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Money Demand and Inflation in Madagascar

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Abstract

This Working Paper should not be reported as representing the views of the IMF.
The views expressed in this Working Paper are those of the author(s) and do not necessarily represent those of the IMF or IMF policy. Working Papers describe research in progress by the author(s) and are published to elicit comments and to further debate.

This paper uses a two-sector model to estimate the relationship between prices, money, and the exchange rate in Madagascar during the period 1982-2004. The estimated model, using quarterly data, finds a stable long-run relationship among monetary aggregates, domestic prices, real income, and foreign interest rates. In addition, the error-correction model shows that changes in the monetary aggregates, the exchange rate, and foreign interest rates exert a significant impact on inflation. The results also suggest that a disequilibrium in the money market has a lasting impact on inflation. The paper concludes with policy recommendations.

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Contents Page

I. Introduction

Countries with underdeveloped financial markets generally rely on the existence of a stable money demand function for the formulation and conduct of efficient monetary policy. The literature on the determinants of inflation in developing countries traditionally postulates a money demand function and then specifies how expansionary monetary policy creates a disequilibrium in the money and goods markets that is eliminated over time through increases in the price level.[2] In the case of Madagascar, two previous studies (Toujas-Bernaté, 1996; and Sacerdoti and Xiao, 2001)[3] support the existence of a stable long-run relationship between monetary aggregates and inflation. However, since 2001, inflation (the consumer price index, CPI) has been highly volatile, while broad money expanded by about 17 percent on average. This raises the question as to whether the link between broad money growth and inflation has changed fundamentally over time.

The purpose of this paper is to model the determinants of inflation in Madagascar over the period 1982-2004, with a view to strengthening the effectiveness of monetary policy. In view of the numerous structural shifts, policy reversions, terms of trade shocks, adverse weather conditions (cyclones), and political crises that have affected the economy, as well as data deficiencies in terms of coverage, time span, and statistical properties, finding an empirically stable and parsimonious model of the determinants of inflation in Madagascar is a major challenge. This study adds to the empirical work on inflation dynamics in Madagascar by extending the literature to recent years, a period characterized by a flexible exchange rate regime. In addition, the analytical framework builds on the institutional setup for the conduct of monetary policy.

The results confirm the existence of a stable long-run relationship between broad money, domestic prices, real income, and foreign interest rates and suggest that a disequilibrium in the money market has a lasting inflationary impact. The results further indicate that changes in the monetary aggregates, the exchange rate, and foreign interest rates have a significant impact on inflation. In addition, the results show inflation inertia, suggesting that the central bank does not adequately explain its monetary policy stance to the public.

The paper is organized as follows. Section II describes the institutional framework for the conduct of monetary policy and the evolution of inflation and relevant macroeconomic variables. Section III specifies the model used in the empirical work. Data issues and results

[2] See for example Blavy (2004), Williams and Adedeji (2004), Maliszewski (2003), Celasun and Goswami (2002), Nachega (2001a and 2001b), Sacerdoti and Xiao (2001), Kalra (1998), Kuijs (1998), Lim and Papi (1997), and Toujas-Bernate (1996). See Sriram (2001) for a survey of earlier empirical money demand studies.

[3] The study by Toujas-Bernate (1996) covered the period 1971–95, while that by Sacerdoti and Xiao (2001) covered 1971–2000.

from cointegration tests are discussed in Section IV. Section V presents the results from estimating the single equation error-correction model for inflation and evaluates its statistical properties. Section V also presents systems estimation and impulse response analysis. Section VI presents the main conclusions.

II. Monetary Policy Framework and Macroeconomic Developments

A. Background

Madagascar entered the 1980s with substantial internal and external imbalances, following decades of state interventions in all sectors of the economy (Sacerdoti and Xiao, 2001; Azam, 2001; and Toujas-Bernaté, 1996). In the late 1970s and early 1980s, inflation was stoked by seigniorage financing of high fiscal deficits. Since the exchange rate was pegged to the French franc and interest rates administratively determined, this triggered a process of financial disintermediation in the early 1980s. Eventually, Madagascar abandoned its currency peg with the French franc in 1982 and instituted a crawling peg system from 1982 to 1994, accompanied by frequent step devaluations, notably in 1987. Private and foreign banks were allowed into the banking sector starting in the early 1990s, and an interbank foreign exchange auction system was introduced in 1994.

The government implemented other structural reforms in the early 1990s, including the liberalization of the export sector, with a view to deregulating economic activity and developing the private sector. These reforms contributed to macroeconomic stability and real GDP growth in the late 1990s. However, a political crisis in 2002 severely impacted economic activity, causing the real GDP growth rate to decline sharply before recovering in 2003.

B. Monetary Policy Framework

The primary objective of monetary policy, as stated in the central bank of Madagascar's (BCM) charter of 1994, is to "maintain price stability." To achieve price stability, the BCM conducts monetary policy within a monetary programming framework that focuses on achieving an annual target for the rate of growth of broad money (M3, including foreign currency deposits). Assuming a stable money demand function, M3 serves as the intermediate guide for monetary policy and is based on assumptions regarding the real GDP growth rate and CPI inflation. The M3 target for the annual program is translated into an operating guide for base money, using an assumed money multiplier that is set on the basis of a three-month moving average. The framework essentially aims at managing base money to attain the target for broad money consistent with the inflation objective. In the process, interest rates and the exchange rate are expected to respond endogenously to the behavior of base money.

The BCM conducts monetary policy mainly with direct policy instruments. Although indirect market instruments were adopted starting with the introduction of a treasury bills market and a money market in the mid-1990s,[4] chronic excess liquidity conditions have hampered the emergence of positive real interest rates and the development of interbank market trading[5] and instruments. In the absence of effective indirect monetary policy instruments, the BCM regulates base money and overall liquidity mainly by changing the statutory reserve requirement ratio. In addition, the BCM announces a basic rate *(taux directeur)*, which is designed to lock in economic agents' inflation expectations and serve as a basis for setting other interest rates.

C. Evolution of Inflation and Real Money Balances

There is evidence of persistent moderate inflation in Madagascar (Figure 1 and Table 1). Over the period 1982–2004, inflation has displayed a strong correlation with broad money growth and exchange rate movements, especially during periods of high inflation. During 1987–2004, Madagascar experienced three large exchange rate shocks: in June 1987 (following the devaluation of the currency), May 1994 (following the introduction of a floating exchange rate regime), and the first half of 2004 (following the tax and tariff exemptions of capital goods and selected other imports put into effect since September 2003). In the aftermath of the 1987 and 2004 depreciation episodes, inflation soared against a background of moderate inflation. However, inflation had already started to accelerate before the 1994 depreciation.

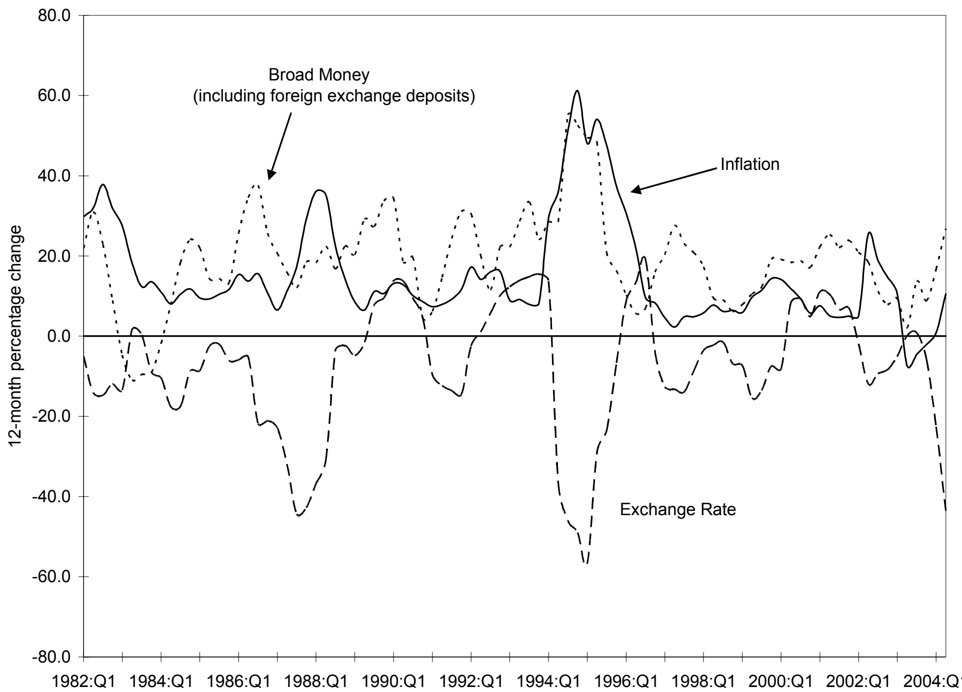
More recently, despite a tightening of monetary policy, demand for real money balances weakened. Following the 2002 economic slump, the central bank lowered the reserve requirement ratio on two occasions—in October 2002 and in January 2003—with a view to accelerating GDP growth. Monetary policy remained expansionary until early 2004, when the exchange rate started to depreciate sharply and inflationary pressures intensified. The central bank took successive monetary tightening measures in 2004, including three consecutive increases of the reserve requirement ratio. These measures increased interest rates on treasury bills across the board and absorbed the excess liquidity that had accumulated in the banking system to the point where commercial banks were compelled to borrow from the central bank at higher costs. However, interest rates on deposits remained relatively stable, reflecting a lack of competition in the banking sector for deposits. Meanwhile, inflation increased sharply, following the adjustment in the exchange rate in the first half of the year, leading to negative deposit rates in real terms. Consequently, the stock

[4] Administrative interest rates were abolished and credit ceilings removed as these markets developed.

[5] The interbank market is largely driven by the changes in the statutory reserve requirement ratio, which requires banks to maintain requirements for domestic and foreign currency deposits in local currency. Trading on the market continues to be based on unsecured lending, mostly overnight, and is segmented, as the major banks are unwilling to deal with weak counterparties.

of treasury bills held by the public increased, further weakening the demand for real money balances.

Figure 1. Madagascar: Broad Money, Inflation, and Exchange Rate, 1982-2004



Source: *International Financial Statistics* (IFS).

Table 1. Correlation Matrix 1/

	p	*m3*	*y*	*e*	*p**	*i**
p	1.000					
m3	0.994	1.000				
y	0.923	0.934	1.000			
e	-0.965	-0.955	-0.890	1.000		
*p**	0.953	0.951	0.876	-0.948	1.000	
*i**	-0.915	-0.911	-0.856	0.904	-0.955	1.000

1/ All series are in logs, except interest rates: *p* =CPI, *m3* =broad money, *y* =real GDP, *e* =nominal effective exchange rate, *p** =foreign prices, and *i** =foreign interest rates.

III. Model Specification

The specification of the inflation equation is a traditional extension of a monetary disequilibrium model to an open economy.[6] It is derived from a theoretical model describing a small economy that has both a tradable goods sector and a nontradable goods sector. The overall price level in logs (p_t) is a weighted average of tradable prices (p_t^T) and nontradable prices (p_t^N):

$$p_t = \lambda\, p_t^N + (1\text{-}\lambda)\, p_t^T, \tag{1}$$

where λ is the weight of nontradable prices in the price index. The price of tradable goods is determined in the world market, with their price in the domestic economy being a function of the foreign currency price expressed in foreign currency terms (p_t*) and of the exchange rate expressed in foreign currency per national currency (e_t):

$$p_t^T = p_t{*} + e_t. \tag{2}$$

The price of nontradables is determined by disequilibrium in the domestic money market, such that inflation (Δp) is obtained as follows:

$$\Delta p_t^N = \varphi[(m_t - p_t) - m_t^d], \tag{3}$$

where m_t is the outstanding stock of money, m_t^d is the demand for real money balances, and φ is a scale factor representing the relationship between economywide demand and the demand for nontradable goods. The demand for real money balances is assumed to be determined by real income (y_t), foreign interest rates (i*), and the expected depreciation of the exchange rate (Δe). Consequently, inflation in the nontradables sector can be written as

$$\Delta p_t^N = \varphi\, (m_t - p_t - \alpha_1 y_t + \alpha_2 i_t{*} - \alpha_3 \Delta e_t). \tag{4}$$

As implied by the quantity theory of money, an increase in the outstanding money stock results in higher inflation; an increase in real income increases the demand for money for transaction purposes and, in turn, leads to a decline in inflation; an increase in the opportunity cost of holding money, by reducing the demand for money balances, results in an increase in inflation; and a depreciation stokes inflationary expectations.

Assuming a stable money demand function, which is confirmed by the data, the error-correction model for inflation can be estimated as follows:[7]

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[6] See for example Khan and Knight (1991), Toujas-Bernate (1996), Callen and Chang (1999), and Williams and Adedeji (2004) for similar specification.

[7] See appendix for the derivation of this equation.

$$\Delta p_t = b_0 + b_1 \sum_{i=1}^{k} \Delta p_{t-i} + b_2 \sum_{i=0}^{k} \Delta m_{t-i} + b_3 \sum_{i=0}^{k} \Delta y_{t-i} + b_4 \sum_{i-0}^{k} \Delta e_{t-i} + b_5 \sum_{i-0}^{k} \Delta i^*_{t-i} + b_6 \sum_{i-0}^{k} p^*_{t-i} + b_7 EMC_{t-1} + \varepsilon_t , \quad (5)$$

where

$$ECM_{t-1} = \beta_1 m_{t-1} - \beta_2 p_{t-1} + \beta 3 y_{t-1} - \beta 4 i^*_{t-1} \quad (5b)$$

corresponds to a measure of disequilibrium in the money market.

IV. Data, Unit Root Tests, and Cointegration Analysis

A. Data

The empirical analysis is conducted using quarterly data from 1982:Q1 to 2004:Q2.[8] All variables are in logarithms, except interest rates. Figure 2 plots the individual time series. The CPI variable used is the composite CPI index, in the absence of a core inflation series or nonfood index dating back to the early 1980s. Broad money is (M3), including deposits in foreign exchange.[9] There is a lack of alternative financial assets. Indeed, owing to financial controls imposed until the mid-1990s, the only time series of domestic interest rates available is the basic rate of the central bank. However, no transaction is actually made at this interest rate and it shows very little variation over the sample period.

To capture the opportunity cost of holding money, the yields on 10-year government bonds in France are used as foreign interest rates.[10] Foreign prices are the CPI (U.S. dollar; 2000=100) weighted by trade imports from advanced economies. The exchange rate is the nominal effective exchange rate, defined as foreign currency per unit of local currency.[11] Given that real GDP (Y) is available only in annual frequency, end-of-period values are converted into quarterly data through interpolation by cubic method. Furthermore, three

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[8] The source of the data is the IMF's *International Financial Statistics*.

[9] M3 is also the intermediate target for monetary policy.

[10] The rate of return on French treasury bonds is expected to be relevant, given that, since Madagascar achieved its independence in 1960, its business community has had a close relationship with France.

[11] This definition of the nominal effective exchange rate has an important implication for its interpretation: an increase corresponds to an appreciation of the domestic currency.

dummy variables (*dum94Q1*, *dum02Q2* and *dum02Q3*) are used to capture (i) the switch from a crawling peg regime to a flexible exchange rate regime and financial sector reforms initiated in the first quarter of 1994, and (ii) the impact of the political crisis in the second and third quarters of 2002. The dummy variables enter the dynamic inflation equation.

B. Unit Root Tests and Cointegration Analysis

A standard Augmented Dickey-Fuller (ADF) test could not reject the presence of a unit root in all variables (Table 2). Tests of cointegration have been carried out using the Johansen (1988) maximum likelihood procedure.

Table 2. Augmented Dickey-Fuller (ADF) Statistics for Unit Root Tests

	ADF Statistics		ADF statistics	
Variables	Lags	In levels	Lags	In first differences
p	0	-1.305	0	-7.845 **
y	5	-0.240	4	-3.524 **
m3	0	0.230	0	-9.603 **
e	0	-0.654	0	-7.006 **
*p**	6	-1.772	5	-3.524 **
*i**	4	-2.181	3	-5.418 **

Note: The estimation period is 1982:Q1-2004:Q2 for all variables. Lags indicate the order of each variable, using the Schwarz information criterion. The ADF statistics are testing a null hypothesis of a unit root in each variable against an alternative of a stationary root. Each regression is run with a constant term. (**) and (*) denote rejection at the 1 percent and 5 percent critical values, which are -3.51 and -2.9, respectively.

As shown in Table 3, the maximal and the trace eigenvalue statistics reject the null hypothesis of no cointegrating vector in favor of one cointegrating vector at the 5 and 1 percent levels, respectively. All the coefficients have the expected signs. The income elasticity is close to unity (1.38). A test imposing a unitary income elasticity was not rejected: $\chi^2(1)=(0.37)[0.55]$. The estimated semi–elasticity of the foreign interest rate indicates that an increase in foreign interest rates would lead to a decline in the demand for money. These findings are consistent with the quantity theory of money. The restricted, stable long-run relationship between the money stock, the price level, real income, and foreign interest rates is estimated as

$$m3 = 1.18p + 1.38y - 0.002i^*. \qquad (6)$$

The coefficients are of the right signs and are significantly different from zero, except for foreign interest rates.

Various misspecification tests of the unrestricted vector autoregression (VAR) underlying Equation (7) are reported in Table 4. These include portmanteau, ARCH 1-4, normality, and heteroscedasticity tests, which reveal some problems, including the rejection at the 1 percent critical value of normality for y and p^*. It is, however, shown that this is not a problem for the Johansen procedure used in this paper (see Gonzalo, 1994).

The price elasticity is close to one (a restriction that price elasticity equals 1 is not rejected based on a χ^2 (1) test statistic of 2.22). The restricted long-run money demand function can be written as:

$$m - p = 1.15y - 0.07i^* \qquad (7)$$

As shown in Table 5, weak exogeneity tests of the variables in Equation (7) suggest that only foreign interest rates are weakly exogenous, implying that if shocks were to cause the system to deviate from its long-run equilibrium, real money balances and output would adjust over time to restore equilibrium. This is expected given that foreign interest rates do not respond to Madagascar's domestic monetary policy. The significance of output in the long-run money demand, Equation (7), implies some degree of effectiveness of monetary policy in regulating aggregate demand. In addition, an increase in foreign interest rates could weaken the demand for real money balances, which would, in turn, increase inflation.

With the existence of a stable long-run money demand relationship established, an error-correction representation of inflation, Equation (5), is estimated in Section V.

Table 3. Cointegration Analysis

Eigenvalues		0.28	0.17	0.09
Hypotheses	r = 0	r ≤ 1	r = ≤ 2	r = ≤ 3
λmax = Max test	29.27*	16.62	8.75	0.97
Probability	0.027	0.198	0.315	0.324
λtrace = rank Trace test	55.61**	26.34	9.72	0.97
Probability	0.007	0.122	0.309	0.324
	Standardized eigenvectors			
	m	*p*	*y*	*i**
	1.00	-1.18	-1.38	0.002
	[0.00]	[0.09]	[0.56]	[0.002]
	Standardized adjustment coefficient			
	m	*p*	*y*	*i**
	-0.003	0.17	-0.02	-0.16
	Statistics for testing the significance of a given variable			
	m	*p*	*y*	*i**
χ^2 (1)	11.71**	10.25**	3.73	0.003

Note: The estimation period is 1981Q1-2004:Q2. The VAR includes five lags on each variable. Standard errors are in brackets.

Table 4. Properties of VAR Residuals

	m	*p*	*y*	*i**
Portmanteau (10)	7.26	4.12	8.26	7.78
Normality test: $\chi^2(2)$	7.48*	20.56**	27.6**	1.28
ARCH 1-4 test: F(4,63)	0.28	0.69	3.35*	1.4
Heteroskedasticity test: F(40,26)	0.56	0.61	0.87	0.48

Notes: The portmanteau statistics is a degrees-of-freedom corrected version of the Box and Pierce statistic for each variable and for the system as a whole. See Doornik and Hendry (1997) for details. Normality denotes the results of the Doornik-Hanson test for each variable and for the system as a whole. Normality checks whether the residuals are normally distributed. ARCH (autoregressive conditional heteroscedasticity) denotes the results of the LM (Lagrange multiplier) tests for autocorrelated squared residuals.

Table 5. Test for Weak Exogeneity

Variable	χ^2	p-Value for the Test Statistic
m-p	12.71	0.00
y	8.57	0.00
*i**	1.25	0.26

V. Determinants of Inflation

In this section, the error-correction model for inflation is constructed by including the first difference of the error-correction term, along with four lags of all the variables in the system. Thus, Equation (5) is estimated, using the ordinary least squares (OLS) estimator, as

$$\Delta p_t = b_0 + b_1\sum_{i=1}^{k}\Delta p_{t-i} + b_2\sum_{i=0}^{k}\Delta m_{t-i} + b_3\sum_{i=0}^{k}\Delta e_{t-i} + b_4\sum_{i-0}^{k}\Delta p*_{t-i}$$
$$+ b_5\sum_{i-0}^{k}\Delta i*_{t-i} + b_6 ECM_{t-1} + b_7 dum94Q2 + b_8 dum02Q2 + b_9 dum02Q3 \quad (8)$$
$$+ b_{10} CSeasonal + b_{11} CSeasonal1 + b_{12} CSeasonal2 + \varepsilon_t,$$

where k=4 is the lag structure; *ECM* is the deviation of money from its long-run equilibrium level (error-correction term) obtained from Equation (6); and *CSeasonals* are centered seasonal dummy variables used in the regression. The interpolated annual variable, y, is not included.

The estimation of the dynamic equation, Equation (8), generated some interesting results, which are presented in Table 6. As expected, the error-correction term is found to exert a positive and significant impact on inflation, suggesting that disequilibrium in the money market does matter for inflation. However, the magnitude of the coefficient (0.07) implies that the adjustment process toward the long-run equilibrium of domestic prices takes more than 2½ years (14 quarters).

All the significant stationary variables that capture the short-run dynamics in inflation also have the expected signs in the parsimonious equation (see column 2 of Table 6). Growth in broad money tended to increase inflation, suggesting that the observed changes in money stock were above desired changes in money balances. The coefficient on foreign interest rates is positive, implying that an increase in foreign interest rates increases the opportunity cost of holding domestic currency after two quarters, which contributes to a decline in real money balances and an increase in inflation. Despite the fact that inflation is exogenously determined by foreign interest rates, there is scope for the monetary authorities to limit the impact of such shocks on inflation. In the absence of an effective domestic interest rate instrument, real GDP growth would have to adjust. This is facilitated by the finding that real GDP is endogenous in the real money-demand equation. The coefficient on the exchange rate is negative (-0.002), suggesting that a 10 percent depreciation will lead to 0.02 percent increase in inflation, which is a very low pass through.

These results are in line with recent money demand studies in developing countries, including Williams and Adededji (2004) and Sacerdoti and Xiao (2001), and confirm the tentative conclusions drawn from Figure 1 that money growth and depreciation are among the dynamic determinants of inflation. Since the sum of the coefficients of the lags of the dependent variable is less than 1 (0.37), no overshooting takes place, but the presence of inflation inertia means that it is inappropriate to assume a mechanical contemporaneous relationship between nominal income and money.

In addition, policy-induced changes and specific shocks (such as the switch from a crawling peg regime to a flexible exchange rate regime and financial sector reforms initiated in 1994 and the political crisis in 2002) appear to have exerted significant impact on inflation. While financial sector reforms tended to lower inflation, the impact of the 2002 political crisis on inflation was mixed.

Figure 3 depicts actual and fitted values of Equation (8), showing a fairly good fit. The error between the actual and fitted values in 2004 may be large owing to cyclones that hit Madagascar during the first quarter of the year and the oil shock.

A. Diagnostic Tests

A battery of tests was conducted to evaluate the statistical properties of the model. The results for the single-equation parsimonious model are presented in the notes to Table 5. Error autocorrelation, ARCH errors, Normality, heteroscedasticity, and RESET errors are rejected. Overall, the residuals seem to be well behaved.

Furthermore, the model is estimated recursively from 1986 to 2004 to assess its stability. The recursive estimates of the coefficients that are significant in the estimated inflation equation are presented in Figure 4. The first nine plots are of the coefficient estimates at each point in the sample, together with their approximate 95 percent confidence intervals ($\pm 2SE$ shown on either side). The estimates are relatively constant over the sample once past the initial estimates. The tenth plot is of the one-step ahead residuals (forecast errors), with an approximately 95 percent confidence interval; the confidence bands are again reasonably constant. The final plot of the break-point Chow test shows that constancy is not rejected over the sample period.

B. Impulse Response Analysis

Systems estimation

The objective of this section is to trace the effect of standard errors originating from variables of the system on other endogenous variables through the dynamic structure of the VAR. To use all the information contained in the data, the full system is estimated using the full information maximum likelihood (FIML) estimator. Table 6 presents the results of the FIML estimation for the three variables of interest: domestic prices, money, and the exchange rate. For brevity, the insignificant regressors are omitted from Table 7.

The inflation equation is essentially the same as in the OLS estimation discussed above. Overall, all responses corroborate the predictions of the quantity theory of money, which provide support to the identifying restrictions that have been imposed.

The money equation shows that broad money growth is affected by lagged inflation and its own lag. An increase in inflation two quarters ago has a positive impact on money, whereas inflation four quarters ago has a negative impact on money, which suggests that the monetary authorities react to inflation with four quarters lag. However, the net impact is positive. The deviation of broad money from its long-run path does not exert any significant impact on money growth. Notice that an exchange rate depreciation impacts inflation and not money growth, which implies that a depreciation causes real money balances to fall, thereby contributing to higher inflation. Regarding the exchange rate equation, Table 7 suggests that domestic inflation one quarter ago contributes to a depreciation of the exchange rate, while broad money growth three quarters ago appreciates the exchange rate. This observation, coupled with the size of the pass-through coefficient, suggest that targeting the exchange rate as a primary objective of monetary policy is neither appropriate nor desirable, as the costs of such a policy (loss of foreign exchange reserves) will outweigh the gains (exchange rate stability). Furthermore, the error-correction term for money demand is not found to exert any significant impact on exchange rate variations.

Impulse response

This subsection examines the impact of different shocks on the variables in the model and analyzes the lagged structure of the responses. Each initial shock is assumed to be one standard error shock. The impulse response and cumulative impulse response results are presented in Figure 5 and Figure 6, respectively. The focus is on the *p*, *m3*, and *e* variables.

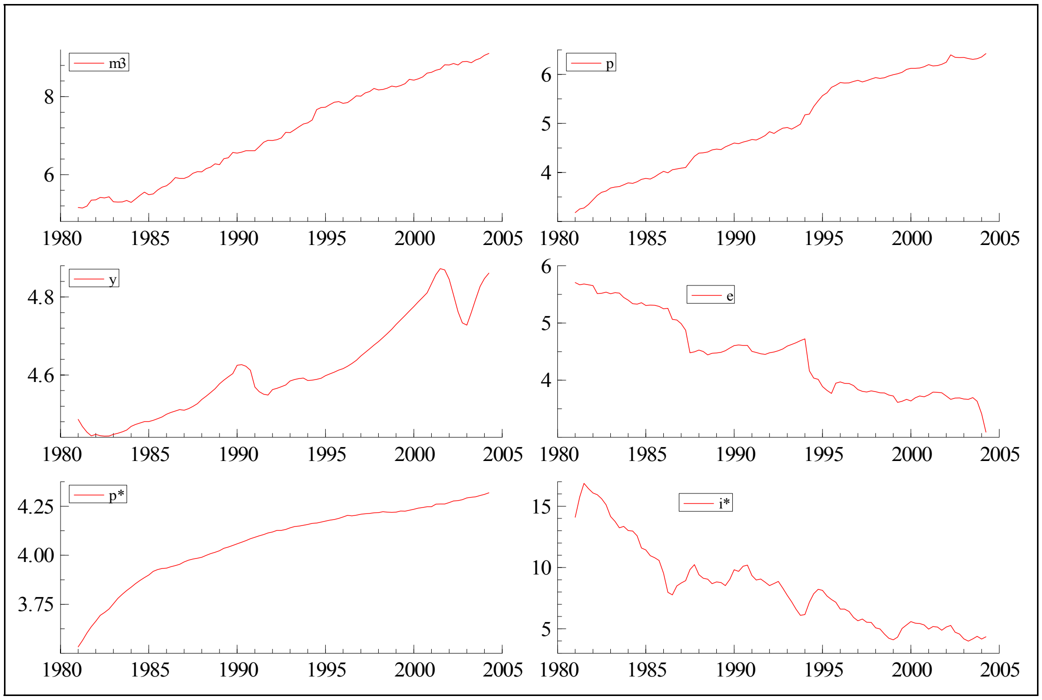
A one standard deviation positive shock on inflation has a transitory but persistent positive impact on money before fading out after 12 quarters, but it depreciates the exchange rate permanently. Note that the cummulative response of real money balances indicates a permanent fall. A money supply shock has a permanent effect on all nominal variables. On the one hand, the exchange rate depreciates temporarily above its permanent level (overshoots) before appreciating over time (in about 10 quarters). On the other hand, inflation falls in the first quarter, increases sharply in the second quarter, and quickly subsides. This outcome, along with the higher-than-proportionate cumulative increase in nominal money stock, suggests that real money balances increase permanently. Finally, a one standard deviation shock to the exchange rate (depreciation) appears to sharply increase inflation in the first period before dissipating over time, but its positive impact on the money supply exhibits a slow decay or persistence.

VI. Conclusion and Policy Implication

This paper analyzes the relationship between money, prices, and income in Madagascar during the period 1982–2004. The estimated results indicate a stable money demand function—a predictable relationship between broad money, the price level, real output, and foreign interest rates—consistent with the quantity theory of money. However, the results must be interpreted with caution, as the long-run effect of foreign interest rates are found to be statistically insignificant. With regard to the short-run dynamic model, the analysis suggests that a disequilibrium in the money market has a lasting impact on inflation. The results also show inflation inertia, which implies that inflation expectations are largely determined by past events. At the same time, policy variables, particularly broad money growth, can be effective in controlling inflation in the short run.

The policy implications are two-fold. First, the existence of a stable money demand function implies that the monetary targeting framework is credible and should allow the central bank to achieve its monetary and inflation targets with greater accuracy. In this regard, the central bank's ongoing efforts to strengthen its capacity to implement monetary policy and to develop indirect monetary policy instruments and the interbank money market are important steps in improving the effectiveness of monetary policy. Second, the finding that inflation is largely driven by past events implies that monetary policy is neither adequately explained or credible. In this regard, attempts to lower inflation through tight monetary policy would need to be complemented by an effective public relations campaign so as to limit its contractionary impact on economic growth.

Figure 2. Prices, Income, Money, Exchange Rate in Madagascar, and Foreign Interest Rates, 1982–2004



M3 = broad money; p = CPI; y = real GDP; e = nominal effective exchange rate; p* = foreign prices; and i* = foreign interest rates.

Table 6. Coefficient Estimates of the Error-Correction Model					
Regressor	Unrestricted Coefficient	Restricted Coefficient	Regressor	Unrestricted Coefficient	Restricted Coefficient
Constant	0.32** (2.4)	0.35** (3.54)	Δ*p**	0.38 (0.42)	
Δ*p*(-1)	0.17* (1.8)	0.17** (2.67)	Δ*p**(-1)	-0.07 (-0.07)	
Δ*p*(-2)	0.08 (0.97)		Δ*p**(-2)	0.12 (0.13)	
Δ*p*(-3)	-0.03 (-0.36)		Δ*p**(-3)	0.40 (0.43)	
Δ*p*(-4)	0.15* (1.89)	0.20** (3.42)	Δ*p**(-4)	-0.62 (-0.73)	
ECM(-1)	0.06** (2.45)	0.07** (3.46)	Δ*i**	-0.004 (-0.42)	
Δ*m3*	0.14** (2.08)	0.13** (3.03)	Δ*i**(-1)	0.01 (1.02)	
Δ*m3*(-1)	0.13* (1.91)		Δ*i**(-2)	0.02** (2.59)	0.02** (4.10)
Δ*m3*(-2)	-0.02 (-0.25)		Δ*i**(-3)	-0.004 (-0.55)	
Δ*m3*(-3)	-0.03 (-0.46)		Δ*i**(-4)	0.005 (0.71)	
Δ*m3*(-4)	0.02 (0.27)		Dum94Q1	0.16** (6.56)	0.16** (7.18)
Δ*e*	-0.001** (-2.13)	-0.001** (-3.23)	Dum02Q2	0.17** (7.01)	0.17** (7.98)
Δ*e*(-1)	-0.001** (-2.28)	-0.001** (-3.90)	Dum02Q3	-0.09** (-3.14)	-0.09** (-3.97)
Δ*e*(-2)	0.00 (0.70)		Cseasonal	0.002 (0.14)	
Δ*e*(-3)	-0.00 (-0.71)		Cseasonal(-1)	-0.03** (-2.11)	-0.04** (-6.50)
Δ*e*(-4)	-0.001* (-1.77)		Cseasonal(-2)	0.01 (0.49)	
R^2				0.83	0.80

Notes: 1. t-statistics are in parentheses. 2. (**) indicates significant at 5 percent level; (*) indicates significant at 10 percent level. 3. Diagnostic tests of the restricted model: testing for error autoregressive (AR 1-5) test F(5,72) = 1.7773 [0.1284]; Autoregressive conditional heteroscedasticity (ARCH 1-4) test F(4,69) = 0.35626 [0.8388]; normality test $\chi^2(2)$ = 0.85063 [0.6536]; heteroscedasticity test F(18,58) = 0.76976 [0.7249]; and RESET test F(1,76) = 3.1217 [0.0813].

Figure 3. Actual and Fitted Inflation

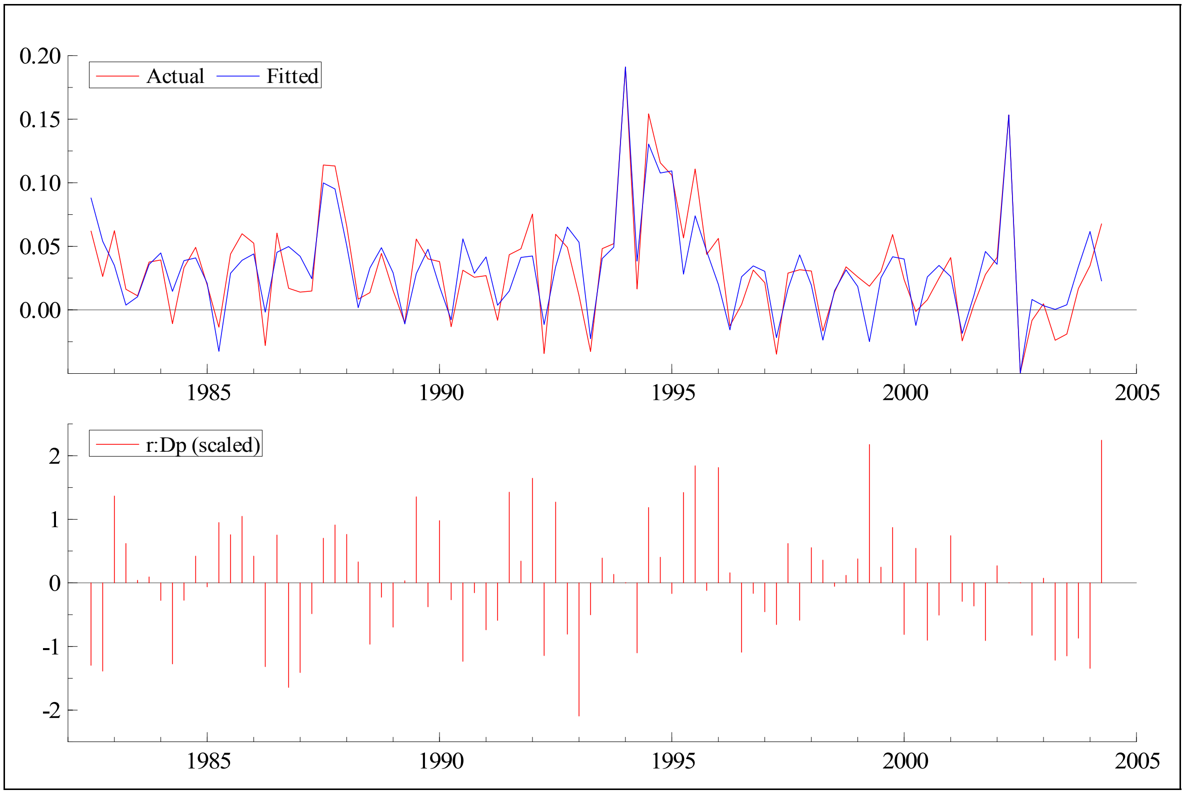


Figure 4. Stability Tests of the Restricted Inflation Equation

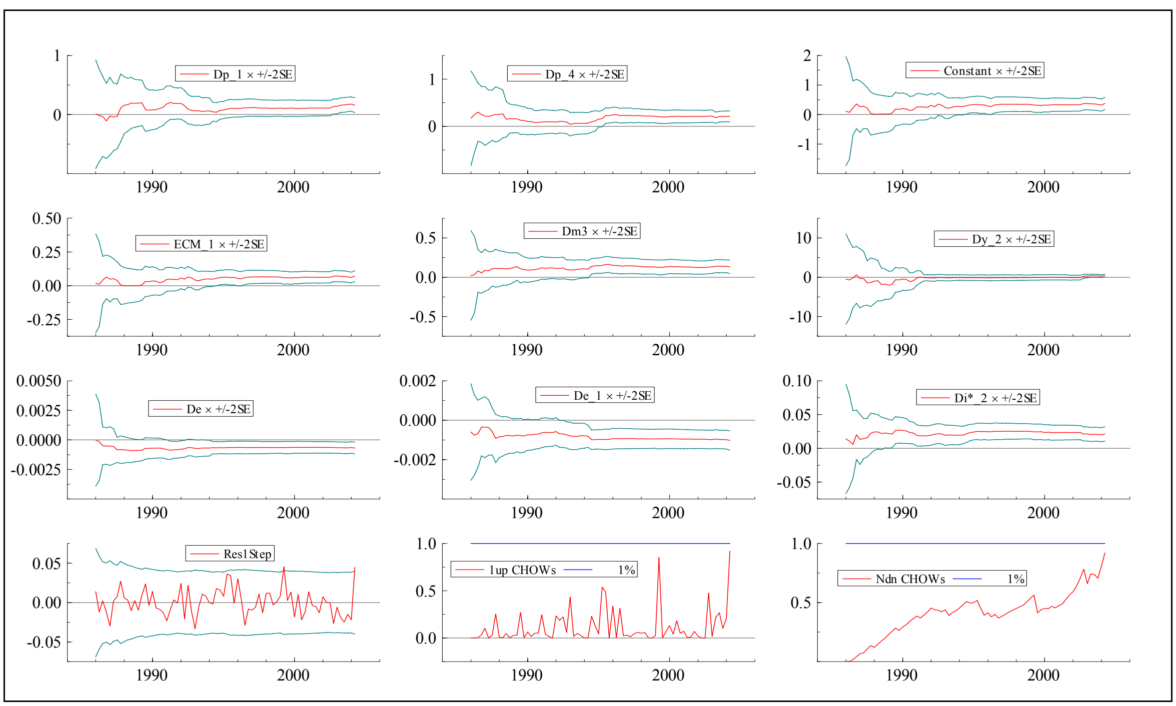


Table 7. FIML Estimates of the Error-Correction System

Regressor	Δp	Δm	Δe
Constant	0.39** (2.84)		
$\Delta p(-1)$	0.18* (1.91)		-0.74* (-1.96)
$\Delta p(-2)$		0.28* (1.738	
$\Delta p(-4)$		-0.26* (-1.73)	
ECM(-1)	0.07** (2.84)		
$\Delta m3(-1)$	0.14** (1.97)		
$\Delta m3(-2)$		0.27** (2.08)	
$\Delta m3(-3)$		-0.26** (-2.02)	0.67** (2.38)
$\Delta e(-1)$	-0.001** (-2.59)		
$\Delta e(-4)$	-0.001** (-2.23)		
$\Delta p^*(-4)$			6.37* (1.83)
$\Delta i^*(-2)$	0.02* (2.72)		
CSeasonal		-0.06** (-2.30)	
Cseasonal_1			-0.13** (-2.42)
Cseasonal_2			-0.14** (-2.54)
Dum94Q1	0.16** (6.26)		
Dum02Q2	0.17** (6.56)		
Dum02Q3	-0.11** (-3.64)		

Notes: 1. t-statistics are in parentheses. 2. (**) indicates significant at 5 percent level; (*) indicates significant at 10 percent level. 3. Diagnostic tests: testing for error autoregressive (EGE-AR) 1-5 test F(125,162) = 1.1892 [0.1496]; normality test $\chi^2(10)$ = 48.609 [0.0000]**; heteroscedasticity test F(675,83) = 0.19554 [1.0000].

Figure 5. Impulse Response in the Full Model

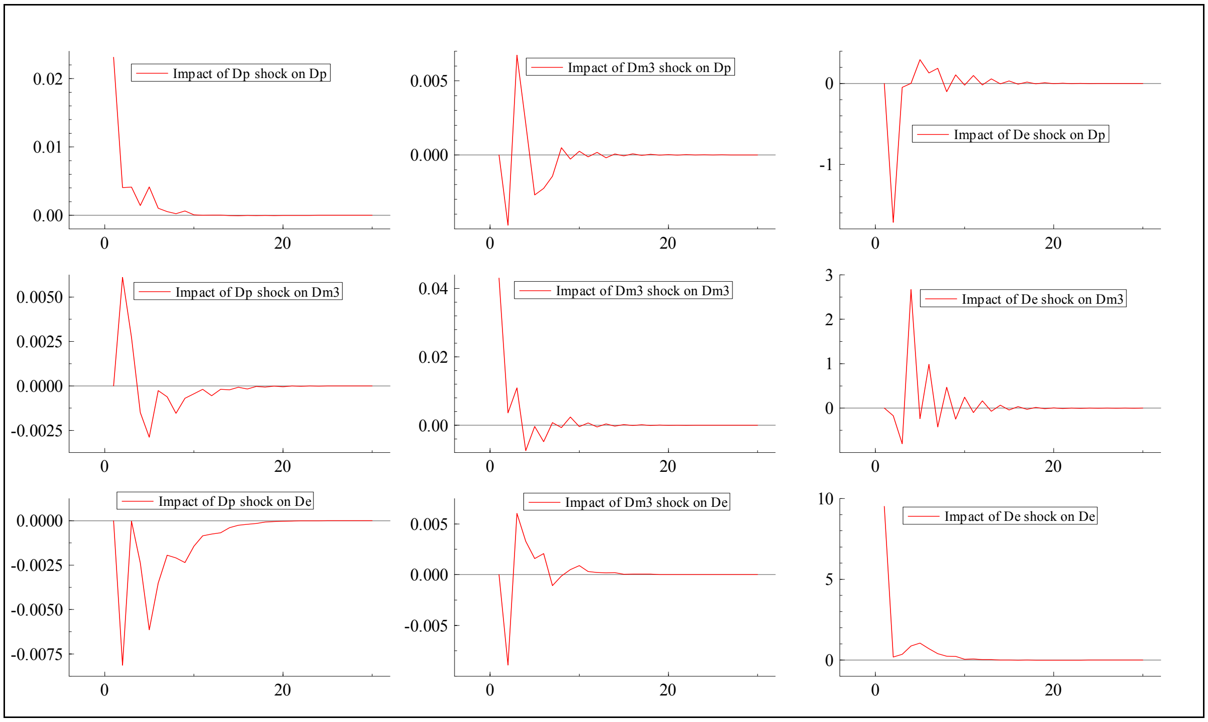
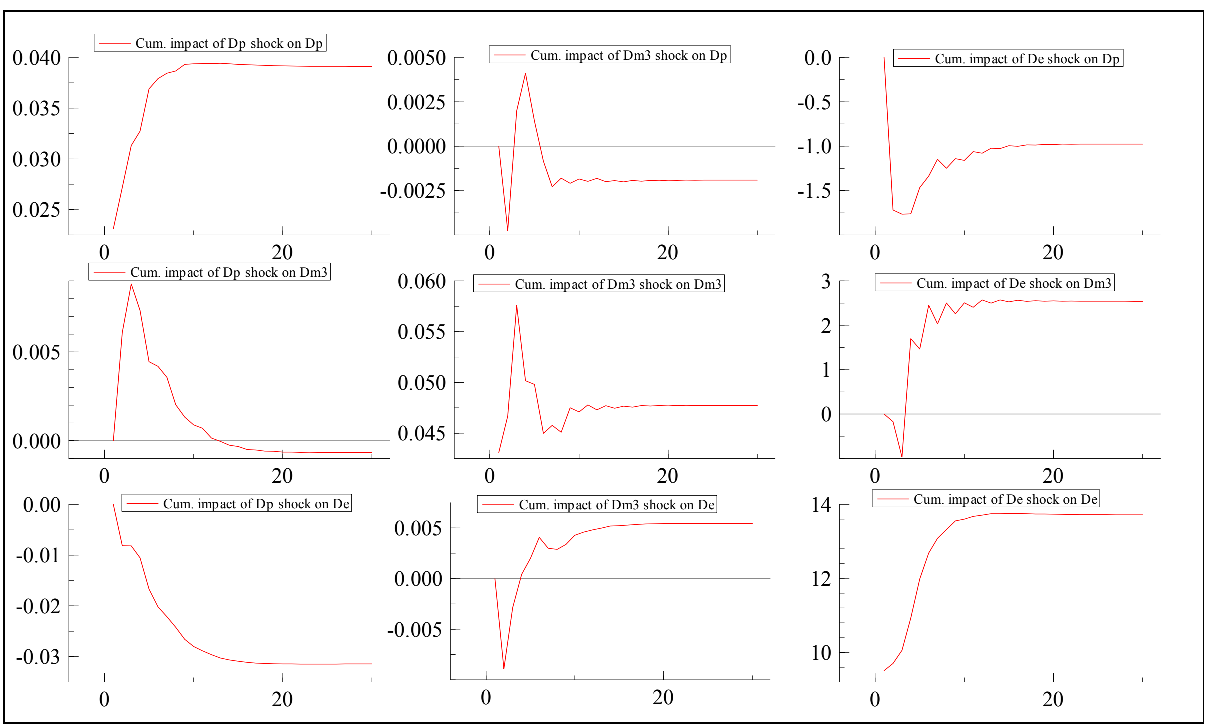


Figure 6. Cumulative Impulse Response in the Full Model



APPENDIX. Derivation of the Inflation Equation

Recall Equation (1), where $p_t^T = (p_t^* + e_t)$,

$$p_t = \lambda p_t^N + (1-\lambda)(p_t^* + e_t) \quad \text{A1}$$

$$\Delta p_t = \lambda \Delta p_t^N + (1-\lambda)(\Delta p_t^* + \Delta e_t) \quad \text{A2}$$

Recall Equation (3)

$$\Delta p_t^N = \varphi\left(\frac{m_t^s}{p_t} - m_t^d\right) \quad \text{A3}$$

Recall Equation (4)

$$m_t^d = p_t + \alpha_1 y_t - \alpha_2 i_t + \alpha_3 \Delta e_t = \lambda p_t^N + (1-\lambda)(p_t^* + e_t) + \alpha_1 y_t - \alpha_2 i_t + \alpha_3 \Delta e_t \quad \text{A4}$$

Substituting (A4) into (A3), where $\Delta p_t^N = p_t^N - p_{t-1}^N$, yields:

$$p_t^N = p_{t-1}^N - \lambda\varphi p_t^N + \varphi m_t - \varphi\alpha_1 y_t + \varphi\alpha_2 i_t - \varphi\alpha_3 \Delta e_t - \varphi(1-\lambda)(p_t^* + e_t) \quad \text{A5}$$

Rearranging (A5) produces:

$$p_t^N = \frac{1}{1+\lambda\varphi} p_{t-1}^N + \frac{\varphi}{1+\lambda\varphi} m_t - \frac{\varphi\alpha_1}{1+\lambda\varphi} y_t + \frac{\varphi\alpha_2}{1+\lambda\varphi} i_t - \frac{\varphi\alpha_3}{1+\lambda\varphi} \Delta e_t - \frac{\varphi}{1+\lambda\varphi}(1-\lambda)(p_t^* + e_t) \quad \text{A7}$$

Substituting (A7) into (A1), produces

$$p_t = \frac{\lambda}{1+\lambda\phi} p_{t-1}^N + \frac{\lambda\phi}{1+\lambda\varphi} m_t - \frac{\lambda\phi}{1+\lambda\phi}[\alpha_1 y_t - \alpha_2 i_t + \alpha_3 \Delta e_t] - \frac{\lambda\phi}{1+\lambda\phi}(1-\lambda)(p_t^* + e_t) + (1-\lambda)(p_t^* + e_t) \quad \text{A8}$$

From (A1),

$$\lambda p_{t-1}^N = p_{t-1} - (1-\lambda)(p_{t-1}^* + e_{t-1}) \quad \text{A9}$$

(A8) can thus be written as

$$p_t = \frac{1}{1+\lambda\varphi}\left[p_{t-1} - (1-\lambda)\left(p^*_{t-1} + e_{t-1}\right)\right] + \frac{\lambda\varphi}{1+\lambda\varphi}m_t - \frac{\lambda\varphi}{1+\lambda\varphi}\left(\alpha_1 y_t - \alpha_2 i_t + \alpha_3 \Delta e_t\right)$$
$$+ (1-\lambda)\left(p^*_t + e_t\right)\left[1 - \frac{\lambda\varphi}{1+\lambda\varphi}\right] \quad \text{A10}$$

Rearranging (A10) obtains

$$p_t = \frac{1}{1+\lambda\varphi}p_{t-1} + \frac{1-\lambda}{1+\lambda\varphi}\left[\Delta p^*_t + \Delta e_t\right] + \frac{\lambda\varphi}{1+\lambda\varphi}m_t - \frac{\lambda\varphi}{1+\lambda\varphi}\left[\alpha_1 y_t - \alpha_2 i_t + \alpha_3 \Delta e_t\right] \quad \text{A11}$$

Define

$$k \equiv \frac{1}{1+\lambda\varphi} \in (0,1)$$
$$1-k \equiv 1 - \frac{1}{1+\lambda\varphi} = \frac{\lambda\varphi}{1+\lambda\varphi} \in (0,1)$$

(A11) can be written as

$$p_t = kp_{t-1} + k(1-\lambda)\Delta p^*_t + (1-k)\left[m_t - \alpha_1 y_t + \alpha_2 i_t\right] + \left[k(1-\lambda) - (1-k)\alpha_3\right]\Delta e_t \quad \text{A12}$$

$\left[k(1-\lambda) - (1-k)\alpha_3\right] = \phi \succ 0,$ positive if $\alpha_3 \prec 0.$

$$\Delta p_t = \pi_t$$

$$\Delta p_t = k(1-\lambda)\Delta p^*_t + \phi\Delta e_t - (1-k)p_{t-1} + (1-k)\left[\Delta m_t - \alpha_1 \Delta y_t + \alpha_2 \Delta i_t\right]$$
$$+ (1-k)\left[m_{t-1} - \alpha_1 y_{t-1} + \alpha_2 i_{t-1}\right] \quad \text{A13}$$

Rearranging (A13) obtains:

$$\Delta p_t = k(1-\lambda)\Delta p^*_t + \phi\Delta e_t + (1-k)\left[\Delta m_t - \alpha_1 \Delta y_t + \alpha_2 \Delta i_t\right] + (1-k)\left[m_{t-1} - p_{t-1} - \alpha_1 y_{t-1} + \alpha_2 i_{t-1}\right]$$

where

$\left[M_{t-1} - P_{t-1} - \alpha_1 y_{t-1} + \alpha_2 i_{t-1}\right]$ is the error-correction term.

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