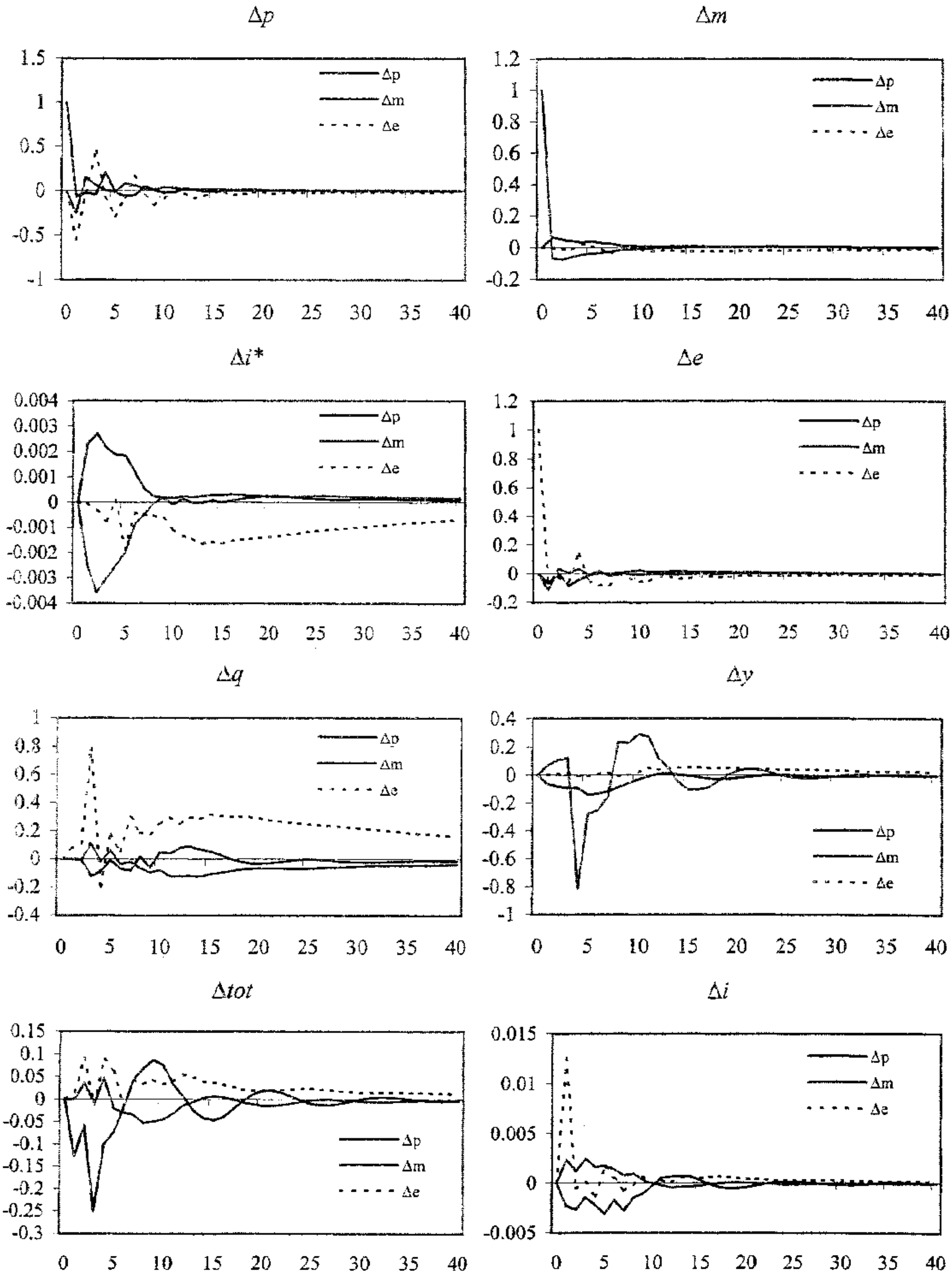
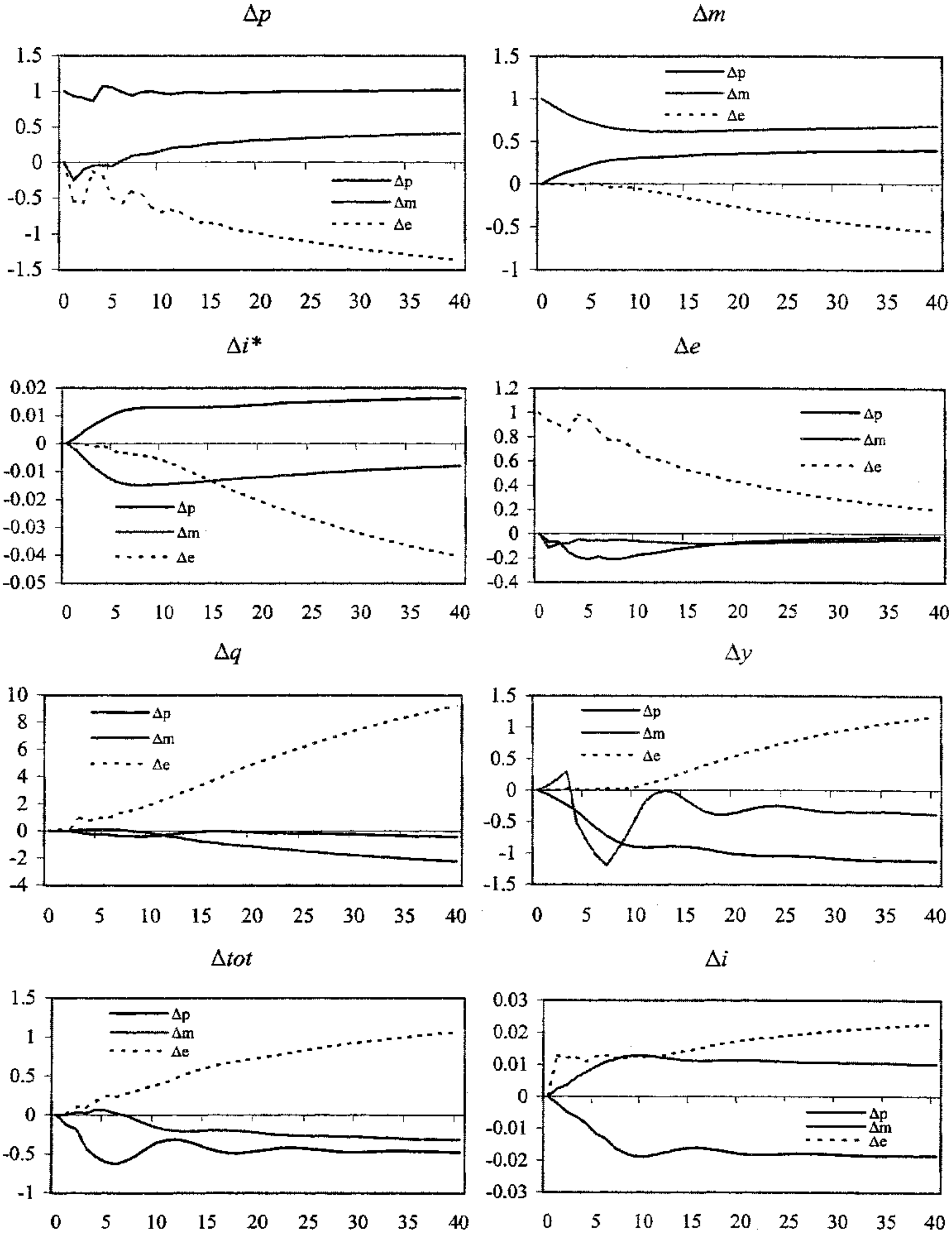


Figure 8. Impulse Responses in the Full Model 1/



1/ Each panel shows the impact of a one-unit shock in the variable indicated on the top of the panel on the three variables: Δp, Δm, and Δe.

Figure 9. Accumulated Impulse Responses in the Full Model 1/



1/ Each panel shows the impact of a one-unit shock in the variable indicated on the top of the panel on the three variables: Δp, Δm, and Δe.