An estimated financial accelerator model for small-open African economies

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An Estimated Financial Accelerator Model for Small-Open African Economies

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Abstract
The paper formulates and estimates an open economy monetary DSGE model to investigate the quantitative significance of the financial accelerator mechanism in business cycle fluctuations for African countries. We employ the Bayesian technique to evaluate the statistical importance of the financial accelerator channel in African countries. We compare the model with financial accelerator model to the model without financial accelerator. The estimation shows that financial accelerator channels are empirically important in African economies. The marginal likelihood results clearly favour the model with financial accelerator in African economies. Moreover, the results show that the financial accelerator channel dampens the expansionary effects of exchange rate depreciation in African economies. African countries should deepen their domestic debt markets to minimize their vulnerability to exchange rate shocks.

Keywords: Financial accelerator, Bayesian technique, Marginal likelihood, Business cycle.

1. Introduction

Financial market imperfections have been identified as one of the amplifiers of relatively small shocks to the aggregate economy (see Bernanke et al., 1999; Christensen and Dib, 2008). In a small open economy with foreign currency-denominated debt, financial market frictions amplify the effects of exchange rate depreciation via the balance sheet channel (Céspedes et al., 2004; Bebczuk et al., 2006). This balance sheet effect is found to be responsible for declining output in East Asia and Latin America after a currency

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devaluation (Krugman, 1999; Aguiar, 2005; Mulder et al. 2012). In addition, evidence suggests that balance sheet weaknesses arising from foreign currency debt triggered financial instability in emerging economies in the 1990s (see Bordo, et al., 2010).

This study seeks to evaluate the quantitative significance of the financial accelerator channel or the balance sheet effect in African economies. Due to financial market imperfections, African countries borrow at a premium. Moreso, they cannot borrow in their own currencies. Hence, financial market imperfections and the inability to borrow in their own currencies expose African economies to foreign interest rate shocks and exchange rate shocks. Foreign currency-denominated debt exposes the balance sheet of firms and countries to exchange rate volatility. Despite the growing importance of the balance sheet channel, especially in developing countries, there have been dearth of empirical studies focusing on African countries. Rather, studies have focused on Asia and Latin America (e.g., Benavente et al., 2003; Bordo et al., 2010).

This study is significant for the conduct of monetary policy particularly on whether monetary policy should react to exchange rate fluctuations or not. The study is also important for the choice of exchange rate regime. While Cook (2004) advocates for a fixed exchange rate regime when the balance sheet effect is empirically important, Céspedes et al. (2004) argue for a flexible exchange rate system. In addition, the study is also important for the conduct of fiscal operation. Findings show that exposure to foreign currency debt constrains the use of fiscal policy instruments to deal with economic shocks (see,Jeanne and Zettelmeyer, 2002). A depreciation of the exchange rate weakens the government net worth and limits its ability to borrow to finance pubic investment.

Our paper contributes to the existing literature in three respects. First, building on the works of Bernanke et al. (1999) and Céspedes et al. (2004), we formulate an open economy monetary DSGE model with financial accelerator framework for African economies. Second, we investigate the quantitative significance of financial accelerator framework in the amplification of economic fluctuations in African economies. Third, to highlight the heterogeneity of each country, we use the Bayesian technique to estimate a monetary DSGE model that includes the financial accelerator mechanism for each of the African economies.

The rest of the paper proceeds as follows. Section 2 reviews the existing literature on the financial accelerator channel. Section 3 constructs the model for the study. Section 4 describes the data and presents the estimated results. Section 5 concludes and makes policy recommendations.

2. Review of literature

Empirical literature has identified financial market imperfections as one of the factors responsible for amplification of relatively small shocks. Bernanke and Gertler (1989) and Carlstrom and Fuerst (1996) show that under asymmetric information where borrower's net worth determines the cost of capital, credit market frictions amplify economic fluctuations. Bernanke et al. (1999) develop a financial accelerator framework where development in the credit markets propagate and magnify shocks to the macroeconomy. The financial accelerator model proposed by Bernanke et al. (1999) has been extended to an open economy to evaluate the role of financial frictions when a country debt is denominated in foreign currency. Aghion et al. (2000) and Aghion et al. (2004) show that in the presence of nominal rigidities, currency depreciation leads to an increase in the firm's debt burden and a decline in profit and net worth. Céspedes et al. (2004) show that in an economy with foreign currency-denominated debt, a currency depreciation increases debt service payment and deteriorates the balance sheets of firms and banks.

Empirical findings on the financial accelerator channel have reported mixed results. For instance, Forbes (2002) finds that following a currency depreciation, firms with foreign sale exposure have higher growth performance, while firms with higher debt ratio have lower growth performance in emerging economies. Carranza et al. (2003) find that for firms having dollar debt in Peru, real exchange rate depreciation leads to a decline in investment. Echeverry et al. (2003) find that firms with liability dollarization exhibit negative balance sheet effects during devaluation in Colombia. Pratap and Urrutia (2004), and Aguiar (2005) find that exchange rate depreciation increases the debt burden and reduces investment in Mexico. Bordo et al. (2010) find evidence of balance sheet effects in a sample of firms in 45 countries. Mulder et al. (2012) find that corporate balance sheet and maturity mismatch play significant role in the amplification of Asian crises.

Other studies, however, have found the balance sheet effect to be insignificant rather the competititve effects dominate. The competitive effects dominate when exchange rate depreciation increases the demand for a country's exports, decreases the domestic demand for imports, increases the trade balance and output. Benavente et al. (2003) find that the competitive effects of currency depreciation dominate the balance sheet effects in Chile. Hence, currency depreciation leads to an expansion of investment. Similarly, Bonomo et al. (2003) find no evidence of balance sheet effects in Brazil. Bleakley and Cowan (2008) find that competitive effects of depreciation dominate the balance sheet effects in 5 Latin American countries. The results indicate that firms with dollar-denominated debt do not reduce their investment after depreciation.

A related strand of literature employs macro data to assess the importance of the balance sheet effects in an open economy. For instance, Berganza et al. (2004) find that devaluation increases the country's risk premium, reduces investment and output in emerging economies. Céspedes (2005) finds that the balance sheet effects have negative impact on output in developed and emerging economies. The impact, however, depends on the level of external debt and financial deepness. Elekdag et al. (2006) find that the balance sheet vulnerabilities magnified the impact of shocks during the Korean crises. Using a panel of 57 countries, Bebczuk et al. (2006) find that liability dollarization diminishes the expansionary effects of devaluation in the countries where external debt as a proportion of GDP is high.

Evidently, the empirical literature has been inconclusive on the quantitative significance of the balance sheet effect in an economy. A major determinant of the balance sheet channel appears to be the level of external debt and the level of financial development. High level of foreign currency-denominated debt amplifies the effect exchange rate shocks on the economy through the deterioration in the net worth and balance sheet of firms, increase in the cost of capital and debt service payment. Similarly, low level of financial development exacerbates the impact of exchange rate shocks by further tightening the credit constraint.

3.3. The model

3.3.1 Households

The representative households maximize utility subject to a standard budget constraint. Similar to Elkhafif (2002) and Rasaki and Malikane (2015), we assume that households allocate a fraction of their real holdings between domestic and foreign currencies , hence $S_t M_t^* = \varrho M_t$, where S_t is the nominal exchange rate, M_t^* is foreign money and M_t is domestic money. The representative household preferences is:

$$U_t = \sum_{t=0}^{\infty} \beta^t \frac{1}{1-\sigma} \left[\left(\frac{C_t}{C_{t-1}^h} \right)^{1-\sigma} \left[\left(1 + \frac{\varrho}{S_t} \right) \frac{M_t}{P_t} \right]^{\phi} \right] - \frac{N_t^{1+\psi}}{1+\psi} \tag{1}$$

where C_t, is the aggregate consumption, $\frac{M_t}{P_t}$ is the real balances, and N_t is units of labour. The parameter h measures the degree of habit formation. The parameter σ is the relative risk aversion coefficient ; $\beta \, \epsilon \, (0, 1)$ is the discount factor; ψ is the inverse of the Frisch labour supply elasticity and ϕ represents interest rate elasticity of money demand.

The budget constraint is:

$$\begin{aligned} C_t + \left(1 + \frac{\varrho}{S_t}\right) \frac{M_t}{P_t} + \frac{B_t}{P_t} + \frac{Q_t K_t}{P_t} - \frac{S_t D_t^*}{P_t} &= \frac{W_t N_t}{P_t} + \left(1 + \frac{\varrho}{S_t}\right) \frac{M_{t-1}}{P_t} \\ &+ \frac{B_{t-1}}{P_t} \left(1 + r_{t-1} + pr_{t-1}\right) \\ &- \frac{S_t D_{t-1}^*}{P_t} \left(1 + r_t^d\right) \\ &+ Q_{t-1}(1-\delta) K_{t-1} \end{aligned} \tag{2}$$

where D_t^*, is the ratio of external debt to the GDP, W_t, is the wage rate, Q_t, is the price of capital, r_t is the nominal interest rate, pr_t, is the risk premium, and r_t^d is the debt service payment. Households enter period t with domestic money holdings M_t, bonds B_t, and foreign debt D_t^*.

The first order conditions are:

$$\frac{1}{C_{t-1}^{h}}\left(\frac{C_t}{C_{t-1}^{h}}\right)^{-\sigma}\left[\left(1+\frac{\varrho}{S_t}\right)\frac{M_t}{P_t}\right]^{\phi} = \lambda_t \quad (3)$$

$$\frac{\phi}{1-\sigma}\left(\frac{C_t}{C_{t-1}^{h}}\right)^{1-\sigma}\left(1+\frac{\varrho}{S_t}\right)^{\phi}\left(\frac{M_t}{P_t}\right)^{\phi-1}\frac{1}{P_t} = \frac{\lambda_t}{P_t}\left(1+\frac{\varrho}{S_t}\right) - \frac{\beta\lambda_{t+1}}{P_{t+1}}\left(1+\frac{\varrho}{S_t}\right) \quad (4)$$

$$\frac{W_t}{P_t} = \frac{N_t^{\psi}}{\lambda_t} \quad (5)$$

$$\beta\lambda_{t+1}\left(1+r_t+pr_t\right)\frac{P_t}{P_{t+1}} = \lambda_t \quad (6)$$

$$\beta\lambda_{t+1}\frac{S_{t+1}}{P_{t+1}}\left(1+r_t^{d}\right) = \lambda_t\frac{S_{t+1}}{P_t} \quad (7)$$

We equate Eqs.(3) and (4) and linearize to derive the Euler equation:

$$\widetilde{c}_t = \frac{h(\sigma-1)}{\sigma_c}\widetilde{c}_{t-1} + \frac{\sigma}{\sigma_c}E_t\widetilde{c}_{t+1} + \frac{\phi}{\sigma_c}\widetilde{m}_t - \frac{\phi}{\sigma_c}E_t\widetilde{m}_{t+1} - \frac{\varrho\phi}{s_0\sigma_c}\widetilde{s}_t + \frac{\varrho\phi}{s_0\sigma_c}E_t\widetilde{s}_{t+1} - \frac{1}{\sigma_c}\left(\widetilde{r}_t - E_t\widetilde{\pi}_{t+1}\right) - \frac{1}{\sigma_c}pr_t \quad (8)$$

where $\widetilde{}$ denotes percentage deviation from the steady state and $\sigma_c = \sigma + h(\sigma-1)$. Eq.(8) is the standard consumption equation showing that consumption depends on past and expected future consumption, real interest rate, real balances (see Castelnuovo, 2012).

In line with McCallum and Nelson (2000), our macro-balance for a small open economy is:

$$\widetilde{y} = \gamma_c\widetilde{c}_t + \gamma_x\widetilde{x}_t - \gamma_z\widetilde{z}_t + \varepsilon_{g,t} \quad (9)$$

where $\widetilde{y}_t, \widetilde{c}_t, \widetilde{x}_t, \widetilde{z}_t$ are percentage deviations of output, consumption, exports, and imports from their steady states respectively. γ_c, γ_x, γ_z are steady state ratios of consumption, exports and imports to output. $\varepsilon_{g,t}$ is the government expenditure and investment shocks. Our net export function is given by:

$$\widetilde{nx}_t = \gamma_{yf}\widetilde{y}_t^f - \gamma_y\widetilde{y}_t + \gamma_r\widetilde{rer}_t \tag{10}$$

where $\widetilde{y}_t^f$, γ_{yf}, γ_y, and γ_r, are the foreign output, elasticity of net export to foreign output, the elasticity of net export to domestic output, and sum of elasticity of substitution in production for home and abroad respectively . The real exchange rate is defined as $\widetilde{rer}_t \equiv \widetilde{s}_t + \widetilde{p}_t^* - \widetilde{p}_t$. Substituting Eq.(10) in Eq.(9) yields the expression:

$$\widetilde{c}_t = \frac{1}{\gamma_c}\left(1+\gamma_y\right)\widetilde{y}_t - \frac{\gamma_r}{\gamma_c}\widetilde{rer}_t - \frac{\gamma_{yf}}{\gamma_c}\widetilde{y}_t^f \tag{11}$$

Substituting Eq.(11) into Eq.(8) yields a dynamic IS equation written as:

$$\begin{aligned}
\widetilde{y}_t \quad = \quad & \frac{h\left(\sigma-1\right)}{\sigma_c}\widetilde{y}_{t-1} + \frac{\sigma}{\sigma_c}E_t\widetilde{y}_{t+1} - \frac{\gamma_c}{\sigma_c\left(1+\gamma_y\right)}\left(\widetilde{r}_t - E_t\widetilde{\pi}_{t+1}\right) \\
& -\frac{\gamma_c}{\sigma_c\left(1+\gamma_y\right)}\widetilde{pr}_t + \frac{\phi\gamma_c}{\sigma_c\left(1+\gamma_y\right)}\widetilde{m}_t - \frac{\phi\gamma_c}{\sigma_c\left(1+\gamma_y\right)}E_t\widetilde{m}_{t+1} \\
& -\frac{\varrho\phi\gamma_c}{s_0\sigma_c\left(1+\gamma_y\right)}\widetilde{s}_t + \frac{\varrho\phi\gamma_c}{s_0\sigma_c\left(1+\gamma_y\right)}E_t\widetilde{s}_{t+1} \\
& -\frac{h\left(\sigma-1\right)\gamma_r}{\sigma_c\left(1+\gamma_y\right)}\widetilde{rer}_{t-1} + \frac{\gamma_r}{\left(1+\gamma_y\right)}\widetilde{rer}_t - \frac{\sigma\gamma_r}{\sigma_c\left(1+\gamma_y\right)}E_t\widetilde{rer}_{t+1} \\
& -\frac{h\left(\sigma-1\right)\gamma_{yf}}{\sigma_c\left(1+\gamma_y\right)}\widetilde{y}_{t-1}^f + \frac{\gamma_{yf}}{\left(1+\gamma_y\right)}\widetilde{y}_t^f - \frac{\sigma\gamma_{yf}}{\sigma_c\left(1+\gamma_y\right)}E_t\widetilde{y}_{t+1}^f + \varepsilon_t^y
\end{aligned} \tag{12}$$

We assume that the innovation ε_t^y follows a first-order autoregressive process as $\varepsilon_t^y = \rho_a\varepsilon_{t-1}^y + \mu_t^a$. Eq.(12) is an open economy IS equation where domestic output also depends on nominal and real exchange rate and foreign output. As a contribution, our dynamic IS equation features output as a function of external finance premium and as a function of lags and leads of real exchange rates and foreign outputs.

3.3.2 Firms

We adopt the hybrid New Keynesian Phillips curve proposed by Galí and Gertler (1999) and Galí et al. (2001) of the following form:

$$\widetilde{\pi}_t = \gamma_f E_t \widetilde{\pi}_{t+1} + \gamma_b \widetilde{\pi}_{t-1} + \lambda mc_t \tag{13}$$

where

$$\begin{aligned} \gamma_f &\equiv \beta\theta\{\theta + \omega\left[1 - \theta\left(1 - \beta\right)\right]\}^{-1}; \lambda \equiv \left(1 - \theta\right)\left(1 - \beta\theta\right)\left(1 - \omega\right)\xi \\ \gamma_b &\equiv \omega\{\theta + \omega\left[1 - \theta\left(1 - \beta\right)\right]\}^{-1}; \xi \equiv \frac{\left(1 - \alpha\right)}{1 + \alpha\left(\varepsilon - 1\right)}\{\theta + \omega\left[1 - \theta\left(1 - \beta\right)\right]\}^{-1} \end{aligned}$$

Similar to Smets and Wouters (2002), we assume a Leontief technology for labour and capital inputs. Labour and capital inputs are used in fixed proportion of output Y_t. The production function is written as:

$$Y_t = \min\left[A_t \varphi_K K_t^{\alpha}, A_t \varphi_N N_t^{1-\alpha}\right] \tag{14}$$

where A_t is technology shocks common to all firms, K_t is the units of capital, N_t is the units of labour, φ_K and φ_N are the proportion of capital and labour used in output production. The total cost is given as:

$$TC_t = w_t N_t + r_t K_t \tag{15}$$

where w_t is the real wage and r_t is the nominal interest rate. We can write the real marginal cost as:

$$mc_t = w_t \left(\frac{1}{(1-\alpha)} \frac{1}{A_t \varphi_n} \left(\frac{Y_t}{A_t \varphi_n} \right)^{\frac{\alpha}{1-\alpha}} \right) + r_t \left(\frac{1}{\alpha} \frac{1}{A_t \varphi_k} \left(\frac{Y_t}{A_t \varphi_k} \right)^{\frac{1-\alpha}{\alpha}} \right) \tag{16}$$

Linearizing Eq.(16) around the steady state and incorporating Eq.(11), we get the following relationship for the marginal cost:

$$\begin{aligned} \widetilde{mc}_t &= \{\kappa_a \widetilde{y}_t - \kappa_b \widetilde{y}_{t-1} + \kappa_c \widetilde{rer}_t + \kappa_d \widetilde{y}^f_{t-1} - \kappa_e \widetilde{rer}_t - \kappa_f \widetilde{y}^f_t \\ &\quad + \kappa_g \widetilde{m}_t + \kappa_h \widetilde{s}_t + \lambda_b \widetilde{r}_t - \lambda_d \widetilde{a}_t \end{aligned} \tag{17}$$

where

$$\begin{aligned} \kappa_a &= \left(\lambda_a(1-\alpha) + \lambda_c - \frac{\lambda_a(1-\alpha)^2}{\psi_m} + \frac{\lambda_a \sigma(1-\alpha(1+\gamma_b))}{\psi_m \gamma_c}\right) \\ \kappa_b &= \frac{\lambda_a h(1-\alpha)(\sigma-1)(1+\gamma_y)}{\psi_m \gamma_c}; \kappa_c = \frac{\lambda_a h \gamma_r (1-\alpha)(\sigma-1)}{\psi_m \gamma_c} \\ \kappa_d &= \frac{\lambda_a h \gamma_{yf}(1-\alpha)(\sigma-1)}{\psi_m \gamma_c}; \kappa_e = \frac{\lambda_a \sigma \gamma_r (1-\alpha)}{\psi_m \gamma_c}; \\ \kappa_f &= \frac{\lambda_a \sigma \gamma_{yf}(1-\alpha)}{\psi_m \gamma_c}; \kappa_g = \frac{\lambda_a \phi(\alpha-1)}{\psi_m}; \kappa_h = \frac{\lambda_a \phi \varrho (1-\alpha)}{\psi_m} \end{aligned}$$

We insert Eq.(17) in Eq.(13) to get the following extended version of the New Keynesian Phillips curve (NKPC) of the following form:

$$\begin{aligned} \widetilde{\pi}_t &= \gamma_f E_t \widetilde{\pi}_{t+1} + \gamma_b \widetilde{\pi}_{t-1} + \lambda(\kappa_a \widetilde{y}_t - \kappa_b \widetilde{y}_{t-1} + \kappa_c \widetilde{rer}_t + \kappa_d \widetilde{y}^f_{t-1} \\ &\quad - \kappa_e \widetilde{rer}_{t-1} - \kappa_f \widetilde{y}^f_t + \kappa_g \widetilde{m}_t + \kappa_h \widetilde{s}_t + \lambda_b \widetilde{r}_t - \lambda_d \widetilde{a}_t) + \varepsilon^\pi_t \end{aligned} \tag{18}$$

The inflation disturbance is assumed to follow an AR(1) process: $\varepsilon^\pi_t = \rho_f \varepsilon^\pi_{t-1} + \mu^f_t$. In Eq.(18), inflation depends on past and expected future inflation, past and current output, and the real balances. Inflation also depends on nominal exchange and real exchange rates.

3.3.3 Exchange rate and external debt

We equate (6) and (7) to derive the uncovered interest parity condition (UIP) expression. We assume $\widetilde{r}_t^d = \widetilde{r}_t^f - \omega_q \widetilde{q}_t + \omega_d \widetilde{d}_t^*$. This implies that external debt service payment depends positively on the foreign interest rates and the level of external debt to GDP ratio, and negatively on commodity prices. The UIP expression is further linearized to yield:

$$\widetilde{s}_t = E_t \widetilde{s}_{t+1} - (\widetilde{r}_t - \widetilde{r}_t^f) - \omega_q \widetilde{q}_t + \omega_d \widetilde{d}_t^* + \varepsilon_t^{er} \tag{19}$$

where $\widetilde{s}_t$ is nominal exchange rate, $(\widetilde{r}_t - \widetilde{r}_t^f)$ is interest rate differential, $\widetilde{q}_t$ is commodity price, and $\widetilde{d}_t^*$ is ratio of external debt to GDP. The innovation is assumed to follow an AR(1) process with an IID-Normal error term: $\varepsilon_t^{er} = \rho_d \varepsilon_{t-1}^{er} + \mu_t^d$. The coefficients ω_q and ω_d represent exchange rate elasticity with respect to commodity price and external debt respectively. Eq.(19) suggests a positive link between exchange rate and external debt to GDP ratio.

The dynamics of external debt depend on the current account balance and foreign debt service payment. Thus, the external debt to GDP ratio evolves according to the following equation:

$$\frac{\Delta D_t^*}{P_t Y_t} = \frac{Z_t - X_t}{Y_t} + \left(1 + r_{t-1}^d\right) d_{t-1}^* \tag{20}$$

where $\frac{D_t^*}{P_t Y_t}$ is the ratio of external debt to GDP, $\frac{Z_t - X_t}{Y_t}$ represents the current account balance and r_t^d is the interest rate on external debt. The change in the debt ratio over time can then be written as:

$$\Delta d_t^* = (z_t - x_t) + d_{t-1}^* \left(1 + r_{t-1}^d - \pi_{t-1} - \Delta y_{t-1}\right) \tag{21}$$

Eq.(21) shows that the change in the external debt ratio is a positive function of net import and foreign interest rate. We linearize Eq.(21) and substitute Eq.(10) to derive the equation for the dynamics of the external debt ratio. Note that from Eq.(19) we have $r_t^d = r_t^f - \omega_q \widetilde{q}_t + \omega_d \widetilde{d}_t^*$ and we substitute $(z_t - x_t) = \widetilde{nx}_t = \gamma_{yf} \widetilde{y}_t^f - \gamma_y \widetilde{y}_t + \gamma_r \widetilde{rer}_t$. Using this fact, we have the debt equation as follows:

$$\widetilde{d}_t^* = \beta_a \widetilde{d}_{t-1}^* + \beta_b \widetilde{r}_t^f - \beta_c \widetilde{y}_t - \beta_d \Delta \widetilde{y}_t - \beta_e \widetilde{q}_t - \beta_f \widetilde{rer}_t - \beta_g \widetilde{y}_t^f + \varepsilon_t^e \tag{22}$$

where

$$\begin{aligned}
\beta_a &= \frac{(1+g_0)+r_0}{\gamma_d}; \beta_b = \frac{r_0}{\gamma_d}; \beta_c = \frac{(1+g_0)\,\gamma_y}{d_0^* \gamma_d}; \\
\beta_d &= \frac{r_0 + (1+g_0)^3}{(1+g_0)}; \ ; \ \beta_e = \frac{r_0 \omega_q}{\gamma_d}; \\
\beta_f &= \frac{(1+g_0)\,\gamma_r}{d_0^* \gamma_d}; \ \beta_g = \frac{(1+g_0)\,\gamma_{yf}}{d_0^* \gamma_d}; \gamma_d = (1+g_0)^2 - r_0 \omega_d
\end{aligned}$$

The external debt shock follows an AR(1) process: $\varepsilon_t^e = \rho_e \varepsilon_{t-1}^r + \mu_t^e$. Eq.(22) describes the external debt evolution where g_0, and r_0, represent average growth rate and average interest rate respectively. There is a negative relation between external debt and commodity prices. Positive commodity price shocks generate more revenue for the government to payoff existing external debt. In addition, external debt to GDP depends negatively on domestic output and positively on foreign output. This indicates that a fall in domestic output increases external debt to GDP while a rise in foreign output leads to a rise in external debt to GDP.

3.3.4 The entrepreneur

Similar to Céspedes et al.(2004) and Cook (2004), the entrepreneur's net worth is defined as assets minus liabilities. Hence, net worth is written as:

$$NW_t = Y_t - r_t^f S_t D_t^* \tag{23}$$

where NW_t is the net worth, Y_t is output, r_t^f is the foreign interest rate, S_t is the exchange rate, and D_t^* is foreign currency debt respectively. From Eq.(23), a rise in the exchange rate (depreciation) reduces the net worth of entrepreneur. This underlines the susceptibility of the firms' balance sheet to exchange rate fluctuations. Eq.(23) is linearized to give:

$$\widetilde{nw}_t = \varphi_y \widetilde{y}_t - \varphi_r \left(\widetilde{r}_t^f + \widetilde{s}_t + \widetilde{d}_t^* \right) \tag{24}$$

where $\varphi_y = \frac{Y_0}{NW_o}$ and $\varphi_r = \frac{r_0^f S_0 D_0^*}{NW_0}$. The denotation $\frac{Y_0}{NW_o}$ represents the steady state ratio of average output to the net worth of the entrepreneur while $\frac{r_0^f S_0 D_0^*}{NW_0}$ is the steady state leverage ratio times the steady state interest rate. Similar to Elekdağ et al.(2006) and Elekdağ and Tchakarov (2007), the external finance premium can be written as an increasing function of the domestic currency value of debt relative to net worth:

$$E_t \left(1 + pr_t\right) = \left(\frac{S_t D_t^*}{NW_t} \right)^{\psi_p} \tag{25}$$

where $E_t \left(1 + pr_t\right)$ is the expected external financing premium and ψ_p is the elasticity of external finance premium with respect to the firm's leverage ratio. A depreciation of the exchange rate will increase the leverage ratio, which in turn increases the external finance premium. This hinders investment and magnifies the effects of exchange rate shocks on output. Eq.(25) is log-linearized to give:

$$\widetilde{pr}_t = \psi_p \left(\widetilde{s}_t + \widetilde{d}_t^* - \widetilde{nw}_t \right) \tag{26}$$

Substituting Eq.(24) in Eq.(25), we derive the log-linearized equation for the external finance premium

$$\widetilde{pr}_t = \psi_p (1 + \varphi_r) \widetilde{s}_t + \psi_p (1 + \varphi_r) \widetilde{d}_t^* + \psi_p \varphi_r \widetilde{r}_t^f - \psi_p \varphi_y \widetilde{y}_t \quad (27)$$

Eq.(27) indicates that the external finance premium is positively related to foreign interest rate, exchange rate, and foreign currency debt, but negatively related to output.

3.3.5 Money market

We equate Eqs.(4) and (6) and linearize to derive the money market equation. We then substitute Eqs.(10) and (11) to get the following money market equation:

$$\widetilde{r}_t = \frac{\alpha_r \left(1 + \gamma_y\right)}{\gamma_c} \widetilde{y}_t - \alpha_r \widetilde{m}_t - pr_t + \alpha_s \widetilde{s}_t - \varrho E_t \widetilde{s}_{t+1} - \frac{\alpha_r \gamma_r}{\gamma_c} \widetilde{rer}_t - \frac{\alpha_r \gamma_{yf}}{\gamma_c} \widetilde{y}_t^f + \varepsilon_t^b, \quad (28)$$

where

$$\alpha_r = \frac{\phi s_0 (1 + r_0 + pr_0)}{m_0 (1 - \sigma)}; \alpha_s = s_0 (1 + r_0 + pr_0).$$

The interest rate shocks follow an AR(1) process: $\varepsilon_t^b = \rho_b \varepsilon_{t-1}^r + \mu_t^b$. Eq.(28) describes the money market equation. Interest rate depends positively on real output and negatively on real balances. Also, interest rate depends positively on current exchange rate and negatively on expected future exchange rate.

3.3.6 Monetary policy

Similar to Muhanji and Ojah (2011) and Rasaki and Malikane (2015), we employ a monetary aggregate Taylor-type rule. Money supply is driven by the inflation gap, the output gap and commodity price gap. The monetary aggregate Taylor-type rule is:

$$\widetilde{m}_t = \rho_m \widetilde{m}_{t-1} - (1 - \rho_m) [\rho_\pi \widetilde{\pi}_t + \rho_y \widetilde{y}_t + \rho_{rer} \widetilde{rer}_t + \rho_q \widetilde{q}_t] + \varepsilon_t^m, \quad (29)$$

where all variables are in percentage deviations from the steady states. $\widetilde{m}_t$ is monetary aggregate, $\widetilde{\pi}_t$ is inflation rate; $\widetilde{y}_t$ is output gap; $\widetilde{rer}_t$ is the real exchange rate gap, $\widetilde{q}_t$ is the commodity price gap. The uncorrelated monetary disturbance follows an AR(1) process: $\varepsilon_t^m = \rho_c \varepsilon_{t-1}^r + \mu_t^c$. The parameter ρ_m is the policy rate smoothing, ρ_π is policy response to inflation gap, ρ_y is policy response to output gap, ρ_{rer} is policy response to real exchange rate shocks, and ρ_q is policy response to commodity price shocks.
The structural shock processes in the model are given as:

$$\widetilde{\xi}_t = \rho_\xi \widetilde{\xi}_t + \varepsilon_{\xi,t}; \qquad \varepsilon_{\xi,t} \sim N\left(0, \sigma_\xi^2\right) \tag{30}$$

where

$$\varepsilon_{\xi,t} = \left[\widetilde{q}_t, \widetilde{r}_t^f, \widetilde{y}_t^f, \widetilde{inp}_t, \widetilde{f\inf l}_t\right]$$

4. Data and estimation

4.1 Data source

Data for the study were obtained from International the Financial statistics (IFS), the World Bank, Central Bank database of the sample countries. The model is estimated with quarterly time series data on fourteen macroeconomic variables in nine (9) African countries for the period 1990:1–2011:4. However, due to data availability, the sample size differs from one country to another. For Egypt, 1998:2 – 2011:4, Ghana, 1990:1 – 2011:4, Kenya, 1990:1 – 2011: 4; Malawi, 1990:1 – 2007:4; Morocco,1995:4 – 2011:4; Nigeria, 1990:1 – 2008:4; South Africa, 1994:1 – 2011:4; Uganda, 1993:2 – 2011:4 ; and Zambia, 1997: 1 – 2011:3.

The foreign interest rate, real foreign output, foreign inflation, and price of foreign inputs are proxied by LIBOR, US real GDP, US consumer price index and US producer price index for manufactured goods respectively. The data were taken from Federal Reserve Bank of St. Louis. The commodity price index was taken from World Bank pink sheet. Real commodity price is derived by deflating the nominal commodity price with the US consumer price index. Due to non-availability of reliable quarterly GDP data for Malawi and Nigeria, we use industrial output for the two countries.

4.2 Prior distribution of the parameters and calibration

We estimate the model by forming priors distributions. Similar to Smets and Wouters(2007), the persistence of the AR(1) processes is assumed to be beta distributed with mean 0.5 and standard deviation 0.2. The standard errors of the shocks are assumed to be distributed according to inverse-gamma distribution with a mean of 0.1 and two degrees of freedom. As in García and González (2013), we use the same prior values for all the countries in our sample. This allows the data to reveal the degree of fit of these values to the realities of the countries. However, the sample draws for the convergence of Metropolis-Hastings (M-H) algorithm differ among countries[1].

The habit parameter h is assumed to be a beta distribution with a mean 0.7 and standard deviation 0.1 and money-interest rate elasticity is a beta distribution with mean 0.2 and standard error 0.05. The degree of price stickiness θ and price indexation ω are assumed to be beta distributed with mean 0.65 and 0.5 and standard errors 0.1 and 0.15 respectively (see Castelnuovo, 2012). Following Elkhafif (2002), the parameter for currency substitution is assumed to be a beta distribution with mean 0.3 and standard deviation of 0.14. Our prior for external premium elasticty $\varphi_p = 0.05$. This is similar to the estimates by Christensen and Dib (2008).

The monetary policy reaction function parameters follow the Taylor's rule. The long run reaction to output and inflation are assumed to be a normal distribution with mean 0.12 and 1.5 and standard error 0.05 and 0.25 respectively. The monetary smoothing parameter is assumed to beta distribution with a mean 0.75 and standard error 0.1. Lastly, the monetary policy function parameters to commodity price shocks and real exchange rate is assumed to be a beta mean 0.5 and standard error 0.1 each.

Some parameters are calibrated for the study. The model calibration is summarized in Table 1. The values chosen for γ_y, γ_r, γ_c, and $\gamma_{yf} = 0.25$ come from McCallum and Nelson (2000).

[1]The M-H algorithm draws are: Egypt (100,000), Ghana, (100,000), Kenya, (50,000), Malawi, (50,000), Morocco, (2,000)Nigeria, (100,000), South Africa, (100,000), Tunisia, (20,000), Uganda, (100,000), and Zambia, (5,000)

Table 1. Calibration of parameter

$\beta = 0.99$	$\gamma_{ls} = 0.5$	$\varepsilon = 6$
$\sigma = 1.5$	$\gamma_r = 0.66$	$\alpha = 0.33$
$\gamma_y = 0.25$	$\gamma_{yf} = 0.25$	$\gamma_c = 0.58$

4.3 Empirical results

Table 2A and 2B present the posterior mean estimates along with the [5th, 95th] posterior percentile of the estimated structural parameters. We contrast the financial accelerator (FA) model where $\varphi_p = 0.05$ with non-financial accelerator (NFA) model where $\varphi_p = 0.00$. Firstly, the elasticity of external finance premium φ_p is significantly different from zero for all the countries. This indicates the statistical significance of the financial accelerator channel in African countries. Moreover, this shows that African economies are vulnerable to shocks affecting the aggregate balance sheets. A negative shock that depreciates the exchange rate may deteriorate the net worth and worsen the balance sheets of firms. Consequently, this increases the cost of borrowing, lowers investment and contracts output.

Based on the standard for model comparison in the Bayesian literature (see Coop, 2007; Castelnuovo, 2012), we compare the marginal likelihoods between the financial accelerator model and the non-financial accelerator model. The ratio of the marginal likelihoods (the posterior odds ratio) clearly favours the model with financial accelerator channel. The marginal likelihood estimates for the model with financial accelerator are higher than for the model without financial accelerator in seven African countries. There is a very strong evidence of financial accelerator channel in Ghana, Kenya, Malawi, Nigeria, South Africa, Uganda, and Zambia. In contrast, the marginal likelihood does not favour financial accelerator model in Egypt and Morocco.

The presence of the balance sheet channels indicates that these seven African economies are vulnerable to exchange rate shocks. Given their exposure to foreign currency denominated debt (see Amadou, 2013), exchange rate depreciation will worsen their balance sheets, increase the risk premium and cost of debt service and consequently lower output. The financial accelerator mechanism may dampen the expansionary effects of exchange rate depreciation on output in African countries. Through the financial accelerator channel, exchange rate depreciation may contract rather than expand output in African economies.

Table 2A: Prior and Posterior Distribution of Structural Parameters

	Prior		Egypt Posterior		Ghana Posterior		Kenya Posterior		Malawi Posterior		Morocco Posterior	
Par.	Distr.	Mean (std)	FA Mean	NFA Mean	FA Mean	NFA Mean	FA Mean	NFA Mean	FA Mean	NFA Mean	FA Mean	NFA Mean
h	Beta	0.70 (0.10)	0.85 (0.)	0.70 (0.01)	0.76 (0.75,0.76)	0.79 (0.00)	0.65 (0.65,0.66)	0.80 (0.01)	0.55 (0.55,0.55)	0.70 (0.00)	0.74 (0.74,0.74)	0.64 (0.01)
ϕ	Normal	0.2 (0.05)	0.06 (0.06,0.07)	0.05 (0.03)	0.05 (0.05,0.05)	0.00 (0.00)	0.04 (0.04,0.04)	0.03 (0.02)	0.03 (0.03,0.03)	0.11 (0.00)	0.06 (0.06,0.06)	0.27 (0.02)
ϱ	Beta	0.30 (0.02)	0.32 (0.32,0.32)	0.29 (0.00)	0.30 (0.30,0.30)	0.28 (0.00)	0.30 (0.30,0.30)	0.30 (0.00)	0.29 (0.29,0.29)	0.29 (0.00)	0.30 (0.30,0.30)	0.30 (0.00)
ψ_p	Beta	0.05 (0.02)	0.04 (0.04,0.04)	–	0.06 (0.05,0.06)	–	0.06 (0.06,0.06)	–	0.06 (0.06,0.06)	–	0.05 (0.05,0.05)	–
θ	Beta	0.65 (0.10)	0.59 (0.59,0.59)	0.51 (0.01)	0.68 (0.68,0.68)	0.67 (0.00)	0.62 (0.62,0.63)	0.64 (0.01)	0.68 (0.67,0.68)	0.60 (0.00)	0.67 (0.66,0.67)	0.81 (0.02)
ω	Beta	0.5 (0.15)	0.56 (0.56,0.57)	0.24 (0.03)	0.54 (0.53,0.55)	0.60 (0.00)	0.65 (0.64,0.65)	0.47 (0.01)	0.70 (0.69,0.70)	0.60 (0.00)	0.49 (0.49,0.49)	0.47 (0.01)
ϖ_d	Beta	0.2 (0.15)	0.01 (0.0,0.03)	0.26 (0.01)	0.23 (0.23,0.23)	0.01 (0.00)	0.28 (0.27,0.28)	−0.01 (0.00)	0.39 (0.38,0.39)	0.06 (0.00)	0.36 (0.36,0.36)	−0.05 (0.00)
ω_q	Beta	0.50 (0.15)	0.45 (0.44,0.46)	0.21 (0.03)	0.55 (0.54,0.55)	0.58 (0.00)	0.42 (0.41,0.42)	0.55 (0.01)	0.46 (0.46,0.46)	0.57 (0.00)	0.56 (0.56,0.56)	0.55 (0.01)
ρ_y	Normal	0.12 (0.05)	0.09 (0.09,0.10)	0.13 (0.01)	0.07 (0.06,0.07)	0.16 (0.00)	0.07 (0.07,0.07)	0.12 (0.00)	0.13 (0.13,0.13)	0.05 (0.00)	0.13 (0.13,0.13)	0.21 (0.00)
ρ_π	Normal	1.50 (0.125)	1.67 (1.65,1.68)	1.65 (0.01)	1.50 (1.50,1.50)	1.37 (0.00)	1.47 (1.46,1.47)	1.46 (0.00)	1.38 (1.38,1.38)	1.47 (0.00)	1.48 (1.48,1.48)	1.64 (0.01)
ρ_{mag}	Beta	0.75 (0.10)	0.98 (0.97,0.99)	0.97 (0.01)	0.81 (0.81,0.81)	0.89 (0.00)	0.82 (0.81,0.82)	0.74 (0.00)	0.89 (0.89,0.90)	0.71 (0.00)	0.75 (0.75,0.75)	0.97 (0.01)
ρ_{rer}	Beta	0.50 (0.10)	0.79 (0.77,0.81)	0.76 (0.01)	0.52 (0.51,0.53)	0.29 (0.00)	0.49 (0.49,0.50)	0.98 (0.03)	0.57 (0.56,0.57)	0.64 (0.00)	0.53 (0.52,0.53)	0.79 (0.01)
ρ_q	Normal	0.50 (0.10)	0.44 (0.43,0.45)	0.14 (0.02)	0.46 (0.46,0.47)	0.42 (0.01)	0.59 (0.58,0.59)	0.94 (0.01)	0.55 (0.54,0.55)	0.54 (0.00)	0.48 (0.48,0.49)	0.69 (0.02)
ML			226.83	905.31	698.35	236.26	591.18	657.46	765.24	269.63	216.96	916.04

Note: FA model stands for model with Financial Accelerator, NFA model stands for model without Financial accelerator, ML is Marginal Likelihood

Table 2B: Prior and Posterior Distribution of Structural Parameters

			Nigeria		South Africa		Uganda		Zambia	
	Prior		Posterior		Posterior		Posterior		Posterior	
Par.	Distr.	Mean (std)	FA Mean	NFA Mean	FA Mean	NFA Mean	FA Mean	NFA Mean	FA Mean	NFA Mean
h	Beta	0.70	0.71	0.69	0.58	0.70	0.74	0.74	0.65	0.77
		(0.10)	(0.71,0.71)	(0.00)	(0.57,0.58)	(0.00)	(0.73,0.74)	(0.01)	(0.64,0.65)	(0.75,0.78)
ϕ	Normal	0.2	0.04	0.00	0.03	0.27	0.05	0.07	0.06	1.32
		(0.05)	(0.04,0.05)	(0.02)	(0.03,0.03)	(0.00)	(0.04,0.05)	(0.01)	(0.06,0.06)	(1.32,1.32)
ϱ	Beta	0.30	0.31	0.33	0.30	0.30	0.31	0.28	0.29	0.31
		(0.02)	(0.31,0.31)	(0.00)	(0.30.0.30)	(0.00)	(0.31,0.31)	(0.00)	(0.29,0.30)	(0.30,0.31)
ψ_p	Beta	0.05	0.06	–	0.05	–	0.06	–	0.05	–
		(0.02)	(0.06,0.06)		(0.05,0.05)		(0.05,0.06)		(0.04,0.05)	
θ	Beta	0.65	0.64	0.71	0.56	0.67	0.59	0.65	0.56	0.56
		(0.10)	(0.64,0.65)	(0.01)	(0.54,0.56)	(0.00)	(0.59,0.60)	(0.01)	(0.55,0.56)	(0.54,0.58)
ω	Beta	0.5	0.60	0.41	0.70	0.49	0.55	0.71	0.50	0.45
		(0.15)	(0.59,0.60)	(0.01)	(0.69,0.72)	(0.00)	(0.55,0.55)	(0.05)	(0.50,0.51)	(0.43,0.47)
ω_d	Beta	0.2	0.25	0.00	0.27	0.12	0.21	0.22	0.21	0.19
		(0.15)	(0.25,0.26)	(0.01)	(0.26,0.28)	(0.00)	(0.20,0.22)	(0.01)	(0.20,0.21)	(0.19,0.19)
ω_q	Beta	0.50	0.36	0.40	0.44	0.47	0.40	0.70	0.49	0.41
		(0.15)	(0.35,0.36)	(0.01)	(0.43,0.44)	(0.00)	(0.40,0.41)	(0.06)	(0.49,0.50)	(0.39,0.42)
ρ_y	Normal	0.12	0.14	0.09	0.08	0.11	0.13	0.14	0.13	0.13
		(0.05)	(0.14,0.14)	(0.00)	(0.08,0.09)	(0.00)	(0.13,0.13)	(0.00)	(0.13,0.13)	(0.13,0.13)
ρ_π	Normal	1.50	1.25	1.49	1.44	1.47	1.50	1.47	1.53	1.66
		(0.125)	(1.25,1.26)	(0.01)	(1.43,1.44)	(0.00)	(1.49,1.50)	(0.01)	(1.53,1.54)	(1.65,1.66)
ρ_{mag}	Beta	0.75	0.83	0.69	0.94	0.78	0.88	0.63	0.76	0.82
		(0.10)	(0.83,0.83)	(0.00)	(0.92,0.96)	(0.00)	(0.87,0.89)	(0.02)	(0.76,0.77)	(0.81,0.82)
ρ_{rer}	Beta	0.50	0.26	0.79	0.14	0.50	0.25	0.46	0.41	0.97
		(0.10)	(0.26,0.27)	(0.01)	(0.10,0.18)	(0.00)	(0.22,0.27)	(0.02)	(0.40,0.41)	(0.95,0.99)
ρ_q	Normal	0.50	0.62	0.24	0.28	0.50	0.65	0.58	0.57	0.52
		(0.10)	(0.61,0.62)	(0.01)	(0.27,0.30)	(0.00)	(0.64,0.65)	(0.01)	(0.57,0.58)	(0.50,0.53)
ML			669.98	209.30	101.96	-2039.06	366.25	714.74	995.82	19.27

Note: FA model stands for model with Financial Accelerator, NFA model stands for model without Financial accelerator, ML is Marginal Likelihood

5. Conclusion

The study investigates the quantitative significance of the financial accelerator channel in African economies. We construct an open economy monetary DSGE model where the entrepreneur's net worth determines the cost of borrowing. Using the Bayesian technique, we estimate structural parameters for two versions of the model: one with and one without the financial accelerator. In line with Bayesian literature, we employ the marginal likelihood ratio to compare the fit of the financial accelerator model and the non-financial accelerator model.

The results indicate that the financial accelerator channel is empirically important in African economies. The marginal likelihood ratio rejects the model without financial accelerator in favour of the model with financial accelerator in seven of the nine African countries under investigation. However, the estimated key parameter of the financial accelerator model, the external finance premium, is statistically different from zero for all African countries. This suggests that the financial accelerator channel plays a significant role in amplification or dampening of business cycles in African economies. This is similar to the findings by Elekdag et al. (2006) for South Korea. The presence of financial accelerator mechanism in African countries dampens the expansionary effects of exchange rate depreciation. Exchange rate depreciation increases the cost of debt service, deteriorates the balance sheet, reduces investment and output. This is similar to the findings by Céspedes (2006) and Bebczuk et al. (2006).

Central to the findings is the appropriate exchange rate policy for African countries when financial accelerator channel is significant. While Cook (2004) recommends fixed exchange rate regime when the balance sheet effects matter, Céspedes et al. (2004) and advocate for flexible exchange rate regime. An important policy recommendation for African countries is the reduction in their exposure to foreign currency debts and deepening of the domestic bond markets. The deepening of domestic bond market will not only reduce their exposure to foreign currency debts but also give African countries the policy space to react to exogenous shocks.

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