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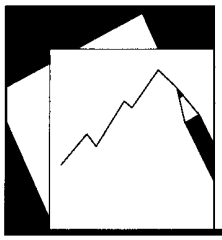

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Modeling Inflation in Chad

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Modeling Inflation in Chad

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Abstract

This paper examines the determinants of inflation in Chad using quarterly data from 1983:Q1 to 2009:Q3. The analysis is based on a single-equation model, completed by a structural vector auto regression model to capture inflation persistence. The results show that the main determinants of inflation in Chad are rainfall, foreign prices, exchange rate movements, and public spending. The effects of rainfall shocks and changes in foreign prices on inflation persist during six quarters. Changes in public spending and the nominal exchange rate affect inflation during three and four quarters, respectively.

JEL Classification Numbers: C22, C32, E31, E62.

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Contents

I. INTRODUCTION

Inflation in Chad reached 8–10 percent over 2008 and 2009, while it averaged 3½ percent in neighboring members of the Central African Economic and Monetary Community (CEMAC). Reducing this gap is important if Chad is to comply with the CEMAC inflation convergence criterion of 3 percent or less. Reducing inflation, in particular food-price inflation, is also critical to protecting the purchasing power of the poor. Therefore, understanding the main drivers of inflation is fundamental to ensuring macroeconomic stability and fighting poverty in Chad.

This paper provides the first empirical analysis of inflation determinants focusing on Chad. Using quarterly data from 1983:Q1 to 2009:Q3, the analysis is based on monetary and external theories of inflation. Supply-side constraints, captured by agricultural shocks, and institutional factors, captured by episodes of political instability, are also accounted for. In addition, the analysis includes major historical events such as the devaluation of the CFAF in 1994 and the start of oil production in 2003.

Several previous studies of inflation and its determinants in Sub-Saharan African countries suggest directions for analysis of Chad. Diouf (2007) analyzed the inflation dynamics in Mali. Like Chad, Mali is a low-income landlocked country and a member of a monetary union similar to the CEMAC. Diouf (2007) found that average national rainfall and monetary and external factors explain inflation. In Ethiopia, Loening, Durevall, and Birru (2009) found that agricultural shocks, exchange rate, and foreign prices affect inflation. In the case of Sudan, an oil-producing country, Moriyama (2008) shows that changes in money supply and nominal exchange rate affect inflation with 18- to 24-month time lags. Klein and Kyei (2009) and Kandil and Morsy (2009) analyzed inflation in other oil-producing countries, such as Angola and the Gulf Cooperation Council (GCC) countries. Klein and Kyei (2009) found that exchange rate movements and excess liquidity drive inflation in Angola. For the GCC countries, Kandil and Morsy (2009) concluded that inflation in trading partners as well as credit and aggregate spending explain inflation. Coleman (2010) analyzed inflation persistence in 13 Communauté Financière Africaine (CFA) member states and highlighted that inflation is persistent in Chad, Cote d'Ivoire, and Niger.[2]

The empirical strategy in this paper combines three estimation methods: the vector error correction model (VECM), the single-equation model, and the structural vector auto regression (SVAR). The single-equation model, augmented with error correction terms from the VECM, shows that supply-side constraints, public spending, and external factors are the

[2] Recent analyses of inflation determinants also include Barnichon and Peiris (2008) for sub-Saharan Africa as a whole, Ubide (1997) for Mozambique, Blavy (2004) for Guinea, Nassar (2005) for Madagascar, and Gottschalk, Kalonji, and Miyajima (2008) for Sierra Leone.

main drivers of inflation in Chad. Rainfall affects domestic prices with a three-quarter lag, through its impact on agricultural production. Public spending has a significant impact on inflation (with a one-quarter lag) through demand pressures on nontradables. Changes in trading partner prices and exchange rate movements are passed through imports to domestic prices, one quarter later.

The SVAR model also points to rainfall, foreign prices, exchange rate, and public spending as the main determinants of inflation. It also shows some persistent effects. For instance, while the impact of rainfall shock on inflation is at its highest three quarters after the shock, this impact persists until the sixth quarter. The dynamics are the same for foreign prices, the exchange rate, and public spending; the effect on inflation persists for three to six quarters.

In what follows, Section II presents recent developments in different sectors of the Chadian economy and analyzes inflation dynamics. Section III presents a simple theoretical framework to analyze inflation determinants. Section IV presents the data, discusses the empirical models, and interprets the results. The last section draws conclusions.

II. MACROECONOMIC DEVELOPMENTS

A. Domestic and External Developments

Since 2003, oil production has offered a unique opportunity for Chad to achieve sustained growth and reduce poverty. Over the past decade, Chad's macroeconomic outlook has been transformed by oil exploitation and related activities through their impact on public finances and the real economy (Figure 1).

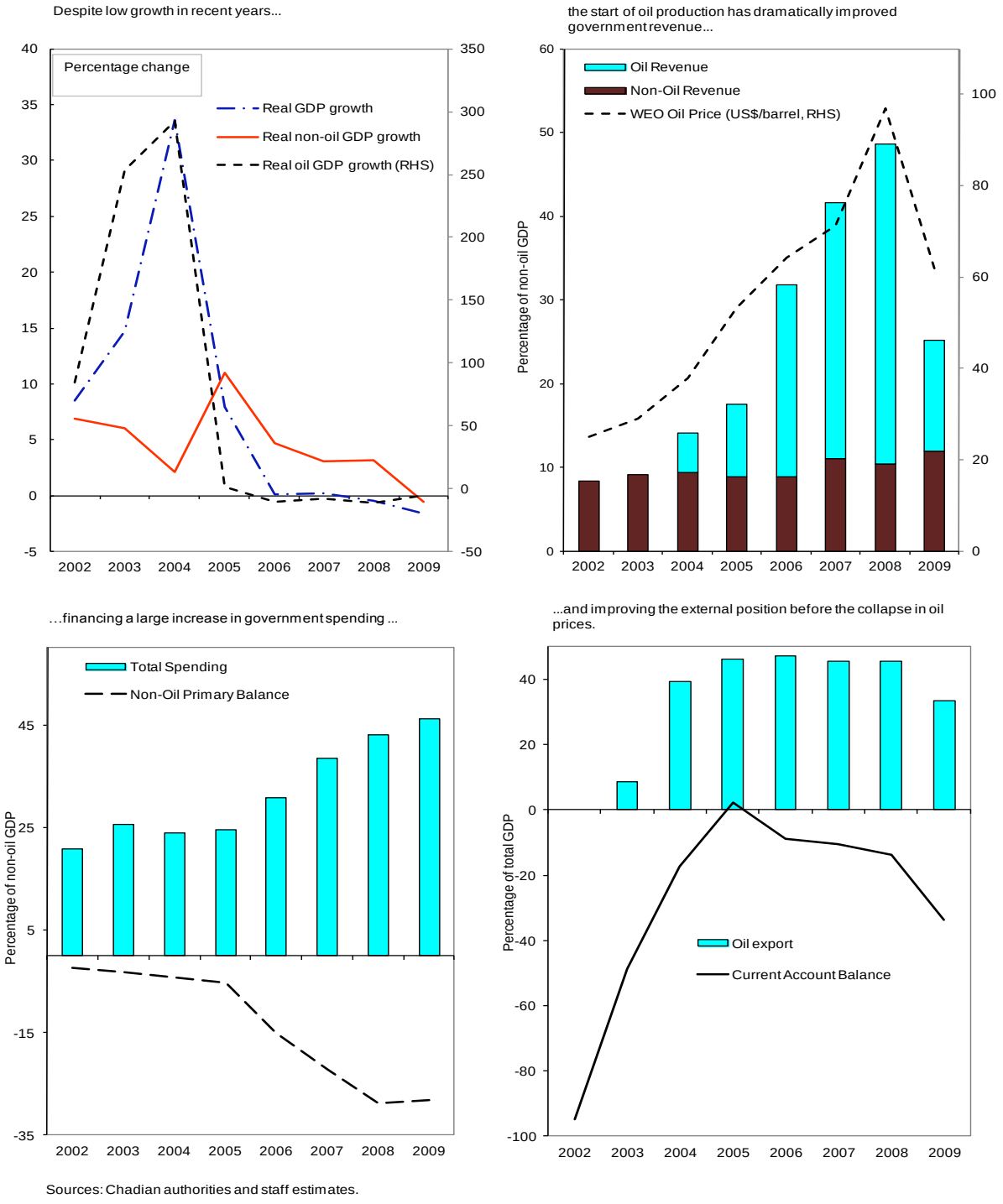
Oil production has dramatically improved government revenue, funding a surge in public expenditure. Public expenditure as a share of non-oil GDP has doubled since 2003, reaching 46 percent in 2009. As a result, the non-oil primary balance reached 28 percent of non-oil GDP in 2009, well above its estimated long-term sustainable level (which is in the low single digits). Thanks to higher revenue from oil exports, the current account balance has also improved by more than 50 percent of the GDP between 2002 and 2009.

Despite the start of oil production, the monetization of the economy remains low, and credit to the private sector limited. The fragile security situation remains a major obstacle for private sector growth, jeopardizing the development of a business-friendly environment that would promote a competitive private sector.

The real exchange rate has appreciated over 2008 and 2009. In addition to the appreciation of the euro against the dollar between 2008 and 2009, which has been partly reversed so far in 2010, inflation in Chad has been higher than in its trading partners, fueling real appreciation and reducing competitiveness.

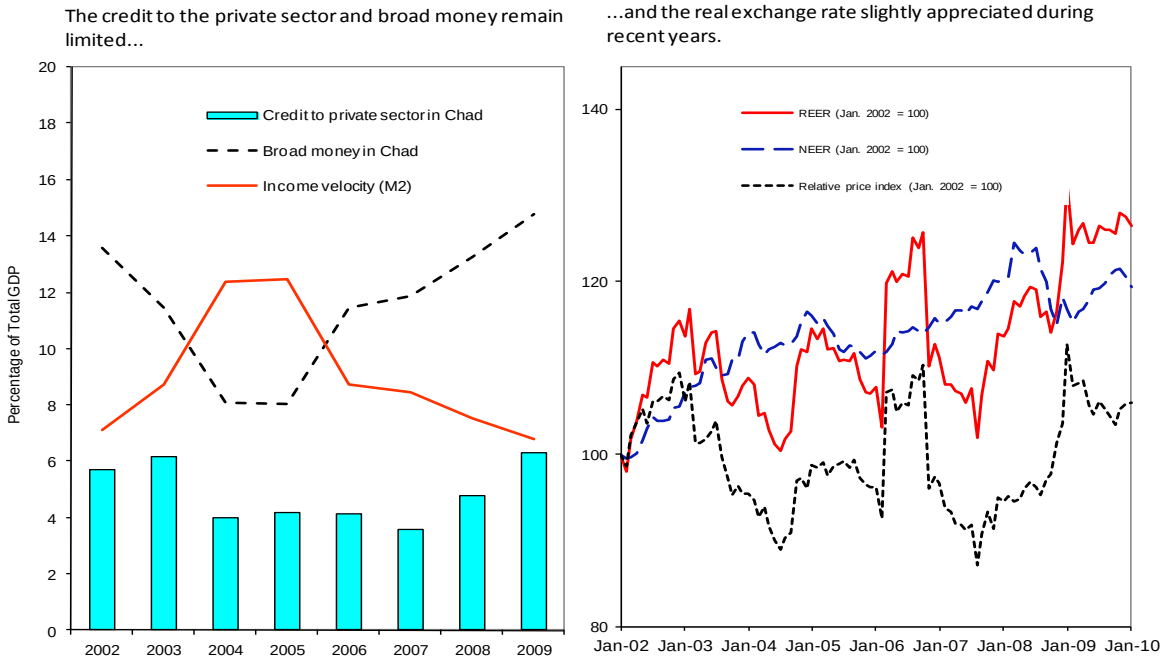
After a surge at the beginning of the oil era, real growth has been disappointing since 2005. Since 2005, growth performance has been poor mainly because of the decreasing trend in oil production. In 2009, real GDP contracted by 1.6 percent because of the contraction in the oil sector and the collapse of agricultural production owing to poor rainfall.

Figure 1. Chad: Domestic and External Developments, 2002–09



Sources: Chadian authorities and staff estimates.

Figure 1. Chad: Domestic and External Developments, 2002–09 [concluded]



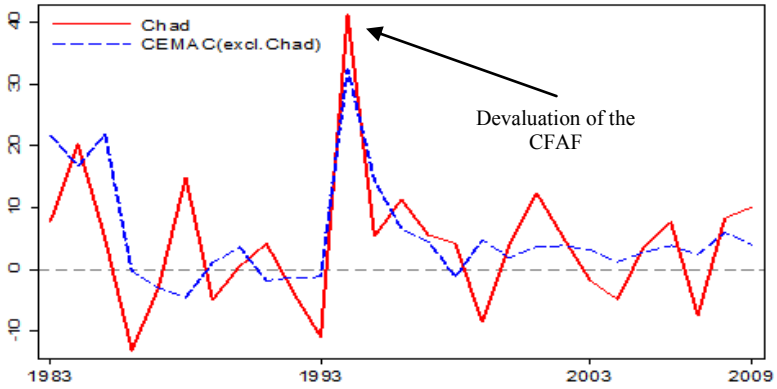
Sources: Chadian authorities and staff estimates.

B. Inflation Dynamics

Inflation[3] in Chad has historically been moderate, averaging 4.5 percent from 1983 to 2009, although with sizeable year-to-year fluctuations. It has moderated since 2000, averaging 3.8 percent, but is still subject to significant shocks. Figure 2 illustrates the inflation dynamics with the devaluation of the CFAF by 50 percent in January 1994 as the major event. Indeed, after the devaluation, inflation surged from minus 8 percent in 1993 to plus 42 percent in 1994. Other events such as the floods in 1999 and 2007 and drought in 2001 were also associated with large increases in inflation.

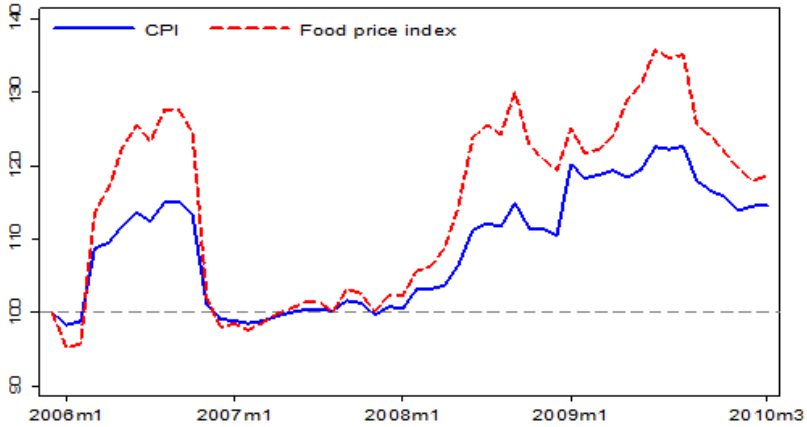
[3] The consumer price index (CPI), which covers only N'Djamena, the capital city, includes 332 products. Its weights are based on a survey that covered 1,024 households in N'Djamena in 2003–04 (ECOSIT2). Table A.1 presents the distribution of the weights across the main categories of products covered. At 46 percent of the index, food and nonalcoholic beverages dominate the CPI.

Figure 2. Chad: Annual Inflation (percent), 1983–2009



In recent years, a significant rise in food prices, concomitant with the global food crisis of 2008, chiefly explains inflation developments (Figure 3).[4]

Figure 3. Chad: Monthly Consumer and Food Price Indexes, 2005:M12–2010:M3



III. THE THEORETICAL FRAMEWORK

This section describes a simple theoretical framework that could be used to explain inflation in Chad. Following Ubide (1997), three theories could explain Chad's inflation behavior: (i) the external sector theory; (ii) the monetary theory; and (iii) the markup theory.

Two of these theories (external sector and monetary) are pertinent to Chad. The third (markup) relies on domestic labor market disequilibrium that is difficult to measure in Chad. Only 9 percent of workers are paid employees in Chad; the majority (63 percent) are self-employed in agriculture (Montenegro and Maximilian, 2009). Therefore, most households in

[4] Components and subcomponents of the CPI have been available since December 2005.

Chad obtain their income from nonwage activities. In addition, wage data are of poor quality. [5]

Applying an IS-LM framework to a small open economy, the general price level is a weighted average of tradable prices (p_t^T) and nontradables prices (p_t^{NT}):

$$p_t = \delta p_t^T + (1-\delta) p_t^{NT} \quad (1)$$

where all variables are expressed in natural logarithms, and $0 < \delta < 1$ represents the share of tradable goods in the total consumption basket. Assuming purchasing power parity (PPP), the price of tradables (p_t^T), which is internationally determined, is a function of foreign prices (p_t^*) and the exchange rate (e_t).

$$p_t^T = p_t^* + e_t \quad (2)$$

Assuming that demand for nontradables follows aggregate demand in the economy, the price of nontradables is determined by the equilibrium in the money market:

$$(m_t - p_t) = (m_t^d - p_t) \quad (3)$$

where $(m_t - p_t)$ is the real money supply and $(m_t^d - p_t)$ the real money demand. m_t represents broad money, and p_t, the price level measured by the CPI. Representing the relationship between aggregate demand and the demand for nontradable goods by φ, the price of nontradables is as follows:

$$p_t^{NT} = \varphi(m_t - (m_t^d - p_t)) \quad (4)$$

Real money demand can be modeled as a function of real income $(y_t - p_t)$, inflation expectations ($E(\pi)$), and the rate of return (r_t), which is measured by the difference between the Bank of Central African States (BEAC) discount rate and the annual time deposit interest rate captures the opportunity cost of substitution between assets and money:

$$m_t^d - p_t = \alpha + \beta(y_t - p_t) + \rho r_t + \mu E(\pi) \quad (5)$$

Assuming for simplicity that inflation expectations depend only on past inflation and the realization of past inflation forecasts ($E(\pi) = \Delta p_{t-1}$) substituting Equation 5 in Equation 4 yields Equation 6:

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[5] Diouf (2007) also concluded that modeling the domestic labor market to explain inflation in Mali was not relevant. Chibber and Shafik (1990) found that wage increases rarely cause inflation in Africa.

$$p_t^{NT} = \varphi(m_t - (\alpha + \beta(y_t - p_t) + \rho r_t + \mu\Delta p_{t-1})) \quad (6)$$

A priori, we expect β to be positive, as higher real income increases money demand for transactions. ρ is expected to be negative because a higher return on assets makes them more attractive than money. Substituting Equation 6 and Equation 2 in Equation 1yields a reduced form equation that can be estimated:

$$p_t = f(e_t, p_t^*, m_t, y_t - p_t, r_t, \Delta p_{t-1}) \quad (7)$$

A depreciation of the exchange rate is expected to fuel inflation by increasing import prices. Higher prices in trading partners, money supply, and real income are also expected to increase inflation. A higher rate of return is expected to be associated with a decrease in money holding, reducing inflation. The effect of past inflation on the current price level is undetermined. On the one hand, higher inflation expectation, resulting from higher inflation in the previous period, could reduce money demand and consequently increase prices. On the other hand, inflation could persist because of sluggish adjustment owing to rigidities and structural constraints, such as those associated with poor infrastructure.

The derived empirical model is augmented to include structural factors specific to Chad, such as agricultural production shocks (captured by national rainfall), periods of political instability (rebel assaults or major social tensions), as well as major events like the devaluation of the CFAF, and the start of oil production.

IV. Data and Empirical Model

A. Data

The study uses quarterly data from 1983:Q1 to 2009:Q3. Quarterly real GDP and quarterly government expenditures are interpolated from annual data using the proportional Denton method (see Bloem, Dippelsman, and Maehle, 2001). Quarterly rainfall data are averages of monthly rainfall data from the Chad Meteorological Office (DREM) for 2000–08. These data are completed with annual rainfall data from the Food and Agriculture Organization for 1983–1999 (Miguel, Satyanath, and Sergenti, 2004). Quarterly rainfall data for 1983–1999 are derived from annual data by applying the seasonal pattern observed from 2000 through 2008. The quarterly political instability variable, which measures rebel assaults, is constructed with information from a variety of sources. Table A.2 summarizes the definitions and sources of variables.

Table A.3 illustrates the statistical properties of the data. Augmented Dickey-Fuller and Phillips-Perron tests reveal that all variables are nonstationary in level but stationary in first difference. Figure A.1 illustrates the evolution of the main variables, and Figure A.2 plots the moving average of lagged national rainfall and the CPI.

B. Inflation Model

Estimating a single-equation model reduces the risk of a heavily parameterized vector auto regression (VAR) model. VAR models of inflation could be estimated or vector error correction models when cointegrating vectors are present. However, because of the small number of observations in this study, we follow an approach widely used to help interpret the interactions between short-run and long-run variables (Juselius, 1992; Diouf, 2007). The approach consists in first estimating the long-run equilibrium in each market (money market and external market) using sectoral VECMs. The deviations from the long-run equilibrium (the error correction terms) are then integrated into a short-run model to specifiy a single-equation inflation model.

Long-run equilibrium in the money and external markets

The long-run money market equilibrium

The long-run money market equilibrium is estimated from Equation 5. Because all variables contain a unit root and are stationary in first difference, Δp_{t-1} is stationary and cannot be included in a long-run relationship. However, Δp_{t-1} could directly integrate the short-run inflation model. The Johansen cointegration test does not reject the null hypothesis of one cointegrating vector (Table A.4). Therefore, there could be one cointegrating vector that explains the long-run equilibrium in the money market.

The long-run equilibrium in the money market is estimated with a vector error correction model. As expected, the results show that real income positively explains money demand (Table 1). Higher real income induces higher demand for money. A higher rate of return on assets, captured by the difference between the BEAC discount rate and the time deposit rate, reduces broad money, but the error correction term is fairly significant in this equation (column 2).[6]

The error correction term (ec_{money}), representing the long-run disequilibrium in the money market (Table 1, column 1) that will be included in the inflation model is as follows:

$$ec_{money} = (m_t - p_t) - \alpha - \beta(y_t - p_t) - \rho r_t$$

$$ec_{money} = (m_t - p_t) - 3.39(y_t - p_t)$$

[6] The central bank discount rate is preferred in estimating the return rate for assets because of its better availability. However, the shallow financial system could limit the impact of the discount rate on broad money.

Table 1. Chad: Long-Run Equilibrium in the Money Market

	Dependent variable: Log(Real broad money)	
	(1)	(2)
Log(Real GDP)	3.39*	5.13**
	(1.83)	(2.23)
Discount minus deposit rate		-0.49***
		(-3.93)
Error Correction	-0.10***	-0.05
	(-2.41)	(-1.52)
Observations	114	114

Numbers in parentheses are t-statistics.
*significant at 10%, **significant at 5% , ***significant at 1%

The long-run external market equilibrium

Chad's long-run external market equilibrium is estimated from Equation 2, (a PPP relationship), without distinction between tradable and nontradable goods prices. Johansen cointegration tests indicate that a single cointegrating vector could explain the long-run external market equilibrium (Table A.5), which allows us to estimate it with a VECM. As expected, higher prices in Chad's trade partners increase domestic inflation (Table 2).

Table 2. Chad: Long-Run Equilibrium in the External Market

	Dependent variable: Log(CPI)
	(1)
Log(NEER)	1.18
	(1.60)
Log(Foreign price)	1.46***
	(3.02)
Error Correction	-0.10***
	(-2.92)
Observations	114

Numbers in parentheses are t-statistics.
*significant at 10%, **significant at 5% , ***significant at 1%

The error correction term (ec_{ext}), representing the long-run external market disequilibrium is as follows:

$$ec_{ext} = \theta_1 p_t^* + \theta_2 e_t - p_t$$

$$ec_{ext} = p_t - 1.46p_t^*$$

The error correction term completes the specification of a single-equation model.

The single-equation inflation model

The single-equation model includes both short-run and long-run inflation determinants. It combines error correction terms derived from the long-run equilibrium models in the money and external markets and the first differences of all variables used in the long-run equations. The single-equation model also includes lagged rainfall to control for supply shocks in agriculture. Various dummies capture events like the CFAF devaluation, the beginning of the oil era, and periods of political instability. The model also includes quarterly dummies to control for seasonality in inflation. Equation 8 illustrates the single-equation inflation model to be estimated with the ordinary least squares (OLS) method.

$$\Delta p_t = \gamma_0 + \sum_{i=1}^{k-1} \gamma_{1i} \Delta x_{t-i} + \sum_{i=1}^{p} \gamma_{8i}\, rainfall_{t-i} + \sum_{i=1}^{q} \gamma_{9i}\, D_t + \gamma_6 (ec)_{t-1} + \varepsilon_t \quad (8)$$

Δp_t represents the first difference of the logarithm of the CPI. All variables are expressed in logarithm terms except interest rates, rainfall, and dummies. Δx_{t-i} includes the lags of the first differences of control variables such as the nominal effective exchange rate, foreign prices, domestic prices, real money, real GDP, and interest rates. *Rainfall* is the national average rainfall during the quarter, D_t represents the set of dummies, and *ec* the error correction terms.

A general-to-specific approach is used to obtain a parsimonious representation of inflation from Equation 8. The specification search of the inflation model does not retain real income as a main determinant of inflation. Given the likely significant impact of fiscal expansion on domestic inflation, the model includes a variable for public expenditure, aiming to capture the effect of the expansionary fiscal policy during the oil era.

C. Results

Estimations of the single-equation model show that the main drivers of inflation are rainfall, public spending, the nominal exchange rate, and foreign prices (Table 3).

Rainfall affects domestic prices through its impact on agriculture with a three-quarter lag; a 10 percent increase in rainfall reduces inflation by 0.35 percent three quarters later. This

result indicates, as expected, the importance of rainfall, used as a proxy for agricultural production, in explaining inflation.[7]

Public spending affects inflation with a one-quarter lag; a 10 percent increase in public spending during one quarter increases inflation by 1 percent the following quarter.[8] Higher government expenditure fuels domestic prices through demand pressures on nontradables. This result suggests that supply-side bottlenecks remain.[9]

The nominal exchange rate affects domestic prices with a one-quarter lag; a 10 percent appreciation (depreciation) of the nominal effective exchange rate decreases (increases) inflation by around 2.6 percent one quarter later. Despite the peg to the euro, a depreciation of the exchange rate with respect to non-euro trading partners contributes to inflationary pressures by increasing import prices.[10]

Changes in foreign prices are passed through in domestic prices via imports, with a one-quarter lag; a 10 percent increase in foreign prices increases domestic inflation by 2 percent one quarter later. Absent adjustment in the exchange rate, higher prices in trading partners increases import prices, which spills over into domestic inflation.[11]

There is a varied degree of significance among control variables, capturing disequilibrium in the money and external markets, inflation seasonality, and the CFAF devaluation.

Money market disequilibrium does not affect inflation in Chad. The error correction term derived from the money market equilibrium is not significant in the single-equation model. Short-term factors in the money market, such as the real rate of return, are also not significant when introduced in the single-equation model. The explanation could be that, as Chad is a member of the CEMAC monetary union, the equilibrium in its own money market reflects

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[7] This is consistent with Diouf (2007) which found that rainfall significantly explained inflation, especially with a two-quarter lag, in another sahelian country, Mali.

[8] In the case of oil-exporting countries such as Bahrain and Kuwait, Kandil and Morsy (2009) found that in the short run, public spending affects inflation by a similar magnitude and with a one-quarter lag.

[9] Efficient public investments, targeting structural bottlenecks, could ease capacity constraints and reduce price inflation in the long run.

[10] Evidence of a significant pass-through channel of the exchange rate to domestic prices has been highlighted for countries with fixed or non fixed exchange rate regimes. For instance, Diouf (2007) found that in Mali, about 33 percent of a nominal depreciation of the CFA franc vis-à-vis the dollar is reflected in domestic prices. In some GCC countries, which have pegged their domestic currencies to the U.S. dollar, Kandil and Morsy (2009) found that exchange rate depreciation tends to increase inflation. In Angola, Klein and Kyei (2009) also found that exchange rate movements drive inflation.

[11] Loening, Durevall, and Birru (2009) confirm that foreign prices explain domestic inflation in Ethiopia.

CEMAC-wide rather than Chad-specific conditions. The very low level of monetization could also explain the limited role of the disequilibrium in the money market in explaining inflation.

However, external goods market disequilibrium contributes to inflation. The error correction term, derived from the external market equilibrium, significantly explains inflation. A 10 percent increase in the external market disequilibrium reduces inflation by 3 percent with a one-quarter lag. This result suggests that inflation movements help to close the gap between inflation and its equilibrium level as determined by the fundamentals in the external market.

Dummy variables confirm that inflation is seasonal and increased after the CFAF devaluation in 1994. The sign and the significance of quarterly dummies suggest that inflation is, on average, lower during the fourth quarter of the year. In particular, the second quarter is the highest inflationary period. The CFAF devaluation dummy is significant in specification 2, suggesting the positive effect of the devaluation on domestic inflation.

The single-equation model predicts actual inflation relatively well. Figures A.3–A.8 illustrate the changes in the actual and predicted CPI as well as the residuals of the inflation models. The possibility of an omitted variable bias is therefore not severe. Various tests (misspecification, normality, heteroskedasticity, and autoregressive heteroskedasticity) analyzing some properties of the models do not reveal any particular problem (Table A.6).

The single-equation model does not fully capture inflation persistence. As highlighted by Coleman (2010), inflation persistence could be present in Chad. In fact, the effect of rainfall, public spending, nominal effective exchange rate, and foreign prices on inflation could last after the first, second, or third quarter, reflecting second round effects.

To capture inflation persistence, the next section of the paper applies a structural vector autoregression model, which analyzes the impact and the persistence of diverse economic shocks on inflation. In addition, the SVAR allows a better handling of possible interrelation among variables that could affect the estimated coefficients with the single-equation model.

Table 3. Chad: Inflation Model

	Dependent variable: Δ(logCPI)		
	(1)	(2)	(3) [1]
$\Delta(\text{foreign price})_{t-1}$	0.183	0.198	0.209
	(1.69) *	(1.82) *	(1.93) *
$\Delta(\text{NEER})_{t-1}$	-0.252	-0.262	-0.269
	(4.05)***	(4.17)***	(4.30)***
$\Delta(\text{Public exp.})_{t-1}$	0.093	0.093	0.095
	(2.10)**	(2.03)**	(2.09)**
Rainfall_{t-3}	-0.036	-0.033	-0.035
	(2.82)***	(2.58)**	(2.70)***
Constant	-0.035	-0.027	-0.032
	(4.04)***	(3.43)***	(3.74)***
EC_{ext}	-0.281	-0.266	-0.291
	(2.40)**	(2.25)**	(2.44)**
Quarter 1	0.198	0.183	0.192
	(3.04)***	(2.80)***	(2.92)***
Quarter 2	0.280	0.262	0.273
	(3.46)***	(3.21)***	(3.33)***
Quarter 3	0.188	0.178	0.184
	(4.14)***	(3.89)***	(4.01)***
Devaluation dummy	0.018		0.013
	(2.07)**		(1.44)
R-squared	0.49	0.47	0.48
Observations	114	114	114

Robust t statistics are in parentheses.
* significant at 10%; ** significant at 5%; *** significant at 1%
All regressions include quarterly dummies, a dummy for oil era, and political instability. Quarter 4 is the reference quarter and is therefore not included in the model.
Political instability and oil-era dummies are not significant in all regressions.
[1]The devaluation dummy in column (3) captures the period one year after the devaluation.

D. Structural Vector Autoregression Model

SVAR results confirm the main determinants of inflation (rainfall, public spending, nominal exchange rate, and foreign prices) and show that their effects persist over few quarters (Figure 4).

The SVAR isolates structural shocks in the VAR system by imposing restrictions suggested by economic theory. The SVAR assumes that the economy behaves recursively, as described by the following five equations:

$$\mathrm{Rain}_t = E_{t-1}\mathrm{Rain}_t + u_t^r \quad (9)$$

$$\Delta p_t^* = E_{t-1}\Delta p_t^* + \alpha_1 u_t^r + u_t^{p*} \quad (10)$$

$$\Delta e_t = E_{t-1}\Delta e_t + \alpha_2 u_t^r + \alpha_3 u_t^{p*} + u_t^e \quad (11)$$

$$\Delta g_t = E_{t-1}\Delta g_t + \alpha_4 u_t^r + \alpha_5 u_t^{p*} + \alpha_6 u_t^e + u_t^g \quad (12)$$

$$\Delta p_t = E_{t-1}\Delta p_t + \alpha_7 u_t^r + \alpha_8 u_t^{p*} + \alpha_9 u_t^e + \alpha_{10} u_t^g + u_t^p \quad (13)$$

Δ and E respectively represent the first difference and the conditional expectation operator. Rain, p_t^*, e_t, g_t, and p_t respectively represent rainfall, foreign prices, nominal effective exchange rate, public spending, and domestic prices. α_i represents the estimated coefficients. The system assumes rainfall (*Rain*) is exogenous and affects other disturbances in the system (Equations 9–13). Foreign prices shocks (u^{p*}) affect disturbances of variables other than rainfall (equation 10–13). Shocks in the nominal effective exchange rate (u^e) affect disturbances of public spending and domestic inflation (equation 11–13). Public spending shocks affect only disturbances of domestic inflation (equation 12–13). Assuming expectations depend on past realizations, we replace the conditional expectations in the system by linear projections of lags[12] of the five variables in the system.[13]

A positive shock in rainfall reduces inflation and the effect persists over six quarters. The impact of a rainfall shock on inflation is at its maximum three quarters after the shock, confirming the result of the single-equation model. The SVAR impulse response highlights that the effect of the rainfall shock is persistent. An increase in rainfall reduces inflation between the first and the sixth quarter. The impact increases between the first and the third quarter, reaches its maximum during the third quarter, and decreases gradually until it becomes insignificant around the sixth quarter.

An increase in foreign prices also pushes up inflation during six quarters. The impact of higher foreign prices on inflation is at its maximum during the first quarter, confirming the results of the single-equation model. After the first quarter, the impact of the increase in foreign prices decreases gradually until it becomes insignificant around the sixth quarter.

A nominal appreciation of the exchange rate reduces inflation during four quarters following the appreciation. The nominal appreciation has its highest effect on inflation with a lag of

[12] The choice of lag length is based on the Schwarz Information Criterion (SIC).

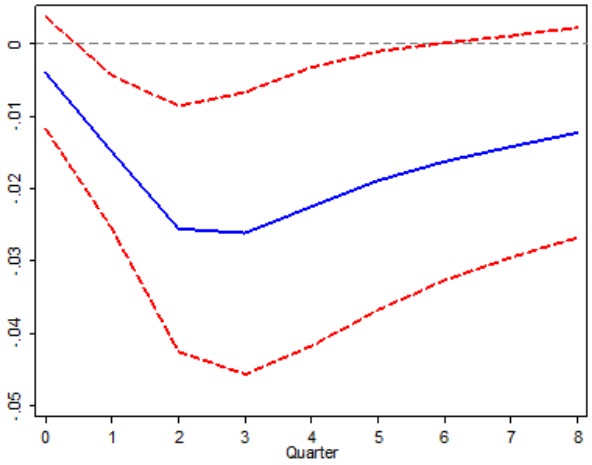
[13] As in the single-equation model, the SVAR includes various dummies as exogenous variables to control for inflation seasonality.

two quarters, one quarter later than predicted by the single-equation model. After the second quarter, the impact of the nominal appreciation gradually decreases until it becomes insignificant around the fourth quarter.

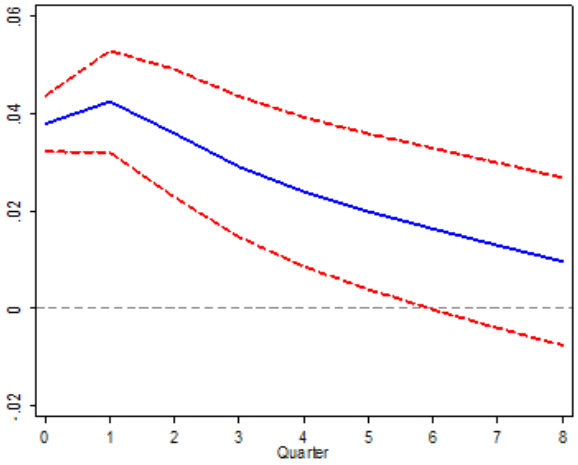
Higher public spending increases inflation between the first and the third quarter. The effect of an increase in public investment on inflation is at its highest around the second and third quarters, one or two quarters later than predicted by the single-equation model.

Figure 4. Chad: Impulse Response of Inflation

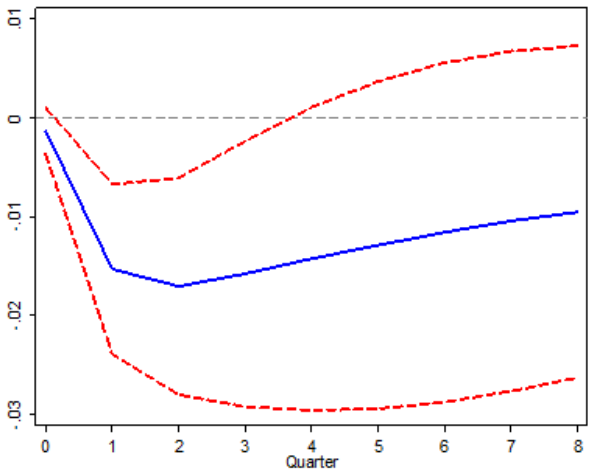
Response of Inflation to Rainfall Shock



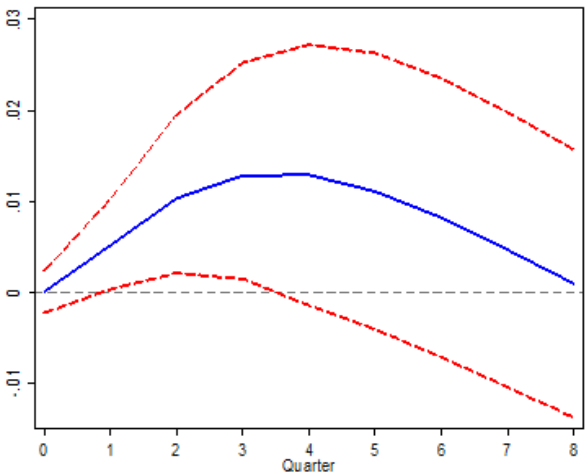
Response of Inflation to Foreign Prices Shock



Response of Inflation to Nominal Appreciation



Response of Inflation to Public Spending Shock



Dashed lines represent 95% lower and upper bounds.

V. CONCLUSION

This paper analyzes the determinants of inflation in Chad, highlighting the role of monetary and external factors. The empirical analysis is based primarily on a single-equation model, supplemented by an SVAR model to investigate inflation persistence. The empirical analysis also controls for supply-side constraints, institutional factors, and major historical events such as the devaluation of the CFAF in 1994 and the start of oil production in 2003.

The results show that the main drivers of inflation in Chad are rainfall, foreign prices, exchange rate movements, and public spending. Rainfall affects domestic prices through its impact on agriculture. An increase in rainfall reduces inflation during the following six quarters although the effect is highest during the third quarter. Changes in foreign prices and the nominal effective exchange rate also affect domestic prices through a pass-through to import prices. Higher foreign prices increase inflation during six quarters after the shock; the maximum impact occurs during the first quarter. A nominal appreciation of the exchange rate reduces inflation during four quarters with the highest effect during the second quarter. Public spending, fueled by oil production since 2003, has a significant impact on inflation through demand pressures on nontradables. Higher public spending increases inflation between the first and the third quarter; the maximum impact occurs around the second and third quarter.

The inflationary effects of rainfall and public spending could be mitigated with domestic policy effort. The results suggest that improved efficiency in agriculture, storage and transportation would reduce the role of rainfall. Improving food storage facilities would indeed help to prevent significant increases in food prices following natural disasters such as droughts or floods. Reducing market segmentation and liberalizing internal and external trade through an improvement in transportation infrastructure such as rural roads would also help to limit pressure stemming from excess demand. Enhancing agricultural productivity through the use of modern techniques, such as irrigation and improved seeds, and the better access to rural credits would also help improve agricultural production and reduce pressures on prices.

Better control of public expenditures is also key to maintaining low inflation in Chad. This could be achieved by improving public financial management through better investment planning and procurement practices as well as by integrating the inflationary effect of public expenditures when designing public spending programs.

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APPENDIX

Table A.1. Chad: Weights of the Components/Subcomponents of the CPI

Components/Subcomponents	Weight
Food and non alcoholic beverages	46.18
Bread and Cereals	17.24
Meat	7.85
Fish	3.64
Milk, Cheese, and Eggs	1.49
Oils and Fats	3.74
Vegetables and Tubers	3.67
Alcoholic beverages and tobacco	3.08
Clothing and shoes	10.88
Housing, water, gas, electricity, and other fuels	13.31
Furniture, houseware, and house maintenance	4.23
Health	2.73
Transportation	6.36
Communications	2.35
Leisure and culture	3.55
Education	0.96
Other goods and services	1.74
Restaurants et hotels	4.63
Total	100

Table A.2. Chad: Definitions and Sources of Variables

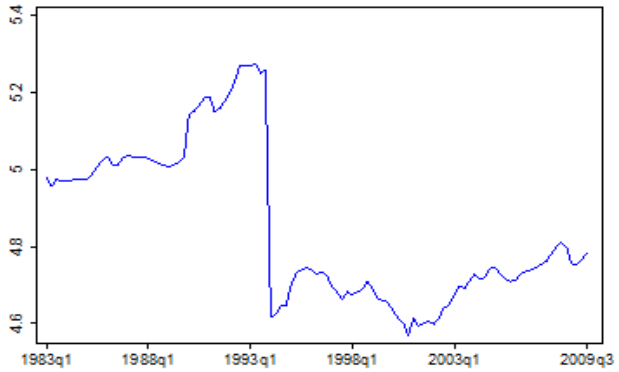
Variable	Definition	Source
Log (CPI)	Logarithm of consumer price index	INSEED
Log (NEER)	Logarithm of nominal effective exchange rate	IMF Effective Exchange Rate Facility
Log(Foreign price)	Logarithm of foreign effective price level	IMF Effective Exchange Rate Facility
Discount rate	BEAC discount rate	International Financial Statistics (IFS)
Deposit rate	Interest rate on time deposits	IFS
Log(Real Money)	Logarithm of real broad money (money and quasi money)	IFS
Log(Government expenditures)	Logarithm of government expenditures	World Economic Outlook (WEO)
Log(Real GDP)	Logarithm of Real GDP	WEO
Log(ToT)	Logarithm of terms of trade	WEO
Log(Rainfall)	Logarithm of Average national rainfall in mm.	Direction des Ressources en Eau et de la Météorologie, Division de la Climatologie (Octobre 2009) and Miguel, Satyanath, and Sergenti (2004).
Political instability dummy	Dummy equal 1 during period of political instability such as rebels' assaults	Polity IV and http://www.jeuneafrique.com/Chronologie-pays_84_Tchad
Devaluation dummy	Dummy equal 1 after the devaluation in 1994	
Oil era dummy	Dummy equal 1 after the start of oil production in 2003	
Quarter	Quarterly dummies	

Table A.3. Chad: Unit Root Test

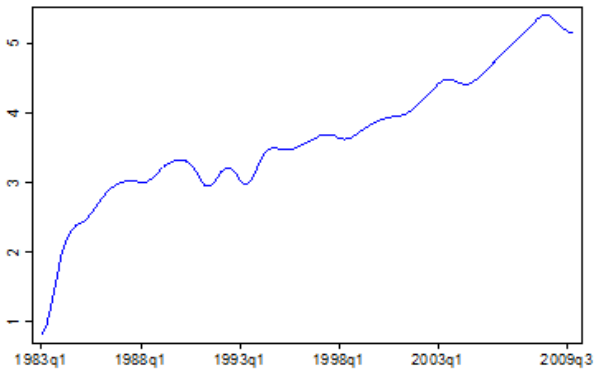
	ADF		Phillips-Perron	
	Statistics	P-value	Statistics	P-value
In level				
Log(CPI)	-0.18	0.94	-0.31	0.92
Log (NEER)	-1.75	0.40	-1.81	0.37
Log(Foreign price)	-2.71	0.07	-2.86	0.05
Discount rate	-1.60	0.48	-0.96	0.77
Deposit rate	-1.13	0.70	-1.91	0.33
Log(Real Money)	-0.79	0.82	-0.44	0.90
Log(Gov. expenditures)	-1.02	0.74	-1.03	0.74
Log(Real GDP)	1.38	0.99	0.368	0.98
Log(ToT)	-1.58	0.49	-1.57	0.50
In first difference				
Log(CPI)	-8.99	0.00	-8.88	0.00
Log (NEER)	-10.91	0.00	-10.91	0.00
Log(Foreign price)	-8.50	0.00	-8.33	0.00
Discount rate	-9.76	0.00	-9.74	0.00
Deposit rate	-9.50	0.00	-9.49	0.00
Log(Real Money)	-11.08	0.00	11.40	0.00
Log(Gov. expenditures)	-3.58	0.01	-4.15	0.00
Log(Real GDP)	-2.34	0.15	-3.41	0.01
Log(ToT)	-3.0	0.03	-3.99	0.00

Figure A.1. Chad: Evolution of the Main Variables

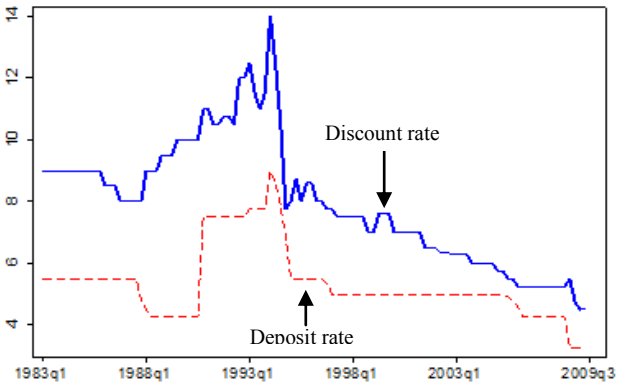
Log (NEER)



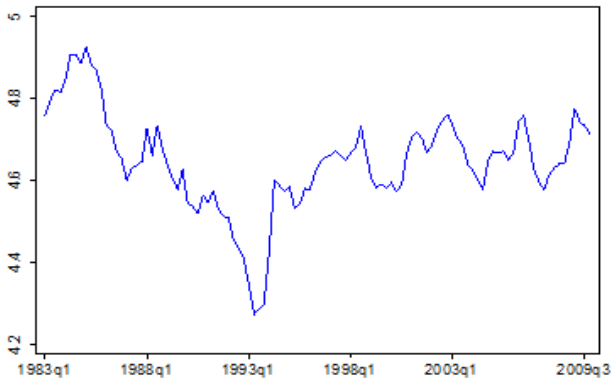
Log(Government expenditures)



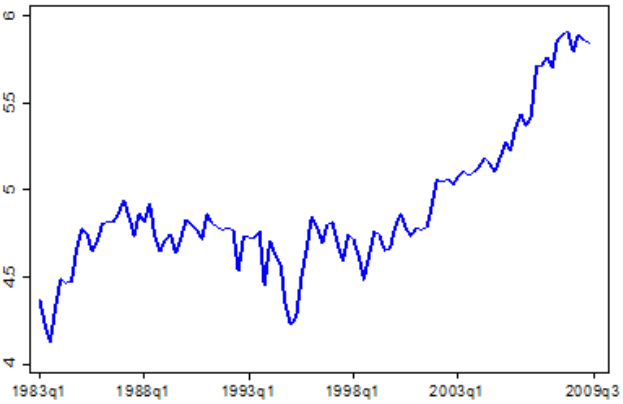
Discount and deposit rate



Log(Foreign price)



Log (Real broad money)



Log(Real GDP)

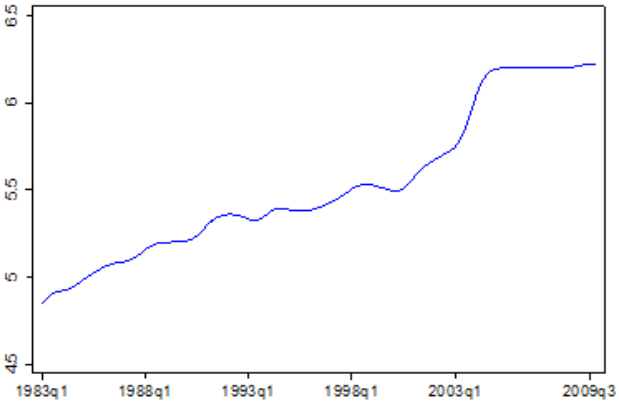


Figure A.2. Chad: Four-Quarter Lag Moving Average of the National Rainfall and CPI

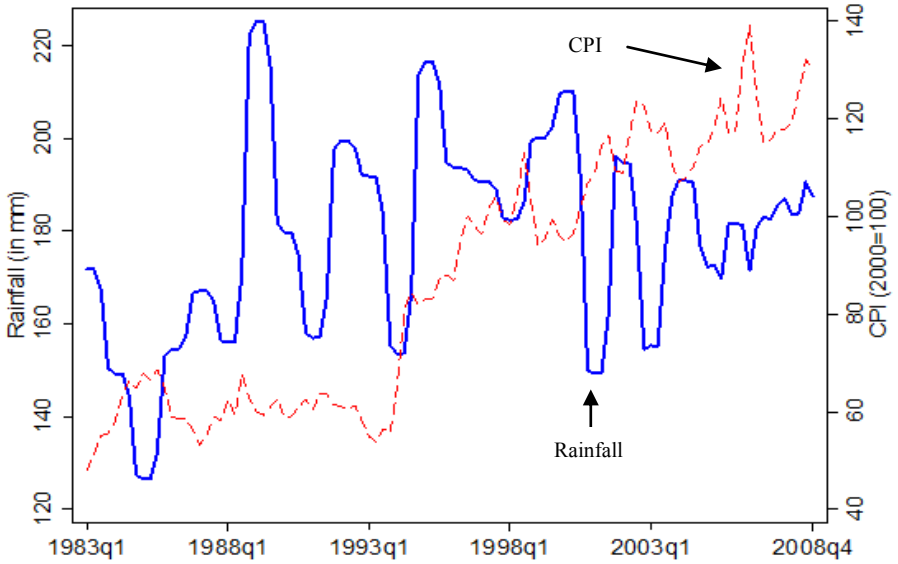


Table A.4. Chad: Johansen Cointegration Test, Money Market Equilibrium

Maximum rank	parms	LL	Eigenvalue	Trace statistic	Critical value (5%)
0	84	559.9		64.1	63.0
1	92	574.3	0.2	35.3*	42.4
2	98	583.3	0.2	17.3	25.3
3	102	589.2	0.1	5.4	12.3
4	104	591.9	0.1		
Maximum rank	parms	LL	Eigenvalue	Max statistic	Critical value (5%)
0	84	559.9		28.9	31.5
1	92	574.3	0.2	18.0	25.5
2	98	583.3	0.2	11.9	19.0
3	102	589.2	0.1	5.4	12.5
4	104	591.9	0.1		

*The null hypothesis that there is one cointegrating equation is not rejected.

Table A.5. Chad: Johansen Cointegration Test, External Market Equilibrium

Maximum Rank	Parms	LL	Eigenvalue	Trace statistic	Critical value 5%
0	105	1058.0		71.1	68.5
1	114	1071.8	0.2	43.4*	47.2
2	121	1080.6	0.2	26.0	29.7
3	126	1088.6	0.1	9.8	15.4
4	129	1092.4	0.1	2.3	3.8
5	130	1093.5	0.0		
Maximum Rank	Parms	LL	Eigenvalue	Trace statistic	Critical value 5%
0	105	1058.0		27.7	33.5
1	114	1071.8	0.2	17.4	27.1
2	121	1080.6	0.2	16.1	21.0
3	126	1088.6	0.1	7.6	14.1
4	129	1092.4	0.1	2.3	3.8
5	130	1093.5	0.0		

*The null hypothesis that there is one cointegrating equation is not rejected.

Figure A.3. Chad: Actual and Predicted Quarterly Inflation (Specification 1)

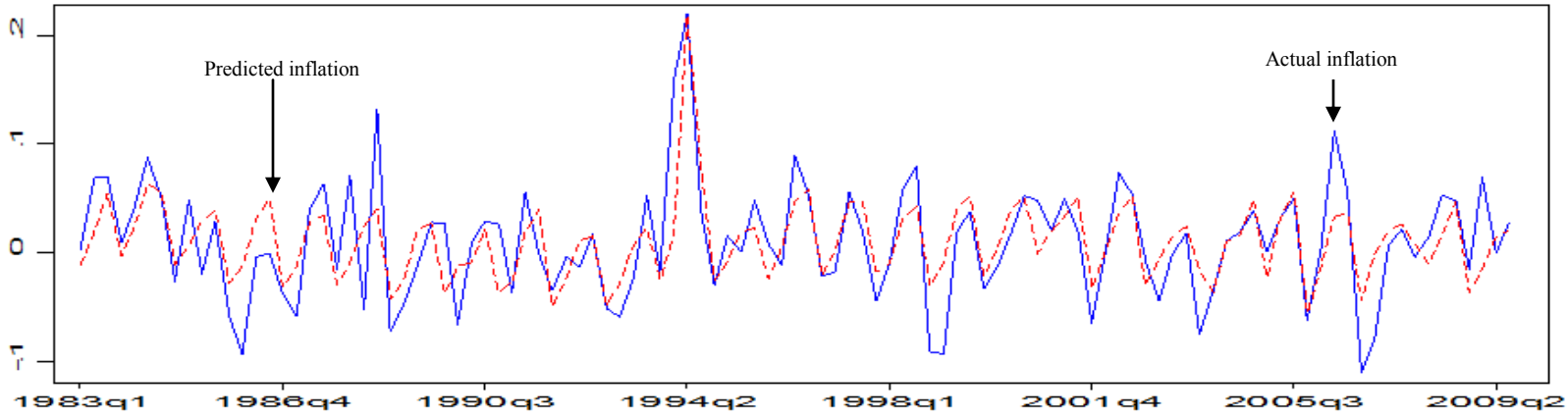


Figure A.4. Chad: Residuals (Specification 1)

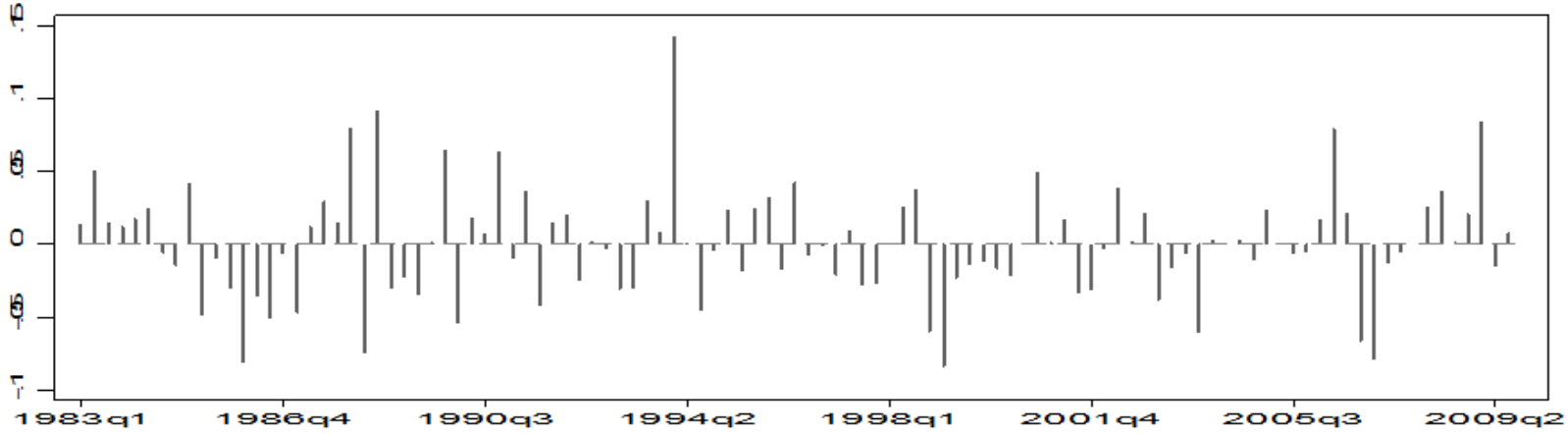


Figure A.5. Chad: Actual and Predicted Quarterly Inflation (Specification 2)

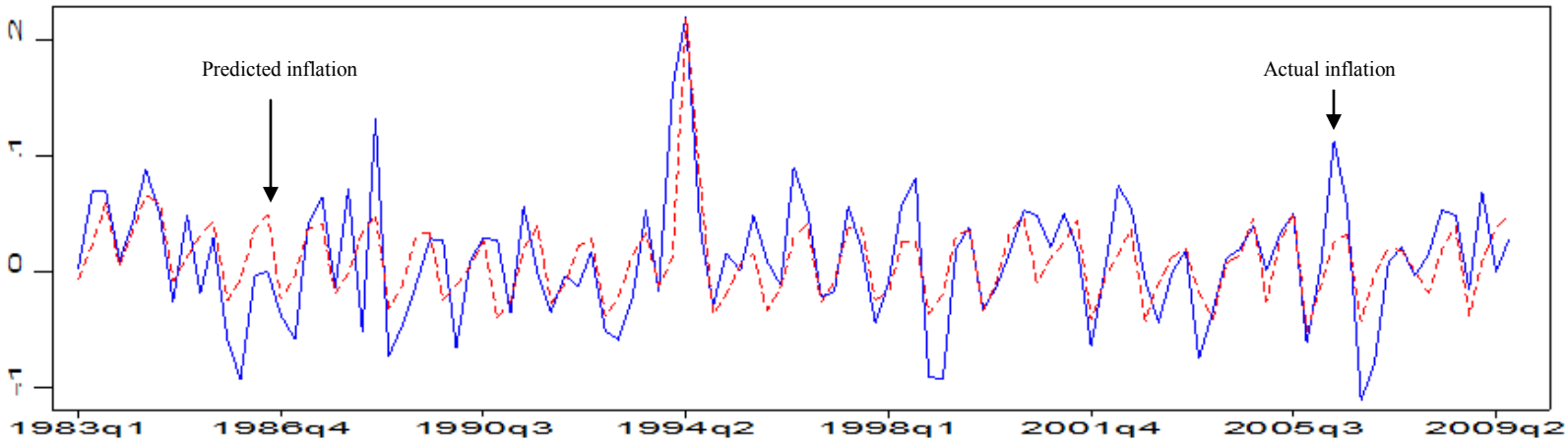


Figure A.6. Chad: Residuals (Specification 2)

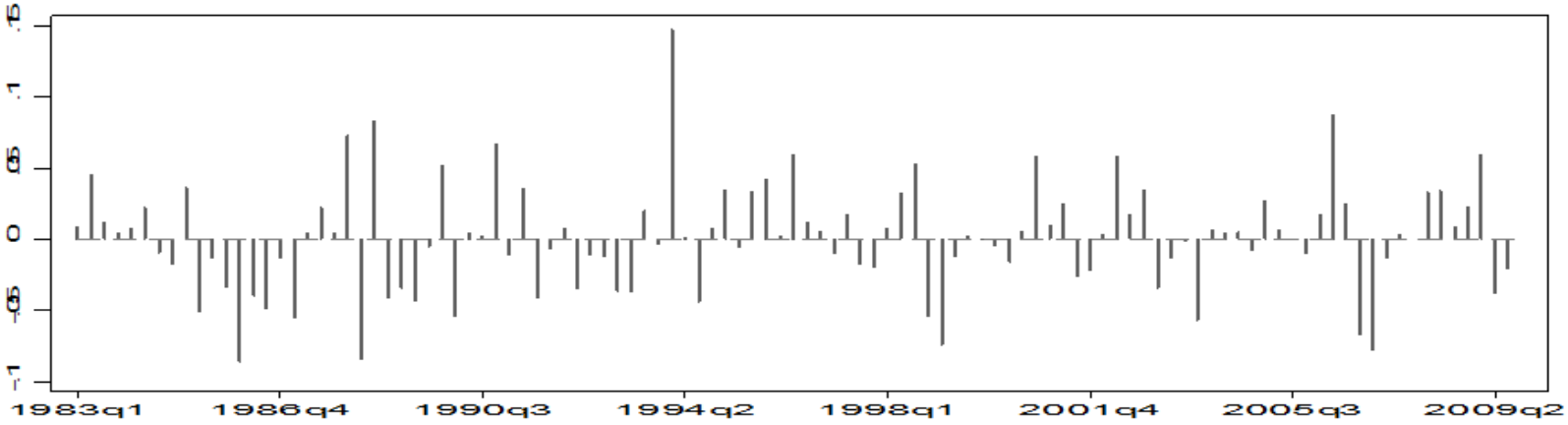


Figure A.7. Chad: Actual and Predicted Quarterly Inflation (Specification 3)

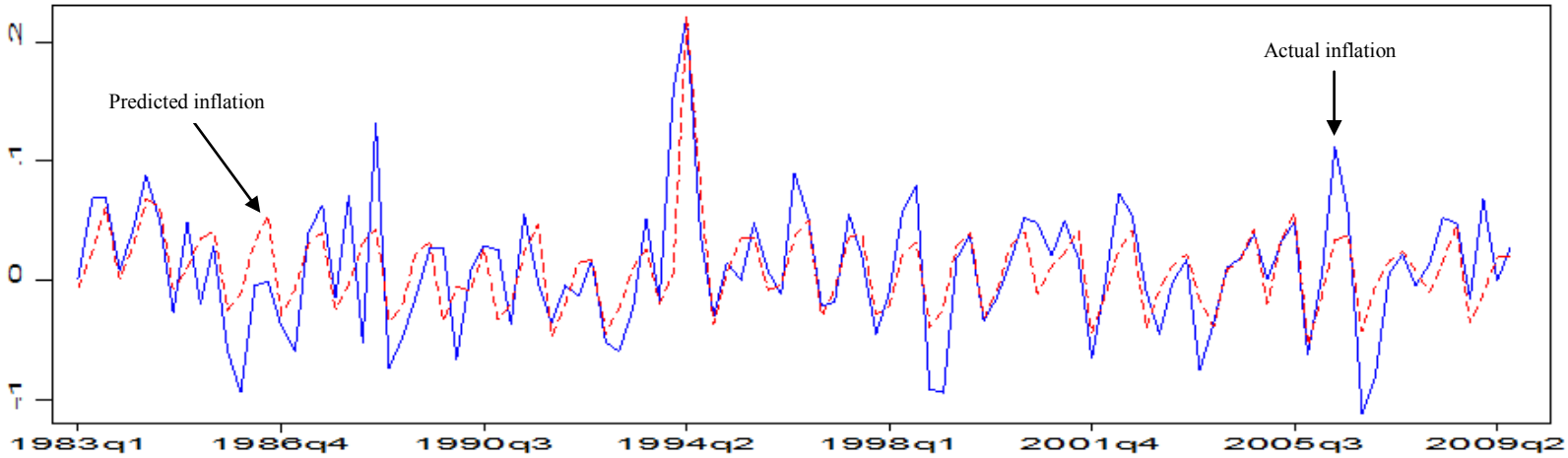


Figure A.8. Chad: Residuals (Specification 3)

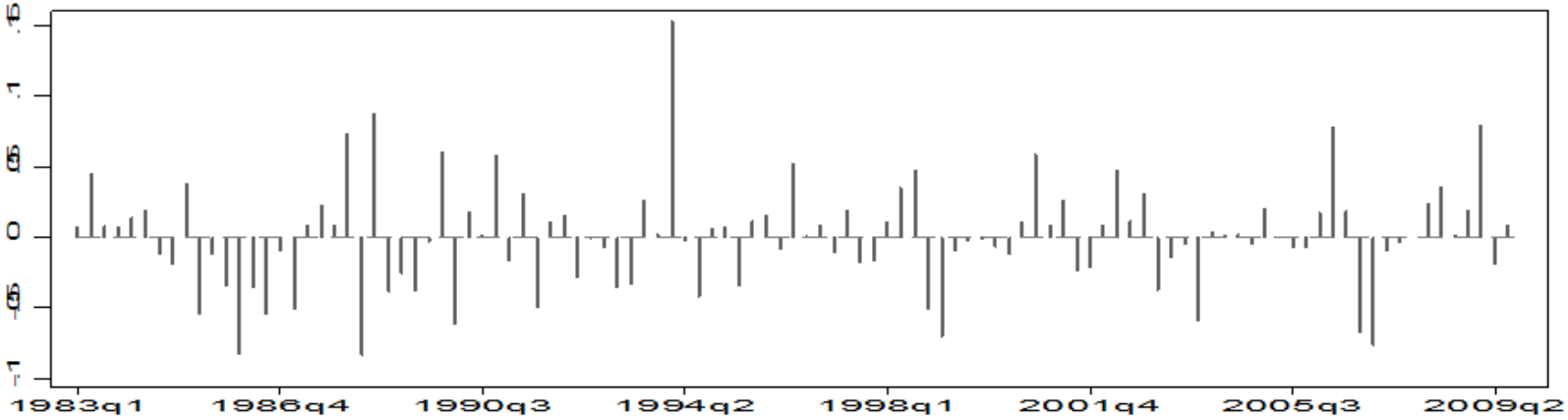


Table A.6. Chad: Diagnostic Statistics for the Single-Equation Inflation Models

	Breusch-Pagan / Cook-Weisberg test for heteroskedasticity	Ramsey RESET	Skewness	Kurtosis	ARCH (1 lag)	ARCH (2 lags)	ARCH (3 lags)
Specification 1	0.86	0.56	6.08	1.46	0.027	0.173	0.223
	(0.35)	(0.64)	(0.81)	(0.23)	(0.87)	(0.92)	(0.97)
Specification 2	0.28	1.29	4.78	1.07	0.035	0.129	0.118
	(0.60)	(0.28)	(0.91)	(0.30)	(0.85)	(0.94)	(0.99)
Specification 3	0.54	1.05	4.87	1.27	0.018	0.065	0.057
	(0.46)	(0.37)	(0.90)	(0.26)	(0.89)	(0.97)	(0.99)

p-values in parentheses.
Null hypothesis for the Breusch-Pagan/Cook-Weisberg test for heteroskedasticity is constant variance.
Null hypothesis for the Ramsey RESET test is the absence of omitted variables.
Null hypothesis for skewness and kurtosis tests is that the distribution of residuals has skewness and kurtosis corresponding to those of a normal distribution.
Null hypothesis for autoregressive conditional heteroskedasticity (ARCH) tests is the absence of autocorrelation.