The Sources of Macroeconomic Fluctuations in Subsaharan African Economies: An application to Côte d'Ivoire

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Abstract

This paper quantifies the empirical importance of various types of relevant shocks in explaining macroeconomic fluctuations in a typical Sub–saharan African economy (Côte d'Ivoire) in the context of a Dynamic Stochastic General Equilibrium (DSGE) model and Bayesian techniques. Our analysis first documents that transitory but persistent productivity shocks are the dominant sources of macroeconomic volatility as they explain more than half of aggregate fluctuations. Second, world interest rate shocks are found to be non–negligible especially in driving fluctuations in consumption growth. Third, while fiscal policy is found to be procyclical, fiscal shocks play a minor role in this economy. In addition, negative productivity shocks coupled with positive world interest rate shocks are at the origins of the poor macroeconomic performances of the economy in the 80s. These findings are in line with the business cycle literature on African economies and also robust to various perturbations of the benchmark set–up. Keywords: Aggregate fluctuations, Subsaharan economies, DSGE model, Bayesian method, transitory and permanent shocks.
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Introduction

Despite the evidence that macroeconomic fluctuations have detrimental effects on growth and accordingly on development (Ramey and Ramey (1995), Easterly, Islam and Stiglitz (2000), Loayza et al (2007) among others), only a narrow strand of the literature has put attention on the issue of business cycles in African countries.[1] While this literature starves in establishing an empirical evidence between volatility and growth, it has offered a shallow description of the origins of fluctuations themselves. In so doing, it leaves a huge gap between the understanding of macroeconomic fluctuations and their consequences in developing economies. Our paper is intended to fill up this gap since it empirically explores the sources of macroeconomic volatility in developing economies and particularly in african economies by focusing on the case of Côte d'Ivoire. Our main objective is to assess the empirical role of various types of shocks in driving aggregate volatility in the context of a Dynamic Stochastic General Equilibrium (DSGE) model. The issue of aggregate fluctuations is particularly relevant for these countries for several reasons. First, business cycles in developing countries are found to present strong differences with respect to those of industrial economies (Agénor et al (2000), Rand and Tarp (2002)). Specifically cycles are found to be much shorter and diverse across economies while recessions are more pronounced (see Kose and Riezman (2001)). Accordingly, the nature of shocks explaining aggregate fluctuations or the mechanism at work in developing countries are expected to differ from those usually found in developed economies. Second, understanding the sources of aggregate volatility is important in a context of high volatility observed in these economies and its welfare effects especially on the poor households.[2] More practically, African countries, as all developing countries, have pledged to promote growth and cut down poverty by half by the 2015 horizon.[3] Thus, the efficiency of implemented policies for the achievement of these targeted objectives requires a thorough understanding of the main causes of business

[1]There is however an abundant work dealing with the determinants of growth and development issues in these economies (see the case studies from Ndulu et al, 2008).

[2]The welfare cost of consumption volatility is evaluated to at least 10 times that in U.S (see Pallage and Robe (2003)).

[3]Halving extreme poverty in the World is the first among the eight Millennium Development Goals (MDG) agreed to by all the World countries with the deadline of 2015.

cycle volatility.

The choice of Côte d'Ivoire as a case study is essentially motivated by two arguments. First, Côte d'Ivoire accounts for a sizeable part of the economic activity in the West African Monetary and Economic Union (WEAMU) region (Giorgioni and Holden (2002), Azam (2007)). It accounts for 20% of GDP of the overall Franc CFA zone and 39% of that of WEAMU on average.[4] Second, and more importantly, unlike most African countries characterized by poor statiscal systems, Côte d'Ivoire has a strong administrative capacity that allowed it to build up a convinient statistical system consistent with standard norms (Arellano et al (2009)). This is particularly relevant in our context as the DSGE model is seriously taken to actual data.

The underlying DSGE model is a stylized standard neoclassical growth model adapted to a small open economy. The core of the model derives from Aguiar and Gopinath (2007) and Garcia-Cicco et al (2009). Four exogenous forces are conjectured to form the potential sources of business cycle volatility in our benchmark economy: total factor productivity (transitory and permanent TFP), fiscal and international interest rate shocks. In addition, the presence of financial frictions on international markets contributes to the propagation of these shocks into the economy. The financial friction is incorporated through a spread, an additional cost on international debt on top of the international interest rate inquired by the representative household. Following Neumeyer and Perri (2005), spreads are specified as an inverse function of future fundamentals represented by future TFP shocks. Fiscal shocks are introduced in a government spending rule where these spending adjust with the state of the economy. Besides the quantification of the contribution of fiscal shocks, this rule helps us to shed light on the ongoing debate about the cyclicality of fiscal policy in developing economies (see Agénor et al (2000), Rand and Tarp (2002)).

The contribution of this paper is twofold. First, unlike much work in the existing literature on African countries that relies on time series representation models like Structural Vector

[4]CFA = Communauté Financière de l'Afrique. The CFA zone includes eight countries forming the WEAMU (Benin, Burkina–Faso, Côte d'Ivoire, Guinea–Bissau, Mali, Niger, Senegal and Togo) and six forming the Eastern African Monetary Union: EAMU (Cameroon, Centrafrique Rep, Chad, Congo, Gabon and Guinea Eq).

Autoregression (SVARs) representations (see Hoffmaister et al (1997), Fielding and Shields (2001), Raddatz (2007)), our paper develops a stylized stochastic general equilibrium (DSGE) model. This modeling device offers two advantages over standard reduced-form approach. First, DSGE models seem more appropriate than SVAR models given the economic environment considered herein. Indeed, the presence of permanent shocks in our set–up renders the use of SVAR troublesome as they exhibit remarkable limits at identifying this type of shocks (see Chari, Kehoe and McGrattan (2008), Christiano, Eichenbaum and Vigfusson (2006), Fève and Guay (2009) among others). Second, a distinct advantage of structural models to conduct empirical research is that an a priori guidance concerning their parametrization is often much more readily available than is the case of reduced-form specifications (Dejong and Dave (2007)). However, the breakthrough at this point does not lie in the adoption of the DSGE modeling itself but the simultaneaous inclusion into the model of several forcing variables identified as potential sources of high economic volatility. The second contribution of the paper lies in the use of Bayesian estimation techniques for estimating a DSGE model for a developing country. Indeed much work in the literature on developing countries (Mendoza (1995), Kose and Riezman (2001), Arellano et al (2009) among others) using DSGE modeling makes use of calibration techniques. However these techniques do thoroughly suffer from lot of shortcomings. Sims and Zha (1996) pointed out their inability to account for potential misspecifications or false models. More importantly, the advantage of bayesian techniques hinges on the possibility of incorporating priors about the parameters. This is particularly relevant in the context of structural models because it allows estimation of these parameters even in small samples.

We estimate the model using annual data from the World Bank database World Development Indicators (WDI 2010). The data span from 1960 to 2008. A number of key empirical results emerge from the study. First, transitory productivity shocks appear to be the dominant force in driving volatility in Côte dIvoire. They account for almost all fluctuations in GDP and more than half in consumption and investment. Second, the role of world interest rate shocks is substantial in consumption volatility (45%) and investment (11%). Third, we find fiscal policy to be procyclical but the role of fiscal shocks to be negligible. These results have proven to be robust across different specifications of preferences, the presence of anticipated shocks (commonly called news shocks) and measurement errors.

The above results suggest that aggregate fluctuations in our representative sub-saharan african economy are overwhelmingly driven by transitory but persistent productivity shocks, a fact consistent with the high volatility (low persistence) of GDP per capita growth rates observed in similar economies. Our results are perfectly in line with the existing literature. Hoffmaister et al (1997) and Raddatz (2007) have documented that domestic shocks (supply–side shocks) account for the bulk of fluctuations in output. These findings are also established in Houssa (2008) and Fielding and Shields (2001). They found that supply shocks outstandingly dominate demand-side shocks in driving business cycle volatility in the CFA countries. Morever, in Hoffmaister et al (1997), fiscal shocks are found to explain a tiny fraction of output volatility. Another common finding of this literature with our results is that world interest rate shocks play a negligible role in driving output volatility in these countries. It's worth noticing that the aforementioned papers are based on VAR models. From this viewpoint, our work can be seen as complementary to the previous papers. However, one has to understand that our label productivity shocks embed an array of shocks: terms–of–trade, conflict, political instability and natural disasters shocks. These shocks may proven to behave as TFP shocks with transitory or permanent effects. This possibility by considering both types of TFP shocks: transitory and permanent.

The remaining of the paper is organized as follow. In section 1, we present some business cycle properties of Côte d'Ivoire, our benchmark econonomy. Section 2 exposes the main features of the small open economy model. Section 3 presents our empirical strategy while the estimation results are exposed in section 4. The robustness check is presented in section 5 and section 6 concludes.

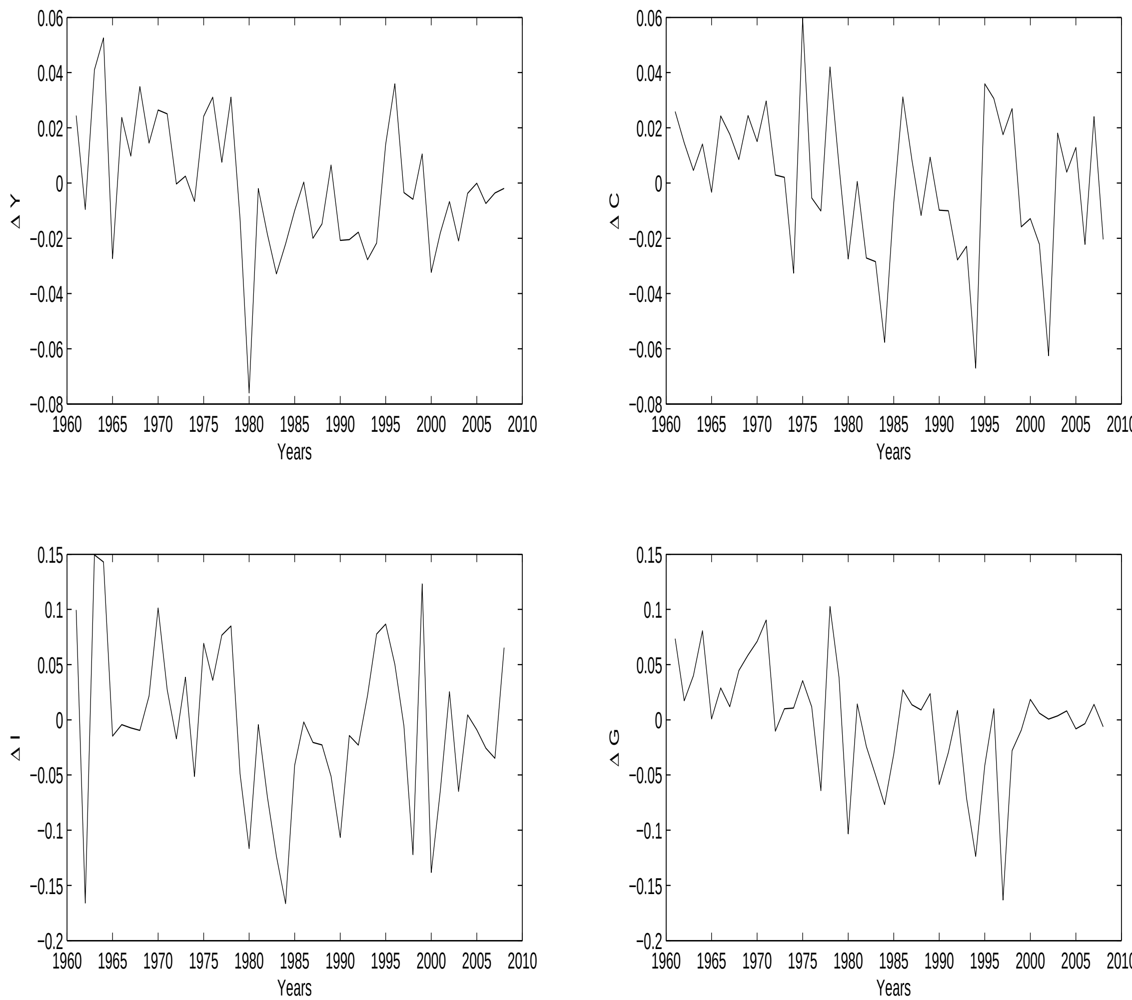
1 Preliminary Data Analysis

We start this study by having a glance on some data characteristics from our benchmark economy: Côte d'Ivoire. For such a purpose, we consider the growth rate of four per capita aggregates: gross domestic product (GDP), households consumption, investment and government spending over the period 1960-2008. The variables are in Constant Local Currency (franc CFA) units. Per capita variables are then obtained by dividing real ones by the population of age above 15. Finally, the growth rates are taken as the differences of the log of the corresponding real variables.

Figure 1 reports the growth rates of the real per capita aggregates of the economy along the analyzed period. Two striking features show up from a first glance on the figure. First, there is evidence of important variability in the aggregates and this is confirmed by the statistics in Table 1. Second, there's a clear break in growth dynamics. Actually Figure 1 reveals that economic growth has been overally positive at the dawn of the independance years (1960) to the end of the 1970s. This corresponds the golden years of Côte d'Ivoire where growth was mainly driven by the rapid expansion of cacao and coffee exports revenues. Within this period the growth rate of per capita GDP was around 1.54%, one of the highest in subsahrian africa. Unfortunately commodity prices have dramatically fallen in the starting of the 1980s leading to unsustainable macroeconomic imbalances and fueled by the high interest rates and the appreciation of the US dollar in terms of the CFA Francs (CFA = Communauté Financière d'Afrique). Export earnings have substantially fallen and debt burden skyrocked leading to an adjustment process with the support of the world bank (World Bank Operations evaluation departement (1998), Azam (2007)). This results in huge government spending cuts that hampered growth. The economy went through a recession which results in poor growth performances as indicated by an average growth rate of per capita GDP of -1.18% over the period 1980-2007. Nevertheless, a sluggish but not sustained recovery started in mid 1990 following the Franc CFA devaluation on January 12, 1994.

Table 1 describes the main properties of business cycles in this economy. A noticeable observation from this table is the extraordinary low performance of this economy over the analyzed period. Indeed, the per capita output has been quite steady and has even undergone a slight fall as shown by its annual mean of -1% on average. The same pattern is shared by per capita investment and government per capita spendings with a mean growth of -0.51% and -0.04% respectively while per capita private consumption has overally and slightly grown by 0.01%. Hence the poor growth performance can be thought to be driven by investment dynamics.

Figure 1: Growth rates of per capita real aggregates



Note: Δy, Δc, Δi and Δg account the growth rate of real per capita GDP, households consumption, private investment and government spending respectively.

Most important is the picture offered by the volatilities of the aggregates. As it can be seen on Figure 1 growth exhibits highly volatile dynamics with a standard deviation of 2.37%. Over the same period, the standard deviation of the growth rate of real GDP per capita is far below 2% in U.S and France for example. Furthermore, as found in the business cycles literature of developing countries consumption growth exhibits a much higher volatility than output growth (1.12 times more). This fact goes at odds with the hypothesis of permanent income theory which states that consumption should be less volatile than income as a result of consumption smoothing. Our results may suggest that the permanent income hypothesis does not hold in these economies or income is essentially transitory. An alternative explanantion may be that permanently binding borrowing constraints due to imperfect financial markets makes it difficult for agents to smooth consumption. Accordingly consumption exhibits more fluctuations than output. Nevertheless, this result should be taken lightly for reasons related to measurement issues. Indeed, consumption data in developing countries do not generally separate out consumption of durables from non–durables while this disctinction is crutially important from a business cycle perspective. Excluding consumption of durables from aggregate consumption is likely to drive this ratio below unity as argued by Ozbilgin (2009). Investment and government spending also present high variabilities: 7.67% and 5.23% respectively which amount to 3.3 and 2.2 the standard deviation of per capita GDP. These facts line up with those in developed economies. Concerning the comovement, it come out that the different components of domestic absorption are all strongly procyclical. Finally while GDP and government spending show reasonable persistent dynamics, consumption and investment growth display relatively low persistence in their dynamics.

These statistics confirm the fact that business cycles in developing economies do not follow the same pattern as in developed nations albeit some similar features emerge.[5]

[5] For a detailed comparison between business cycles in developing and developed economies, see Agénor et al (2000) and Rand and Tarp (2002).

Table 1: Some Business Cycle Facts

Statistics	Δy	Δc	Δi	Δg
Mean (%)	-0.10	0.01	-0.51	-0.04
Standard deviation (%)	2.37	2.66	7.67	5.23
Relative volatility (to GDP)	1	1.12	3.32	2.20
Correlation with (Δy)	1	0.56	0.69	0.61
First order autocorrelation	0.28	0.10	0.06	0.25

Note: Δy, Δc, Δi and Δg account for the annual growth rates of real per capita GDP, households consumption, private investment and government spending respectively.

2 The Model

This section describes the economic framework we use to deal with the empirical regularities established in the preceding section and that will serve to identify the sources of volatility in our economy. The model is the standard one–good neoclassical small open economy first developed by Mendoza (1991) and discussed by Schmitt-Grohe and Uribe (2003). The model has been deeply developed by Chang and Fernandez (2009) and Garcia-Cicco et al (2009). We particularly adopt the encompassing model of Chang and Fernandez (2009) where they use a small open economy model combining stochastic trend productivity shocks and financial frictions to evaluate his ability to replicate some stylized business facts of the Mexican economy. On top of these features, we supplement the model with fiscal shocks so as to provide a much wider range of possible sources of aggregate fluctuations. We describe in the following the main features of the model.

2.1 Technology

The economy produces one single good using a Cobb–Douglass production function with constant return to scale as follow:

$$Y_t = a_t \bar{A} K_t^{\alpha} (X_t n_t)^{1-\alpha}, \tag{1}$$

where Y_t denotes output in period t, K_t denotes capital in period t, n_t denotes labor input period t, $\bar{A} > 0$ is a scale parameter that pins down the level of output. Two productivity shocks drive the level of output: a transitory shock a_t and a permanent shock X_t.

The log of the transitory productivity shock is assumed to follow a first-order autoregressive process *i.e*

$$ln(a_t) = (1-\rho_a)ln(\bar{A}) + \rho_a ln(a_{t-1}) + \epsilon_t^a; \quad \epsilon_t^a \sim N(0, \sigma_a^2) \tag{2}$$

with $|\rho_a| < 1$ is the persistence of the transitory productivity shock.

The permanent productivity shock X_t is assumed to grow at a stochastic rate, that is $\frac{X_t}{X_{t-1}} = \gamma_t$. Furthermore this growth rate follows a first-order autoregressive process *i.e*

$$ln(\gamma_t) = (1-\rho_\gamma)ln(\gamma) + \rho_\gamma ln(\gamma_{t-1}) + \epsilon_t^\gamma; \quad \epsilon_t^\gamma \sim N(0, \sigma_\gamma^2) \tag{3}$$

where ρ_γ represent the persistence paramater of the process γ_t and γ its mean with $|\rho_\gamma| < 1$.

We borrow the above specification and its justification from studies of fluctuations of Latin American countries (Aguiar and Gopinath (2007) and Garcia-Cicco et al (2009)). The intuition behind such an ingredient follows from the permanent income hypothesis. Consider indeed a favorable productivity shock, that is a positive ϵ^γ. This will induce a permanent increase in productivity and accordingly permanent income will rise up being greater than current income. Hence consumption will increase and this can explain why consumption is much more volatile than income in developing economies.

The ressource constraint of the economy is given by:

$$Y_t + q_t D_{t+1} = C_t + I_t + D_t + G_t + \Phi(K_{t+1}, K_t)K_t \tag{4}$$

where C_t, I_t and G_t denote private consumption, private investment and government spending respectively. D_t accounts for the debt held by the representative household from previous period and q_t its price (see next subsection).

The law of motion of capital is given by:

$$K_{t+1} = (1-\delta)K_t + I_t \tag{5}$$

with $\delta \in (0,1]$ being the depreciation rate of capital and the function $\Phi(.)$ represents the capital adjustment costs function which takes the form:

$$\Phi(K_{t+1}, K_t) = \frac{\phi}{2}(\frac{K_{t+1}}{K_t} - \gamma)^2 \tag{6}$$

where $\phi \geq 0$ is the elasticity of the capital adjustment costs function. Capital adjustment costs are added in DSGE models because the later cannot generate realistic moments of investment had these costs being ignored (Koze and Riezman (2001), Mendoza (1991) among others). Their formulation in (6) indicates that changing the stock of capital by a given amount increases with the speed of the desired adjustment and thus gives incentives to the firm to spread out this change over several periods.

The process driving government spending is generated by equation (7) in which g_t and y_t are the log deviation of the deflated level of government spending and output with respect to the level of permanent productivity i.e. $g_t = G_t/X_{t-1}$ and $y_t = Y_t/X_{t-1}$.

$$ln(g_t) = \rho_g ln(g_{t-1}) + \tau ln(y_t) + \epsilon_t^G \tag{7}$$

The parameter τ accounts for the adjustment of government spending to the state of the economy. The modeling of fiscal policy in this set up is motived by an ongoing debate about the cyclicality of fiscal policy in developing economies. There is in fact evidence of procyclical fiscal policy in developing countries (Agénor et al (2000)), countercyclical (Carmignani (2010)) and non clear cut conclusions (Rand and Tarp (2002)). Then, at modeling fiscal policy as in (7), we adopt an agnostic view in that the sign of the parameter τ is left to be settled by the data.

2.2 Preferences

The economy is populated by a representative household whose preferences are given by:

$$E_t \sum_{t=0}^{\infty} \beta^t U(C_t, n_t, X_{t-1}) \tag{8}$$

where $\beta \in [0, 1)$ is the discount factor, C_t is current consumption, U(.) a period utility function and $E_t(.)$ is the conditional expectation operator on the information available to the household up to period t. The objective of the household is to maximize the above utility subject to the ressource constraint given by (4).

The utility function is assumed to be of Greenwood, Hercowitz and Huffman (GHH) type, that is:

$$U(C_t, N_t, X_{t-1}) = \frac{\left(C_t - X_{t-1}\theta \frac{N_t^{\omega}}{\omega}\right)^{1-\sigma} - 1}{1-\sigma} \tag{9}$$

where ω governs the intertemporal substitution of labor supply, σ is the inverse of the intertemporal elasticity of consumption and θ is the parameter controling for the steady state level ol labor. The single-period utility is defined over consumption and labor. The introduction of the permanent productivity shock X_{t-1} in the utility function relies on the purpose of getting a balance growth path. The choice of such preferences is based on their empirical success in the macro literature of developing economies. While initially introduced by Greenwood et al (1988), they have been extensively used in open economy models by Mendoza (1991), Correia et al (1995), Garcia-Cicco et al (2009) and among others. The empirical success of GHH preferences resides indeed in their ability to improve the performances of small open economy models in reproducing some business cycles facts for example the conutercyclical behavior of current account, trade balance and also of international interest rates. We will also analyze the extent to which our results are affected when we use other types of specifications.

2.3 International financial markets

The representative agent has access to international capital markets for noncontigent debt. Then D_t in (4) represents the debt or the number of promises from the previous period the agent pays and q_t the price at which he can sell a promise to a unit of goods to be delivered at t+1. Given that the only traded asset in this economy is the debt, our economy has an incomplete asset markets structure. Furthermore, these markets are assumed to be competitive and accordingly the gross interest rate, denoted Q_t, on foreign borrowing is given by the inverse of the price of bonds:

$$\frac{1}{q_t} \equiv Q_t = R_t + \psi(\tilde{D}_{t+1}) \tag{10}$$

$\tilde{D}_{t+1} = D_{t+1}/X_t$ represents the country's (stationnary) aggregate debt which equalizes to the household's debt in equilibrium. The function $\Psi(\tilde{D}_{t+1}) = \psi(e^{\tilde{D}_{t+1}-\bar{d}} - 1)$ is an increasing and convex function reflecting the sensitivity of the cost of foreign borrowings to the debt burden. The parameter ψ governs the elasticity of real world interest rate to the level of debt held by the household. This debt elastic interest rate specification rests only on technical necessities. Without this function, the solution of the model of the debt process would be a random walk and thus a non stationary equilibrium. It actually follows the work of Schmitt-Grohe and Uribe (2003) who showed that this trick helps in having a stationnary equilibrium in small open economy models.[6]

[6] In fact, Schmitt-Grohe and Uribe (2003) show that for small open economy with incomplete asset market to generate a stationnary equilibrium one has to use one of the three devices: endegenous discount factor, debt-elastic interest rate premium, convex portfolio adjustment costs.

R_t represents the country specific interest rate that is modeled as follow:

$$R_t = R_t^* S_t, \tag{11}$$

where R_t^* is the world gross interest rate for risky assets which is not specific to the country and S_t a country specific spread. This specification entails two sources of variations in the interest rate faced by the economy: one stemming from fluctuations in the world interest rate and the other attributable to fluctuations in the spreads.

The world interest rate is exogenously determined and is assumed to follow a first-order autoregressive process $i.e$

$$ln(R_t^*) = (1 - \rho_R) ln(R^*) + \rho_R ln(R_{t-1}^*) + \epsilon_t^R; \quad \epsilon_t^R \sim N(0, \sigma_R^2) \tag{12}$$

with R^* is the real gross interest rate mean and ρ_R represents its persistence and satisfies $|\rho_R| < 1$.

In modeling the country risk component S_t we follow the approach of Neumeyer and Perri (2005). Formally, the log of the country spread is modeled as follow:

$$ln(S_t/S) = -\eta_1 E_t a_{t+1} - \eta_2 E_t \gamma_{t+1} + \epsilon_t^S \tag{13}$$

where η_1 and η_2 are positive parameters describing the elasticities of spreads to future productivity (stationary and non-stationary). The intuition behind such a specification is that the probability of default in debt payment proxied by country risk may be driven by two different sets of factors. The first are related to economic conditions of the economy so that they are linked to the fondamental shocks to the economy. These are represented here by the productivity shocks a_t and γ_t. Movements in spreads may also originate from exogenous factors independent from the country's reaslizations of shocks. Such a possibility is accounted for by the spread shocks, ϵ_t^S. It summarizes all non-fundamental fluctuations in spreads attribuable to exogenous events like contagion and others foreign events.

3 Empirical strategy

The bayesian estimation method is used in this setting to estimate the model. The underlying motivation behind the choice of this method over the classical techniques hinges in its various advantages. Indeed, a distinct advantage in using bayesian method is that it allows to incorporate prior information in the parameters being estimated but also gives some voice to the data regarding model parametrization (Dejong and Dave (2007)). Particularly, the pointed argument is useful in our case given that our sample size is short so that prior information would substantially help in shaping out the parmaters estimates.

3.1 A glance at bayesian estimation

A thorough technical exposition of the bayesian techniques is beyond the scope of this paper. A full description of this method is provided in Dejong and Dave (2007), Canova (2008), Geweke (2007) and An and Schorfheide (2007) among others. However in the spirit of gaining further insight, we offer here a brief description of this estimation technique.

Let X denote the sample of observations of the observed variables and θ the vector collecting the parameters of the log-linearized form of model under scrutiny. Then the likelihood of the model, $L(X|\theta)$, is obtained by combining the state space representation of the model and the distributional assumptions about the exogenous disturbances. The bayesian perspective offers the possibility for the researcher to place prior distribution, $p(\theta)$ on θ. These priors are updated using data through the likelihood function. The central focus of Bayesian analysis is the posterior distribution of the underlying parameters. Using the Bayes theorem, this distribution is given by:

$$p(\theta|X) = \frac{L(X|\theta)p(\theta)}{\int p(X|\theta)p(\theta)d\theta} = \frac{L(X|\theta)p(\theta)}{p(X)} \tag{14}$$

Given the computional burden required by the analytical calculation, the derivation of posterior distribution is made using numerical methods. Once these posterior distributions are available, the researcher can make use of them to compute some conditional expected value of a function of parameters $g(\theta)$:

$$E[g(\theta)] = \frac{\int g(\theta)p(\theta|X)d\theta}{\int p(\theta|X)d\theta} \tag{15}$$

$E[g(\theta)]$ is the weighted average of $g(\theta)$ with the weight assigned to a particular value of θ jointly determined by the data (through the likelihood) and the prior. Depending upon the specification of the function $g(\theta)$, (15) accounts for a wide range of time series characteristics of the variables of the model.

3.2 Estimation strategy

In accordance with the central objective of this paper, that is to provide a quantitative assessment of the leading forces of macroeconomic fluctuations, we restrict our estimation to the parameters driving the exogenous processes and only some of the structural parameters. Let Θ be a vector stacking all the model parameters. We then split Θ in two subsets, Θ_1 and Θ_2. $\Theta_1 = \{\gamma, \beta, \sigma, \alpha, \delta, \omega, \psi, \bar{d}\}$ encompasses all the parameters to be calibrated prior to estimation (the deep parameters) while $\Theta_2 = \{\rho_a, \rho_\gamma, \rho_g, \rho_R, \sigma_a, \sigma_\gamma, \sigma_g, \sigma_R, \eta_1, \eta_2, \phi, \tau\}$ stacks the parameters to be estimated. Hence, among the structural parameters, only the spread elasticities, the capital adjustment costs and the fiscal policy parameters are to be estimated.

Calibration: We set the discount factor $\beta = 0.95$, the capital share $\alpha = 0.30$ and the depreciation rate to be $\delta = 0.10$ as in Arellano *et al* (2009). The value of the discount factor implies the steady state world real interest rate of 5.26%, a value compatible with the observed interest rate faced by African countries on international markets. We set $\omega = 1.62$, implying a labor elasticity of 1.62, a standard value in developing countries studies. The risk-aversion coefficient, σ, is set equal to 2.61 which is the GMM estimate from the panel study of a group of developing countries, some of which are african countries from Ostroy and Reinhart (1992). The debt sensitivity parameters ψ and $\bar{d}$ are assumed to be 0.005 and 0.80 respectively. The former is set as in Schmitt-Grohé and Uribe (2003) while the later is given the debt to GDP ratio. These values guarantee the existence of a stationary equilibrium. The debt sensitivity parameter is chosen to be very small in order to avoid this function to act as an additional risk premium imposed on interest rate. We calibrate the debt-to-GDP and governement-spending-to-GDP ratios to their average values in the data over the relevant periods which are given by 80% and 14% respectively.[7] Furthermore, we computed the debt-to-GDP ratio using only the non-concessional debt. The gross mean value, γ of the growth rate of the non–stationnary productivity is set to 0.999, consistent with the average growth rate of per capita output of -0.1%. However, setting this parameter to values compatible with the growth rates of the other aggregates does not qualitatively affect our conclusions. Table 2 presents all the calibrated parameters.

Table 2: Calibrated parameters

Parameters	Description	Value
β	Discount factor	0.95
α	Capital to output ratio	0.30
σ	Risk-aversion parameter	2.61
γ	Steady state gross growth rate of permanent TFP	0.999
δ	Depreciation rate of capital	0.10
ω	Inverse of labor supply elasticity	1.62
ψ	Bonds price sensitivity to debt level	0.005
$\bar{d}$	Steady state debt target	0.80
D/Y	Debt-to-GDP ratio	0.80
G/Y	Government spending to GDP ratio	0.14

Priors: Setting priors is a very crucial step in bayesian estimation. However this task seems to be tedious in our case as we have a limited set of sources to base our priors. This explains why most of DSGE modeling for african economies makes use of calibration method instead. As such, some of our priors are drawn from studies applied to countries sharing some similarities with our ivoirian economy. Specifically we borrow some of our priors from Chang and Fernandez (2009) who are essentially based on the analysis of Aguiar and Gopinath (2007) on Mexican economy

[7]The debt-to-GDP ratio has sharply declined after Côte d'Ivoire has been admitted for the HIPC debt relief project but this does not alter our results given that it started only in 2002.

and from Neumeyer and Perri (2005) for some emerging countries. Table 3 summarizes these priors. We set the priors about the parameters $\rho_a, \rho_\gamma, \rho_R, \sigma_\gamma, \sigma_R$, as in Chang and Fernandez (2009). The persistence parameter, ρ_a, of the transitory productivity shock follows a beta distribution with mean 0.95 and a standard deviation of 1.1% compatible with the commonly used values in calibrated models. The standard deviation of the same parameter, σ_a is assumed to follow a gamma distribution with mean 3% and standard deviation 2% according to the estimates of Kose and Riezman (2001).[8] The choice of the prior about the autoregressive coefficient of the permanent productivity shock may however prove to be a little blindy in that we just follow Chang and Fernandez (2009). Accordingly, ρ_γ, the autoregressive coefficient of the growth rate of the permanent productivity shock follows a beta distribution with centered around 0.72 with a standard deviation of 2.25%. The prior of the persistence of government consumption, ρ_g, follows a beta distribution with mean 0.8 and a standard deviation of 2.5% while the prior of government spending shock σ_g is assumed to follow a gamma distribution with mean equal to 3.18% and a standard deviation of 0.56%. The prior mean of σ_g is consistently chosen in a way to match the empirical standard deviation of the growth rate of government spending of 5.23%.

The literature on the interaction between international interest rates and business cycles in developing economies has received great attention and the prominent work of Neumeyer and Perri (2005) and Uribe and Yue (2006) are quite appealing in this sense. This helps us to choose their priors about not only the world interest rate parameters ρ_R and σ_R but also the elasticities of spreads to the expected productivity η_1 and η_2 as defined in equation (13). For the autoregressive parameter of the world interest rate, the distribution is assumed to be a beta with mean 0.83 and a standard deviation of 5.1% while the interest rate shock follow a gamma distribution with mean 0.72% and a standard deviation of 0.31%. These follow from Uribe and Yue (2006).

The elasticities of spreads to expected productivity shocks, η_1 and η_2, are drawn from Neumeyer

[8]Using a sample of 22 developing countries mostly african ones, Kose and Riezman (2001) estimated the standard deviation of the productivity shocks in the non–traded final and primary goods sectors to be 3% and 4% respectively.

and Perri (2005) having the same gamma distribution with unit mean and standard deviation of 10%. However while conducting the estimation, our modeling of spreads in (13) rises identification issues. The first concerns the exogenous spread shocks, ϵ_t^S and exogenous world real interest shocks, ϵ_t^R. Indeed given the specification of country specific interest rate in (11), exogenous shocks in R_t^* and S_t can be encompassed in a single shock as follow:

$$R_t = \tilde{R_t}^* \tilde{S}_t \varepsilon_t^R, \tag{16}$$

where $\tilde{R_t}^*$ and $\tilde{S}_t$ account for deterministic parts of world interest rate and spreads while ε_t^R accounts for a combination of the two exogenous shocks ϵ_t^R and ϵ_t^S. Any combination of these two shocks would be equivalent so that one cannot disentangle shocks to world interest rate shocks from shocks to spreads.

The other identification problem arises between the paramters η_1 and η_2 in equation (13). It happens that one the parameters cannot be identified when both are taken to the empirical estimation.

To cope with these issues and in the spirit of preserving the core features of equation (13), we adopt the following specification:

$$ln(S_t/S) = -\eta(E_t a_{t+1} + E_t \gamma_{t+1}) \tag{17}$$

An additional feature of our analysis with respect the other business cycles studies applied to african economies is the presence of fiscal shocks in our model. The inclusion of such an ingredient in the analysis is twofold. First, it allows us to explore all the potential driving forces of business cycles beyond the commonly explored productivity and international interest rate shocks. Second and most importantly, this is a first step to test the cyclicality of government spending. Indeed a large body of literature has found that fiscal policy is strangly procyclical in developing economies which goes at odds with the observed countercyclicality in developed economies. Thus allowing goverment spending to adjust with output and adopting an agnostic statement will allow us to test this puzzle. We thus estimated the model with a diffuse uniform prior centered around zero on the $[-1, 1]$ support.

Finally we make the capital adjustment cost parameter, ϕ, follow a uniform distribution on the interval [0,15], equivalent to a mean of 7.5. Capital adjustment costs may be quantitatively important in such economies because of decrepit infrastructure, underdeveloped financial markets and secondary capital markets, distributional size of firms but also for some institutional reasons related to interventionist industrial policies (Bigsten et al (2005), Tybout (2000)).

The empirical implementation of our strategy follows four steps. First, we derive the stationary model by deflating all the nonstationnary variables by the non–stationnary productivity component in the equilibrium and the first order conditions. Formally, for any variable Z_t we define the deflated variable by $\tilde{Z}_t = Z_t/X_{t-1}$. Second, we compute the implied deterministic steady state of the economy implied by its stationary version. Third, we loglinearize the stationary model around the deterministic steady state. Finally, we estimate the linearized version of our model.

Table 3: Prior Distributions

Name	Description	Prior mean	Prior s.d. (in %)	Density	Domain
$100\sigma_\gamma$	Standard deviation of the permanent productivity shock	0.74	0.56	Gamma	R^+
$100\sigma_a$	Standard deviation of the transitory productivity shock	3	2	Gamma	R^+
$100\sigma_R$	Standard deviation of the world interest rate shock	0.72	0.31	Gamma	R^+
$100\sigma_g$	Standard deviation of government spending shock	3.18	0.56	Gamma	R^+
ρ_γ	Persistence of the permanent productivity shock	0.72	2.25	Beta	(0,1]
ρ_a	Persistence of the transitory productivity shock	0.95	1.12	Beta	(0,1]
ρ_R	Persistence of the world interest rate shock	0.83	5.10	Beta	(0,1]
ρ_g	Persistence of government spending shock	0.8	2.25	Beta	(0,1]
ϕ	Capital adjustment cost parameter	–	–	Uniform	$[0, 15]$
η	Spreads sensitivity parameter	1	10	Gamma	R^+
τ	Fiscal policy adjusment	–	–	Uniform	$[-1, 1]$

4 Main Results

Before addressing the question at hand, that is the exploration of sources of aggregate fluctuations, it is worthwhile examining first the model performances along side some basic dimensions. Particularly, we assess the quality of the estimates of our parameters for that they are key ingredients of the predictions of the model.

4.1 Parameters Posteriors

Table 4 reports the posterior modes, the posterior means and the 90-percent confidence intervals of the estimates and their respective standard deviations. We notice the following facts:

First, our data are informative as shown by the narrow width of the confidence intervals of all the estimates. This is a good news because, as we have argued before, our sample size does not allow to estimate all the parameters.

Second, the results assign a heavier weight to transitory TFP shocks with respect to permanent productivity shocks. The posterior mode of the standard deviation of the former is twice that of the latter. This is robust to different changes in priors of both shocks. This suggests that transitory productivity shocks are more likely to be the leading forces in driving fluctuations in Côte d'ivoire as will become obvious in the next sections.

Third, fiscal policy is found to be procyclical. The estimate of τ, the elasticity of government spending to output, is indeed positive and statistically significant with a posterior mode of 0.5072. A clear implication of this result is that fiscal policy has dampening effects as it can amplify cycles. This finding goes in line with Rand and Tarp (2002) who find evidence of procyclical fiscal policy in developing economies. While we are aware of the stylized fashion of our fiscal policy, we do not claim that this result represents a conclusive one. Nevertheless, it has the vertue of contributing to the ongoing debate about the cyclicality of fiscal policy in developing economies.

Finally, interest rate spreads are very sensitive to movements of future fundamentals represented by productivity prospects. The posterior mode of the estimated parameter of the elasticity of spreads with respect to the solow residuals ,η, is equal to 0.93. This is a mechanism through which productivity shocks and interest rate rate shocks get amplified and transmitted into the economy. A higher value of η implies that a favorable productivity shock, say ϵ_t^a, reduces the probability of default payments of international debt and thus the cost at which government borrows from abroad. Hence beyond the positive effects induced by this shock in increasing productivity, another potential effect is to allow for additional debt issuing possibilities. Nevertheless, the sensitivity works on the other way round. Indeed, a negative productivity shock is amplified through increased costs of borrowing because of higher default probability. Such an hypothesis is in line with the findings that the debt of côte d'Ivoire has skyrocked after the country has experienced adversed shocks that affected his manufactured sector (Azam (2007), World Bank (1999)).

Table 4: Posteriors

Parameters	Description	Prior mean	Post mode	SD	Post mean	Conf interval	
σ_z	Standard deviation of the permanent TFP shock	0.007	0.0017	0.0003	0.0018	0.0013	0.0023
σ_a	Standard deviation of the transitory TFP shock	0.030	0.0126	0.0013	0.0130	0.0108	0.0152
σ_g	Standard deviation of government spending shock	0.032	0.0389	0.0033	0.0399	0.0343	0.0453
σ_R	Standard deviation of world interest rate shock	0.007	0.0048	0.0011	0.0056	0.0037	0.0075
ρ_z	Persistence of permanent TFP shock	0.720	0.7384	0.0243	0.7364	0.6975	0.7755
ρ_a	Persistence of transitory TFP shock	0.950	0.9271	0.0102	0.9246	0.9079	0.9417
ρ_g	Persistence of government spending process	0.800	0.7818	0.0218	0.7868	0.7471	0.8251
ρ_R	Persistence of world interest rate shock	0.830	0.9889	0.0033	0.9865	0.9811	0.9926
ϕ	Capital adjustment cost	7.500	11.0469	2.2400	11.3718	8.5902	14.7351
η	Spreads sensitivity	1.000	0.9309	0.0911	0.9434	0.7923	1.0910
τ	Fiscal policy adjusment	0.000	0.5072	0.0692	0.5071	0.3924	0.6196

Note: SD accounts for standard deviation.

4.2 The performance of the model

We have chosen to assess the performance of our model on its ability to match the stylized facts exposed in section 1 namely the volatility, the persistence of the observables and their comovements with output as measured by their standard deviations, their autocorrelations and their correlations with output respectively. Although it is not the main question we want to answer for, this exercise is useful in the sense of strengthening our trustworthiness into the model. Table 5 presents the theoretical moments generated by the model along with empirical ones for comparison purpose.

Several results deserve to be highlightened here. First, our model is able to replicate the volatilities of the aggregates and specially those of the growth rate of GDP and government spending but generates slightly high volatile consumption and investment growth rates as compared to the data. Consumption growth in the model is almost twice more volatile than in the data while investment growth is 1.3 more volatile than in the data. Besides these high consumption and investment volatilities, the model predictions preserve the ranking of the relative volatilities of consumption, investment and government spending with respect to GDP. Indeed, in the data (model) the growth rates of consumption, investment and government spending are respectively 1.12 (1.71), 3.23 (4.19) and 2.20 (2.08) more volatile than the growth rate of GDP. As already stressed out, the fact that consumption is more volatile than output is a feature of developing countries and that traditional RBC models used to explain business cycles in developed economies failed to replicate (Mendoza (1995), Correa *et al* (1995), Aguiar and Gopinath (2007), Garcia-Cicco *et al* (2009) among others). However, augmenting the model with the permanent productivity shock has the ability of improving the model's capacity at replicating such a fact. The intuition is as follow. A positive realization of ϵ_t^{γ} induces a permanent and persistent increase in TFP and accordingly in income. Hence permanent income will increase more than current income eliciting an increase of consumption beyond current income.

Another result worth emphasizing is the procyclicality of all aggregates. The model replicates quite closely the high positive correlation of consumption and investment with output. Indeed, the correlation between consumption and GDP growth rates is 0.72 in the model while it is 0.56 in the data. These numbers are respectively 0.57 and 0.69 for the correlation of investment. Only the comovement of government spending seems to be quite underestimated by the model. Furthermore, the model does overally predict well the persistence of the observables. Although slightly underpredicted, these numbers are close to their empirical counterparts.

Table 5: Some Business Cycle Properties

	Model				Data			
Statistics	Δy	Δc	Δi	Δg	Δy	Δc	Δi	Δg
Standard deviation (%)	2.38	4.07	9.98	4.94	2.37	2.66	7.67	5.23
Relative volatility (to GDP)	1	1.71	4.19	2.08	1	1.12	3.32	2.20
Correlation with Δy	1	0.72	0.57	0.34	1	0.56	0.69	0.61
First order autocorrelation	0.16	0.03	-0.05	0.19	0.28	0.10	0.06	0.25

Note: Δy, Δc, Δi and Δg account for the annual growth rates of real per capita GDP, households consumption, private investment and government spending respectively.

4.3 The main drivers of fluctuations

The main question of this paper is to quantify the relative importance of all potential forces in driving aggregate fluctuations in a typical african economy. As is common in the literature, we make use of variance decomposition techniques to determine the relative contribution of each shock in explaining economic fluctuations.

Table 6 reports the results. First, it comes out that productivity shocks play a more important role in driving aggregate fluctuations than the other shocks. Our results show that roughly 97% and 90% of fluctuations in GDP and investment growth rates respectively are due to productivity shocks. However they do not substantially outweight the other types of shocks in driving consumption volatility as the later account for around 45% of fluctuations in consumption growth. Second, transitory productivity shocks are more relevant than non-stationary shocks in all aggregates. Indeed, among the 97% of fluctuations of GDP explained by productivity shocks, non-stationary productivity shocks explain only 4%. However, permanent productivity shocks prove to drive around 40% of investment fluctuations. Third, world interest rate shocks are not negligible in this setting. While they explain only around 3% and 11% of output and investment fluctuations respectively, they drive roughly 45% of consumption fluctuations.

The result that productivity shocks are major sources of aggregate fluctuations in our economy is consistent with the findings of Rand and Tarp (2002), Hoffmaister et al (1997) and Houssa (2008). Using simple correlation, Rand and Tarp (2002) found a significant negative correlation between CPI and GDP in most developing countries in their sample. They interprete this result as an evidence of the dominance of supply–side shocks over demand–side shocks in leading fluctuations in developing economies. On the other side, Houssa (2008) studied a FVAR model and identified supply and demand shocks using sign restrictions: (positive) supply shocks are identified as those who do not have a negative affect on output and a positive effect on prices while (positive) demand shocks do not cause a fall in output and prices. He concludes that in the two big african monetary unions (WAEMU: Western African Economic and Monetary Union and EAMU: Eastern African Monetary Union) supply shocks are more relevant than demand ones. In a richer VAR model including world interest rates, terms of trade, output, real exchange rate and prices, Hoffmaister et al (1997) found that despite the difference in exchange regimes prevailing in the CFA franc countries on one side (among which Côte d'Ivoire) and non–CFA countries on the other side, the main source of output fluctuations in countries are the supply shocks and especially productivity shocks.[9]

The contribution of our work to this literature hinges in the distinction between permament and transitory productivity shocks. While the aforementioned literature does not explicitely make such a distinction, our work brings an unprecedented contribution as it clearly shows that our benchmark economy is much more hitted by transitory shocks than permanent shocks. More importantly, the label of productivity shocks in this setting ought to be seen as a black box that encompasses a wide range of shocks: terms of trade, natural disasters, political instability and energy prices. Greenwood (1983) considers that terms of trade shocks are part of TFP shocks given that GDP is a tradable good. Natural disasters and political instability are part of exogenous phenomena whose effects can be interpred as productivity shocks. Energy is part of an important input in developing countries whose price is determined exogenously on international commodity markets. Putting aside energy from the production function is equivalent to

[9]The CFA currency is pegged to a fixed parity vis--vis French franc until the January 1994 devaluation while most of the non CFA franc countries had oftenly adjusted their exchange rates and some have moved to more flexible arrangements. Its convertibilty is now indexed to the Euro since 2000.

considering that energy price shocks are included in transitory productivity shocks. Following these arguments, our findings have one natural interpretation: macroeconomic fluctuations in this economy overwhelmingly originate from shocks related to terms of trade, energy prices, natural disasters and political instability (Raddatz (2007)). Furthermore these shocks are transitory in their nature. This interpretation does perfectly matches the findings that terms of trade shocks are short-lived in subsaharan economies (Cashin, McDermott and Patillo (2004)) and cycles in developing economies are much more frequent in developing economies than in the developed ones (Rand and Tarp (2002)).

The minor role of world interest rate in driving output fluctuations (3%) is in line with Hoffmaister et al (1997), Raddatz (2007) and Fielding and Shields (2001). All these three papers have tried to separate out the role on internal and external shocks in driving fluctuations in developing economies among which Côte d'Ivoire. While the set of external shocks may differ from one paper to another, they all contain world interest rates. They find that these shocks are not that relevant as expected. However, they appear to play a leading role in explaining consumption growth fluctuations 45%. The implications of this result should not be overlooked as they suggest that swings in consumption are mainly led by country exogenous shocks, that is shocks unrelated to countries fundamentals. Given the methodological differences between the aforementioned works and our analysis, this paper brings a complementary sight to their findings.

Table 6: Variance Decomposition

Shocks	Δy	Δc	Δi	Δg
Non–stationary productivity	03.75	01.54	39.78	01.91
Stationary productivity	93.12	53.47	49.12	24.92
Interest rate	03.12	45.00	11.00	03.13
Government spending	00.00	00.00	00.00	70.03

Note: Δy, Δc, Δi and Δg account for the annual growth rates of real per capita GDP, households consumption, private investment and government spending respectively.

4.4 Historical decomposition

The historical decomposition retraces the relative historical contributions of shocks to the growth rates of key macroeconomic variables over the sample period. This decomposition is provided in Figures 2-5 in the appendix. Figure 2 decomposes the growth rate of per capita GDP dynamics over the underlying period. It comes out that two distinct subperiods can be traced out. The first subperiod starting from 1960 to 1980 is characterized by a positive growth around a 2% average. As suggested by the figure, this positive dynamics is mainly driven by positive productivity shocks (both permanent and transitory) and small negative interest rate shocks. The second period that spans from 1980 to 2008 features a negative growth but with a temporary spike in 1995-1999.[10] While negative transitory productivity shocks are dominantly responsible of this situation, positive interest rate shock do play a non–negligible role. Qualitatively the patterns of consumption (Figure 3) and investment (Figure 4) growth rates are similar. From 1960 to 1980 both variables have experienced positive average, poor performances in 1980–1995 and high swings from 1995 to 2008. The positive dynamics of consumption over the first subperiod raises from negative interest rate shocks and positive transitory shocks whereas investment positive performances stem mainly from positive TFP shocks. Negative TFP shocks both transitory and permanent explain the negative growth rates observed from 1980 to 1995. Morever and consistent with the variance decompostion results, positive interest rate shocks are at the core of the negative consumption growth over this period. The last period 1995–2008 is characterized by important fluctuations in both aggregates due to frequent and sizeable TFP and interest rates fluctuations.

It is worth linking the above analysis to the economic history of Côte d'Ivoire over this period. The positive macroeconomic performances over the 60s to the beginning of the 80s came as a result of relatively high and stable cocoa prices, the main export product of Côte d'Ivoire. This enables the country to increase his borrowing capacities as its creditworthiness improves and to invest in education and other public infrastructures. But in the 80s the cocoa prices fall

[10]The period 1995-1999 follows the devaluation of the CFA Franc which was intended to restablish CFA countries competitiveness and reduce external huge and chronic deficits.

sharply and the export sector squeezed considerably driving with it persistent external imbalances. The dramatic drop of cocoa prices resulted in gloomy economic prospects and inflating international interest rate (see Azam (2007)). In response to these lackluster macroeconomic developments, structural adjustment programs under the monitoring of the International Monetary Fund (IMF) have been implemented implying substantial cuts in government spending in order to ensure country's creditworthiness. Figure 5 illustrates this fact as government spending fall sharply during this period namely due to negative productivity and government spending shocks. The last period (1995–2008) stresses the political instability that Côte d'Ivoire has gone through. The end of the 90s have experienced a military coup followed by civil turmoils.

5 Robustness Check

The previous sections have come with the result that TFP shocks and more precisely transitory TFP shocks are at the heart of business cycles in our subsaharan african economy, Côte d'Ivoire. These findings rest on particular assumptions about preferences and the structure of shocks. In this section, we evaluate the robustness of our results along four interesting extensions. First, following the newly emerging and expanding literature on news shocks, we introduce anticipated shocks in TFP and fiscal processes. The second extension introduces measurement errors into the observables used in the estimation. In the third extension we explore the case in which government spending are allowed to provide a direct utility to households. Finally, we discard the assumption of GHH preferences and adopt a King-Plosser-Rebelo (KPR) types instead.

5.1 A model with Anticipated (News) shocks

The interest toward news shocks in business cycles analysis is quite new even in studies related to developed economies. We introduce news or anticipated shocks into the two productivity precesses a_t and γ_t and in the government spending process. News in TFP have been extensively used in business cycles models in developed economies by Beaudry and Portier (2005, 2006), Fujiwara and Shintani (2008), Schmitt–Grohé and Uribe (2008) among others while fiscal news are mainly developed in Leeper *et al* (2009), Mertens and Ravn (2009a,b). The rationale behind the introduction of the former is that future TFP prospects are well conveyed by some informational variables like stock prices (e.g. Beaudry and Portier (2005)). Fiscal news shocks are justified by the presence discusion lags in the political institutions (Leeper *et al* (2009)). These shocks have been shown to play a substantial role in driving fluctuations in developed economies. For developing economies, anticipated shocks (for example expected low agricultural crops, natural resources discovery or civil turmoil) have great implications for their access to international financial markets. Our modeling of financial spreads in (13) reflects this relationship. Spreads and accordingly interest rate increase (decrease) in expectation of negative (positive) productivity shocks.

News are specified so as the anticipation horizon be one year given the annual frequency of our data.[11] Formally the exogenous shocks, ϵ_t^i in equations (2), (3) and (9) are replaced by the following specification respectively:

$$\tilde{\epsilon}_t^i = \epsilon_{0,t}^i + \epsilon_{1,t-1}^i \tag{18}$$

for $i = a, \gamma$ and G. $\epsilon_{0,t}^i$ accounts for the standard surprise shock while $\epsilon_{1,t-1}^i$ denotes the one period expected or news shock. The shocks are assumed to be uncorrelated at all leads and lags. In the analysis the anticipation horizon is limited to one period (one year) to be much more consistent with data frequency. This is also realistic in the sense that in developing countries information flows and its processing can be thought to be complicated.

We provide the priors about the additionnal parameters induced by this extension in Table 7. These priors are chosen as the same of the benchmark model for sake of simplicity but also given the informational constraints we face.

[11] A combination of different horizons is used in Schmitt–Grohé and Uribe (2009), Fujiwara and Shintani (2008) among others.

Table 7: Prior Distributions of News Innovations (%)

Parameters	Prior mean	Prior st dev	Distribution	Range
$\sigma_{\gamma,n}$	0.74	0.56	Gamma	R^+
$\sigma_{a,n}$	0.03	0.02	Gamma	R^+
$\sigma_{g,n}$	3.18	0.56	Gamma	R^+

The literature on news shocks has extensively shown that anticipated shocks have the feature of increasing fluctuations in endogenous variables (Fève et al (2009), Schmitt–Grohé and Uribe (2009) among others). One way of checking for such a theory is to compute the ratio of standard deviations induced by the News model to the standard deviations from the benchmark model. We call this ratio sd^n/sd^b which is shown in line 5 of Table 8. A value of this ratio below unity suggests that news tend to reduce the volatility of the aggregates and thus news imply a stabilizing effect in the economy. Actually it happens that the values of this ratio are all a little below unity for output, consumption and investment. Hence, even though we cannot strongly admit the stabilizing effects implied by news, we can unambiguously conclude that anticipation does have no destabilizing consequence in our economy.

In addition the performances of the benchmark model in fitting the comovement and the autocorrelations of the observables are not substantially affected by the presence of anticipated shocks.

The results on the variance decomposition are provided in Table 9. Several comments stand out from these figures. First our finding that productivity shocks are the main drivers of aggregates fluctuations is robust to the inclusion of news. They contribute to about 97% of output and government spending fluctuations, 54% in consumption and around 90% in investment. These numbers are quite close to those in the benchmark model. Second, the contribution of permanent productivity in the variance of investment has considerably improved moving from 39% in the benchmark model to 49% in the "news" augmented model. In addition news in government spending contribute as much as unanticipated shocks in their variance (37%

each). Finally, the contribution of world interest rate shocks to all aggregates remains unaffected relative to the benchmark model.

The above results suggest that while the central findings of the baseline model are robust to news shocks, attempts in identifying the sources of business cycles in african countries have to explicitly take into account the anticipated nature of some of these shocks.

5.2 Measurement errors

Given the low standards in statistical systems prevailing in developing countries and specially in most african countries, measures of aggregate data from national accounts may undoubtly be provided with huge measurement errors. These errors have great implications in the sense that the model's estimates based on these data might be distorted. In this section, we include measurement errors in the observables and assumed to be independent across observables as follows:

$$\Delta z_o = \Delta z + (\gamma - 1) + \epsilon_{z_o}$$

where z_o denotes the growth rate of per capita observables (GDP, household consumption, Investment and government spending) and z the growth of the same variables from the model. ϵ_{z_o} corresponds to the measurment errors attribuated to the observable z_o. Given the lack of reliable studies on this issue and also the presumed importance of these errors, we set their priors to be same *i.e.* a gamma distribution with mean 2% and a standard deviation of 1%.

It happens that (see Table 8) measurement errors help at improving the model' s fit of some features of the data. Indeed the model does offer a nice picture of the volatilities of all observables consistent with their empirical counterparts. In addition it reasonably predicts the comovement and persistence of observables.

The variance decomposition results (Table 9) show that productivity and mostly transitory shocks still dominate the other shocks in all aggregates except government consumption. However, interest rate shocks are no more relevant as their relative contribution falls below 4%

of total variance in all aggregates. The low contribution of interest rate shocks stems from a shift towards measurement errors. Indeed, 29% of fluctuations in output growth and 44% in consumption growth are due to their respective measurement errors. This result consolidates the assumption of imprecise measures of households consumption in developing countries. Concluding from these numbers that measurement errors are responsible for a substantial part of macroeconomic fluctuations in african economies would be excessive. But this analysis comes with the warning that empirical models of business cycles in developing countries should not overlook such data measurement issues.

5.3 Edgworth Complementarity/Substituability between Private and Public Consumption

So far we have assumed that government spending do not enter the utility function of the household. Within this framework, we have established the fact that shocks to government spending (fiscal shocks) play a meaningless role in driving macroeconomic fluctuations. From now on, let government consumption to be part of the utility function of the representative agent. The objective of such a change is twofold. First, we want to test the robustness of our finding that productivity shocks are given a leading role as sources of economic fluctuations in Côte d'Ivoire. Second, this change would likely make the contribution of fiscal shocks significant in that they alter the agent' s optimal decisions.

We thus modify specification (10) in the following way:

$$u(C_t, n_t, G_t) = \frac{\left(C_t + \alpha_G G_t - \theta X_{t-1} \frac{N_t^{\omega}}{\omega}\right)^{1-\sigma} - 1}{1-\sigma} \tag{19}$$

Given that government consumption and private consumption may be edgworth complements ($\alpha_G < 0$) or substitutes ($\alpha_G > 0$) we tried several different setting of the parameter α_G. In the first round the prior is assumed to be a diffuse uniform distribution on the [-1,1] support. This agnostic position about the sign of α_G gives all the power to the data. It comes out that the resulting parameter is not statistically significant. We conduct the estimation by setting new priors with more informative containt. In fact α_G is assumed to follow a gamma distribution with mean 0.51 and standard deviation 10%. The prior mean is equal to the empirical correlation between the growth rate of per capita private and public consumption while the standard deviation reflects our lack of enough information about the parameter. The posterior mode of α_G is found to be equal to 0.44 with a standard deviation of 8.49%. Thus public consumption acts as a substitute of private consumption which induces a crowding–out effect on households consumption.

The moments generated by the model are reported in Table 8. The augmented model perfectly matches the volatility of the growth rate of per capita GDP (2.38%) but generates highly volatile consumption and investment compared to the baseline model (4.39% and 10.28% respectively) and data. However the model generates data-consistent time series features for almost all observables in terms of their comovement with output and their persistence.

The variance decomposition in Table 9 shows that our results are pretty robust to this additional feature. Productivity shocks still explain the bulk of fluctuations in output and in investment while fluctuations in consumption are overwhelmingly driven by interest rate shocks and transitory technology shocks. They account for 96% of output growth fluctuations, 56% in consumption and 88% in private investment. The most stricking result is the negligible role played by fiscal shocks. Their relative contribution in the other macroeconomic variables has remained identical to the benchmark setup.

5.4 Separable utility function

Our benchmark results rest on the assumption that the representative household has GHH preferences type. These preferences are characterized by a high substituability between consumption and leisure, low income effects on labor supply because the later is independent of consumption levels. In addition, these preferences have been widely used in analyzing business cycles in developing economies and have proven to provide satisfactory results in terms of matching some key business cycles facts (see Mendoza (1991), Arellano et al (2009), Neumeyer and Perri (2005), Chang and Fernandez (2009), Garcia-Cicco et al (2009) among others).

In this section we adopt a log utility specification separable in consumption and labor. With these preferences, the labor supply decision of the houselhold depends on his consumption level. This is equivalent to stating that the risk aversion parameter, σ is unity. There's little basis of making such an assumption given the divergence in the literature about the estimate of such a parameter. Indeed while Ostry and Reinhart (1992) found this parameter to lie between zero and unity, Reinhart and Vegh (1995) find a value around 5 for a set of emerging economies. Thus adopting a log utility constitutes an informal way of testing the suitable values of this parameter. Thus the new preferences specification is given by:

$$u(C_t, N_t) = log(C_t) - \theta \frac{N_t^{\omega}}{\omega} \tag{20}$$

In the specification (20), labor supply is no more independent of consumption. Thus the income effect will make the agent easily substitute consumption to leisure in order to smooth out consumption.

The resulting moments from the model are shown in Table 8, last block. The model does fairly a good job in matching the volatilities of the observables but its predictions in terms of the comovement and persistence of consumption growth are a bit disappointing.

A very striking result from this extension is that the relative contribution of different shocks are not substantially affected. Indeed, while the leading role of transitory productivity shocks still prevails, one can observe a substantial refinement in the relative contribution of permanent productivity shocks. In the benchmark, their largest contribution is in investment (40%) while in the separable utility case they drive 38% and 45% of fluctuations in consumption and investment respectively.

An important exercise worth to be undertaken herein is the inclusion of government consumption in the utility function as we did in the previous subsection. One can indeed conjecture that the negligible contribution of fiscal shocks in the previous cases hinges on the absence of the income effect in the GHH preferences. The results are practically the same along all dimensions as those without government consumption. Nevertheless, the targeted objective that fiscal shocks would have been important is not met. In both preferences, the contribution of these shocks remains incredibly nil.

All in all, the central finding that productivity shocks are the main sources of aggregate fluctuations is maintained throughout all the different dimensions we explored.

6 Concluding Remarks

This paper brings an important contribution to the narrow but expanding literature of business cycles in subsaharan african economies. The objective is to provide a quantitative assessment of the relative contribution of relevant types of shocks driving the observed high aggregate volatility in these economies in the context of a Dynamic Stochastic General Equilibrium (DSGE) model. For reason related to data precision and availability, our analysis has been applied to the case of Côte d'Ivoire. Previous attemps have been made in this way but focus on a narrow subset of potential sources or adopt a different modeling perspective. Our analysis differs from the existing work in two ways. First, while most of the literature makes use of SVAR models, our modeling strategy is based on a dynamic stochastic general equilibrium (DSGE) model. Specifically we augment the one sector small open economy neoclassical growth model with transitory and permanent productivity, fiscal and interest rate shocks so as to assess the contribution of all potential sources of fluctuations. Second, business cycle studies in developing economies using DSGE modeling framework have relied on calibration techniques while we take advantage of the bayesian methods to estimate our model.

Our findings can be summarized as follow. First, fluctuations in our economy are essentially driven by productivity shocks and specifically transitory but persistent productivity shocks. This result perfectly lines up with the literature of business cycles on african economies but goes at odd with the findings in emerging economies. Second, world interest rate shocks play a negligible role in output growth fluctuations. However, they are very important for the volatility of consumption growth as they drive about half of the variance of consumption per capita growth. Third, our results show that while fiscal policy is procyclical, fiscal shocks account for a minor fraction of aggregate fluctuations in our economy. Their contribution is actually nil in all observables. The procyclicality of fiscal policy implies hence that this policy can no longer be used to smooth out adverse shocks that could have been otherwise offset. Finally, historical decomposition of the growth rates of output, consumption and investment shows that negative TFP shocks coupled with positive world interest rate shocks were at the heart of gloomy macroeconomic performances of Ivoirian economy during the 1980s.

Clearly the above results raise up an interesting debate in the analysis of macroeconomic fluctuations within developing economies. While the analysis relied on a stylized model, it comes out with important results. To further lighten these results, issues related to the modeling approach have to be seriously considered. Indeed, the functionning of developing economies and african ones is far away different from the developed economies and thus the modeling strategy should not overlook such differences. In addition, Africa is characterized by the coexistence of currency unions and regional trade agreements. These are channels through which real shocks (trade) and nominal (monetary) shocks are easily transmitted accross economies. Thus an extension quite appealing but also challenging for the future research relies in the construction of a multicountry DSGE model encompassing real and nominal shocks that would help understand the transmission of shocks within african economies. This is to bring answers to the ongoing debate about the integration of african economies in the context of unified economy. Another extension worth making is the construction of a model that explicitly disentangles the different shocks labelled as productivity shocks in the paper. Such a distinction is quite important in that policy implications could be clearly identified in this way. These questions are part of our future research agenda.

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Appendix

A Tables

Table 8: Some Business Cycle Facts of extended models

Statistics	Δy	Δc	Δi	Δg
News shocks				
st. dev (%)	2.33	3.92	9.96	5.27
$sd(i)/sd(\Delta y)$	1	1.68	4.27	2.26
$corr(\Delta i,\Delta y)$	1	0.71	0.53	0.31
$corr(\Delta i_t,\Delta i_{t-1})$	0.15	0.03	-0.06	0.14
sd^n/sd^b	0.97	0.96	1	1.07
Measurement errors				
st. dev (%)	2.13	3.18	7.62	4.65
$sd(i)/sd(\Delta y)$	1	1.49	3.58	2.18
$corr(\Delta i,\Delta y)$	1	0.61	0.51	0.23
$corr(\Delta i_t,\Delta i_{t-1})$	0.11	0.02	-0.05	0.12
Government spending in the utiility: GHH				
st. dev (%)	2.38	4.39	10.28	4.83
$sd(i)/sd(\Delta y)$	1	1.84	4.31	2.02
$corr(\Delta i,\Delta y)$	1	0.71	0.58	0.33
$corr(\Delta i_t,\Delta i_{t-1})$	0.15	0.00	-0.06	0.17
Model with log utility preferences				
st. dev (%)	2.98	2.63	9.23	4.67
$sd(i)/sd(\Delta y)$	1	0.88	3.09	1.56
$corr(\Delta i,\Delta y)$	1	-0.04	0.59	0.32
$corr(\Delta i_t,\Delta i_{t-1})$	0.02	-0.08	-0.11	0.12

Note: Δy, Δc, Δi and Δg account for the annual growth rates of real per capita GDP, households consumption, private investment and government spending respectively. ρ_i is the first order autocorrelation of variable i and *st. dev* is its standard deviation. corr(Δi,Δy) is the correlation between variable i and Δy.

Table 9: Variance Decomposition of extended models

Shocks	Δy	Δc	Δi	Δg
News shocks				
Non–stationary prod	00.62	00.21	06.42	00.28
Non–stationary News prod	02.22	00.55	42.09	01.48
Stationary prod	89.01	52.51	39.20	19.60
Stationary News prod	04.96	01.32	01.89	01.00
Interest rate	03.19	45.40	10.51	02.80
Government spending	00.00	00.00	00.00	37.50
Gov. Spending News	00.00	00.00	00.00	37.35
Measurement errors				
Non–stationary prod	02.37	01.37	34.37	01.11
Stationary prod	68.27	53.91	53.09	18.99
Interest rate	00.37	00.63	04.36	00.23
Government spending	00.00	00.00	00.00	56.24
ME in Δy	28.99	–	–	–
ME in Δc	–	44.19	–	–
ME in Δi	–	–	08.19	–
ME in Δg	–	–	–	23.44
Goverment spending in the utility:GHH				
Non–stationary prod	03.66	01.43	37.24	01.70
Stationary prod	92.98	54.03	50.63	23.33
Interest rate	03.36	43.55	12.13	03.23
Government spending	00.00	00.99	00.00	71.74
log utility preferences				
Non–stationary prod	05.34	38.37	45.32	00.91
Stationary prod	82.23	12.40	43.18	22.50
Interest rate	12.39	49.07	11.49	01.37
Government spending	00.04	00.16	00.01	74.84

Note: Δy, Δc, Δi and Δg account for the annual growth rates of real per capita GDP, households consumption, private investment and government spending respectively.

B Figures for historical decomposition

Figure 2: Per capita GDP growth

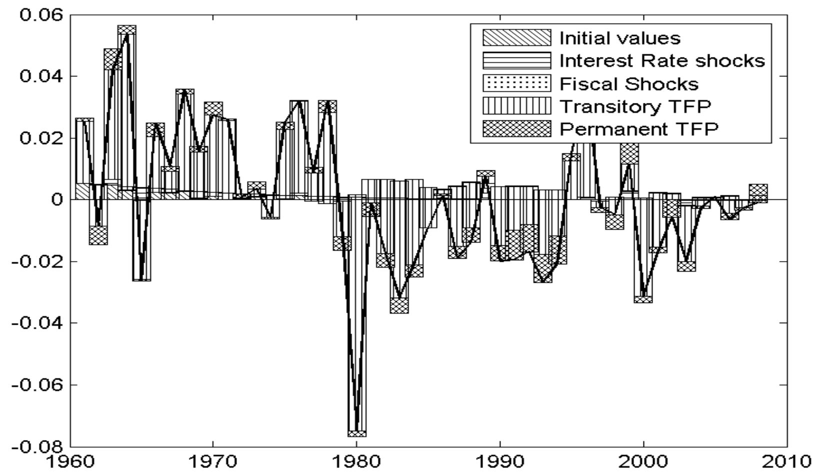

Figure 3: Per capita households consumption growth

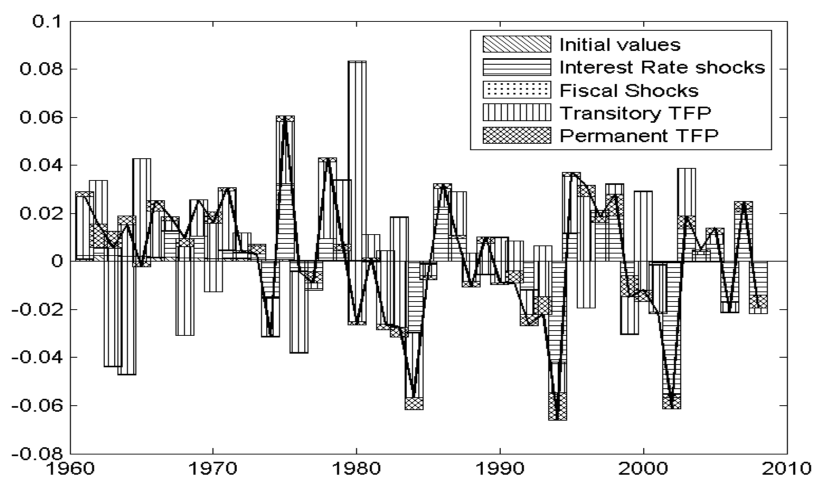

Figure 4: Per capita private investment growth rate

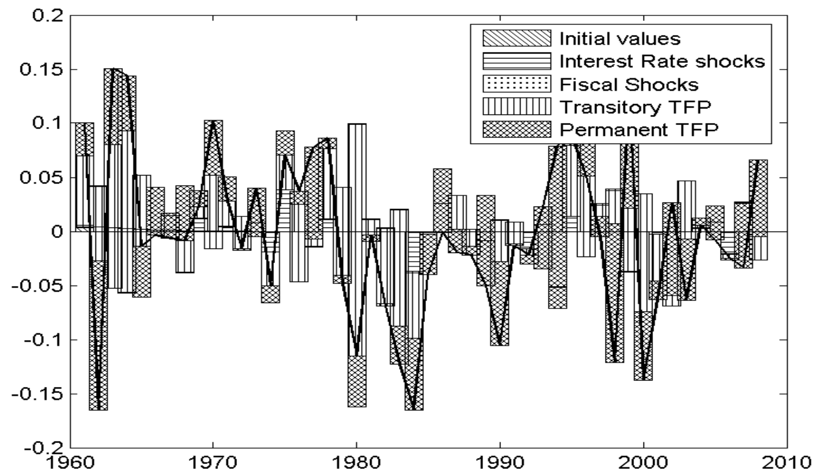

Figure 5: Per capita government consumption growth rate