Modeling Inflation in the WAEMU's Zone

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Abstract

This paper introduces a simple AS-AD model to examine the determinants of inflation for the members of the West African Economic and monetary union. On the supply side, we found France's inflation, rainfall, and real crude oil inflation to be the most important drivers of domestic inflation. On the demand side, we found the output gap to be a significant determinant of domestic inflation. Given the estimated size of the effect of the output gap on inflation, we can conclude that the short-run aggregate supply curve may be relatively flat; bolstering the Keynesian view that monetary policy could be extremely effective in stabilizing output in the short-run.

Key Words: macroeconomics, inflation dynamics, BCEAO, Two-Stages Least Squares
JEL Codes: E52, E58, F45.

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1 Introduction

Price stability remains the most important macroeconomic objective for the members of the West African Economic and Monetary Union (WAEMU). While the current peg with the euro has refrained the ability monetary authorities to propagate inflation from the monetary sector, it has been less effective in preventing inflation feeding from the external sector and productivity shocks (for example, large swings in rainfall and adverse oil shocks are all examples valid).

It is vital for a central bank to understand the underlying macroeconomic forces that affect domestic inflation in order to contain them. Therefore, this study proposes a simple theoretical model of price determination capable to identify the driving forces of inflation for the WAEMU so as to provide local policy makers with further understanding on the causes of inflation in the WAEMU'zone.

The main proposition in this paper is that the aggregate price level is determined by an interaction between the forces that affect the aggregate demand for goods and services and those that affect the ability of firms to supply these goods and services. On that note, on the supply side, the aggregate supply relation is determined by a price and wage setting relationship and a production function linked to a productivity factor driven by rainfall. On the demand side, the aggregate demand relation is determined by an IS-LM equilibrium.

2 A simple model of price determination

2.1 The aggregate supply side

Let's assume that in the short-run, each firm employs a certain number of people given a fixed amount of capital. The firm production function can be expressed as follow

$$Y_i = \bar{K}_i R E_i$$

where R denotes rainfall, which is an important factor that drives labor productivity in most agricultural based economies, [1] E_i denotes the number

[1] see Kinda (2011)

of people employed by each firm, and $\bar{K}_i$ denotes the stock of capital employed by each firm, which is one of the factors of production that is expected to be fixed in the short run. For theoretical simplicity, we assume a homogeneous cost function. Hence, each producer faces the following cost function

$$C_i = ((1 + \Upsilon)W)E_i + c\bar{K}_i$$

where C_i denotes the cost function of each firm. This cost function is simply comprised of a fixed and variable cost. For simplicity, the only variable cost in this study emanates from labor costs and a mark up (Υ) that each firm charges over the nominal wage (W). This mark up can arise as a result of changes in world energy prices, or other production costs driven by the sporadic increases in the world price of key fertilizers used in the farming process. c is the rental cost of capital. We aggregate all production and cost functions as follow

$$P = (1/n) \sum_{i=1}^{n} P_i$$

$$C = (1/n) \sum_{i=1}^{n} C_i$$

the profit maximization problem for the representative firm can be derived as follow

$$\underset{E}{max}\, \Pi = P\bar{K}RE - (1 + \Upsilon)WE - c\bar{K}$$

taking the first order condition with respect to E yields the optimal price setting condition. Note that since the capital stock is fixed in the short run, it can be viewed as a constant, such that $\bar{K} = 1$. The price setting behavior of the representative firm would be governed by the following price setting function

$$P = P(R, W, \Upsilon) \tag{1}$$

where rainfall (R) is an exogenous productivity factor that bolsters the ability of a farm to produce more output. The environment is not entirely competitive, thus the firm charges a mark up (Υ) over its marginal cost of production. An increase in the mark up is expected to put upward pressure on prices. The price setting relation can be linearized as follow

$$dP = P_W dW + P_\Upsilon d\Upsilon + P_R dR$$

$$P_W > 0,\ P_\Upsilon > 0,\ P_R < 0$$

the wage setting relation can defined as follow

$$W = W(P^e, u) \tag{2}$$

note that because rainfall shocks are unpredictable and difficult to forecast, they may or may not necessarily impact the wage setting behavior.[2] In this study, we assume that rainfall does not affect wage contracts. u denotes the unemployment rate, P^e is the expected price level. An increase in the unemployment rate should reduce workers' bargaining power and put downward pressure on nominal wages (Blanchard, 2005). Expectations about future increases in the price level should force workers to seek higher wages. The wage setting relation can be linearized as follow

$$dW = W_{P^e} dP^e + W_u du$$

$$W_{p^e} > 0,\ W_u < 0$$

Okun's law predicts a negative relationship between real output and the unemployment rate. This relationship can be expressed in functional form as follow

$$u = U(Y) \tag{3}$$

where Y denotes aggregate real output. A positive change in real output should put downward pressure on the unemployment rate. We can linearize Okun's law as follow

$$du = U_Y dY$$

$$U_Y < 0$$

[2]Note that the wage setting equation is quite generic in this study. However, there are other exogenous factors that may affect the wage setting relation. For instance, changes in unemployment benefits, or minimum wage requirements are some examples of plausible exogenous factors that may directly impact wages.

combining all necessary terms, the inverted short run aggregate supply relation can be expressed as follow

$$dP = \lambda_1 dP^e + \lambda_2 dY + \lambda_3 d\Upsilon + \lambda_4 dR \tag{4}$$

$$\lambda_1 = P_W W_{P^e} > 0,\ \lambda_2 = P_W W_u U_Y > 0,\ \lambda_3 = P_\Upsilon > 0,\ \lambda_4 = P_R < 0$$

the slope of the inverted short run aggregate supply relation can be expressed as follow

$$\frac{dP}{dY} = \lambda_2 > 0$$

the positive sign of slope indicates that the law of supply holds. Therefore, there should be a positive relationship between changes in real output and changes in prices.

2.2 The aggregate demand side

The goods market equation can be expressed as follow

$$Y = Y(i - P) + NX(Y^*, Y, \varepsilon) + G \tag{5}$$

Y denotes real aggregate output. NX denotes net exports, which is a function of a weighted average index of foreign income (Y^*), domestic output (Y), and an exogenous favorable terms of trade variable (ε). G is a purely exogenous fiscal expenditure factor. The real interest rate ($i - P$) affects the most sensitive components of aggregate demand for domestic output. These components can be domestic consumption and investment. For theoretical simplicity, we have assume that the velocity of money is constant. We can express the monetary equilibrium as follow

$$\frac{M}{P} = m(Y, i^*) \tag{6}$$

where M denotes the nominal money supply which is fairly exogenous in a fixed exchange rate regime. (P) is the aggregate price level. The demand for money is mainly influenced by domestic output and the opportunity cost of holding domestic bonds, which in this case is the foreign interest rate (i^*).

Furthermore, the economy is governed by the following covered interest rate parity condition

$$i = i^* + e^e$$

where e^e denotes the expected rate of depreciation of the nominal exchange rate. We are assuming that the central bank operates under a fixed exchange rate regime. Hence, there is no reason to expect any changes in the spot rate. Therefore, there is also no reason to formulate any expectation about any future depreciation of the exchange rate. This assumption can be illustrated as follow $e^e = 0$. Hence, the interest rate parity condition can be rewritten as follow

$$i = i^* \tag{7}$$

we insert the interest parity condition into the goods market equation as follow

$$Y = Y(i^* - P) + NX(Y^*, Y, \varepsilon) + G$$

we linearize the goods market as follow

$$dY = Y_{i^*}di^* - Y_P dP + NX_{Y^*}dY^* + NX_Y dY + NX_\varepsilon d\varepsilon + dG \tag{8}$$

$$Y_{i^*} < 0,\ Y_P > 0,\ NX_{Y^*} > 0,\ NX_Y < 0,\ NX_\varepsilon > 0$$

an increase in the foreign interest rate and the aggregate price level should reduce the aggregate demand for domestic output. An increase in domestic output would corroborate to an increase in domestic income and lead to more imports, thereby decrease net exports. An increase in foreign income and the world export prices of the country's main cash crops would improves net export, ceteris paribus. Let's linearize (6) as follow

$$\frac{1}{P}dM - \frac{M}{P^2}dP = m_{i^*}di^* + m_Y dY$$

$$m_{i*} < 0,\ m_y > 0$$

an increase in the foreign interest rate would lead to a decrease in the domestic demand for money. An increase in domestic output would lead to an increase in the demand for money. Let's solve for di^*as follow

$$di^* = \left(\frac{1}{Pm_{i^*}}\right) dM - \left(\frac{M}{P^2 m_{i^*}}\right) dP - \left(\frac{m_Y}{m_{i^*}}\right) dY$$

let's insert di^* into dY as follow

$$dY = Y_{i*} \left[\left(\tfrac{1}{m_{i^*}}\right) \tfrac{dM}{P} - (\tfrac{Y_{i^*}M + P^2 m_{i^*} Y_P}{P^2 m_{i^*}}) dP - \left(\tfrac{m_Y}{m_{i^*}}\right) dY\right] + NX_{Y^*} dY^* + NX_Y dY + NX_\varepsilon d\varepsilon + dG$$

let's solve for the aggregate demand relation as follow

$$dY = \lambda_5 dM - \lambda_6 dP + \lambda_7 dY^* + \lambda_8 d\varepsilon + \lambda_9 dG \tag{9}$$

$$\lambda_5 = \Theta \tfrac{Y_{i^*}}{Pm_{i^*}} > 0,\ \lambda_6 = \Theta(\tfrac{Y_{i^*}M + P^2 m_{i^*} Y_P}{P^2 m_{i^*}}) > 0,\ \lambda_7 = \Theta NX_{Y^*} > 0,\ \lambda_8 = \Theta NX_\varepsilon > 0,\ \lambda_9 > 0$$

$$\Theta = \left(\frac{m_{i^*}}{(1 - NX_Y) m_{i^*} + Y_{i^*} m_Y}\right) > 0$$

the slope of the short run aggregate demand relation can be expressed as follow

$$\frac{dY}{dP} = -\lambda_6 < 0$$

the negative sign of the slope indicates that the law of demands holds. Therefore, there should be a negative relationship between changes in output and changes in prices.

2.3 Comparative Statics

We can express the aggregate demand and aggregate supply curves as a system of linear equations as follow

$$\begin{bmatrix} 1 & -\lambda_2 \\ \lambda_6 & 1 \end{bmatrix} \begin{bmatrix} dP \\ dY \end{bmatrix} = \begin{bmatrix} \lambda_1 dP^e + \lambda_3 d\Upsilon + \lambda_4 dR \\ \lambda_5 dM + \lambda_7 dY^* + \lambda_8 d\varepsilon + \lambda_9 dG \end{bmatrix} \tag{10}$$

note that the aggregate supply side is over-identified, because the number of exogenous demand instruments excluded from the short-run aggregate supply curve exceeds the number of endogenous variables. Let's examine the effect of an exogenous shock in rainfall on the change in the price level

$$\frac{dP}{dR} = \frac{\lambda_4}{(1+\lambda_2\lambda_6)} < 0$$

a positive change in rainfall shifts the short run aggregate supply curve downward, putting downward pressure on prices. Lets say for instance that the firm's mark up rises as a result of an increase in energy costs

$$\frac{dP}{d\Upsilon} = \frac{\lambda_3}{(1+\lambda_2\lambda_6)} > 0$$

a positive change in the mark up shifts the short run aggregate supply curve upward, putting upward pressure on prices.[3] Let's consider the effect of a positive change in government spending on prices and output

$$\frac{dY}{dG} = \frac{\lambda_9}{(1+\lambda_2\lambda_6)} > 0$$

$$\frac{dP}{dG} = \frac{\lambda_2\lambda_9}{(1+\lambda_2\lambda_6)} > 0$$

an exogenous shock in government spending shifts the short run aggregate demand curve upward, causing both an increase in the price level and domestic output in the short-run. Let's examine the effect of a favorable terms of trade shock (for example, a positive change in the world price of cocoa) on output as follow

$$\frac{dY}{d\varepsilon} = \frac{\lambda_8}{(1+\lambda_2\lambda_6)} > 0$$

a favorable terms of trade shock caused by an increase in the export price of cocoa should cause real output to rise. Given some nominal rigidities, as farmers' profits begin to rise, they would be inclined to produce more. That is the so called law of supply argument.

[3]Note that in this example, we are assuming that the country in question is a net oil importer.

2.4 Empirical methodology

The inverted short-run aggregate supply curve can be expressed as a reduced form equation as follow

$$dp = \frac{\lambda_1}{(1+\lambda_2\lambda_6)}dP^e + \frac{\lambda_3}{(1+\lambda_2\lambda_6)}d\Upsilon + \frac{\lambda_4}{(1+\lambda_2\lambda_6)}dR + \frac{\lambda_2(\lambda_5 dM + \lambda_7 dY^* + \lambda_8 d\varepsilon + \lambda_9 dG)}{(1+\lambda_2\lambda_6)} \tag{11}$$

if the goal to estimate (11) directly, note that we already face two visible econometric issues: output is endogenous and the inverted short-run aggregate supply curve is over-identified. Hence, given the endogeneity of output and the over-identification issue, we can still obtain the unbiased estimates of all the parameters expressed in (11) by using the Two Stage Least Squares estimator specified in (12)

$$\hat{\phi}_{2sls} = (X^{'}GG^{'}G)^{-1}(X^{'}GG^{'}G)^{-1}G^{'}Y \tag{12}$$

2.5 Data

We use annual data from 1970 to 2012 to estimate the determinant of inflation at the one year horizon. Rainfall data were collected from the Center for Environmental Data Analysis (CEDA) database. Nominal commodity price data were collected from the Global Economic Monitor (GEM) database. Macroeconomic data were collected from the World Development Indicators (WDI) database, the International Finance Statistics (IFS) database, and the BCEAO database. We collected data for the founding members of the WAEMU (Benin, Burkina Faso, Cote d'Ivoire, Mali, Niger, Senegal, and Togo). Guinea-Bissau was omitted from the analysis, because the country joined the monetary union in the summer of 1997, so we faced a lack of historical data.

2.5.1 The endogenous variables

The exp-post inflation rate

I used the GDP deflator and the consumer price data as my two proxies for approximating the aggregate price level for the WAEMU. We calculate the inflation rate as follow

$$\pi_t = p_t - p_{t-1}$$

where p_t is the log of the GDP deflator or the consumer price index, π_t is the actual inflation rate measured by the first difference of the log of the price indicator. Figure 1 plots the inflation rate (deflator) series for the WAEMU overtime. In the case of the WAEMU, although the MA(1) and ARMA(1 1) models provided some good empirical results, modeling inflationary expectations with the random walk model produced the strongest empirical estimates. Figure 2 provides a graphical depiction of the ex-ante inflation rate and the actual inflation rate (deflator) estimated for the WAEMU.[4]

[4]Please refer to Table 8 for unit root tests.

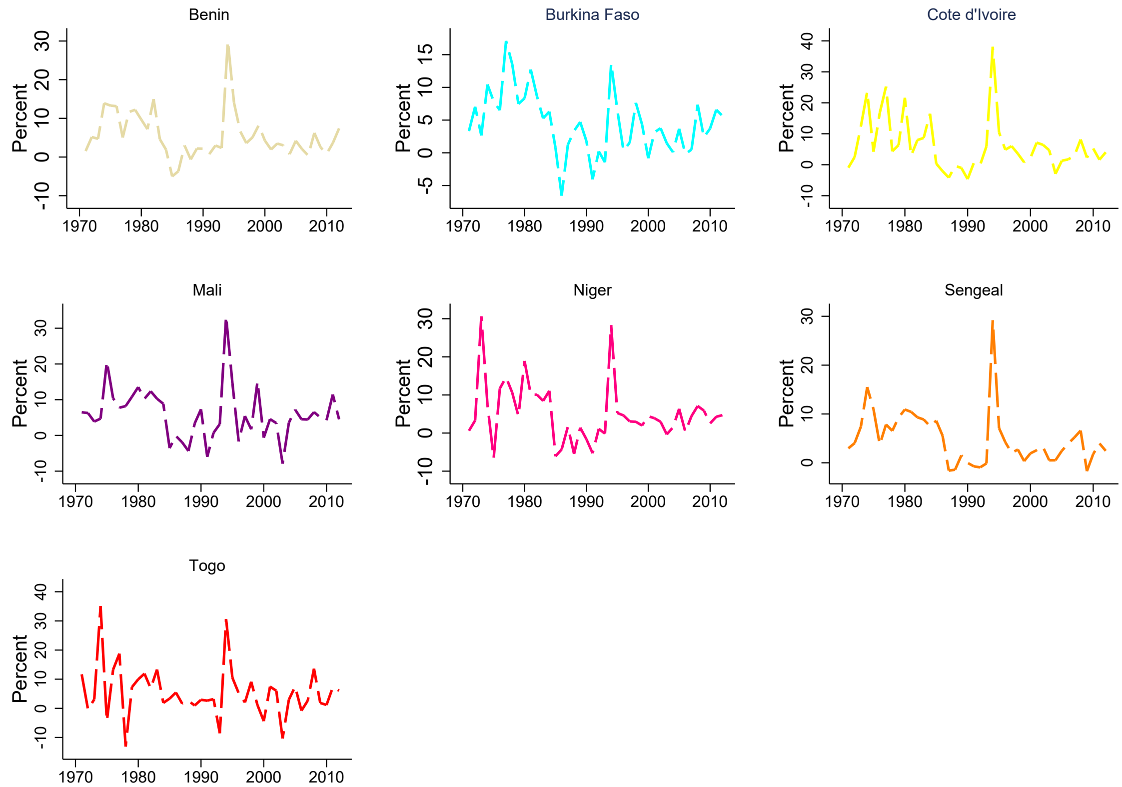


Figure 1: Inflation (GDP deflator) base year=2010

I used the MA(1), AR(1), and ARMA(1 1) processes to model inflationary expectations. I used the residuals from the MA(1), AR(1), and ARMA(1 1) models as my three proxies for the ex-post inflation rate and named them as follow: ($INFARMAD$), ($INFMAD$), and ($INFRWD$).

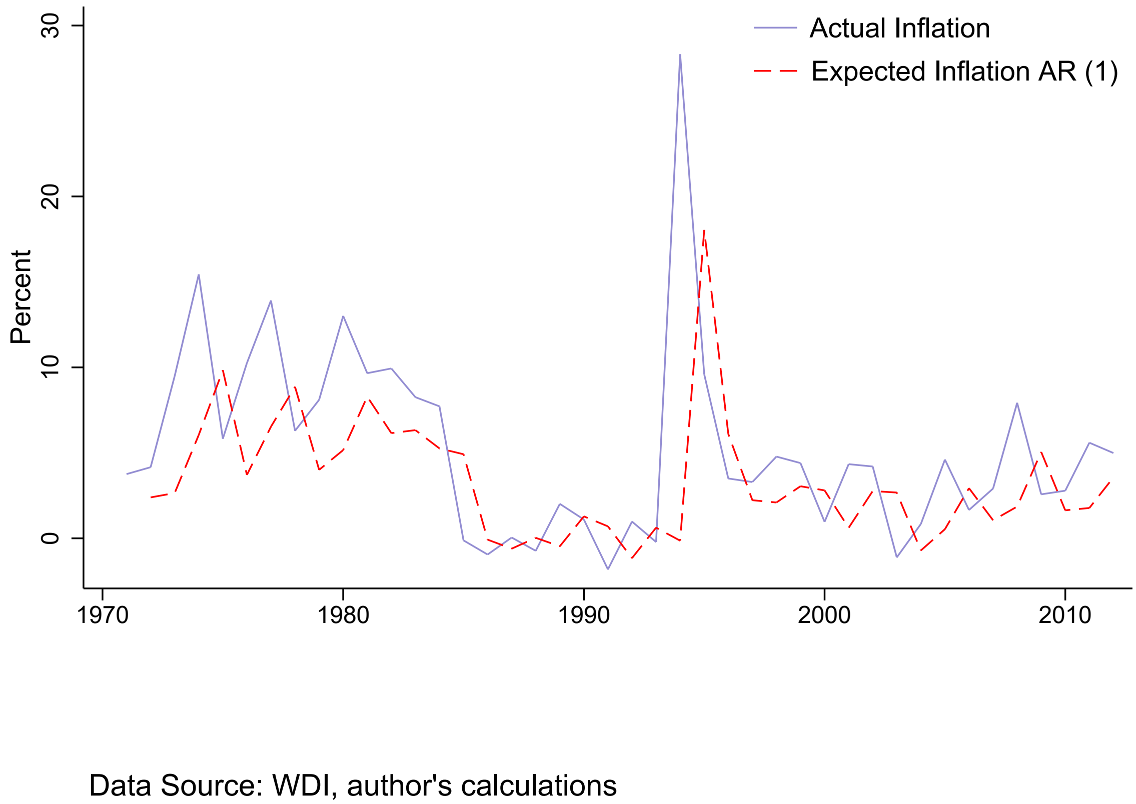


Figure 2: Expected inflation versus actual inflation

The real output gap

I used an aggregated index of real GDP expressed in local currency as the proxy for real output for the WAEMU. I used a similar approach taken by Hodrick and Prescott (1997) to compute the cyclical component of the index and used it as my main proxy for the real output gap ($ogap_t$).[5] Figure 3 presents the real output gap series for the WAEMU. We find that the effects of the Sahel droughts during the early 1980s were strongly correlated across the countries. Cross correlation of real shocks within a monetary union is a desirable outcome for monetary policy efficiency.

[5]Please refer to Table 9 for unit root tests.

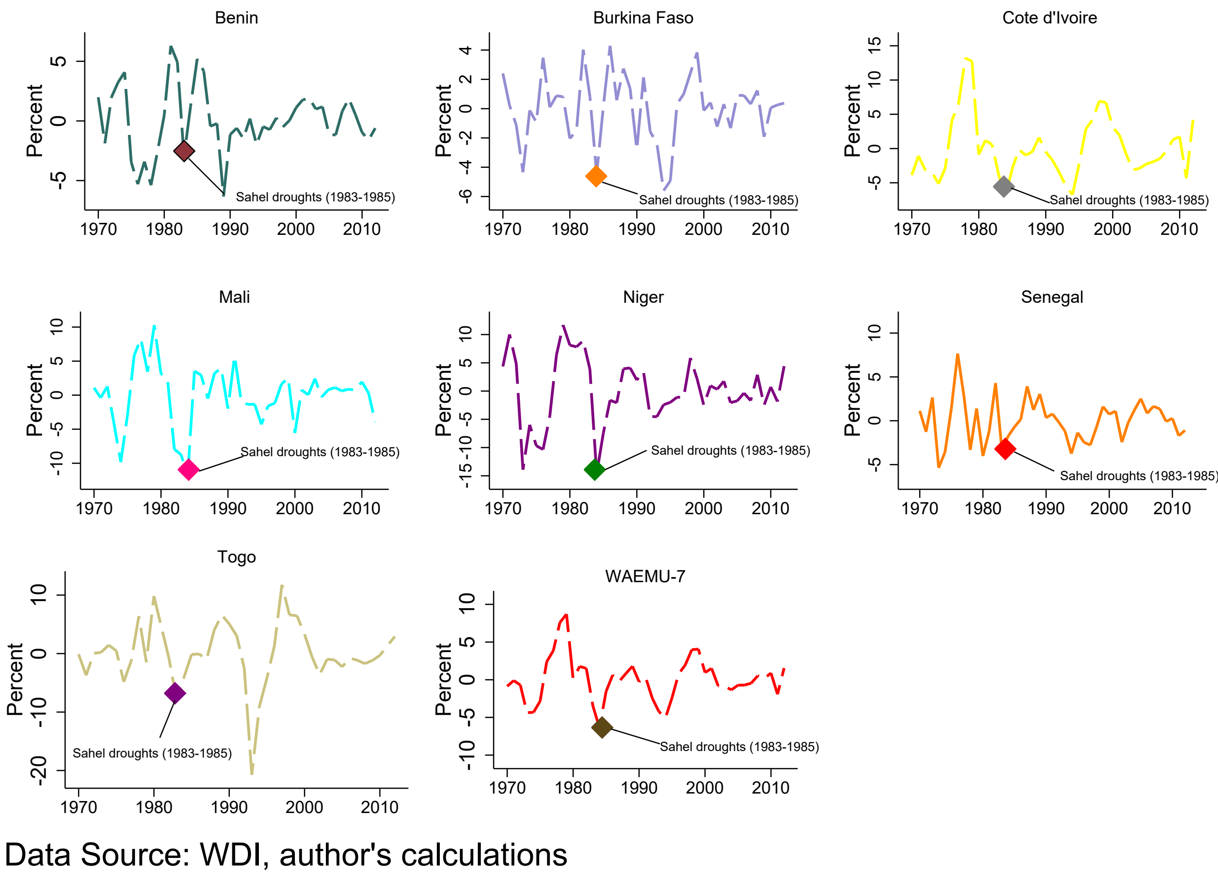


Figure 3: The real output gap (base year=2010)

2.5.2 Exogenous demand instruments

Foreign income proxy

We used nominal GDP data expressed in dollars for the key historical trading partners (for example, we used the United States, Germany, the Netherlands, India, China, and France). We converted the series from dollars to CFA francs and then deflated them by the price level proxy. I used various weights to create a weighted index of foreign income; note that the United States was given the highest weight, because it remains the most essential trading partner for the WAEMU. I used the cyclical component of the index as my main proxy for world demand ($wogapD_t$).[6] Figure 4 shows a strong correlation between nominal economic activities proxy by the nominal GDP gap and our proxy for world demand.

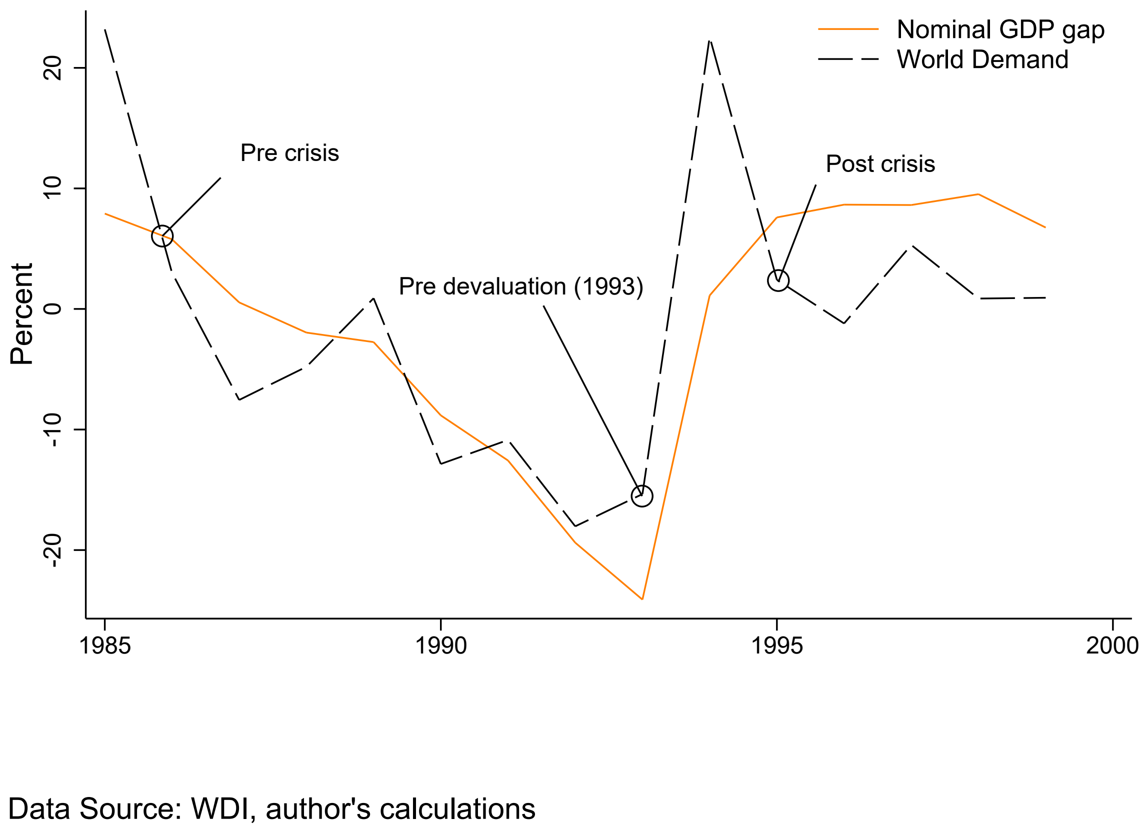


Figure 4: Co-movements: nominal economic activities (nominal GDP gap) and world demand (Key trading partners)

We see a strong correlation between the economic crisis of 1988-1993 and the collapse in world demand associated with the exact period. Furthermore, we can see that world demand was weak prior the devaluation of the CFA franc, but not surprisingly we observe a significant surge in world demand after the devaluation of CFA franc in 1994. The surge in world demand following the devaluation of the CFA franc in 1994 is an expected outcome

[6] Please refer to Table 9 for unit root tests.

since the price of the domestic currency fell. The stoutness of the correlation between the nominal GDP gap and world demand can only bolster the robustness of our world demand indicator.

Export price proxies

I used the world prices of three key commodities: cocoa, cotton, and tobacco. The prices were converted into CFA franc and deflated by a price level proxy. I used the cyclical component of real cocoa prices as my real cocoa price surprise indicator ($cocoasD_t$). I used the cyclical component of real tobacco prices as my real tobacco price surprise indicator ($tabasD_t$).

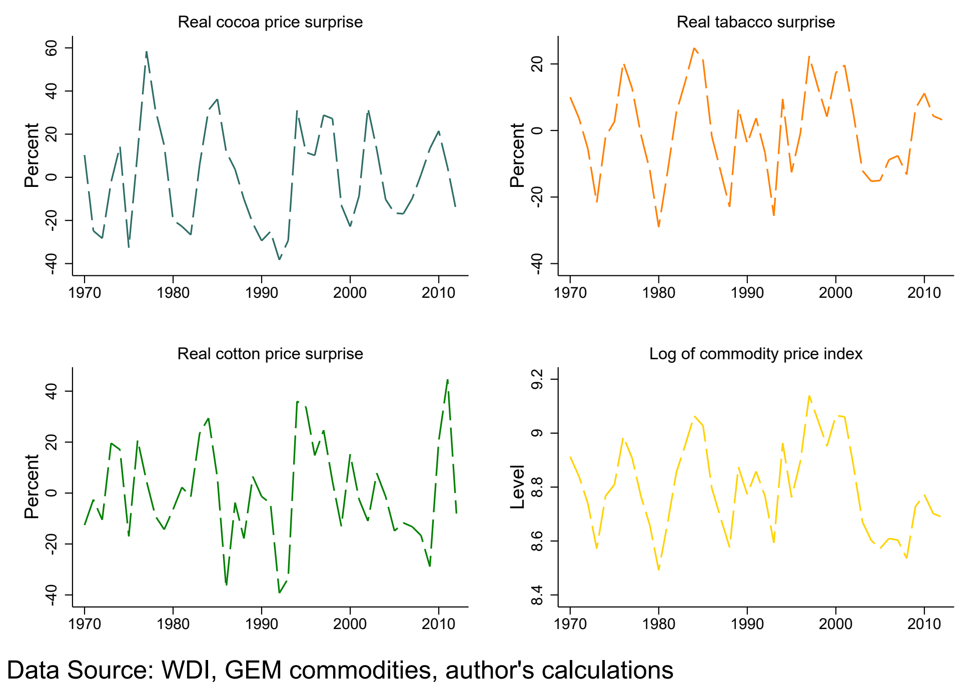
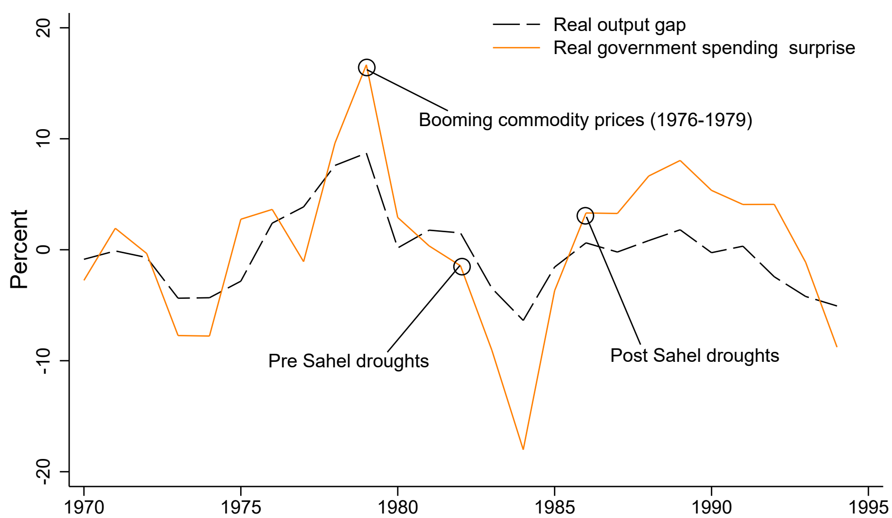


Figure 5: Commodities price indicators for the WAEMU-7: real cocoa price surprise ($cocoasD_t$), real tobacco price surprise ($tabasD_t$), real cotton price surprise ($cottonsD_t$), and the log of the commodity price index ($compexD_t$)

I used the cyclical component of real cotton prices as my real cotton price surprise indicator ($cottonsD_t$). I created a real commodity price index by using a weighted average price index based on real cocoa prices, real cotton prices, and real tobacco prices. I used the log of this index as my main commodity price index ($compexD_t$). The index followed a random walk and was stationary at levels, which shows that real commodity prices remain highly unpredictable for the WAEMU. Figure 5 depicts the movements of the four export price proxies overtime.

Fiscal indicator

I used final government consumption expenditures deflated by the price level proxy as the fiscal indicator. I used the cyclical component of the index as my real government spending surprise indicator (gsD_t). Figure 6 depicts a relationship between the real output gap and real government spending surprise.[7]



Data Source: WDI, author's calculations

Figure 6: Co-movements: real economic activities and real government spending surprise for the (WAEMU-7)

[7] Please refer to Table 9 for unit root tests.

Fiscal policy is most effective in a fixed exchange rate regime, so we expect our real government spending surprise indicator to be strongly correlated to the real output gap. In fact, in Figure 6, we see a strong positive correlation between real economic activities and real government spending; but the interesting part is that government spending tends to be pro-cyclical. We observe strong government spending during booming commodities prices and weak government spending during adverse economic conditions.

Monetary policy indicators

In a fixed exchange rate regime, the money supply is determined exogenously. Hence, we rely on this exogeneity principle in order to utilize the monetary mass and M1 deflated by the price level proxy as our two exogenous monetary policy indicators. I used the cyclical component of these two indicators as my two exogenous monetary policy indicators ($mmsD_t$) and (msD_t).[8] We see a strong and positive correlation between real economic activities and real money surprise in Figure 7.

[8] Please refer to Table 9 for unit root tests.

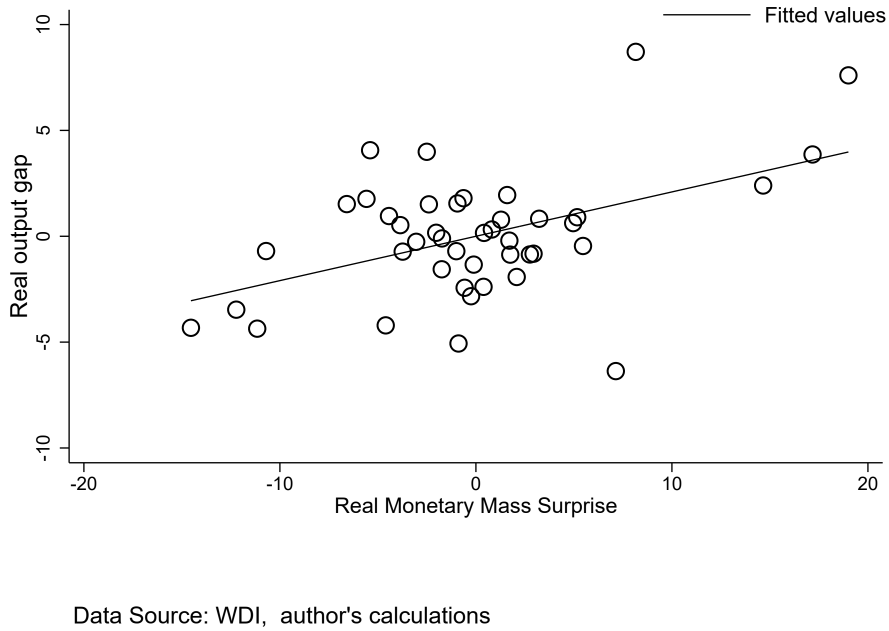


Figure 7: Correlation: real output gap and real money surprise

Exogenous supply instruments

Rainfall

I used monthly days of rainfall per year as my main proxy for rainfall. The variable was stationary at level, which tells us that daily rainfall patterns follow a random walk. However, I have also used the cyclical component of the variable so as to capture the effect of rainfall surprise ($rains_t$). We expect a strong correlation between rainfall surprise and the real output gap and since rainfall is a positive supply shock it should shift the short run aggregate supply curve downward; putting downward pressure on inflation.

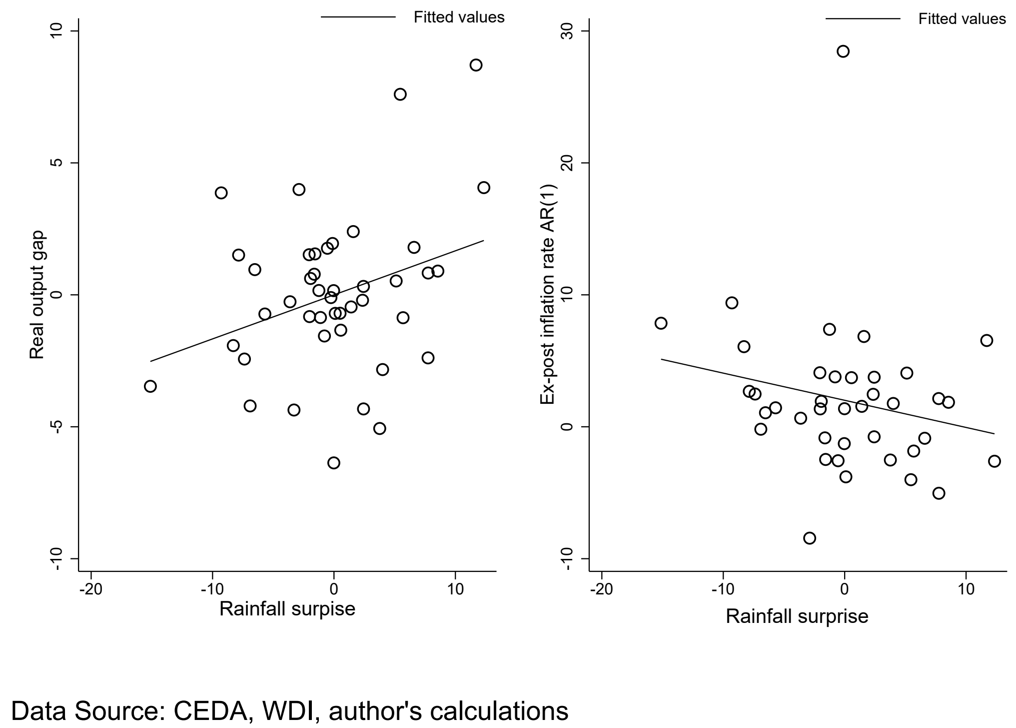


Figure 8: Correlations: rainfall surprise, ex-post inflation, and the real output gap.

We examine the correlation between rainfall surprise ($rains_t$), the ex-post inflation rate ($INFRWD$), and the real output gap ($ogap_t$) in Figure 8. We can see a positive relationship between the real output gap and rainfall surprise; we also see a negative relationship between the ex-post inflation rate and rainfall surprise.

Devaluation

I used the devaluation of the CFA franc in 1994 as a negative terms of trade shock ($devaluation_{1994}$) because the cost of imports rose rapidly during that specific year; we expect to find a significant pass-through of the devaluation on domestic inflation.

Mark up proxy

I used the crude oil average spot prices deflated by the domestic price level proxy as my proxy for the mark up. I converted the prices from US dollars to CFA franc and then deflated the prices by the price level proxy. Real crude oil inflation ($goilD_t$) was calculated by using the first difference of the real crude oil price index. Real crude oil price surprise ($oilsD_t$) was calculated by using the cyclical component of the real oil price index. The effect of the 1970s oil shocks were mildly felt across the WAEMU, but the strongest case was the Togolese case. In Figure 9, we examine this case.[9]

Figure 9: Correlation: real crude oil inflation ($goilD_t$) and the exp-post inflation rate ($INFRWD$) for Togo

[9]Please refer to Table 9 for unit roots tests.

Foreign inflation index

This study uses France's consumer price inflation ($finf_t$) as a proxy for capturing the effect of an exogenous change in foreign inflation on domestic inflation. Since the CFA franc has been pegged to France's exchange rate since 1948, it is likely that inflation across both countries would be strongly correlated. We failed to satisfy the unit root test, but that was prior to the identification of a structural break identified for the year of 1984. The structural break could have been caused by the French authorities' efforts to curb inflation through forceful legislation at the onset of the 1980s series of currency depreciations. In Figure 10, we plot the results of the unit root test with breakpoints. The estimated ADF test statistic was found to be -4.45 with a corresponding p-value of less than 0.02, allowing us to reject the previous findings of a unit root in the series.

2.6 Empirical Results

2.6.1 WAEMU-7

Table 1 reports the first stage results estimated for the aggregated WAEMU-7 (Benin, Burkina Faso, Cote d'Ivoire, Mali, Niger, Senegal, and Togo). The Breusch-Pagan and Cook-Weisberg tests for heteroskedasticity allowed us to reject the presence of heteroskedasticity in all the estimated regressions (1-8). In the first stage, the instrument relevance condition was satisfied in all the estimated regressions (1-8). The tests of weak instruments also suggest that the instruments are not weak. These results are based on the fact that when we are willing to tolerate a rejection rate of 15 percent of a nominal 5 percent Wald test, we find that the the Cragg-Donald minimum eigenvalue test statistic is greater than the test statistic associated with the nominal 5 percent Wald test.

Given the robustness of the diagnostic tests found in the first stage results, we found no surprises in the second stage results. Furthermore, all directions of causality found between the instruments and the output gap ($ogap_t$) were as predicted by the theoretical framework. In models (1-8), Rainfall surprise ($rains_t$) is highly significant in explaining the real output gap, which is is consistent with our theoretical claim that rainfall remains a significant determinant of aggregate output for agriculture based economies. The 1994 devaluation ($devaluation_{1994}$) may have stabilized nominal output, but our results show that it had a negative impact on the real output gap.

As expected, our monetary policy indicators do play a significant role in explaining demand; both ($mmsD$) and (msD) were found to be significant in explaining the real output gap. The fiscal indicator was also significant in explaining demand. (gsD_t) was found to be statistically significant in explaining the real output gap. ($wogapD_t$) was found to be statistically significant in explaining the real output gap, which implies that world demand from the main trading partners is a significant determinant of domestic demand. Commodity prices remain the anchor of growth for all the WAEMU; we can clearly see that all the commodity price indicators were found to be significantly robust in explaining demand. Real cocoa prices surprise ($cocoasD_t$), real tobacco prices surprise ($tabasD_t$), and our commodity price index ($compexD$) were found to be statistically significant in explaining the real output gap. It is safe to conclude that the first stage results were consistent across all estimated models (1-8).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	$ogap_t$	$ogap_t$	$ogap_t$	$ogap_t$	$ogap_t$	$ogap_t$	$ogap_t$	$ogap_t$
$rains_t$	0.127**	0.141**	0.215***	0.184***	0.221***	0.118**	0.164***	0.137**
	(0.0580)	(0.0567)	(0.0582)	(0.0592)	(0.0574)	(0.0507)	(0.0564)	(0.0545)
$goilD_t$	-0.00585	-0.00172	-0.0116	-0.0107	-0.0123	-0.00411	-0.00214	-0.00650
	(0.00972)	(0.0101)	(0.0101)	(0.0108)	(0.00987)	(0.00864)	(0.00981)	(0.00912)
$devaluation_{1994}$	-0.0215	-0.0322	-0.0378*	-0.0388*	-0.0356	-0.0423**	-0.0381*	-0.0363*
	(0.0205)	(0.0204)	(0.0218)	(0.0228)	(0.0213)	(0.0183)	(0.0200)	(0.0202)
$ogap_{t-1}$	0.411***	0.552***	0.626***	0.619***	0.642***	0.509***	0.572***	0.456***
	(0.121)	(0.105)	(0.110)	(0.113)	(0.109)	(0.0945)	(0.103)	(0.115)
gsD_t	0.180***							0.217***
	(0.0578)							(0.0563)
$mmsD_t$		0.150***					0.135***	
		(0.0488)					(0.0481)	
$compexD_t$			0.0423**				0.0334*	
			(0.0197)				(0.0183)	
$finf_t$				-0.0110				
				(0.0903)				
$cocoasD_t$				0.0269*				
				(0.0145)				
$tabasD_t$					0.0587**			
					(0.0237)			
msD_t						0.227***		
						(0.0490)		
$wogap_t$								0.0855**
								(0.0352)
_cons	0.00111	0.00135	-0.369**	0.00260	0.00221	0.00161	-0.292*	0.00156
	(0.00309)	(0.00309)	(0.173)	(0.00520)	(0.00320)	(0.00274)	(0.161)	(0.00290)
Years	(1970-2012)	(1970-2012)	(1970-2012)	(1970-2012)	(1970-2012)	(1970-2012)	(1970-2012)	
R^2	0.639	0.637	0.594	0.583	0.609	0.714	0.669	0.691
*Breusch − Pagan*Prob > chi2	0.5840	0.4507	0.2926	0.2582	0.2391	0.2832	0.4798	0.4692
Cragg − Donald Minimum Eigenvalue Statistics	22.0983	21.9227	17.6653	16.1239	19.0191	32.5277	16.6731	18.7109
Nominal 5 Percent Wald Test	11.59	11.59	11.59	11.59	11.59	11.59	12.83	12.83
Ho : Instruments are weak	*rejected*	*rejected*	*rejected*	*rejected*	*rejected*	*rejected*	*rejected*	*rejected*

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < .01$

Table 1: First Stage Results WAEMU-7

Table 2 reports the second stage results estimated for the WAEMU-7.[10] The diagnostics tests support that the estimated regessions (1-8) were structured appropriately. This conclusion is based on the fact that we cannot reject the null hypothesis that the overidentifying restrictions are valid. Hence, we can conclude that the instruments are valid and that the models were structured appropriately. Our estimates for the slope of the inverted short run aggregate supply curve are statistically significant and the range of the point estimates is from .37 to .54. These results are consistent with the findings of Bhandari and Frankel (2015) in the case of India. The slope is positive, suggesting that the short run aggregate supply curve is upward sloping with a range of 1.85 to 2.70.

Given the range of the elasticities, it is safe to conclude that the short-run aggregate supply curve could be relatively flat. As expected, rainfall surprise puts downward pressure on inflation. There is a significant pass through of imported oil inflation on domestic inflation. Crude oil inflation ($goilD_t$) was found to be statistically significant in explaining domestic inflation. Obviously, the 1994 devaluation has had a significant and positive impact on domestic inflation. However, the effect was inelastic, which is a desire result. Imported inflation from France ($finf$) was also found to be a significant determinant of domestic inflation. The second stage results are fairly consistent across the estimated regressions (1-8).

[10] We also report the second stage results estimated for the individual members of the WAEMU for whom we found meaningful econometric results in the appendix.

	(1) $INFRWD$	(2) $INFRWD$	(3) $INFRWD$	(4) $INFRWD$	(5) $INFRWD$	(6) $INFRWD$	(7) $INFRWD$	(8) $INFRWD$
$ogap_t$	0.476**	0.503**	0.431*	0.538**	0.474*	0.417*	0.410*	0.374*
	(0.241)	(0.242)	(0.252)	(0.251)	(0.249)	(0.221)	(0.231)	(0.224)
$rains_t$	-0.291***	-0.296***	-0.282***	-0.290***	-0.290***	-0.279***	-0.278***	-0.271***
	(0.0977)	(0.0983)	(0.0983)	(0.0968)	(0.0985)	(0.0953)	(0.0961)	(0.0953)
$goilD_t$	0.0576***	0.0578***	0.0573***	0.0492***	0.0576***	0.0572***	0.0571***	0.0569***
	(0.0152)	(0.0153)	(0.0151)	(0.0155)	(0.0152)	(0.0150)	(0.0150)	(0.0150)
$devaluation_{1994}$	0.291***	0.293***	0.289***	0.304***	0.291***	0.288***	0.288***	0.286***
	(0.0345)	(0.0347)	(0.0346)	(0.0340)	(0.0347)	(0.0338)	(0.0340)	(0.0338)
$finf_t$				0.248*				
				(0.128)				
_cons	0.00910*	0.00904*	0.00919*	-0.00191	0.00910*	0.00922*	0.00923*	0.00930*
	(0.00494)	(0.00497)	(0.00491)	(0.00737)	(0.00494)	(0.00489)	(0.00489)	(0.00487)
$Years$	(1970-2012)	(1970-2012)	(1970-2012)	(1970-2012)	(1970-2012)	(1970-2012)	(1970-2012)	(1970-2012)
R^2	0.684	0.681	0.689	0.703	0.685	0.690	0.690	0.693
$Sargan\ Test$ Prob > chi2	.852729	.497588	0.0972	0.9633	0.2770	0.2556	0.2453	0.2697

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < .01$

Table 2: Two stage least squares estimates: second stage results (WAEMU-7)

3 Conclusions

Overall, we can conclude that the sources of inflation in the WAEMU's zone emanate from real crude oil inflation, France's inflation, rainfall, and the output gap. The size of the effect of aggregate demand on domestic inflation indicates that the short-run aggregate supply curve may be relatively flat; suggesting that the economy maybe located in the excess capacity zone.

Appendix

	(1)	(2)	(3)
	$INFMA$	$INFRW$	$INFRW$
$ogap_t$	1.229*	1.239*	1.578**
	(0.662)	(0.678)	(0.757)
$rains_t$	-0.0974	-0.182	
	(0.190)	(0.201)	
$oils_t$	0.0454		
	(0.0429)		
$finf_t$	0.862***	0.848***	0.868***
	(0.250)	(0.246)	(0.264)
$devaluation_{1994}$	0.277***	0.299***	0.305***
	(0.0684)	(0.0725)	(0.0722)
$\_cons$	0.000225	-0.00710	-0.00795
	(0.0130)	(0.0133)	(0.0142)
$Years$	(1970-2012)	(1970-2012)	(1970-2012)
R^2	0.412	0.367	0.272
$Sargan$ p-value	0.6293	0.5422	0.8190

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < .01$

Table 3: Two stage least squares estimates: second stage results (Burkina Faso)

	(1) INFRW	(2) INFMA	(3) INFMAD
$ogap_t$	0.318*	0.295**	0.490*
	(0.174)	(0.148)	(0.285)
$rains_t$	-0.192*	-0.0747	-0.0570
	(0.111)	(0.0977)	(0.186)
$oils_t$	0.0110		
	(0.0285)		
$devaluation_{1994}$	0.224***	0.232***	0.343***
	(0.0412)	(0.0364)	(0.0691)
$finf_t$		0.527***	
		(0.142)	
$oilsD_t$			0.109**
			(0.0458)
_cons	0.00576	0.00873	0.0292***
	(0.00654)	(0.00858)	(0.0109)
$Years$	(1970-2012)	(1970-2012)	(1970-2012)
R^2	0.438	0.581	0.409
$Sargan$ p-value	0.8294	0.2192	0.6021

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < .01$

Table 4: Two stage least squares estimates: second stage results (Cote d'Ivoire)

	(1) $INFMAD$	(2) $INFRWD$	(3) $INFARMAD$
$ogap_t$	0.577***	0.594***	0.500**
	(0.214)	(0.229)	(0.222)
$rains_t$	-0.256***	-0.249**	-0.207**
	(0.0991)	(0.106)	(0.103)
$finf_t$	0.448**	0.321	0.304
	(0.211)	(0.226)	(0.219)
$devaluation_{1994}$	0.318***	0.318***	0.320***
	(0.0539)	(0.0577)	(0.0559)
$\_cons$	0.00583	0.00418	-0.0239*
	(0.0128)	(0.0137)	(0.0133)
$Years$	(1970-2012)	(1970-2012)	(1970-2012)
R^2	0.443	0.387	0.429
$Sargan$ p-value	0.6027	0.6467	0.4049

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < .01$

Table 5: Two stage least squares estimates: second stage results (Niger)

	(1) $INFMA$	(2) $INFRW$	(3) $INFMA$
$ogap_t$	0.956*	1.070**	0.698*
	(0.503)	(0.455)	(0.413)
$rains_t$	-0.111*	-0.125**	-0.133**
	(0.0646)	(0.0583)	(0.0528)
$oils_t$	0.0923***	0.0793***	
	(0.0260)	(0.0235)	
$devaluation_{1994}$	0.302***	0.323***	0.326***
	(0.0427)	(0.0386)	(0.0359)
$finf_t$			0.768***
			(0.143)
$\_cons$	0.0231***	0.0101*	-0.00720
	(0.00601)	(0.00543)	(0.00756)
$Years$	(1970-2012)	(1970-2012)	(1970-2012)
R^2	0.656	0.714	0.758
$Sargan$ p-value	0.4449	0.3644	0.0239

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < .01$

Table 6: Two stage least squares estimates: second stage results (Senegal)

	(1) $INFRWD$	(2) $INFMAD$	(3) $INFMA$
$ogap_t$	0.724*	0.720*	0.466**
	(0.419)	(0.417)	(0.223)
$oilsD_t$	0.102**		
	(0.0506)		
$rains_t$	-0.302*	-0.308*	-0.172*
	(0.166)	(0.165)	(0.0933)
$devaluation_{1994}$	0.321***	0.355***	0.370***
	(0.0908)	(0.0898)	(0.0515)
$finf_t$		0.702**	0.680***
		(0.330)	(0.191)
$\_cons$	0.0422***	0.0103	-0.00174
	(0.0128)	(0.0200)	(0.0114)
$Years$	(1970-2012)	(1970-2012)	(1970-2012)
R^2	0.215	0.223	0.568
$Sargan$ p-value	0.5459	0.2933	0.8117

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < .01$

Table 7: Two stage least squares estimates: second stage results (Togo)

Table 8: Augmented Dickey Fuller tests: inflation proxies

$INFRWD$	Test Statistic	5 Percent Critical Value	P-value
WAEMU-7	-8.177	-2.955	0.000
Burkina Faso	-7.586	-2.955	0.000
Cote d'Ivoire	-7.667	-2.955	0.000
Niger	-7.667	-2.955	0.000
Senegal	-7.917	-2.955	0.0000
Togo	-8.594	-2.955	0.000
$INFARMAD$	Test statistic	5 percent critical value	P-value
WAEMU-7	-6.027	-2.955	0.000
Burkina Faso	-5.847	-2.955	0.000
Cote d'Ivoire	-6.215	-2.955	0.000
Niger	-5.513	-2.955	0.000
Senegal	-5.549	-2.955	0.000
Togo	-7.979	-2.955	0.000
$INFMAD$	Test statistic	5 percent critical value	P-value
WAEMU-7	-6.027	-2.955	0.000
Burkina Faso	-7.314	-2.955	0.000
Cote d'Ivoire	-7.391	-2.955	0.000
Niger	-7.462	-2.955	0.000
Senegal	-7.312	-2.955	0.000
Togo	-8.493	-2.955	0.000
$INFRW$	Test statistic	5 percent critical value	P-value
WAEMU-7	-8.177	-2.955	0.000
Burkina Faso	-9.286	-2.955	0.000
Cote d'Ivoire	-7.707	-2.955	0.000
Niger	-6.900	-2.955	0.000
Senegal	-8.187	-2.955	0.000
Togo	-7.816	-2.955	0.000
$INFARMA$	Test statistic	5 percent critical value	P-value
WAEMU-7	-6.027	-2.955	0.000
Burkina Faso	-6.851	-2.955	0.000
Cote d'Ivoire	-6.273	-2.955	0.000
Niger	-6.036	-2.955	0.000
Senegal	-5.272	-2.955	0.000
Togo	-6.192	-2.955	0.000
$INFMA$	Test statistic	5 percent critical value	P-value
WAEMU-7	-7.551	-2.955	0.000
Burkina Faso	-7.972	-2.955	(0.00)
Cote d'Ivoire	-6.945	-2.955	0.000
Niger	-6.306	-2.955	0.000
Senegal	-6.994	-2.955	0.000
Togo	-7.144	-2.955	0.000
$finf_t$	Test statistic	5 percent critical value	P-value
France	-1.116	-2.955	0.7087

Table 9: Augmented Dickey Fuller tests: other variables

$mmsD_t$ *or* mms_t	Test Statistic	5 Percent Critical Value	P-value
WAEMU-7	-3.351	-2.952	0.0127
Burkina Faso	-4.998	-2.952	(0.00)
Cote d'Ivoire	-3.782	-2.952	0.0031
Niger	-6.189	-2.952	0.000
Senegal	-4.579	-2.952	0.0001
Togo	-5.927	-2.952	0.000
msD_t *or* ms_t	Test Statistic	5 Percent Critical Value	P-value
WAEMU-7	-3.205	-2.952	0.0197
Burkina Faso	-4.705	-2.952	0.0001
Cote d'Ivoire	-3.962	-2.952	0.0016
Niger	-3.316	-2.952	0.0142
Senegal	-4.955	-2.952	0.000
Togo	-5.118	-2.952	0.000
gsD_t *or* gs_t	Test statistic	5 percent critical value	P-value
WAEMU-7	-3.670	-2.952	0.0046
Burkina Faso	-4.827	-2.952	0.000
Cote d'Ivoire	-4.684	-2.952	0.0001
Niger	-3.889	-2.952	0.0021
Senegal	-4.103	-2.952	0.0010
Togo	-5.363	-2.952	0.000
$rains_t$	Test Statistic	5 percent Critical Value	P-value
WAEMU-7	-6.469	-2.952	0.000
Burkina Faso	-7.151	-2.952	0.000
Cote d'Ivoire	-6.084	-2.952	0.000
Niger	-6.389	-2.952	0.000
Senegal	-7.563	-2.952	0.000
Togo	-6.684	-2.952	0.000
$ogap_t$	Test Statistic	5 Percent Critical Value	P-value
WAEMU-7	-3.011	-2.952	0.0339
Burkina Faso	-5.233	-2.952	0.0000
Cote d'Ivoire	-3.237	-2.952	0.0179
Niger	-3.690	-2.952	0.0043
Senegal	-5.424	-2.952	0.000
Togo	-3.734	-2.952	0.0037
$compexD_t$ *or* $compex_t$	Test Statistic	5 Percent Critical Value	P-value
WAEMU-7	-3.123	-2.952	0.0249
Burkina Faso	-3.291	-2.952	0.0153
Cote d'Ivoire	-2.656	-2.952	0.0820
Niger	-2.966	-2.952	0.0381
Senegal	-3.409	-2.952	0.000
Togo	-3.132	-2.952	0.0243
$cocoasD_t$ *or* $cocoas_t$	Test Statistic	5 Percent Critical Value	P-value
WAEMU-7	-3.795	-2.952	0.0030
Burkina Faso	-3.878	-2.952	0.0022
Cote d'Ivoire	-3.688	-2.952	0.0043
Niger	-3.668	-2.952	0.0046
Senegal	-4.146	-2.952	0.0008
Togo	-3.656	-2.952	0.0048
$tabasD_t$ *or* $tabas_t$	Test Statistic	5 Percent Critical Value	P-value
WAEMU-7	-3.952	-2.952	0.0017
Burkina Faso	-4.038	-2.952	0.0012
Cote d'Ivoire	-3.578	-2.952	0.0062
Niger	-4.021	-2.952	0.0013
Senegal	-4.033	-2.952	0.0012
Togo	-4.161	-2.952	0.000
$wogapD_t$ *or* $wogap_t$	Test Statistic	5 Percent Critical Value	P-value
WAEMU-7	-3.796	-2.952	0.0030
Burkina Faso	-4.047	-2.952	0.0012
Cote d'Ivoire	-3.377	-2.952	0.0118
Niger	-3.838	-2.952	0.0025
Senegal	-3.788	-2.952	0.0030
Togo	-3.908	-2.952	0.0020
$goilD_t$ *or* $goil_t$	Test Statistic	5 Percent Critical Value	P-value
WAEMU-7	-3.796	-2.952	0.0030

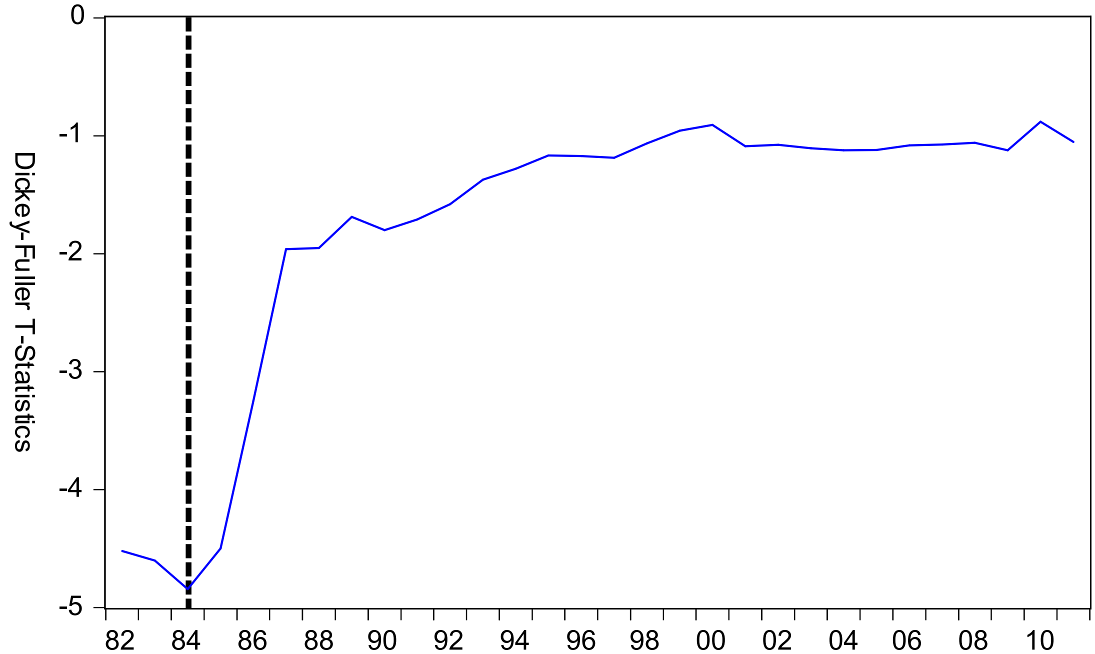


Figure 10: France's Inflation (CPI): unit roots test with break points results

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