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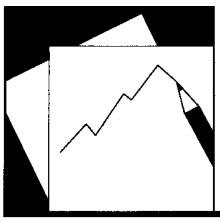

IMF Working Paper

Modeling Inflation for Mali

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Modeling Inflation for Mali

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Abstract

This paper investigates how consumer price inflation is determined in Mali for 1979–2006 along three macroeconomic explanations: (1) monetarist theories, emphasizing the impact of excess money supply, (2) the structuralist hypothesis, stressing the impact of supply-side constraints, and (3) external theories, describing the effects of foreign transmission mechanisms on a small open economy. The analysis makes use of cointegration techniques and general-to-specific modeling. Average national rainfall, and to a lesser extent deviations from monetary and external sector equilibrium are found to be the main long-run determinants of inflation. The paper offers policy recommendations for controlling inflation in Mali.

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Contents

I. INTRODUCTION

1. This paper investigates the determinants of inflation in Mali between 1979 and 2006. Variations in Mali's consumer price index (CPI) are largely driven by changes in food prices, with food items accounting for 50 percent of the CPI (see Figure A.1). In this country where households at the bottom quintile of the income distribution spend more than 80 percent of their income on food, controlling food price inflation could thus greatly reduce poverty. When food price inflation is high, the cost of food leaves few resources for expenditures like health and education. In the extreme case, high food price inflation leads to hunger. Similarly, high nonfood price inflation reduces real money balances and the income that can be spent on food, again leading to food insecurity.[2] Understanding the determinants of inflation is then important to designing policies that can improve food security in Mali.

2. The economic literature proposes two main sources of inflation: demand-side factors, driven by expansionary monetary and fiscal policies, and supply-side factors, stemming from an increase in the costs of production (e.g., wage increases, input price increases). The two main schools of thought at the forefront of the inflation debate are the monetarist and the structuralist.

3. Monetarists argue that inflation is essentially a monetary phenomenon (see Friedman, 1963). Assuming that economic agents are rational, increases in the money supply lead to proportionate price increases, leaving real money balances and output unchanged. Monetarists model the mechanisms by which monetary policy affects inflation and how they can be used to control price inflation (see Svensson, 2000; Hendry, 2001). The rate of growth of the money stock is often exogenous, and inflation can result from increases in the money supply in excess of the desired real money balances (excessive money creation).

4. Structuralists highlight the role of supply-side constraints as a cause of monetary growth and therefore a source of inflation (see Bernanke, 2005). In these models, inflation is often driven by bottlenecks in the real economy. In developing countries, food supply is relatively inelastic: occasional excess demand—arising, for example, after an increase in nonagricultural incomes—cannot be absorbed quickly enough to avoid price increases. Likewise, foreign exchange constraints often lead to inflation. If food imports are restricted, negative supply shocks such as droughts or locust invasions will lead to food shortages and price increases. Furthermore, when wages are indexed and monetary policy is accommodative, an initial increase in prices will lead to wage adjustments to compensate for the lost real income, reinforcing inflation inertia.

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[2] This effect may be lowered by the subsistence cultures that influence farmers' activities. Nevertheless, cotton cultivation represents the majority of the Mali primary sector, involving a total of 3.3 million people and 200,000 farm families (see OECD, *2006 African Economic Outlook*), representing the main source of income and expenditure for Malian farmers. Considering how many Malian workers are affected (see ¶14 for details), the food security implications are very important even when the dampening effect of the subsistence culture is accounted for.

5. Empirical studies in the 1990s investigated the structuralist hypothesis for the case of developing economies, including sub-Saharan Africa. Moser (1994) found that, in addition to monetary aggregates, weather conditions (as proxied by rainfall) significantly influenced inflation in Nigeria, reflecting both the weight of food items in the consumer basket (about 70 percent of the CPI) and the dependence of Nigerian food production on the vagaries of the weather. Durevall and Ndung'u (2001) used an error-correction model to study inflation dynamics in Kenya from 1974 to 1996. Incorporating maize-price inflation as a proxy for food supply constraints in their model, they conclude that monetary factors and food supply constraints have a significant effect in the short run, though external factors matter in the long run. More recently, Khan and Schimmelpfennig (2006) investigated a mixed monetarist-structuralist model to explain inflation in Pakistan, using the wheat support price to represent supply-side constraints. Although they found that monetary factors had a dominant influence on inflation, the effect of supply-side factors was significant in the short run.

6. A few papers have investigated price inflation in Mali. Jayne and al. (1996) studied the impact of several food system reforms—e.g., removal of trade barriers, elimination of food price subsidies, and increases in food aid—on real food prices in six sub-Saharan African countries, Mali being one of them. After controlling for seasonality, rainfall, and world prices, they concluded that all reforms that affected the supply side had a significant impact on food price inflation. Traore, Jeudy, and Blein (2003) explored the determinants of the steep rise in cereal prices in Mali, Burkina Faso, and Niger after the 2001–02 droughts. They found that cereal production and cereal prices in Mali were influenced by the same factors. Newhouse (2006) analyzed the distributional effects of liberalizing the agricultural sector in Africa. He found that in Mali, liberalization increased the production of cereals and reduced the spread between cereal prices there and in the other African countries. However, none of these papers has tested the structuralist hypothesis.

7. This paper investigates the determinants of inflation in Mali using error correction modeling and quarterly time series data for the period 1979–2006Q1. The study period covers several important events, such as the drop in cotton export prices in 1986, the devaluation of the CFA franc in 1994, and the major droughts of 1982–85 and 2001–02. The paper tests both monetarist and structuralist theories of inflation using external and monetary indicators, rainfall, and the terms of trade, and makes policy recommendations for achieving price stability in Mali. First, we investigate the long-run equilibrium in the money market and the external goods market. This allows us to derive a long-run demand for broad money and test the purchasing power parity (PPP) assumption in Mali. Second, we estimate a general model for inflation that accounts for disequilibrium in the money market and the foreign exchange market and for short-term interactions between the potential determinants of inflation. The model uses average national rainfall to account for supply-side constraints. Finally, a parsimonious model is derived using sequential model selection and its stability is tested. The results show that inflation in Mali has both monetary and imported sources. They also show that rainfall significantly affects inflation, with a lag of one to two quarters. These findings suggest that structural reforms to reduce food shortages and improve cereal market efficiency should help stabilize inflation in Mali.

8. The paper is organized as follows: Section 2 gives background on Mali's economy. Section 3 describes the theoretical model. Section 4 reviews the data and presents the results. Section 5 draws conclusions.

II. BACKGROUND

9. Mali is part of the West African Economic and Monetary Union[3] (WAEMU), whose common currency, the African Financial Community (CFA) franc, is pegged to the euro. On January 12, 1994, the CFAF was devalued to half its value in foreign currency terms, from a parity of 50 CFAF per French franc to 100 CFAF per French franc. The central bank of the WAEMU is the *Banque Centrale des Etats de l'Afrique de l'Oues*t (BCEAO), which conducts monetary policy at a regional level. Its main objectives are to (1) secure a fixed parity between the CFA franc and the euro and (2) achieve a regional net foreign assets position consistent with the peg. The WAEMU countries traditionally have very low rates of inflation, for two reasons.[4] First, because countries in the CFA zone carry out almost half their foreign trade with the euro area, they benefit from low inflation in that area, which curbs rises in the price of imports. The peg with the euro also allows CFA countries to benefit from the recent appreciation of the exchange rate because it dampens the cost of imports, in particular energy imports. Second, because the BCEAO has concentrated its policy on consolidating net external assets and price stability.

10. Mali has not historically suffered from high inflation: although it reached a record of 21 percent after the devaluation of the CFA franc in 1994, the annual rate has since remained under 7 percent . Although some of the devaluation was passed onto consumer prices in subsequent years, the shock on Malian CPI has generally been contained. Figure A.2 plots annual inflation in Mali from 1971 to 2005 as measured by the first difference of the logarithm of the CPI. In general, inflation, though volatile during the period, has been smoother since 2000. The most important downward shock occurred in 1987, when the CPI fell by 15 percent following a steep drop in cotton export prices in 1986 and abundant crops in 1985–86 and 1986–87 after years of severe droughts in 1982–85. From 1987 on, cereal production rose, reflecting the liberalization of producer prices in late 1987, less government intervention in the cereal markets, and favorable weather. These factors led to some periods of deflation, though none as steep as in 1987. Major inflationary shocks occurred in 1975 and 1994. In 1975 the oil crisis pushed inflation from 5 percent in 1974 to 19 percent, though it fell to 10 percent in 1976. Later, difficult weather during the severe drought of 1982–85 kept inflation at an annual average of 8 percent. The second inflationary shock occurred in 1994, when the

[3] The other WAEMU countries are Benin, Burkina Faso, Guinea-Bissau, Côte d'Ivoire, Niger, Senegal, and Togo. Mali joined on June 1, 1984.

[4] From 1997 to 2005 average annual inflation was 2.3 percent in WAEMU and 2.1 in CEMAC countries, whereas it exceeded 12 percent for sub-Saharan Africa as a whole (Banque de France, press release on the 2005 Report for the Franc Area).

CFA franc was devalued to half its value against the euro in foreign currency terms. Inflation jumped from –0.2 percent in 1993 to 21 percent in 1994 before falling to 11 percent in 1995 as import prices doubled. After about 18 months of high volatility, Mali's inflation rate stabilized.

11. With a pegged currency and free capital mobility with France, WAEMU interest rate policy is limited and is closely tied to policy in the French money market. The discount rate changed only three times between 1975 and 1985 and six times between 1986 and 1990; rates on deposits and advances in the money market have been adjusted more often. Changes in interest rates mainly followed the decrease in the Paris money market rate in March 1986 and September 1986 and its rise in December 1988 and March 1989. However, in 1990 interest rates held constant while French rates decreased, making deposits within the WAEMU more attractive. The biggest change occurred in 1993, when interest rates were cut by about half. After that there was no adjustment until 2004 (see figure A.4). As a consequence, Malian authorities must rely on policies other than monetary to control price inflation.

12. Over the last two decades, average national rainfall has been negatively correlated to the annual inflation rate. Figure A.3 draws the four-quarterly moving average inflation and the lagged–one quarter rainfall from 1979 to 2006. In general, good and bad years have succeeded each other throughout the period but inflation has been controlled since the CFA franc devaluation. Two major droughts are to be noted, in 1982–85 and 2001–02. Inflation and lagged–one quarter rainfall appear to be highly and negatively correlated (see table A.3). For instance, the deflation in 1986–87 coincided with the return to favourable weather after years of severe droughts. With sufficient rainfall spread out over a good rainy season and without negative shocks such as flooding or locust invasion, agricultural production (in particular, the cereal harvest) is likely to be high enough to cover population needs. This reduces excess demand, which minimizes upward pressure on prices. But if cereal production is too low, excess demand raises food prices and thus boosts the overall CPI. The negative correlation between inflation and rainfall supports our decision to include rainfall as a potential determinant of inflation and a proxy for supply-side constraints.

III. THE MODEL

13. We model Mali's inflation in terms of three economic adjustments: deviations from long-run equilibrium in the major macroeconomic markets, short-term interactions between macroeconomic features, and supply-side constraints. Following Juselius (1991), Nachega (2001), and Durevall and Ndung'u (2001), we assume that in the long run inflation results from disequilibria in the money market and the external market.

14. Ideally, one should analyze long-run equilibrium in both markets in a single system and build an inflation model from there (Moser, 1994; Khan and Schimmelpfenning, 2006). However, because we have only a small number of observations, we adopt a widely used alternative strategy that makes it easier to interpret interactions between the series (see Juselius, 1991). First, we investigate the equilibrium

relationship in each market separately. Second, we examine the relative importance of deviations from these relationships, the supply-side constraints, and the short-run adjustments between macroeconomic series in determining inflation in Mali. We use cereal production, proxied by rainfall, to capture the supply-side constraints.

15. The domestic labor market is often added as a third market whose disequilibrium may affect the inflation rate. However, in Mali it is not relevant. In 2004 workers represented only 45 percent of the total population.[5] In 1997 81.4 percent of Malian workers were in the agricultural sector, where remuneration depends mostly on the harvest.[6] At the time the formal sector was using less than 10 percent of total workers. These facts, added to the lack of data on wages, lead us to assume that disequilibrium in the labor market does not have a significant impact on inflation in Mali. This hypothesis is consistent with a number of studies that show that "wage push inflation is rare in Africa" (Chibber and Shafik, 1990).

A. Monetary Sector Equilibrium

16. The determinants of money demand have been well investigated. Recent empirical studies set money demand as a function of a scale variable, proxied by income, and a vector of rate of returns on relevant assets (see, for instance, Ericsson, 1998):

$$(m - p) = \alpha_0 + \alpha_1 y + \alpha R + \varepsilon \qquad (1)$$

where m represents the logarithm of broad money (money plus quasi-money), p is the logarithm of price level (as measured by the CPI), y is the logarithm of real income, R is a vector of rates of return, and ε is an error term. The demand for money is assumed to be increasing in y ($\alpha_1 > 0$), with $\alpha_1 = 1$ under the quantity theory, and $\alpha_1 = 0.5$ under the Baumol-Tobin model of economies of scale.[7] Money demand is also assumed to be increasing in the elements of R which represent rate of return on the assets included in m, and decreasing in the rates of returns on alternative assets to m. Five assets are of interest in this study: CFA franc broad money (as measured by M_2), domestic goods, U.S. dollar cash holdings, domestic bonds, and foreign bonds. The expected rates of return for the five assets are proxied by the annual interest rate offered on time deposits (i_{depo}), the rate of inflation (Δp), the depreciation rate of the CFA franc against the U.S. dollar (Δe), the BCEAO discount rate (i_{disc}), and interest on French bonds (i^f_{bond}).

16. Assuming that i_{disc} and i_{depo} have equal semi-elasticities (in absolute value), $(i_{disc} - i_{depo})$ is the opportunity cost of holding money rather than domestic financial assets. This allows us to rewrite equation (1) as follows:

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[5] Source: Enquête Permanente auprès des Ménages (EPAM, 2004)

[6] Source: Bilan de l'Emploi sur le Secteur rural, 1997 (Observatoire de l'Emploi et de la Formation).

[7] Equation (1) assumes a long-run unitary elasticity of the nominal cash balances with respect to the price level; this assumption of price homogeneity is widely used and can be tested empirically.

$$(m-p) = \alpha_0 + \alpha_1 y + \alpha_2 \Delta p + \alpha_3 (i_{disc} - i_{depo}) + \alpha_4 i^f_{bond} + \alpha_5 \Delta e + \varepsilon \qquad (2)$$

where the expected signs are $\alpha_1 > 0$, $\alpha_2 < 0$, $\alpha_3 < 0$, $\alpha_4 < 0$, and $\alpha_5 < 0$. The motivation behind these expected signs is intuitive: First, an increase in real income is supposed to increase money demand (for transaction reasons). Second, an increase in Δp or Δe represents a loss of purchasing power for the domestic currency compared to goods and U.S. dollar holdings. Thus, economic agents are motivated to replace broad money holdings by assets the value of which does not suffer from inflation (i.e., domestic goods) or from exchange rate depreciation (i.e., US$ holdings). Last, an increase in $(i_{disc} - i_{depo})$ or i^f_{bond} makes money less attractive than domestic and foreign bonds, thus decreasing the demand for money.

B. External Sector Equilibrium

17. Following Durevall and Ndung'u (2001), the long-run equilibrium of the external sector of a small open economy can be summarized by a modified PPP:

$$p - p^* - neer = \gamma_0 + \gamma_1 \, tot + \eta \qquad (3)$$

where p is the logarithm of the CPI, p^* is the logarithm of the foreign effective price level, *neer* is the logarithm of the nominal effective exchange rate (expressed in CFA francs per unit of foreign currency), *tot* is the logarithm of the terms of trade, and η is an error term that represents deviations from the PPP. If the strong PPP holds (i.e., if $\gamma_1 = 0$ and η is stationary), changes in exchange rate are determined by changes in relative prices, and Mali's prices are affected by foreign prices and the exchange rate. This conclusion can be conveniently tested by examining the stationarity of the real effective exchange rate ($reer = p - p^* - neer$).

Several theories have attacked the validity of the PPP. Among proposed explanations are differences in productivity growth between countries, exchange rate movements due to monetary disturbances, transport costs and other obstacles to trade, and the limited substitution in world trade. In accordance with the dependent economy model, equation (3) predicts that if the PPP does not hold, the real exchange rate adjusts to movements in the terms of trade (see Dornbush, 1980). The coefficient γ_1 is expected to have a positive sign. A worsening in the terms of trade raises the price of tradable foreign goods relative to domestic goods and depreciates the real exchange rate.

18. The long-run relationships described by equations (2) and (3) must be investigated with caution. Indeed, macroeconomic series are usually not stationary, requiring special treatment through cointegration analysis to avoid spurious relations. Such procedures, developed by Johansen (1988) and Johansen and Juselius (1990), will be used for our estimations.

C. Inflation Equation

19. The inflation equation is:

$$\Delta p_t = \pi_0 + \pi_1\ \varepsilon_{t-1} + \pi_2\ \eta_{t-1} + \sum_{l=1}^{p-1} \pi_{3l}\ \Delta p_{t-l} + \sum_{l=1}^{p-1} \pi_{4l}\ \Delta y_{t-l} + \sum_{l=1}^{p-1} \pi_{5l}\ \Delta m_{t-l} + \sum_{l=1}^{p-1} \pi_{6l}\ [\Delta(i_{disc} - i_{depo})]_{t-l}$$
$$+ \sum_{l=1}^{p-1} \pi_{7l}\ \Delta i^{f}_{bond,\,t-l} + \sum_{l=1}^{p-1} \pi_{8l}\ \Delta e_{t-l} + \sum_{l=1}^{p-1} \pi_{9l}\ \Delta p^{*}_{t-l} + \sum_{l=1}^{q} \pi_{10l}\ rainfall_{t-l} + \sum_{l=1}^{r} \pi_{11l}\ D_l + \xi_t \quad (4)$$

where all the variables are defined as before, *rainfall* is Mali's national average rainfall (expressed in thousandths of a millimeter), D_l is a vector of deterministic variables including seasonal and impulse dummies, and ξ_t is an error term. x_t denotes the value of the variable x at time t. π_1 and π_2 determine the rate of transmission to inflation of previous disequilibria in the money market and the foreign market. The equation is estimated using ordinary least squares (OLS) procedure, and the number of lags for each series will be determined to avoid model misspecification. π_1 is expected to be positive and π_2 to be negative. A positive π_1 means that current excess money supply ($\varepsilon > 0$) raises inflation for the next period. Assuming that PPP holds in the long run (i.e., $\eta = reer$), a negative deviation from the equilibrium real exchange rate corresponds to a domestic currency depreciation and increases inflation through two channels (Dornbush and Kuenzler, 1988): (1) A depreciation of the real effective exchange rate (REER) driven by nominal currency depreciation has a direct inflationary effect on domestic prices because it increases the price of imported goods expressed in CFA francs. (2) A decrease in the relative price of domestic goods allows firms to increase their profit margins through higher prices without losing market share. The overall effect of rainfall on inflation is expected to be negative. Better weather should reduce food shortages and thus depress inflation, with a lagged effect due to crop delay in the absence of natural disaster. The coefficients of the lagged inflation may be either positive or negative. Positive and significant π_{3l}s would be evidence of inertial forces in the inflation process in Mali. Inertial forces usually show up in countries where formal and informal contracts typically index nominal wages to inflation. In Mali, the lack of an organized labor market suggests that such forces do not play a significant role in inflation.

IV. DATA AND ESTIMATION

A. The Data

21. The study uses quarterly data from 1979:1 to 2006:1. Details on the sources and the definition of variables are given in the appendix. All variables except interest rates and rainfall are in logarithmic terms. Table A.1 describes selected indicators, tables A.2 and A.3 provide some descriptive statistics, and figures A.4 and A.5 plot the individual time series involved in the analysis of the demand for money and of PPP.

22. Figure A.5 shows that the terms of trade and the REER have been continuously falling since 1985. Mali's export prices, and thus terms of trade, are mostly driven by cotton prices because cotton constitutes 42 percent of Mali's exports. In 1985 cotton export prices dropped by 18 percent and in 1986 by 43 percent, so the terms of trade deteriorated by over 7 percent in 1985 and 26 percent in 1986. They then appreciated by 7.1 percent a year on average from 1987 to 1990 as Mali reorganized its supply of petroleum products, decreasing unit import prices for petroleum products in 1989. These

variations of terms of trade have brought depreciation of the REER over the period despite some occasional appreciation.

23. The period from 1986 to 1994 was characterized by general instability, especially in the external sector. Real GDP growth slowed, domestic prices plunged, and the terms of trade depreciated, leading to an overvaluation of the domestic currency. This instability was exacerbated by the decision of the Malian authorities in 1987 to abandon the structural adjustment program they had been implementing since the early 1980s, which led to severe economic adjustments.

24. Before we investigate long-run equilibria in the monetary and the external sectors, we study the order of integration of the variables using the Augmented Dickey-Fuller test (see table A.4). The results demonstrate that all variables in log-level are integrated at order one: the presence of a unit root is shown in variables in log-level but first differenced series are stationary. This finding implies that price inflation and the rate of depreciation of the CFA franc are also stationary. Thus we exclude both from the analysis of the money market equilibrium. [8]

B. The Long-Run Equilibria

In the Money Market

25. The long-run equilibrium in the money market is analyzed applying the Johansen procedure for cointegration analysis to a sixth-order vector autoregression[9] over the set of variables (y, i_{disc}- i_{depo}, i^{f}_{bond}).[8] The maximal and trace tests show evidence of one cointegration vector (see Table 5):

$$(m - p) = 1.45\, y - 0.15\, (i_{disc} - i_{depo}) - 0.05\, i^{f}_{bond} \qquad (5)$$

Various misspecification tests performed on the unrestricted VAR(6) (e.g., portmanteau, normality, AR, ARCH, and heteroscedasticity) did not reveal a serious problem. The normality test is rejected for $m–p$, y, the relative domestic interest rate, and the system equation, but this does not pose a problem because Johansen procedure is robust to non-normality. [10]

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[8] Given that Δp and Δe are stationary, we can include them in the inflation equation without any fear of spurious regression. The results show that the first lags of these variables enter significantly into the inflation equation (see Table 6). The total effects could be as well decomposed into an effect through the disequilibrium in the money market and a direct short-term effect.

[9] The optimal lag length of the VAR models is chosen according to the Akaike criterion and the properties of the residuals (white noise). The model incorporates a constant, dummy variables for 1986 and 1987 (for the steep deflation in those years), and a dummy variable for the period 1994:1–2006:1 (for the period of new CFA franc-euro parity after the 1994 devaluation); all are unrestricted. For brevity's sake, the reported results omit these variables.

[10] Whether money demand in Mali is stable is questionable. In other currency unions, in some cases the aggregate currency area money demand function is more stable than the money demand functions of

26. All coefficients have the expected sign. The demand for broad money in Mali is positively related to income and negatively related to both the rate of return on French bonds and the opportunity cost of holding money rather than domestic financial assets. The income elasticity is larger than unity (1.45) and significant: $\chi^2(1) = 14.19$ [0.000].[11] The demand for broad money is negatively related to $(i_{disc} - i_{depo})$ and i^f_{bond} with moderate semi-elasticities. Significance tests of the interest rates show that the effect of $(i_{disc} - i_{depo})$ is statistically different from zero ($\chi^2(1) = 7.48$ [0.006]), whereas the effect of i^f_{bond} is not ($\chi^2(1) = 2.95$ [0.08]). This finding is not surprising, given the high correlation between the two interest rates and between the two rates and income y (see Table 3). The presence of y and $(i_{disc} - i_{depo})$ reduces the effect of the foreign interest rate to insignificance. Hence, we keep the French interest rate in the long-run relationship. A fall in the spread between i_{disc} and i_{depo} increases money holdings at the expense of holdings of domestic bonds. Conversely, a rise in the spread between i_{disc} and i_{depo} stimulates holdings of domestic bonds. Similarly, an increase in the rate of return on French bonds triggers capital outflows. However, the substitution between foreign and domestic assets is imperfect. A test for equal semi-elasticity between $(i_{disc} - i_{depo})$ and i^f_{bond} is rejected (under income nonhomogeneity): $\chi^2(1) = 6.02$ [0.01].

27. Using the Johansen procedure we perform a multivariate test for stationarity. For each variable, we test the null hypothesis that it is stationary against the alternative that it is not. The results (see table A.5) confirm that all the variables are stationary. Tests show that the weak exogeneity of broad money and income is not accepted but it cannot be rejected for i^f_{bond} and $(i_{disc} - i_{depo})$. However, the small feedback coefficient of income (0.062) compared to the coefficient for broad money (–0.273) suggests that broad money is more likely to be endogenous than income.

28. In sum, the cointegration analysis shows that the demand for broad money is determined by income, the domestic interest rate, and the foreign interest rate. The evidence also suggests that the substitution between domestic and foreign assets is imperfect, with some preference going to domestic assets.

In the External Sector

29. An Augmented Dickey-Fuller (ADF) test on the real effective exchange rate (*p-p*-neer*) rejects the null hypothesis of nonstationarity. The optimal zero-order VAR provides a t-statistic of – 4.05, which is smaller than the 5 percent ADF critical value (–2.9), but this stationarity holds for 1987:1 through 2006:1. The same test performed for 1979:1 through 2006:1 cannot reject the nonstationarity at a level of 5 percent (t–ADF = 0.9 for an optimal zero-order VAR). Thus while strict absolute PPP has held since 1987, it did not necessarily hold over the whole period.

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individual countries (the euro area); in other cases even if money demand is stable at the regional level, it may not be for individual member countries (the Eastern Caribbean Currency Union). For Mali, the stability of money demand can be explained by the fact that WAEMU countries might still be segmented.

[11] Throughout this paper the asymptotic p-values are presented in square brackets following the observed chi-square statistics.

30. However, the ADF test is known to be biased when there are structural breaks in the data, which is likely to be the case here. Interestingly, a Johansen multivariate test of stationarity performed on the real exchange rate and the terms of trade concludes that the real exchange rate is stationary from 1982:2 to 2006:1. The optimal 12-order vector autoregression reveals two cointegrating vectors that correspond to the real exchange rate and the terms of trade.[12] We therefore conclude that the real exchange rate is stationary and PPP holds in Mali from 1982:2 to 2006:1, when the relative dynamics between the real exchange rate and the terms of trade are accounted for.

31. We define the deviations from long-run equilibria in the money market and in the external market as follows:

$$ecm\_m = m - p - 1.447\, y + 0.151\, (i_{disc} - i_{depo}) + 0.049\, i^{f}_{bond} \quad (6)$$

$$ecm\_ppp = p - p^{*} - neer = reer \quad (7)$$

These error-correction terms are plotted in figure A.6 and will be included in the inflation model.

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32. We estimate an inflation model using the ordinary least squares procedure.[13] The general model (equation 4) includes the lagged-one values of the error-correction terms *ecm_m* and *ecm_ppp,* the first four lags of price inflation, and the current value and the first four lags of the first difference of the other macroeconomic indicators. The model incorporates a constant term, seasonal dummy variables, dummy variables for 1986 and 1987 to account for the steep deflation then, and a dummy variable for the period 1994:1–2006:1 corresponding to the years after devaluation. The inflation model also incorporates the current value and the first four lagged values of Mali's average national rainfall (measured in thousandths of millimeters) to capture the supply-side constraints.

33. A parsimonious inflation model is derived using a general-to-specific model selection procedure.[14] Three specifications are reported in table A.6.

Various tests are performed to analyze the properties of the model: tests for serial autocorrelation (AR), autoregressive heteroscedasticity (ARCH), heteroscedasticity, regression misspecification (RESET), nonnormal errors (normality test). None of them

[12] The optimal lag length is chosen for the unrestricted VAR using the Akaike criterion and the desired white noise property of the residuals. The model is estimated for the period 1982:2–2006:1 and incorporates a constant, seasonal dummies, two dummy variables for 1986 and 1987, and a dummy for the period 1994:1–2006:1, all unrestricted.

[13] The estimation period is 1987:2–2006:1. This period provides a more robust model with better properties while still including the main early events: the deflation of 1987 and the devaluation of 1994.

[14] We use the PcGets procedure. The routine is described in the manual of PcGets by Hendry and Krolzig (2001).

reveal problems. Likewise, the robustness of the model is proven using graphical diagnostics and tests for omitted variables. The results concerning specification 1 are reported in figures A.7, A.8, and A.9 and table A.7. The recursive estimates of the parameters and Chow tests demonstrate the stability of the model. The 1-step errors lie within their 95 percent confidence bands with constant standard errors. Break point Chow test reveal two breaks that are significant at the 5 percent level but are no longer so at the 1 percent level. Furthermore, adding dummies for these years does not change the conclusions of the model.

34. The plot of predicted vs. actual values in figure A.9 shows that the model fits inflation relatively well. The deflation in 1987 and the unstable period after it are both depicted fairly clearly. The residuals also behave well. Tests for omitted variables show the stability of the model. However, the tests for omitting lagged income, rainfall, and foreign prices are close to being accepted. Adding those variables (specifications 2 and 3) slightly modifies the conclusions of specification 1, but not much.

35. Previous disequilibria from the monetary and the external sectors matter in the determination of price inflation. The coefficients of both ECM terms are significant and have the expected signs. A disequilibrium of 10 percent in the monetary sector leads to an increase of around 0.7 percent in inflation, and a 10 percent disequilibrium in the external sector leads to an 0.7 percent decrease (specification 1). As the monetarist model would predict, excess money supply positively affects inflation. This effect is barely significant in specifications 1 and 3 but shows up more strongly in specification 2. Because Mali is part of a monetary union, its demand for money is very difficult to distinguish from demand in other WAEMU countries. This noise induces imprecision in the effect of the monetary sector disequilibrium on inflation and reduces its significance. By contrast, real appreciation of the domestic currency depresses inflation in the long run, with a higher magnitude and a more significant effect than the money market disequilibrium (specifications 2 and 3). The highest speed of adjustment is given by specification 2, with about 10 percent of the previous disequilibrium transmitted to the inflation rate each quarter. In sum, inflation in Mali appears to have both monetary and imported long-run sources.

36. Not all stationary variables that were considered as potential determinants of inflation enter into the equation. However, the short-run determinants have the expected signs. Although we notice that changes in the discount rate increase inflation through their impact on money demand, the effect is reversed in the short run: an increase in the BCEAO discount rate decreases inflation with a lag of three quarters. Similarly, a rise in the deposit rate has a positive effect on inflation three quarters later, whereas it decreases inflation over the long term via money demand. However, this effect is cancelled one quarter later.

37. Changes in the CFA franc / U.S. dollar exchange rate have a substantial inflationary effect. About 33 percent of a nominal depreciation of the CFA franc against the dollar is reflected in prices two quarters later. This is the most important inflationary effect in

specification 1, even if it is partly cancelled one quarter later, which suggests an initial overshooting. This result shows the effect of an increase in the rate of return on foreign currency holdings but also the high percentage of imported goods covered by the CPI. The latter is confirmed by the high positive coefficient of foreign inflation in specifications 2 and 3, which suggests that policies to promote trade with countries inside the CFA franc and European Union zones could help control inflation in the short term. However, such policies can be difficult to implement. Mali's imports are usually pumped up by additional needs due to food shortages during droughts. Moreover, restricting imports from some countries can be interpreted as protectionist and lead to further problems. Likewise, some imported goods like oil imports are not easily controllable and cannot be reduced.

38. Another important short-term source of inflation in specifications 2 and 3 is real income growth. Table A.6 shows that a 10 percent increase in real income pushes up inflation by approximately 8 percent two quarters later. With rainfall accounting for agricultural production, the effect of real income growth can be thought of as reflecting the effect of a rise in nonagricultural income. From an expenditure point of view, this inflationary effect can also be attributed to a rise in public expenditures. This result is in accordance with the conclusions of the Phillips inflation-income curve.

39. The structuralist hypothesis is validated for Mali: supply-side constraints have a significant and large effect on inflation. Rainfall appears to decrease inflation significantly one quarter (for specification 3) and two quarters later, with a major impact for the lag-two variable. The magnitude of the influence of rainfall is high considering the unit of the variable. Each thousandth of a millimeter reduces inflation by 7 percent the next quarter (for specification 3) and more than 10 percent the following quarter. Because rainfall is used to proxy agricultural—particularly cereal—production, this result suggests that cereal production has a large impact on price inflation while itself relying on the weather. The introduction of real income makes it possible to distinguish between agricultural and nonagricultural revenues, deepening the effect of supply-side constraints.

40. A major implication of our findings is that policies that reduce food shortages should be effective in stabilizing price inflation. Policies aiming to (i) increase cereal production, (i) free production from weather conditions, (iii) secure cereal supply during droughts, and (iv) minimize the impact of natural disasters like locust invasions or droughts by improving food security in Mali should reduce price inflation.[15] For instance:

- The Malian government can encourage the building of food storage facilities. Such facilities are helpful to fill unexpected food shortages and prevent sudden sharp price inflation due to natural disasters. However, this

[15] New techniques to locate locusts or provoke rains by bombing clouds are being used in some African countries.

solution may lead to the loss of a large part of the production if storage is not secure and efficient.[16] Among potential problems are invasion of rats, insects, and other animals; misuse of chemical protections like pesticides; and deficient conservation systems.

- Liberalizing trade and procedures to improve transportation infrastructure like roads, railroads, and air cargo could make Mali more open to trade internally, regionally, and internationally and help reduce excess demand for goods.

- Malian authorities should work to increase agricultural productivity by promoting modernized agriculture techniques, increasing irrigated areas, and introducing more productive grains, and also make credit more accessible for farmers.[17]

Such improvements will increase and secure cereal production and should soften inflationary pressures. Moreover, the OECD has shown that increasing agricultural productivity in developing countries does much more than just raise farmers' incomes. Agricultural growth reduces poverty by lowering and stabilizing food prices; it improves employment for the poor in rural areas, increases demand for consumer goods and services, and thus stimulates activity beyond the farm.

41. In sum: Inflation in Mali has monetary, domestic, and foreign causes. Supply-side constraints seem to be one of the most important. The adjustments in real income, domestic interest rates, foreign inflation, and the nominal CFA franc/U.S. dollar exchange rate are shown to capture the short-term adjustments of inflation. In the long run, previous disequilibria in the monetary and the external sectors both affect inflation.

V. CONCLUSION

42. This paper investigates the determinants of inflation in Mali for 1979–2006 using a mixed monetarist-structuralist model and cointegration methods. We derive a long-run demand for money and show that PPP holds when dynamics between the real exchange rate and the terms of trade are accounted for. An error-correction model is used to investigate simultaneously the long-run and short-run determinants of Mali inflation. The model incorporates average rainfall to catch supply-side constraints. The general-to-specific procedure is used to derive a parsimonious model, and the potential misspecification and the robustness of the model are analyzed.

[16] Depending on the crop, the loss can reach 50 percent in some African countries.

[17] An example of more productive grain is the cotton Bt. This new type of cotton incorporates some bacteria (the Bacillus Thuringiensis) that release toxins and kill rodents and other animals. However, the contracts linked to the use of such variety of cotton are very restricted and must be analyzed carefully.

43. Mali's inflation appears to be driven by monetary and external factors in both the short and the long term. Disequilibrium in the monetary market has lasting inflationary effects, and disequilibrium in the tradable goods market has lasting deflationary effects. Increases in real income, the exchange rate, and the deposit interest rate have a short-term inflationary impact, but a rise in the discount interest rate is shown to lower inflation. Supply-side constraints also appear to have an inflationary impact. An increase in average national rainfall substantially decreases inflation one quarter and two quarters later. Thus, policies to reduce food shortages and improve food security in Mali should be effective in lowering inflation.

44. This paper offers perspectives for better understanding and forecasting inflation in Mali. First, the paper opens room for a new way of predicting inflation. While several studies have emphasized the correlation between price inflation and agricultural production, this is the first to prove and quantify such a relation statistically. A next step can be to study how rainfall or cereal production forecasts can be used to improve inflation projections. Second, it may be interesting to study the causes of supply bottlenecks. One attractive pattern, for example, is to analyze the efficiency of cereal markets in Mali by looking for evidence of market segmentation. This feature may be tackled using three concepts of segmentation: inefficient transmission of domestic prices (internal segmentation); inefficient transmission of international prices (external segmentation); and asymmetric price transmission. Better understanding of how prices are formed will help promote structural reforms to lower inflationary pressures.

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APPENDIX

Definitions and Sources of Variables

All data except interest rates and rainfall are in logarithmic form. Most data are from the IMF International Financial Statistics (IFS, 2006), GDP data are from the World Economic Outlook database, and rainfall data are from the Malian authorities. The original GDP series is annual; quarterly values have been interpolated using Eviews' quadratic-average interpolation technique.

e: CFA franc / U.S. dollar exchange rate

Δe: depreciation rate of the CFA franc / U.S. dollar exchange rate

i^f_{bond}: interest rate on French bonds—the annual government bond yield

i_{depo}: deposit rate—the annual rate offered by commercial banks on time deposits of less than six months

i_{disc}: BCEAO discount rate

m: broad money (money plus quasi-money) in nominal terms

neer: nominal effective exchange rate (from the ER Facility tool)

p: Consumer Price Index (CPI), basis 2000=100

m-p: real broad money balances

Δp: rate of inflation, as measured by the CPI growth rate

p^*: foreign effective price level, as measured by the average CPI of the main trade partners; computed using the Exchange Rate (ER) Facility tool

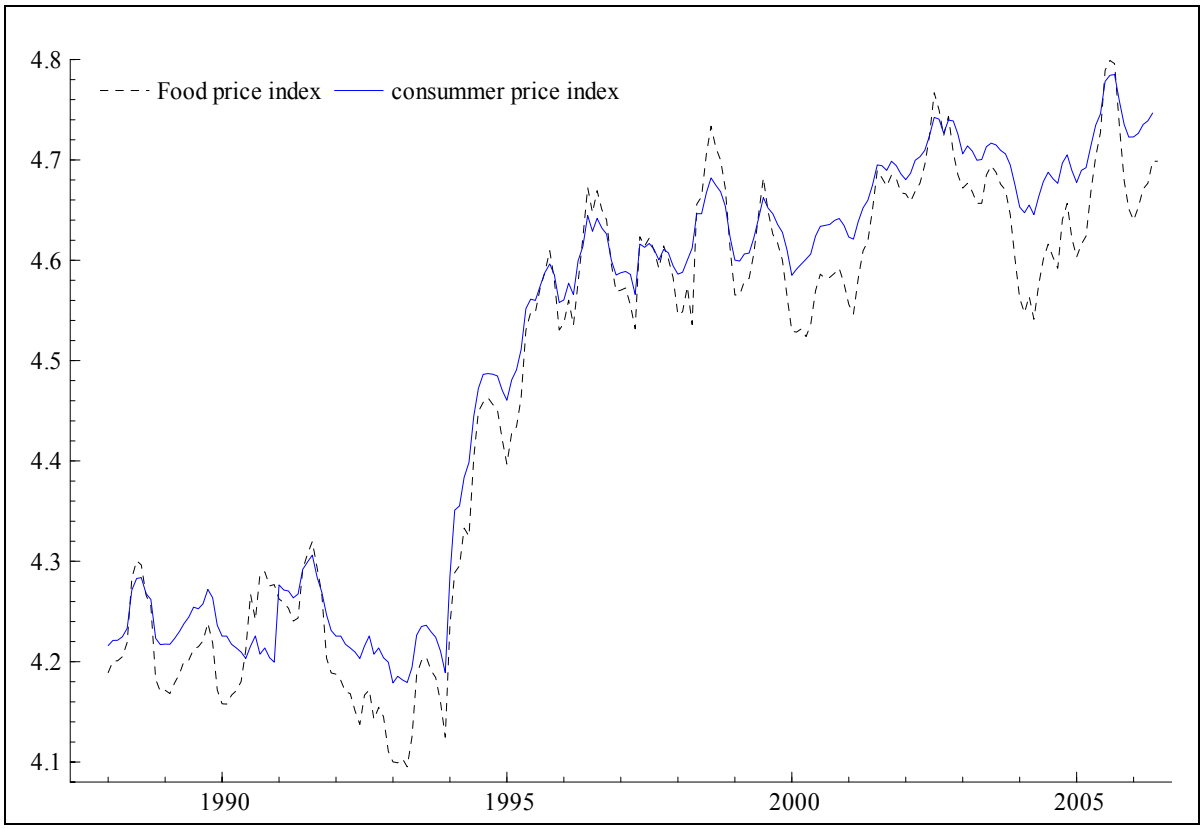
Δp^*: foreign rate of inflation

y: real GDP (in constant prices)

tot: terms of trade

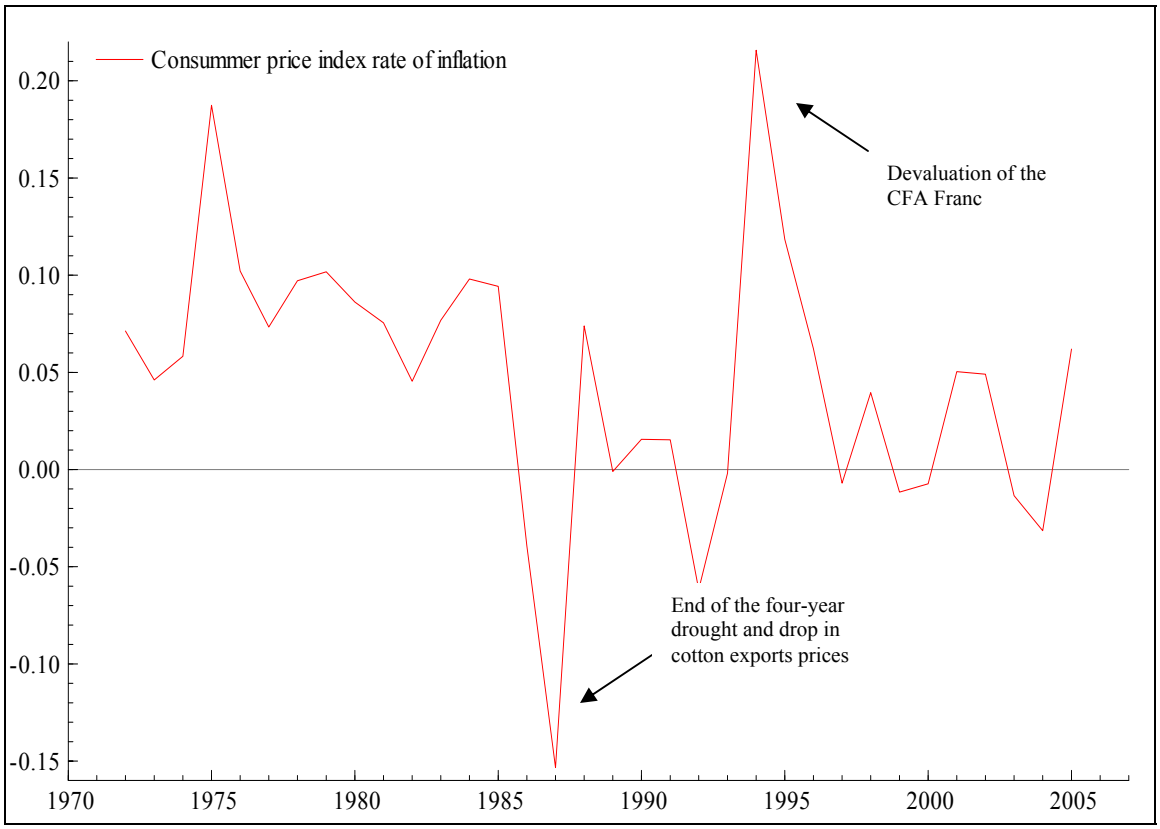
rainfall: average national rainfall expressed in 0.1 mm (unless otherwise specified). The average involves measures from the weather stations at Bamako, Gao, Kayes, Kidal, Mopti, Segou, Sikasso, and Tombouctou. The weights are the share of each city in the total national cereal crop in 2004.

Figure A.1. Mali: Food Price and Consumer Price Indexes, 1988:1–2006:5
(Logarithm of variables)



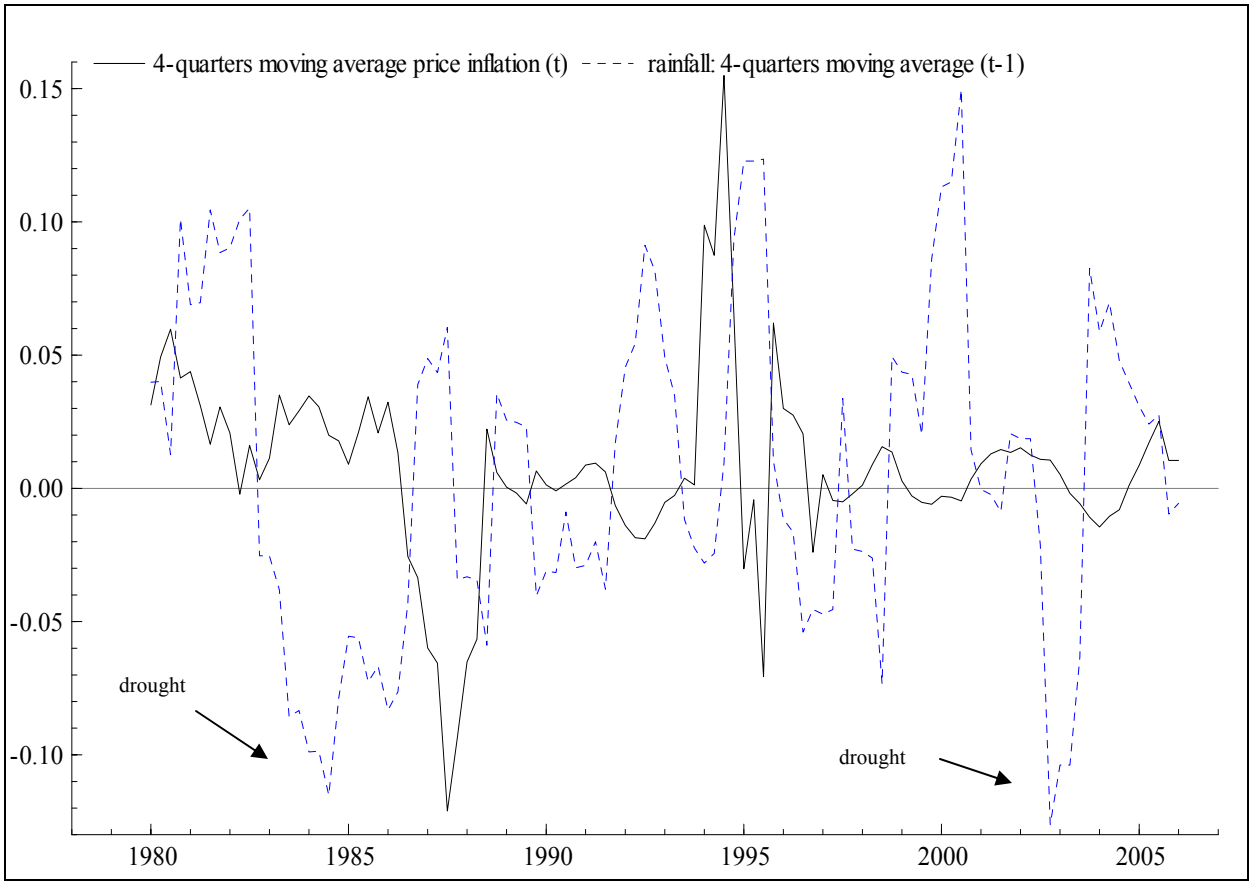
Sources: Malian authorities and author's calculations

Figure A.2. Mali: Annual Rate of Inflation, 1971–2005



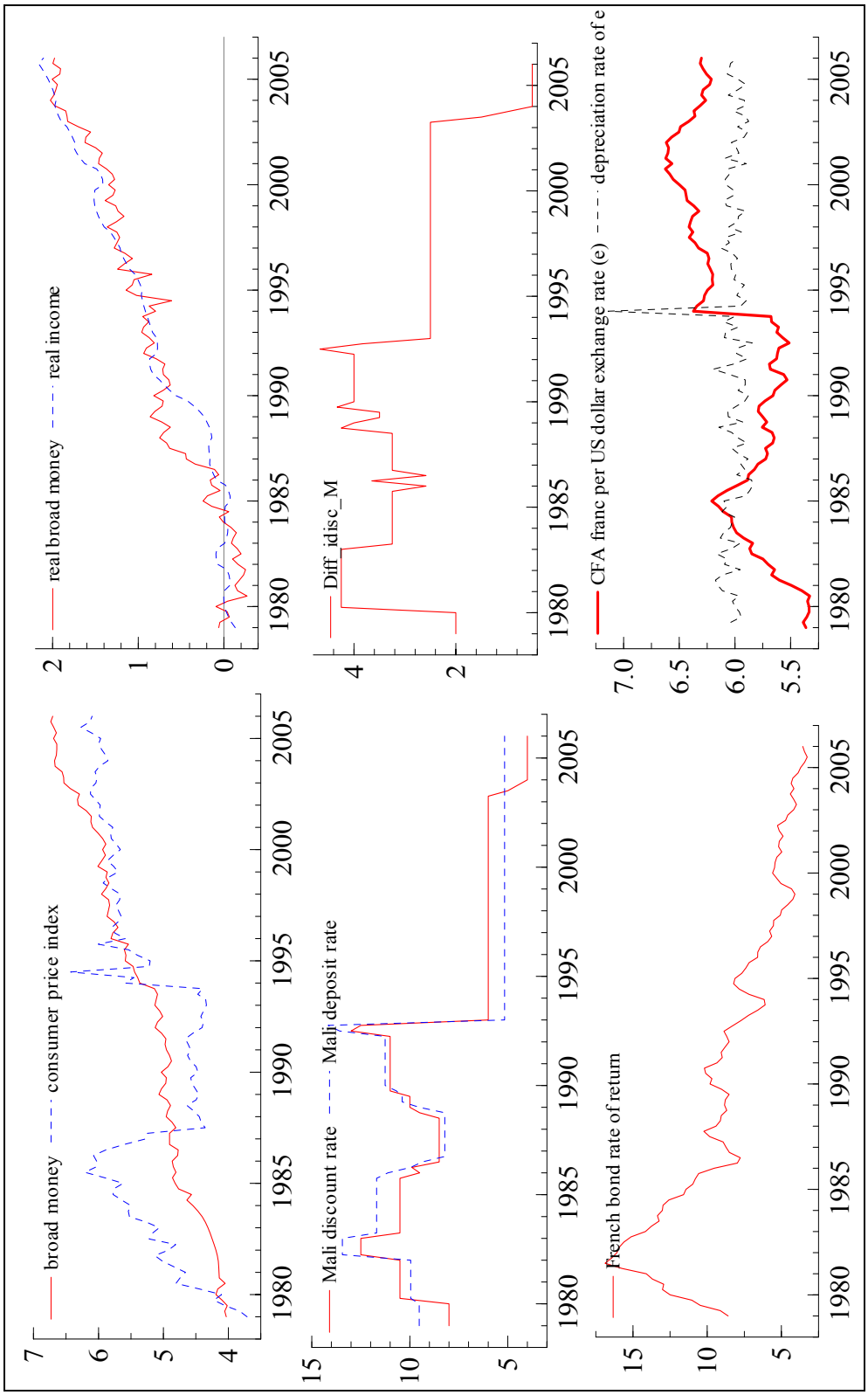
Sources: IMF(2006) and author's calculations

Figure A.3. Mali: Inflation and Rainfall (in mm), 1979:1–2006:1
(Mean and Ranges Adjusted)



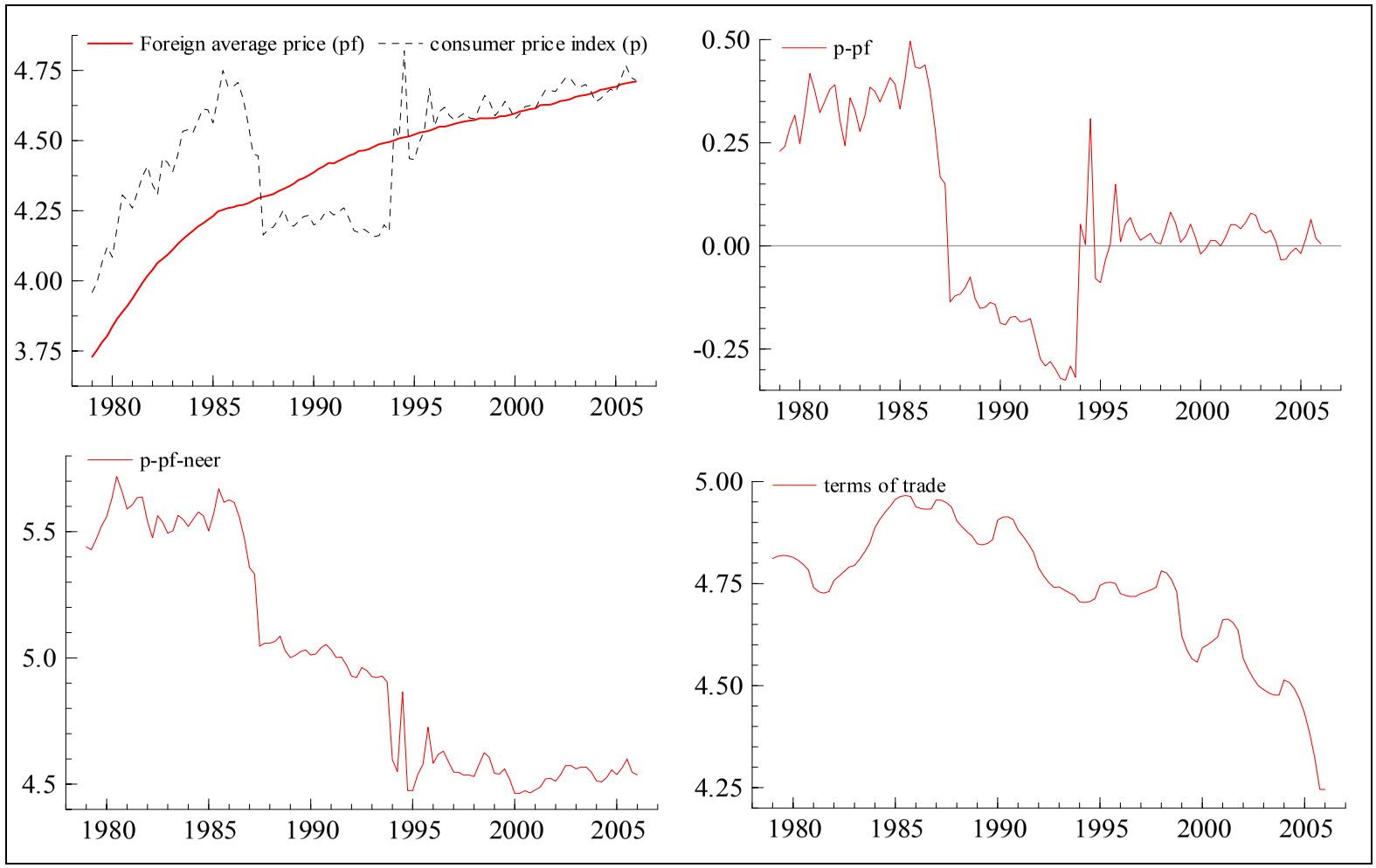
Sources: Malian authorities and author's calculations.

Figure A.4. Mali: Money, Income, Interest Rates and Exchange Rate, 1979:1–2006:1
(All variables in logarithm except the interest and exchange rates)



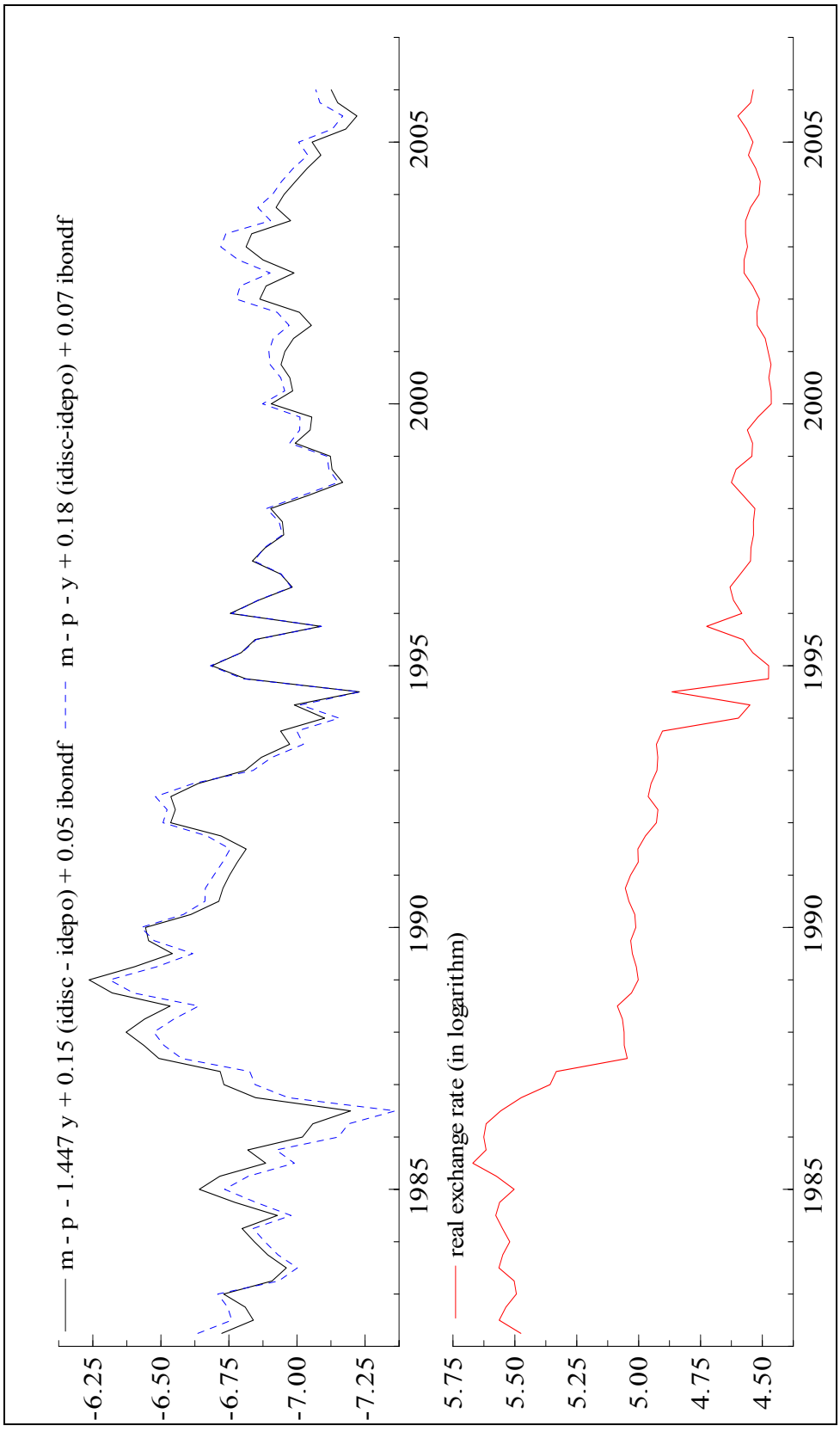
Sources: IMF(2006) and author's calculations.

Figure A.5. Mali: Domestic and Foreign Prices, Exchange Rate and Terms of Trade, 1979:1–2006:1
(All variables in logarithm except the interest rates and the exchange rates)



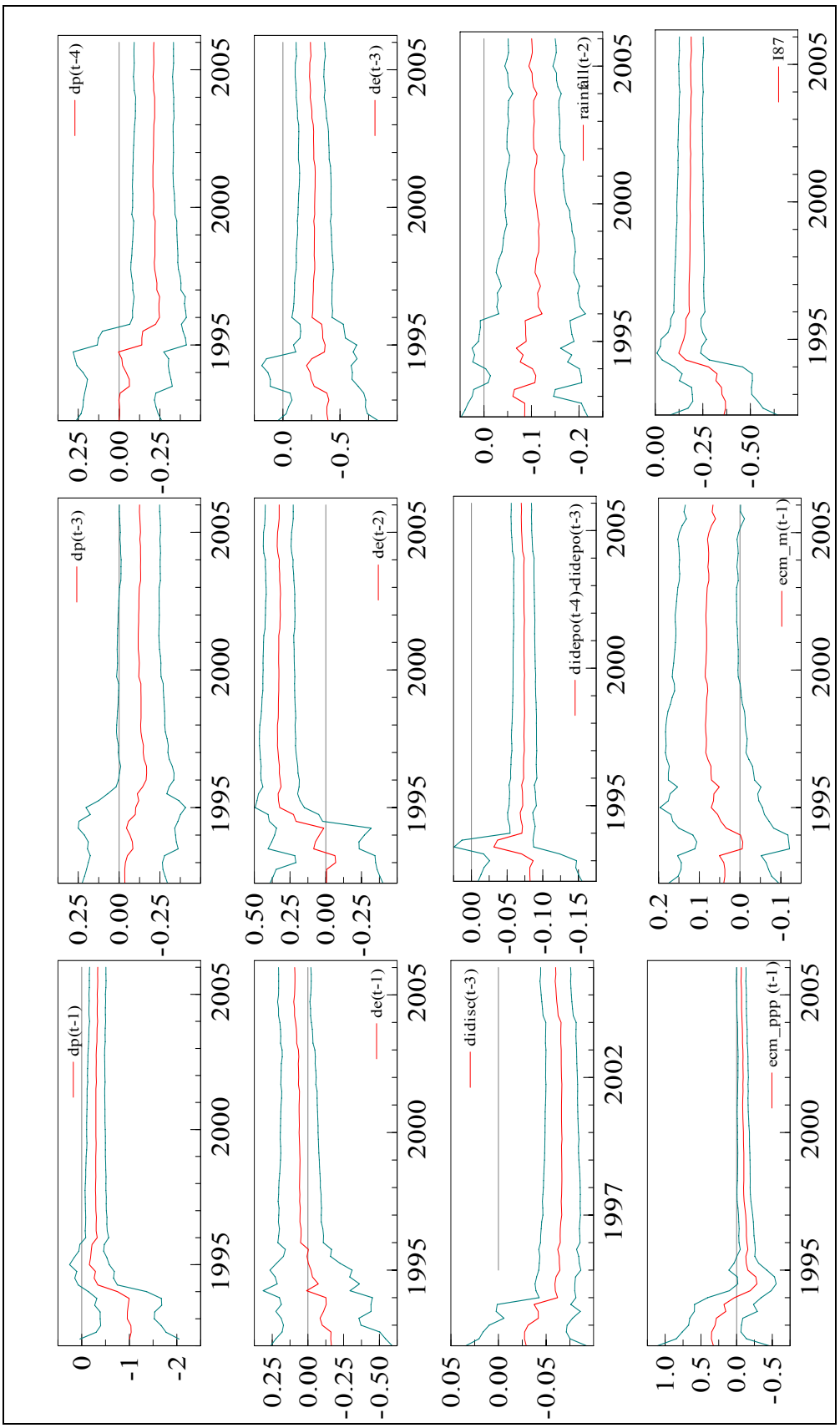
Sources: IMF (2006) and author's calculations.

Figure A.6. Mali: Cointegrating Vectors for the Money Market and the Foreign Sectors, 1982:2–2006:1
(Mean Adjusted for the Money Market)



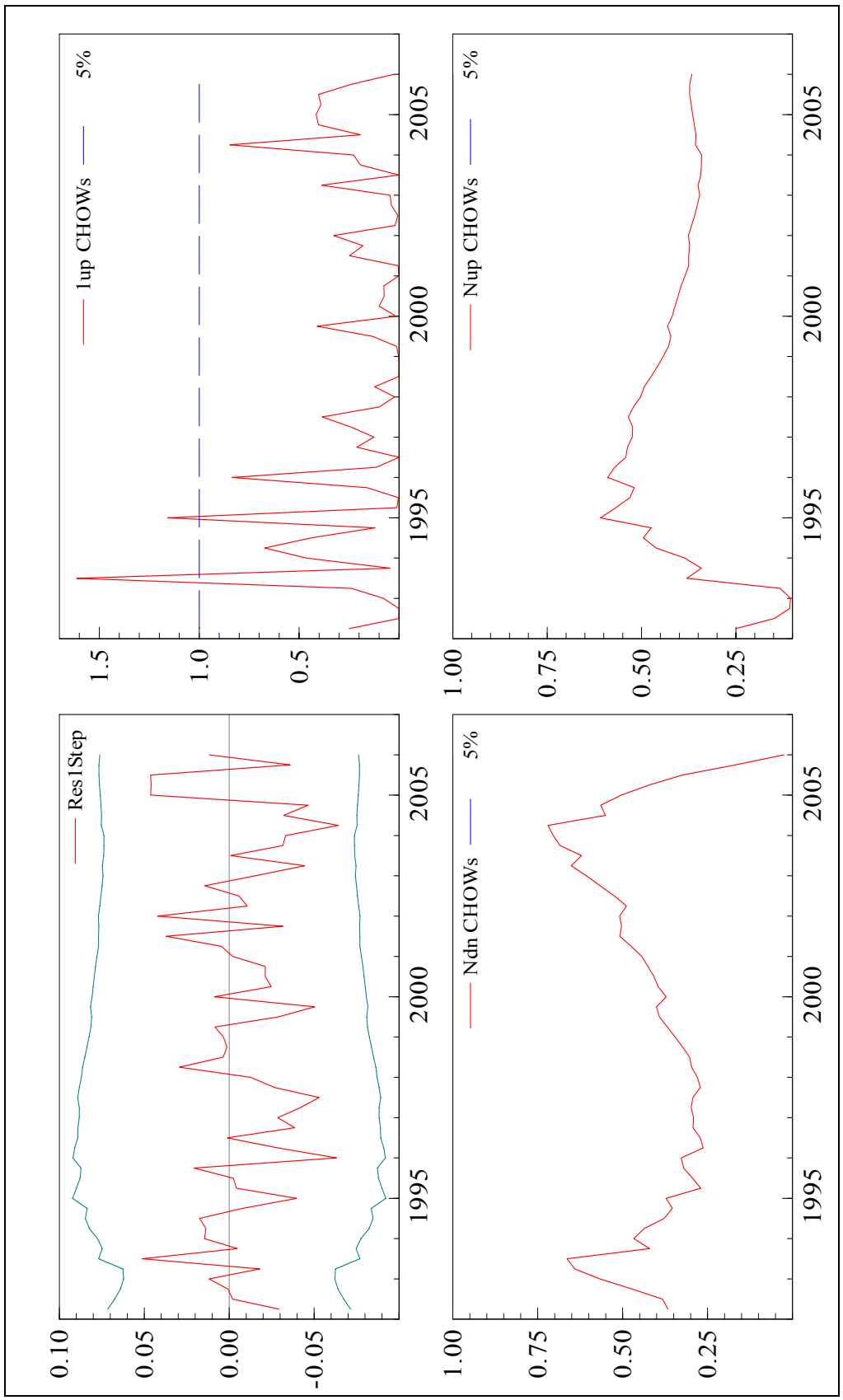
Source: Author's calculations

Figure A.7. Mali: Inflation Model: Recursive Estimates, 1992:2–2006:1



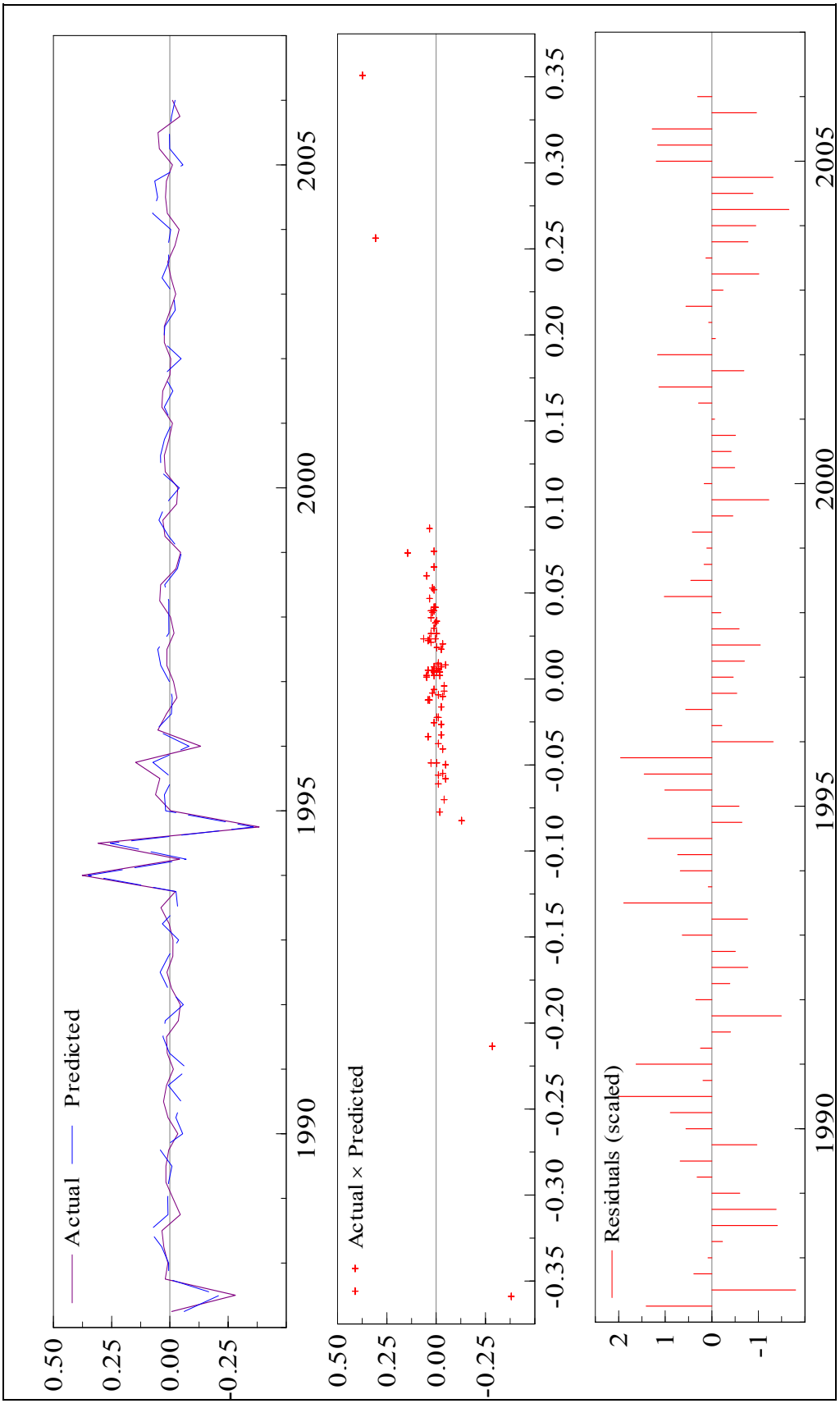
Source: Author's calculations

Figure A-8. Mali: Inflation Model: One-Step Residual and Chow Stability Tests, 1992:2–2006:1



Source: Author's calculations.

Figure A.9. Mali: Inflation Model: Actual, Predicted and Residuals, 1987:2–2006:1



Source: Author's calculations

Table A.1. Mali: Selected Financial, Ecoomic, and Climatic Indicators, 1979-2005
(All variables in logarithm except the interest and exchange rates and the rainfall)

	m-p	**y**	**Δp**	**Δe**	$\mathbf{i_{disc}}$	$\mathbf{i_{depo}}$	$\mathbf{i^{f}_{bond}}$	**Δneer**	**Δp***	**rainfall**
1979Q4	-0.04	5.50	0.05	-0.02	8.00	6.00	11.04	-0.01	0.02	85.74
1980Q4	-0.16	5.51	-0.02	0.07	10.50	6.25	13.69	0.02	0.02	32.89
1981Q4	-0.25	5.50	0.04	-0.03	10.50	6.25	16.43	0.01	0.02	35.90
1982Q4	-0.15	5.55	-0.02	0.02	12.50	8.25	15.12	0.00	0.02	35.75
1983Q4	-0.08	5.49	0.01	0.03	10.50	7.25	13.35	0.00	0.02	10.19
1984Q4	0.14	5.51	0.00	0.04	10.50	7.25	11.59	0.00	0.01	48.42
1985Q4	0.14	5.50	-0.06	-0.10	10.50	7.25	10.58	-0.01	0.01	21.39
1986Q4	0.33	5.59	-0.09	-0.03	8.50	5.25	8.50	-0.01	0.01	37.48
1987Q4	0.67	5.59	0.02	-0.06	8.50	5.25	10.23	0.00	0.00	39.28
1988Q4	0.72	5.60	-0.04	-0.04	9.50	5.25	8.68	0.00	0.01	22.96
1989Q4	0.71	5.71	0.00	-0.05	11.00	6.67	9.03	-0.01	0.01	38.28
1990Q4	0.64	5.85	0.01	-0.06	11.00	7.00	10.19	-0.01	0.01	39.77
1991Q4	0.79	5.90	-0.04	-0.07	11.00	7.00	8.80	-0.02	0.01	86.21
1992Q4	0.87	5.87	-0.01	0.06	12.50	8.67	8.31	-0.01	0.00	32.96
1993Q4	0.95	5.92	-0.02	0.00	6.00	3.50	6.09	-0.01	0.00	23.60
1994Q4	1.02	5.95	-0.38	-0.01	6.00	3.50	8.22	0.00	0.00	71.76
1995Q4	0.84	5.98	0.15	0.00	6.00	3.50	7.17	0.00	0.00	36.09
1996Q4	1.16	6.05	-0.03	0.02	6.00	3.50	5.92	0.00	0.00	33.12
1997Q4	1.25	6.11	-0.02	-0.03	6.00	3.50	5.52	-0.03	0.00	31.66
1998Q4	1.24	6.18	-0.03	-0.06	6.00	3.50	4.23	-0.01	0.00	22.05
1999Q4	1.27	6.19	-0.03	0.01	6.00	3.50	5.31	0.01	0.00	66.43
2000Q4	1.37	6.18	0.00	0.04	6.00	3.50	5.32	0.01	0.00	41.99
2001Q4	1.50	6.30	0.00	-0.01	6.00	3.50	4.88	-0.01	0.00	38.90
2002Q4	1.70	6.34	0.00	-0.01	6.00	3.50	4.57	0.00	0.00	75.72
2003Q4	1.98	6.40	-0.02	-0.06	4.50	3.50	4.39	-0.01	0.00	36.53
2004Q4	1.94	6.43	0.02	-0.06	4.00	3.50	3.88	-0.02	0.00	22.56
2005Q4	2.00	6.49	-0.04	0.03	4.00	3.50	3.44	0.01	0.00	29.25

Note: See appendix for definitions, construction, and sources of variables.

Table A.2. Mali: A Sample Descriptive Statistics of Variables, 1979:1–2006:1
(All variables in logarithm except the interest and exchange rates and the rainfall)

	m-p	y	Δp	Δe	i_{disc}	i_{depo}	i^{f}_{bond}	Δneer	Δp*	rainfall
Maximum	2.03	6.49	0.38	0.70	13.00	8.67	16.87	0.67	0.03	682.73
Minimum	-0.27	5.45	-0.38	-0.10	4.00	3.50	3.26	-0.03	0.00	0.00
Mean	0.82	5.88	0.01	0.01	7.97	5.11	8.30	0.01	0.01	174.03
Median	0.83	5.89	0.01	0.00	8.00	5.25	8.22	0.00	0.01	85.74
Std. Dev.	0.67	0.33	0.08	0.08	2.55	1.70	3.51	0.07	0.01	201.41

Note: See appendix for definitions, construction, and sources of variables.

Table A.3. Mali: Correlation Between Selected Variables, 1979:1–2006:1
(All variables in logarithm except the interest and exchange rates and the rainfall)

	m-p	y	Δp	Δe	i_{disc}	i_{depo}	i^{f}_{bond}	neer	p*	rainfall	$rainfall_{t-1}$	$rainfall_{t-2}$	$rainfall_{t-3}$	$rainfall_{t-4}$
m-p	1.00													
y	0.96	1.00												
Δp	-0.12	-0.03	1.00											
Δe	-0.09	-0.06	0.39	1.00										
i_{disc}	-0.80	-0.80	0.00	-0.01	1.00									
i_{depo}	-0.78	-0.78	0.01	-0.04	0.96	1.00								
i^{f}_{bond}	-0.92	-0.88	0.05	0.08	0.84	0.81	1.00							
neer	0.80	0.86	0.04	0.06	-0.82	-0.85	-0.78	1.00						
p*	0.91	0.89	-0.08	-0.07	-0.68	-0.69	-0.85	0.79	1.00					
rainfall	-0.04	0.02	0.28	-0.04	0.00	-0.01	0.00	0.01	0.00	1.00				
$rainfall_{t-1}$	0.01	0.04	-0.20	-0.17	0.01	0.00	0.00	-0.01	0.01	-0.15	1.00			
$rainfall_{t-2}$	0.06	0.00	-0.22	0.12	-0.06	-0.05	-0.02	0.03	0.01	-0.64	-0.16	1.00		
$rainfall_{t-3}$	0.03	0.01	0.10	0.10	-0.01	-0.03	0.01	0.02	0.00	-0.14	-0.64	-0.15	1.00	
$rainfall_{t-4}$	-0.04	0.02	0.26	-0.01	0.01	0.00	0.02	0.01	0.00	0.94	-0.14	-0.64	-0.15	1.00

Note: See appendix for definitions, construction, and sources of variables.

Table A.4. Mali: ADF Test for Unit-Root, 1979:1–2006:1
(All variables in logarithm except the interest and exchange rates and the rainfall)

Variables	t-ADF	Prob value	Lag	1% critical value
In log-levels				
m-p	-0.07	0.95	6	-3.50
y	0.87	0.99	5	-3.50
p	-2.53	0.11	0	-3.49
e	-1.67	0.45	0	-3.49
$\mathbf{i_{disc}}$	-1.24	0.65	0	-3.49
$\mathbf{i_{depo}}$	-1.68	0.44	0	-3.49
$\mathbf{i^{f}_{bond}}$	-0.97	0.76	1	-3.49
neer	-1.11	0.71	0	-3.49
p*	-1.58	0.49	4	-3.49
reer	0.90	0.78	0	-3.50
tot	0.05	0.99	9	-4.08
rainfall	-3.24	0.02*	7	-3.50
In first difference				
m-p	-5.08	0.00**	5	-3.50
y	-3.77	0.00**	4	-3.50
p	-12.82	0.00**	3	-3.49
e	-9.44	0.00**	2	-3.49
$\mathbf{i_{disc}}$	-9.89	0.00**	0	-3.49
$\mathbf{i_{depo}}$	-10.32	0.00**	0	-3.49
$\mathbf{i^{f}_{bond}}$	-6.07	0.00**	0	-3.49
neer	-10.41	0.00**	0	-3.49
p*	-2.93	0.05*	3	-3.49
reer	-5.46	0.00**	5	-3.50
tot	-6.43	0.00**	8	-4.08
rainfall	-7.40	0.00**	6	-3.50

Notes: See Appendix for definitions, construction and sources of variables.
For each variable, the estimated VAR incorporates a constant except the terms of trade for which the estimated VAR incorporates a constant and a trend.
"*" and "**" indicate significance at the 5 percent and 1 percent levels respectively.

Table A.5. Mali: Cointegration Analysis of Broad Money Demand, 1979:1–2006:1

	Rank test			
Null Hypothesis	r = 0	r ≤ 1	r ≤ 2	r ≤ 3
Eigenvalues	0.295	0.177	0.044	0.007
Lambda max	57.9**	23.92	5.07	0.66
Prob-value	0.00	0.21	0.80	0.42
Lambda trace	33.97**	18.85	4.41	0.66
Prob-value	0.01	0.10	0.81	0.42
	Standardized eigenvectors (βs)			
	m-p	y	i_{disc}- i_{depo}	i^{f}_{bond}
	1.000	-1.447	0.151	0.049
	Standardized adjustment coefficients (αs)			
	m-p	y	i_{disc}- i_{depo}	i^{f}_{bond}
	-0.273	0.062	-0.141	0.508
	Weak exogeneity test statistics			
	m-p	y	i_{disc}- i_{depo}	i^{f}_{bond}
$\chi^2(1)$	7.79**	15.12**	0.09	1.43
	Statistics for testing the significance of a given variable			
	m-p	y	i_{disc}- i_{depo}	i^{f}_{bond}
$\chi^2(1)$	12.41**	14.19**	7.48**	2.95
	Multivariate statistics for testing stationarity			
	m-p	y	i_{disc}- i_{depo}	i^{f}_{bond}
$\chi^2(3)$	30.67**	29.036**	30.74**	29.68**

Notes: The estimation period is 1982:1–2006:1. See appendix for definition, construction, and sources of variables. The VAR includes six lags on each variable, a constant term, and dummies for the years 1986, 1987 and the period 1994:1–2006:1. The system-based test statistics for weak exogeneity, significance, and stationarity are evaluated on the assumption that r=1 and on the hypothesis that income is not homogeneour. Hence, they are asymptotically distributed as $\chi 2(1)$, $\chi 2(1)$ and $\chi 2(3)$ under the null hypothesis. "*" and "**" indicate significance at the 5 percent and 1 percent levels respectively.

Table A.6. Mali: The Determinants of Inflation, 1987:2–2006:1

	Error Correction Terms														
	Money Market	Foreign Sector	Lagged Inflation			Foreign Prices	Real Income	Nominal Exchange Rate			Interest Rates		Rainfall		Dummies
	ecm_m_{t-1}	ecm_ppp_{t-1}	Δp_{t-1}	Δp_{t-3}	Δp_{t-4}	Δp^*_{t-3}	Δy_{t-2}	Δe_{t-1}	Δe_{t-2}	Δe_{t-3}	$(\Delta i_{disc})_{t-3}$	$(\Delta i_{depo})_{t-3} - (\Delta i_{depo})_{t-4}$	$rainfall_{t-1}$	$rainfall_{t-2}$	I_{1987}
Specification 1	0.0663	-0.0664	-0.337	-0.125	-0.213	-	-	0.093	0.326	-0.240	-0.060	0.070	-	-0.1	-0.189
	(1.96)	(-2.01)	(-3.93)	(-2.03)	(-3.55)			(1.65)	(6.68)	(-3.85)	(-4.02)	(9.87)		(-4.06)	(-6.05)
Specification 2	0.073	-0.106	-0.333	-0.153	-0.232	3.999	0.804	0.095	0.349	-0.221	-0.063	0.073	-	-0.133	-0.169
	(2.31)	(-3.42)	(-4.33)	(-2.73)	(-4.27)	(2.34)	(2.85)	(1.87)	(7.93)	(-3.91)	(-8.80)	(11.5)		(-4.92)	(-5.96)
Specification 3	0.048	-0.091	-0.334	-0.201	-0.267	4.160	0.783	0.075	0.362	-0.179	-0.063	0.072	-0.071	-0.149	-0.176
	(1.59)	(-3.14)	(-4.72)	(-3.75)	(-5.23)	(2.65)	(3.01)	(1.60)	(8.88)	(-3.35)	(-9.56)	(12.20)	(-3.44)	(-5.88)	(-6.71)

	R^2	DW	AR	ARCH	Heterosce-dasticity	Normality	RESET
Specification 1	0.83	1.69	1.51	0.15	1.44	2.33	0.004
Specification 2	0.87	1.63	1.29	1.04	1.29	1.01	0.01
Specification 3	0.89	1.59	0.87	1.24	1.33	1.07	0.22

Source: Author's calculations
Notes: The dependent variable is Δp_t. The t-statistics are in parentheses. "*" and "**" indicate significance at the 5 percent and 1 percent levels respectively.

Table A.7. Mali: Diagnostic Tests for Omitted Variables, 1987:2–2006:1

Variables					F-tests
Lagged inflation					
Δp_{t-2}					F(1,62) = 0.01 [0.91]
Real income					
Δy_t	Δy_{t-1}	Δy_{t-2}	Δy_{t-3}	Δy_{t-4}	F(5,58) =2.32 [0.05]
Nominal exchange rate					
Δe_t	Δe_{t-4}				F(2,61) = 0.52 [0.59]
Domestic interest rates					
$(\Delta i_{disc})_t$	$(\Delta i_{disc})_{t-1}$	$(\Delta i_{disc})_{t-2}$	$(\Delta i_{disc})_{t-4}$		F(9,54) = 1.53 [0.16]
$(\Delta i_{depo})_t$	$(\Delta i_{depo})_{t-1}$	$(\Delta i_{depo})_{t-2}$	$(\Delta i_{depo})_{t-3}$	$(\Delta i_{depo})_{t-4}$	
Rainfall					
$rainfall_t$	$rainfall_{t-1}$	$rainfall_{t-3}$	$rainfall_{t-4}$		F(4,59) = 2.50 [0.05]
Interest rate on French bonds					
$(\Delta i^f_{bond})_t$	$(\Delta i^f_{bond})_{t-1}$	$(\Delta i^f_{bond})_{t-2}$	$(\Delta i^f_{bond})_{t-3}$	$(\Delta i^f_{bond})_{t-4}$	F(5,58) = 0.19 [0.96]
Broad money					
Δm_t	Δm_{t-1}	Δm_{t-2}	Δm_{t-3}	Δm_{t-4}	F(5,58) = 1.29 [0.27]
Foreign price index					
Δp^*_t	Δp^*_{t-1}	Δp^*_{t-2}	Δp^*_{t-3}	Δp^*_{t-4}	F(5,58) = 2.26 [0.06]
Terms of trade					
Δtot_t	Δtot_{t-1}	Δtot_{t-2}	Δtot_{t-3}	Δtot_{t-4}	F(5,58) = 0.99 [0.43]

Notes: See appendix for the definition, construction and sources of variables. The p-values are in square brackets. The tests are performed using Specification 1 inflation model (see Table 6).