Productivity-Enhancing Reforms, Private Capital Inflows, and Real Interest Rates in Africa

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Abstract

The rise in economic growth in some countries of Africa over past two decades, powered mainly by productivity boom, has been associated with large private capital inflows despite poor integration of the African countries with the world capital markets. While these countries lack access to world capital markets, they are nonetheless highly dollarized and allowing for this fact can explain large private capital inflows and other stylized macroeconomic facts associated with the productivity-enhancing reforms in Africa. With a number of African economies poised to reap gains in productivity, as they return to stable and sound political and economic environment, the paper suggests the framework that can be used to understand the macroeconomic implications of and suggest appropriate policy responses to such gains in productivity.

Keywords: Africa, currency substitution, productivity-enhancing reforms, capital flows, inflation, overshooting, real interest rate.

JEL Classification: F32, F41, O55.

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1 Introduction

Between 1970 and 1997, per capita GDP in Sub-Saharan Africa (excluding South Africa) fell by one-third (World Bank, 2000). The region is not entirely devoid of success stories, however. Economic growth has increased significantly in a number of countries. Most of the episodes of positive growth have been powered by productivity booms. The World Bank report notes, for example, that “growth recovery since 1994 has relied on productivity gains rather than an increase in investment” (p.19).\(^1\) The sources of the productivity boom are diverse, comprising trade liberalization, removal of price controls, the end of civil war and military demobilization, public sector reform (civil service downsizing, rationalization/privatization of state-owned enterprises), and aid-financed rehabilitation of social and economic infrastructure.\(^2\)

A distinct set of stylized facts have accompanied the productivity booms in Africa. Contrary to conventional wisdom, a steep increase in consumption spending was accompanied by a significant decline in inflation. The current account and trade deficits soared, the real exchange rates appreciated, and real interest rates rose considerably.\(^3\) Private capital inflows mirrored rising current account deficits that surprised the experts on Africa due to lack of access of these countries to world capital markets.\(^4\) Rising real interest rates following re-

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\(^1\) Artadi and Sala-i-Martin (2003) report continued lack of private investment in Africa in 1990s. Despite rising by 1.5 percentage points in early 1990s, private investment, at less than 5.5% of GDP, was abysmally low when compared with the 15% level typical for a developing country. Further, most of the investment in SSA countries is financed by aid inflows, and hence, represents an exogenous increase in productivity for the economy: a poor African country typically receives foreign assistance amounting to 9% of GDP.

\(^2\) For example, economic reforms of 1983 in Ghana significantly improved export competitiveness by realigning the overvalued real exchange rate (the relative price of the nontraded good fell by over 70%) resulting in the per capita GDP increase of 16.38% over 1983-91. In countries like Uganda, the end of civil war, and consequent military demobilization, has combined with trade and public sector reforms to provide a much stronger impetus to economic growth. In Uganda, as part of the sweeping economic and political reforms started in 1987, 114,000 workers in public sector were removed, and 33,000 soldiers were demobilized. Supported, in addition, by foreign aid averaging 6.26% of GDP, Uganda’s per capita GDP rose by 44.27% over 1987-94.

\(^3\) After initiation of reforms in 1987, Uganda saw its merchandise trade balance worsen from 1.35% to 11.75% of GDP with the real exchange rate appreciating by 27.80% on impact in 1987. Inflation fell from 196.11% in 1988 to 61.44% a year later. The \textit{ex post} annual real interest rate rose steadily from highly negative levels to 16.67% in 1990. Ghana experienced more modest gains from reforms in 1983. Yet inflation declined immediately from 55.14% to 28.40% per annum, balance on goods and services fell by 2.75% of GDP over 1983-86, and \textit{ex post} annual real interest rate on treasury bills turned positive (4.82%) after stagnating at high negative levels for past five years. Hadjimichael \textit{et al.} (1996) find similar evidence for the economic reforms in Senegal during 1980s: real interest rate rose and real exchange rate appreciated during the initial phase of the reforms, inflation declined, and the current account deficit and consumption increased.

\(^4\) Ghana attracted cumulative private capital inflows of 6.01% of GDP during 1983-87. Among other countries in Africa, Lopez-Mejia (1999) finds that Tunisia and Morocco experienced cumulative capital inflows of 17.6% (1992-95) and 18.3% (1990-95) of GDP at least 2/3\(^d\) of which was accounted for by ‘other investments’: a category that includes both private capital inflows and foreign aid.
forms have caused concern among policy makers in Africa and international development agencies. High real interest rates are held partly responsible for a sluggish response of private investment in these countries casting doubt on the sustainability of growth once the gains from rise in productivity are exhausted.

This paper develops a theoretical framework that sheds light on the macroeconomic implications of and appropriate policy responses to sustained productivity booms in African economies. It works with a perfect foresight, currency substitution model of a small open economy. Buffie (2003) and Buffie et al. (2004, 2008) have shown that models of this type can explain many of the stylized facts associated with major macroeconomic shocks (tight-money episodes, sudden large aid inflows). Their analysis, however, ignores supply-side effects and focuses exclusively on issues related to short-term macroeconomic management.

By contrast, analysis here concentrates on the supply-side repercussions of productivity-enhancing reforms. Such reforms mix wealth and supply shocks. As a result, the price effects, real exchange rate dynamics, and current account patterns are very different. In addition, in contrast to earlier work, our focus is on the long-run macroeconomic implications and analysis is done for economies with high inflation economies that have been facing significant macroeconomic problems.

Our highly dollarized, small-open representative agent economy has two sectors producing nontraded and traded goods, and full employment prevails. The government finances fixed real transfers through consumption and inflation taxes. The economy experiences a sequence of exogenous positive productivity shocks affecting both sectors identically. In view of lack of access to world capital markets, agent can only hold nontraded bonds issued by the government.

In the model, the agent desires to increase consumption in response to the anticipated

There is evidence that the uncertain political environment has also severely impaired the productivity of capital. As the World Bank (2000) report notes, the incremental capital-output ratio was 8.33 for Africa over 1970-97 against 4.35 for South and East Asia and 7.14 for Latin America. Thus, many countries in Africa also have potential to reap the peace dividend from return to stable political environment: countries such as Mali, Zaire, Chad, Mozambique, and Angola that have faced prolonged, major conflicts like Uganda. The direct cost of civil conflict in Africa is estimated at $1.8 billion per year in terms of the resources diverted from development alone besides the much larger indirect costs (The World Bank, 2000). In the case of Sudan high military spending has reduced growth by up to 8% of GDP. According to Collier (1999) the growth rate of GDP per capita falls by 2.2% during civil wars, partly due to the direct reduction in production, and partly due to the gradual loss of capital as a result of destruction, dissaving, and capital flight. (Also see the World Bank, 2000, Goudie and Neyapti, 1999, Azam, Morrison et. al., 1999, Klugman et. al., 1999, and Sharer et. al., 1995.)

Chatterjee, Soukalis, and Turnvosky (2003) study supply-side effects of aid. However, they focus on the growth effects of aid and abstract from its macroeconomic effects. In particular, they work with a real endogenous growth small-open economy where aid is invested in infrastructure. Furthermore, as their focus is on central and east European (CEEC) countries, in their model, the economy has access to international borrowing, albeit imperfect.
rise in productivity. He achieves consumption smoothing by financing the resultant current account deficit by reducing foreign currency balances. Thus, there are private capital inflows immediately on implementation of reforms in accordance with the stylized facts. The relative price of the nontraded good rises and real exchange rate appreciates as consumption smoothing results in an *ex ante* excess demand for the nontraded good. With identical rise in productivity in both sectors, real exchange appreciation lasts as long as current account deficit persists. Consumption smoothing notwithstanding, the consumption path is upward sloping giving rise to a higher real interest rate during transition. Thus, qualitative behavior of real exchange rate and real interest rate is also as documented earlier.

Inflation falls across steady states as higher real income increases desired domestic real money balances and lowers the fiscal deficit by raising tax revenue. Seeing lower future inflation, agents immediately start accumulating domestic currency. This delivers an immediate sharp decline in inflation despite a strong increase in consumption as observed in African countries undergoing productivity-enhancing reforms. In the flexible exchange rate regime, the desired shift from ‘dollars’ to ‘nairas’ in response to immediate sharp decline in inflation leads to a strong spot nominal appreciation of domestic currency that far outweighs the rise in the relative price of the nontraded good so that the price level jumps down on impact. Thus, both the rate of inflation and the price level fall on impact lowering inflation unambiguously. However, with a fixed exchange rate, agents achieve the desired shift from dollars to pesos by transacting with the central bank. As a result, foreign exchange reserves rise substantially on impact but there is no spot nominal appreciation. In absence of spot nominal appreciation, there is a spike in price level at the time of reform due to the increased relative price of the nontraded good but inflation still declines.

The positive income effect of the reform tends to raise foreign currency balances across steady states. However, it is countered by the substitution effect arising out of the fall in inflation. Thus, there may be private capital inflows or outflows in the long run. Yet, the desire to smooth consumption leads to private capital inflows in the short run *irrespective* of the long-run outcome.

Besides matching the stylized facts qualitatively, the model, when calibrated to Uganda and Ghana, also generates quantitative variations that compare well with the empirically observed magnitudes. In particular, it generates an appreciable increase in the real interest rate. It also produces large private capital inflows, as in the data, despite the lack of access to the world financial markets. In fact, consumption smoothing causes a strong *overshooting* of private capital inflows that are partly reversed in the long run. Inflation jumps close to its new lower steady state value on impact. For fixed exchange rate regime, inflation actually *overshoots* and jumps below the new steady state value.
Rest of the paper is organized as follows. Section 2 contains the description of the model. The changes across the steady states are characterized in section 3. Section 4 solves for and characterizes the transition path of important macroeconomic variables. In section 5, the model is calibrated and the results of calibrated model are compared with the data for Uganda and Ghana. Section 6 concludes.\(^7\)

## 2 The Model

As economic growth in Africa has been driven mainly by the rise in productivity or aid inflows rather than capital accumulation, the paper abstracts from capital accumulation and concentrates on effects of rising productivity. The productivity-enhancing reform leads to a Hicks-neutral technological progress in both the traded and the nontraded sectors whose outputs, \(Y_T\) and \(Y_N\), are given by

\[
Y_T = \alpha \bar{Y}_T, \quad \text{and} \quad Y_N = \alpha \bar{Y}_N,
\]

where \(\bar{Y}_T\) and \(\bar{Y}_N\) are appropriate constants, and \(\alpha\) is the productivity parameter with

\[
\dot{\alpha} = \beta (\alpha^* - \alpha),
\]

where \(\alpha^*\) represents the new long-run level of productivity in both sectors, and \(\beta\) is the speed of adjustment to the new long-run level. By virtue of (2) output of both sectors rises proportionally over time and across steady states, and therefore, the productivity-enhancing reform is sector-neutral.

With world price of traded good, \(P_T\), normalized to 1, the consumption-based price index, \(P\), is

\[
P = \bar{\nu}^{1-\gamma} \tilde{P}_N^\gamma,
\]

where \(\bar{\nu}\) is the nominal exchange rate which equals the price of the traded good in the domestic currency; \(\tilde{P}_N\) is the domestic currency price of the nontraded good; and \(\gamma\) is the consumption share of the nontraded good. Thus, the real exchange rate, \(\nu\), is

\[
\nu \equiv \frac{\bar{\nu}}{P} = P_N^{-\gamma},\quad (3')
\]

where \(P_N\) (\(\equiv \tilde{P}_N/\bar{\nu}\)) is the relative price of the nontraded good in terms of the traded good.

\(^7\)Algebraic details including proofs of results are relegated to the Appendix available from author upon request.
that is normalized to 1 for the pre-reform period. Hence, in the model, the real exchange rate appreciates if and only if \( P_N \) rises.

Given high dollarization in African economies, the representative agent is assumed to derive utility from consumption of both goods and from the holdings of the domestic currency, \((M)\), and the foreign currency \((F)\) deflated by the consumption based price index, \(P\). The utility function is

\[ V(P_N, E) + \phi(P_N^{-\gamma}m, P_N^{-\gamma}F), \]

where \( E \) and \( m \) are consumption expenditure and domestic real currency balances measured in terms of traded good or foreign currency; \( V(.) \) is the indirect utility function; and \( \phi(.) \) represents the utility yielded by the money balances. Note that the utility function is separable in consumption and money balances. Both \( V(.) \) and \( \phi(.) \) are assumed to be CES-CRRA functions with \( \tau \), \( \zeta \), and \( \sigma \) respectively the elasticity of intertemporal substitution, the elasticity of substitution in consumption, and the elasticity of substitution between domestic and foreign money balances.

Besides the two types of currencies, agents also hold domestic/ nontraded bonds, \( b \), issued by government that pay real interest at the rate \( r \). The government levies a consumption tax at the rate \( z \) and makes transfers, \( g \), to the agents. Both government bonds and transfers are denominated in terms of the consumption basket. Thus, the agent’s total assets denominated in foreign currency are

\[ A = m + F + P_N^\gamma b, \]

using which her budget constraint in foreign currency can be written as

\[ \dot{A} = P_N Y_N + Y_T + P_N^\gamma (r + \pi - \chi) b + P_N^\gamma g - (1 + z)E - \chi m, \]

where \( \pi \) is the rate of inflation and \( \chi \) is the rate of nominal depreciation of the domestic currency.

The representative agent chooses consumption expenditure, \( E \), holdings of domestic bonds, \( b \), domestic real money balances, \( m \), and foreign money balances, \( F \), subject to (4a) and (4b), to maximize his lifetime utility,

\[ \max_{\{E,m,F,b\}} \int_0^\infty [V(P_N,E) + \phi(P_N^{-\gamma}m, P_N^{-\gamma}F)] e^{-\rho t} dt. \]

The consumption tax rate, \( z \), and the real lump-sum transfers, \( g \), are fixed. Although it has outstanding debt, \( b_o > 0 \), government does not issue new bonds. In the fixed exchange rate regime the government is also committed to exchanging domestic and foreign currencies.
on demand. Thus, the government’s consolidated budget constraint is

\[ \dot{m} - \dot{F}_g = P_N^\gamma (g + rb_o) - zE - \chi m, \]  

(5)

where \( F_g \) is the foreign currency holding of the central bank. The market clearing condition for the nontraded good is

\[ D_N(P_N, E) = Y_N, \]  

(6)

where \( D_N(P_N, E) \) is the demand for the nontraded good. Let \( F_t \) denote the total foreign currency held by the agents and the central bank. Then, the current account identity gives

\[ \dot{F}_t = P_N Y_N + Y_T - E, \]  

(7)

where \( P_N Y_N + Y_T \) is the GDP denominated in the foreign currency.

## 2.1 Solving the Model

The maximization of the Hamiltonian yields following first-order conditions

\[ E : \quad V_E(P_N, E) = \lambda(1 + z), \]  

(8a)

\[ m : \quad \phi_m - \phi_F = \lambda P_N^\gamma \chi, \]  

(8b)

\[ b : \quad \phi_F = \lambda P_N^\gamma (i - \chi), \]  

(8c)

where \( \lambda \) is the multiplier associated with (4b) and \( i \) is the nominal interest rate.\(^8\)

The co-state equation for \( A \) is

\[ \dot{\lambda} = [\rho - (i - \chi)] \lambda. \]  

(9)

The first order conditions are quite intuitive. The multiplier \( \lambda \) is the shadow price of wealth denominated in foreign currency, and (8a) equates the marginal utility of consumption to the shadow price of wealth with \( (1 + z) \) representing the wedge created by the consumption tax. Similarly, (8c) equates the marginal utility of the real foreign currency balances to the cost of foregone interest earning, where \( \lambda P_N^\gamma \) is the shadow price of the real wealth. The difference in the marginal utilities of the real domestic and foreign currency balances equals the capital loss on holding domestic currency arising out of nominal depreciation as shown by (8b).

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\(^8\)In this paper \( \phi_m \) and \( \phi_F \) are partial derivatives of \( \phi \) with respect to the first and the second arguments and not with respect to \( m \) and \( F \), i.e. \( \phi_m = \partial \phi(x_1, x_2) / \partial x_1 \), and \( \phi_F = \partial \phi(x_1, x_2) / \partial x_2 \).
Using (8a) to eliminate $\lambda$ from (8b-8c) and solving for $\phi_m$, and $\phi_F$ yields
\[
\phi_m = \frac{P_N^2 V_E (P_N, E)}{(1 + z)} \rho, \quad \text{and} \quad \phi_F = \frac{P_N^2 V_E (P_N, E)}{(1 + z)} (i - \chi). \tag{10a-10b}
\]

As the government does not issue any new bonds, the agent’s equilibrium budget constraint is
\[
\dot{L} = P_N Y_N + Y_T + P_N^2 (g + rb_o) - (1 + z) E - \chi m, \tag{4b'}
\]
where $L \equiv m + F$ is the total currency holding of the agents denominated in the foreign currency.

### 2.2 The Steady-State Equilibrium

In the steady state, levels of real variables are constant. Therefore, (5) and (7) give
\[
\pi m = P_N^2 (g + rb_o) - zE, \tag{5'}
\]
\[
E = P_N Y_N + Y_T. \tag{7'}
\]

The steady-state equilibrium is defined by equations (3'), (5'), (6), (7'), and (10a-10b) which can be solved for $E, m, F, \nu, \pi,$ and $P_N$. To analytically characterize the behavior of the model, these equations are solved for small changes across steady states. In what follows, it will prove useful to define the share of domestic and foreign real money balances in providing liquidity services as
\[
\theta_m \equiv \frac{\nu m \phi_m}{\nu m \phi_m + \nu F \phi_F} = \frac{im}{im + (i - \chi) F}, \quad \text{and} \quad \theta_F \equiv \frac{\nu F \phi_F}{\nu m \phi_m + \nu F \phi_F} = \frac{(i - \chi) F}{im + (i - \chi) F}.
\]

### 3 Comparative Statics

Solving (6) and (7') one obtains
\[
\hat{P}_{N,ss} = k(\hat{E}_{ss} - \hat{\alpha}_{ss}), \tag{11a}
\]
\[
\hat{E}_{ss} = \hat{\alpha}_{ss}, \tag{11b}
\]
where $k \equiv 1/(\eta + \gamma)$, and $\eta$ is the compensated price elasticity of demand for the nontraded good, and for a variable $x$, $\hat{x}_{ss} \equiv (x^* - x_o)/x_o$, where $x_o$ and $x^*$ respectively denote the
values of \(x\) in the initial and the final steady state.\(^9\) Equations, (11a-11b) imply \(\dot{P}_{N,ss} = 0\). \(P_N\) does not change across steady states as the nontraded and the traded goods available for domestic consumption rise proportionally due to sector-neutral rise in productivity. Further, it follows from (3') that \(\dot{v}_{ss} = 0\). Therefore, the change in significant real variables across steady states, except domestic and foreign real money balances, is independent of the change in inflation.

From (5') and (10a-10b), one can obtain

\[
d\pi_{ss} = -\frac{1}{1 - \varepsilon} \frac{\mu \pi_o + z}{\mu} \dot{\hat{\pi}}_{ss}, \tag{11c}
\]

\[
\dot{m}_{ss} = \left[\frac{1 + \varepsilon}{1 - \varepsilon} \frac{\mu \pi_o + z}{\mu \pi_o}\right] \dot{\hat{\pi}}_{ss}, \tag{11d}
\]

\[
\dot{F}_{ss} = \left[1 - \frac{\sigma - \tau}{1 - \varepsilon} \frac{\theta_m}{1 + \rho/\pi_o} \frac{\mu \pi_o + z}{\mu \pi_o}\right] \dot{\hat{\pi}}_{ss}, \tag{11e}
\]

where

\[
\mu \equiv \frac{m}{E}, \quad \varepsilon = \frac{\pi_o}{\rho + \pi_o} (\sigma \theta_F + \tau \theta_m) < 1. \tag{11*}
\]

The inflation elasticity of demand for the domestic currency, \(\varepsilon\), is assumed to be less than 1 to avoid perverse inflation dynamics.\(^{10}\)

Equations (11c-11d) show that a productivity-enhancing reform reduces inflation and increases domestic real money balances across steady states (\(\dot{m}_{ss} > 0\)). Comparison of (11b) and (11d) shows that \(\dot{m}_{ss} > \dot{E}_{ss}\). The reason is quite straightforward. \textit{Ceteris paribus}, the wealth effect of increased output raises real consumption and real money balances proportionally due to homotheticity of preferences. However, increase in domestic real money balances lowers inflation with elasticity \(\varepsilon\) leading to more than proportional rise in domestic real money balances. In fact, one has \(\dot{m}_{ss} = \dot{E}_{ss} - \varepsilon \dot{\hat{\pi}}_{ss}\). This basic mechanism operates even when \(z = 0\). For \(z > 0\), in addition, fiscal deficit falls due to increased consumption tax revenues producing a larger decline in \(\pi\) and a greater rise in \(m\).

One can show that \(\dot{F}_{ss} = \dot{E}_{ss} + (\sigma - \tau) d\pi_{ss} / (\rho + \pi_o)\). Hence, the less than proportional rise in foreign currency balances in (11e), when \(\sigma > \tau\), is the flip side of the more than proportional rise in domestic real money balances that occurs due to fall in inflation. The reason for this opposite effect of inflation on \(m\) and \(F\) is that, with \(\sigma > \tau\), the currencies are substitutes. Thus, a fall in inflation leads to substitution away from the foreign and towards the domestic currency. As the income and substitution effects, therefore, pull in

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\(^9\)Although (11a) is written for changes across steady states, it also holds along transition. On the other hand, (11b) hold only across steady states.

\(^{10}\)With \(\varepsilon > 1\) the economy will be on the wrong side of the Laffer curve as a reduction in inflation would increase seigniorage due to a more than proportional increase in the domestic currency balances.
different directions for foreign currency holding, the response of foreign money balances to
the reform is ambiguous. The assumption that $\sigma > \tau$ is very reasonable on two grounds.
First, empirical evidence indicates $\sigma \gg \tau$. That $\sigma$ should be greater than $\tau$ is also reasonable
from another perspective: substitution between domestic and foreign currencies in practice
appears to be much easier than substitution of consumption across time. Thus, without
sacrificing the generality of the results, the paper assumes that $\sigma > \tau$.

The substitution from foreign to domestic currency becomes stronger as $\sigma$ rises relative
to $\tau$ as seen from (11d) where it manifests as a higher (but still less than 1) value of $\varepsilon$,
the inflation elasticity of domestic real money balances. If the substitution effect is strong
enough $F$ can decline leading to private capital inflows, and from (11e) we easily have the
following:

**Proposition 1** A productivity-enhancing reform leads to private capital inflows in the long
run if and only if

$$\sigma > \sigma^* \equiv \frac{\mu (\rho + \pi_o) + \tau \theta_m z}{\mu \pi_o + \theta_m z}.$$ 

The stability restriction, $\varepsilon < 1$, along with the assumption that $\sigma > \tau$, leads to the
following sufficient condition:

**Corollary 1.1** A productivity-enhancing reform leads to private capital inflows in the long
run if $\sigma > \sigma^*_{\text{max}} \equiv 1 + \rho/\pi_o$.

According to empirical estimates, the sufficient condition in Corollary 1.1 is not at all
stringent. First, as the estimates of $\tau$ for the LDCs are much below 1, even very large values
of $\sigma$ are compatible with the stability restriction $\varepsilon < 1$. Second, the condition in the corollary
is satisfied for values of $\sigma$ as small as 1.5 not only for high inflation but also for moderate
inflation economies (e.g. $\rho = .1$, $\pi_o = .2$) whereas its estimates vary widely from 1.5 to 8.
Hence, the reform in all likelihood leads to long-run private capital inflows.

The restriction on $\sigma$ in Corollary 1.1 can be weakened if tighter restrictions are put on $z$
and $\tau$:

**Proposition 2** If

(a) $z > \rho (\mu + F/E)$, and

(b) $\tau < \frac{\pi_o \theta_F}{\rho + \pi_o \theta_F},$

then the minimum value of $\sigma$ for private capital inflows in the long run in response to
a productivity-enhancing reform is less than 1.
The conditions in Proposition 2 are quite intuitive. The higher the $z$, the larger the increase in government revenues due to the increase in $E$ and the larger the decline in $\pi$. For $\tau$ sufficiently small, the substitution effect is then strong enough to cause $F$ to decline even for a value of $\sigma$ below unity. A higher value of $\mu$ raises the threshold value of $z$ because, given $\pi$, the ratio of seigniorage to the consumption tax revenues is higher for a higher value of $\mu$. Thus, for a given change in real consumption, $z$ needs to be higher to result in a prescribed fall in $\pi$. A higher value of $F/E$ implies a stronger positive wealth effect on $F$ raising the threshold value of $z$ that ensures a sufficient fall in $\pi$ for substitution effect to dominate the wealth effect.

The condition on $z$ in Proposition 2 is rarely binding as $\rho(\mu + F/E)$ is of the order of .02-.05. For high inflation, highly dollarized economies, condition on $\tau$ is not very restrictive either. For example, $\theta_F = .2$, $\pi_o = .5$ and $\rho = .1$ requires $\tau < .5$ which includes much of the range of the empirical estimates of $\tau$. In fact, numerical solutions for $\sigma^*$ for a range of plausible values of $\tau$, $\mu$, $m/F$, and $\pi_o$ indicate that for $\tau \leq .5$, $\sigma^*$ is less than 1 even when condition (b) in Proposition 2 is not satisfied. Hence, private capital inflows are virtually certain following the reform.

Figure 1 illustrates the effect of the productivity-enhancing reform on $F$. The $\pi\pi$ schedule shows the negative relationship (11c) between $\pi$ and $\alpha$. Ceteris paribus, the $\pi\pi$ schedule is steeper for higher values of $z$ and $\sigma$. The $FF$ contours show the value of $\pi$ and $\alpha$ consistent with a given $F$. It has a positive slope when substitution effect on $F$ is stronger than the wealth effect as $\pi$ must rise for agents to be willing to hold the unchanged amount of $F$. This argument also shows that $F_1 < F_0$. Thus, as economy moves down along the $\pi\pi$ curve as a result of the reform, $F$ falls.

4 Transition Dynamics

In this section, we derive the transition path of the economy for the flexible and the fixed exchange rate regimes and characterize the behavior of important macroeconomic variables by combining analytical and numerical techniques.
4.1 Flexible Exchange Rate Regime

Post-reform dynamics of the economy is governed by the system consisting of \( m, F, E, \) and \( \alpha \). With flexible exchange rate \( \hat{F}_g = 0 \) which implies \( \hat{F}_t = \hat{F} \). Thus, (5) and (7) now become

\[
\begin{align*}
\dot{m} &= P_N^e (g + rb_o) - zE - \chi m, \\
\dot{F} &= P_N Y_N + Y_T - E.
\end{align*}
\]

Equations (5”) and (7”) govern the path of \( m \) and \( F; \) and the exogenous path of \( \alpha \) is given by (2). The Euler equation—obtained from (8a) and (9)—that completes the system is

\[
\dot{E} = \frac{\tau}{1 - \gamma k} (r - \rho) + \frac{\gamma k}{1 - \gamma k} \frac{\beta}{\alpha - \alpha^*}.
\]

Linearizing and eliminating the endogenous variables from the system yields

\[
\begin{bmatrix}
\dot{m} \\
\dot{F} \\
\dot{E} \\
\dot{\alpha}
\end{bmatrix} = 
\begin{bmatrix}
c_1 & -c_2 & c_3 & -c_4 \\
0 & 0 & -(1 - \gamma k) & \frac{E}{\alpha} (1 - \gamma k) \\
c_5 & -c_6 & c_7 & \beta c_8 \\
0 & 0 & 0 & -\beta
\end{bmatrix}
\begin{bmatrix}
m - m^* \\
F - F^* \\
E - E^* \\
\alpha - \alpha^*
\end{bmatrix},
\]

where \( c_i \)'s are suitable constants and saddlepath stability of the system requires \( \det(H) = \beta \frac{\rho(\rho + \pi)}{\sigma(1 + \gamma T/\eta)} \frac{E}{F} (1 - \varepsilon) > 0 \) which restricts inflation elasticity, \( \varepsilon \), to less than 1 as alluded to earlier. As the system has two predetermined variables, saddlepath stable system has two negative eigenvalues. One negative eigenvalue is \( \delta_4 \equiv -\beta \), and denote the other by \( \delta_3 \).

With reform taking place at \( t = 0 \), the saddle point solution of the system is

\[
\begin{bmatrix}
m(t) - m^* \\
F(t) - F^* \\
E(t) - E^* \\
\alpha(t) - \alpha^*
\end{bmatrix} = 
\begin{bmatrix}
X_{13} & X_{14} \\
1 & X_{24} \\
X_{33} & X_{34} \\
0 & 1
\end{bmatrix}
\begin{bmatrix}
h_3 e^{\delta_3 t} \\
h_4 e^{-\beta t}
\end{bmatrix}, \quad t \geq 0,
\]

where \( X_{ij} \) is the \( i \)th component of the eigenvector corresponding to the \( j \)th eigenvalue; and \( h_3 \equiv X_{24} [\alpha^* - \alpha(0)] - [F^* - F_o], \) and \( h_4 \equiv -[\alpha^* - \alpha(0)] \) are constants determined by the initial conditions. When productivity gains are realized over time \( \alpha(0) = \alpha_o \). Since \( \delta_3 \) is a solution to a cubic equation, it is not possible to derive the expression for \( \delta_3 \). Nevertheless, a lot can still be said about the dynamics, especially the impact effects of the reform, by
combining analytical and numerical methods with economic intuition.\textsuperscript{11}

4.1.1 The Current Account Balance

At the outset, recall that the path of $P_N$ (and hence also of $\nu$) is linked to the path of the current account: real exchange rate appreciation lasts as long as current account deficit persists. The agent’s desire to consume more than the domestic output, on one hand, causes a current account deficit, and on the other hand, causes \textit{ex ante} excess demand for the nontraded good raising its price and causing real exchange rate appreciation. Thus, in what follows, we look at the behavior of the current account only.

To this end, from (14), one obtains

$$F(t) - F_o = (F^* - F_o) \left[1 - e^{\delta t}\right] + X_{24} \left[\alpha^* - \alpha(0)\right] \left[e^{\delta t} - e^{-\beta t}\right],$$

which gives the initial jump in the current account, $CA$, as

$$CA(0) = \hat{F}(0) = -\delta_3 (F^* - F_o) + X_{24} [\delta_3 + \beta] [\alpha^* - \alpha(0)].$$

To determine the sign of the impact effect on the current account, we begin with:

\textbf{Lemma 1} With flexible exchange rate regime

\begin{itemize}
  \item[(a)] if $\sigma > \sigma^*$ and $\tau < \theta_m$, then there exists unique $\beta^*$ such that $X_{24} [\delta_3 + \beta] < 0$ if and only if $\beta > \beta^*$; and
  \item[(b)] if $\sigma < \sigma^*$ and $\tau < \theta_m$, then $X_{24} [\delta_3 + \beta] < 0.\textsuperscript{12,13}$
\end{itemize}

The intuition for this result is as follows. The first term in (15a) is the contribution of the long-run fundamentals to the current account balance as agents increase or decrease $F$ across steady states depending on whether $\sigma$ is smaller or greater than $\sigma^*$. The second term in (15b) mainly captures consumption smoothing motive. Lemma 1 shows that consumption smoothing indeed causes current account deficit as consumption exceeds output when productivity rises over time. The adverse impact effect of consumption smoothing on current account becomes smaller as $\beta$ falls as slower growth reduces the wealth effect of the reform. Finally, note that as $\beta$ tends to zero output growth recedes far into the future delivering no

\begin{flushright}
\textsuperscript{11}To characterize the behavior of the system, $b_o$ is set to zero, which makes all $c_i$’s in $H$ independent of $\beta$.
\textsuperscript{12}When $\sigma = \sigma^*$, we have $F^* = F_o$ and $X_{24} = 0$ hence $CA(0) = 0$ and the economy immediately jumps to the final steady state.
\textsuperscript{13}It can also be shown that $\beta^* \to 0$ as $\sigma \searrow \sigma^*$.
\end{flushright}
gain and its current account impact must go to zero. For $\sigma > \sigma^*$, this implies second term must turn positive for sufficiently small $\beta$ as first term is negative.

Table 1 contains numerical simulations for the path of the current account for different values of $\pi$, $\mu$, $\tau$, and $\sigma$, and $z = .05$.

The second column shows the contribution of the first term in (15b) to current account on impact ($CA(0)$). Recall that second term is zero if productivity gain is realized immediately. The overall impact effect, $CA(0)$ is more negative in all cases with $\sigma < \sigma^*$ implying contribution of second term in (15b) is negative in accordance with Lemma 1. In cases with $\sigma > \sigma^*$, for $\tau = .25$ the impact effect is more negative for $\beta = .1$ than an immediate rise in productivity in the second column. Thus contribution of second term in (15b) is negative and $\beta^* < .1$ in this case. However, for $\tau = .5$ the impact effect for $\beta = .1$ is smaller than in the second column implying second term in (15b) is positive and, by Lemma 1, $\beta^* > .1$. But comparison with impact effect for $\beta = .5$ shows that it is still close to .1.

The following is an immediate consequence of Lemma 1:

**Proposition 3** If $\sigma > \sigma^*$, $\tau < \theta_m$, and $\beta > \beta^*$, then a productivity-enhancing reform under a flexible exchange rate regime leads to a current account deficit at $t = 0$.

Proposition 3 shows that the current account almost always goes into deficit on impact as numerical simulations suggest $\beta^*$ is quite small, and empirically $\sigma \gg \sigma^*$ and $\tau < \theta_m$. Simulations in Table 1 actually strengthen the theoretical results. Even for less plausible scenario with $\sigma < \sigma^*$ but with plausible values of $\beta$, second term in (15b) is large enough for the current account to go into deficit on impact although the first term is positive. First line in the first panel shows that if $\sigma = .5\sigma^*$ a 10% rise in productivity causes current account to jump to a surplus of .607% of GDP when $\alpha(0) = \alpha^*$. However, if productivity rises over time and $\beta = 1$, the current account shows a deficit of 3.63% of GDP on impact and does not shift into a surplus until one year has passed. Current account shows deficit for $\beta$ as small as .1.

Private capital inflows are, therefore, virtually certain following a productivity-enhancing reform. Figures 4 and 5 show the paths of important macroeconomic variables for two illustrative cases with $\sigma \geq \sigma^*$ when $\beta = .3$ and $\tau = .25$ which are in the middle of the range of plausible values.

The paths for the current account are quite representative. In the most plausible scenario with $\beta \in [.1, .5]$ and $\sigma = 3\sigma^*$, Table 1 shows that the current account deficit persists for at least 5.9 years. It worsens appreciably at the onset of reforms: a 10%

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14 The detailed description of the choice of parameter values follows later when the model is calibrated for numerical simulation to match the stylized facts.

15 Here $m/F = .5$, $\pi_o = .5$, $\mu = .075$, $z = .05$, and $\gamma = .5$. 

14
enhancement in productivity causes current account deficit as a fraction of GDP to rise by 2.82%-7.68% during the first year.

Lemma 1 also implies the following result:

**Proposition 4** Consider a productivity-enhancing reform when exchange rate is flexible. If $\tau < \theta_m$ and $\beta > \beta^*$, then, for all $t > 0$, the foreign currency holding of agents is lower when $\alpha(0) < \alpha^*$ than with $\alpha(0) = \alpha^*$.

Thus, for the empirically relevant case ($\sigma > \sigma^*$ and $\alpha(0) < \alpha^*$), agents’ desire to smooth consumption motivates them to reduce their foreign currency holding faster than with immediate rise in productivity generating larger private capital inflows in the short run. In fact, the negative contribution of second term is so strong that for $\sigma > \sigma^*$ the foreign currency balances overshoot their new lower long-run level during transition (Figure 3). Even for $\sigma = .5\sigma^*$, the accumulation of foreign currency is delayed by about 2 years, and returns to its initial level only after about 7 years (Figure 2).

4.1.2 Inflation, Real Interest Rate, and Fiscal Deficit

We now turn to the discussion of the response of other macroeconomic variables. Representative simulations in Figures 2-3 already show that qualitative responses accord well with stylized facts and quantitative effects are significant. The attention is restricted to the empirically most relevant scenario in this subsection where productivity rises over time, and $\alpha(0) = \alpha_o$. In this case, the consumption smoothing motive leads to an increase in consumption, a current account deficit and real exchange rate appreciation on impact. To consume in excess of their current income, agents run down their currency holdings. We now intuitively discuss various trade-offs the agent faces when deciding to reduce his domestic and/or foreign currency balances. This determines the response of inflation and price level on impact.

Recall, across steady states, domestic real money balances rise more compared to consumption and foreign money balances: difference being large for empirically relevant situation with $\sigma \gg \tau$. Thus, the pull of long-run fundamentals to immediately accumulate domestic currency is very strong which lowers inflation on impact. This decline in inflation and increase in desired domestic real money balances is further strengthened by the immediate decline in fiscal deficit due to rise in consumption tax revenues.

Thus, *ex ante*, agents would like to increase not only consumption but also holding of the domestic currency by running down the only other asset which is foreign currency. The agent’s desire to move out of foreign currency into domestic currency causes a strong (nominal) appreciation of the domestic currency. In most empirical cases, including all those
in Table 1, nominal exchange rate appreciation is strong enough to cause the price level to fall on impact even though the aggregate spending rises sharply. A rise in price level is possible but only under very strong conditions. Such exceptional cases aside, the price level falls, and the real value of domestic currency holding as conventionally measured (\(M\) divided by consumption-based price index) rises on impact. This rise aids the fall in fiscal deficit on impact and the pull of long-run fundamentals to deliver an immediate, large decline in inflation. In the empirically relevant case where \(\sigma = 3\sigma^*\) (see Figure 3), on impact, inflation jumps down very close to its new long-run level. Figure 2 corroborates the fact that for \(\sigma = .5\sigma^*\) the pull of the long-run fundamentals (causing substitution of domestic currency for foreign currency) is weaker and hence the impact effects, though qualitatively similar, are smaller.

To understand the behavior of the real interest rate, write the Euler equation, (12), as

\[
r = \rho + \frac{1 - \gamma k \dot{E}}{\eta} + \frac{\gamma k \beta}{\tau \alpha} (\alpha^* - \alpha).
\]

The second term in (12’) captures the familiar consumption smoothing motive when goods prices are constant over time. The third term on the right side of (12’) captures the effect of changes in goods prices over time. If \(\alpha (0) < \alpha^*\), \(P_N\) falls over time ensuring that the agent consumes traded good in larger proportion during initial period when nontraded goods are in short supply. More importantly, the fall in \(P_N\) over time, however, renders the current consumption relatively costlier. To make the given path of \(E\) acceptable to the agent despite a relative increase in marginal utility of current consumption, requires an increase in real interest rate as captured by the third term in (12’).

The contribution of the third term can be significant: for a 20% rise in productivity, with \(\beta = .3\), \(\gamma = .5\), \(\eta = .25\), and \(\tau = .25\) this term contributes to an 8 percentage point increase in the real interest rate at \(t = 0\). The contribution of the second term depends on the path of \(E\). When \(\sigma < \sigma^*\), \(F\) increases across steady states. This long-run tendency limits the fall in \(F\) and hence consumption does not jump as much on impact implying a higher slope of the consumption profile than if \(\sigma > \sigma^*\) (compare Figures 4 and 5). More generally, the real interest rate rises more for smaller values of \(\sigma\).

**Real Interest Rate and Fiscal Deficit.** For \(b_o \neq 0\), the increase in the real interest rate during the transition raises the debt service burden. If the real interest rate rises

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16In numerical simulations, for \(\pi_o = .5\), \(\mu = .075\), \(m/F = .5\), \(z = .05\), \(\rho = .1\), and \(\beta = .3\) price level rises on impact only when (i) \(\sigma = \tau\) (no substitution in favor of domestic currency), (ii) \(\gamma = .25\), \(\eta = .05\), (the nontradables’ demand is extremely price inelastic), (iii) \(z\) is low (decline in inflation at \(t = 0\) is small), and (iv) \(\tau = .2\), (strong consumption smoothing motive forces agents’ to run down their currency holdings substantially).
strongly or the government debt is large, fiscal deficit may deteriorate on impact. While most countries in Africa currently have low debt to GDP ratios as they have developed markets for government securities in 1990s, this short-run adverse fiscal impact of the reform will become important as they accumulate more public debt. Notwithstanding the fiscal deterioration, in most empirical cases, inflation still jumps down significantly immediately as forward looking behavior continues to strongly raise the demand for domestic real money balances on impact.

4.2 Fixed Exchange Rate Regime

With fixed exchange rate, agents in aggregate can instantaneously swap domestic currency for foreign currency by transacting with the central bank. Hence, total currency holding, $L$, is the state variable and the system governing response of the economy consists of $E$, $L$, and $\alpha$. Asset accumulation condition (4b'), which describes evolution of $L$, along with (2) and (4b') forms the system.\(^{17}\)

The linearized system in this case is given by

$$
\begin{bmatrix}
\dot{L} \\
\dot{E} \\
\dot{\alpha}
\end{bmatrix} =
\begin{bmatrix}
 c_{11} & -c_{12} & c_{13} \\
 c_{14} & c_{15} & \beta c_8 \\
 0 & 0 & -\beta
\end{bmatrix}
\begin{bmatrix}
 L - L^* \\
 E - E^* \\
 \alpha - \alpha^*
\end{bmatrix},
$$

where $c_i$’s are again appropriate constants and $\det(H_x) = \beta \frac{\rho(\rho + \pi)}{\sigma(1+\gamma/\eta)} \frac{(1+\pi)E+\mu \pi}{k'} > 0$, as $k' \equiv (\frac{\rho}{\sigma} + \frac{\pi \theta}{\tau} (\frac{-\sigma}{\tau})) + \frac{\pi F}{\tau L} > 0$. Hence, the system is saddle path stable with two negative eigenvalues and two predetermined variables, $L$ and $\alpha$. Label the negative eigenvalues as $\kappa_2$ and $\kappa_3 \equiv -\beta$. The solution to (16) then reads

$$
\begin{bmatrix}
 L(t) - L^* \\
 E(t) - E^* \\
 \alpha(t) - \alpha^*
\end{bmatrix} =
\begin{bmatrix}
 1 & Z_{13} \\
 Z_{22} & Z_{23} \\
 0 & 1
\end{bmatrix}
\begin{bmatrix}
 h_5 e^{\kappa_2 t} \\
 h_6 e^{-\beta t}
\end{bmatrix},
$$

where $Z_{ij}$ is the $i^{th}$ component of the eigenvector corresponding to the $j^{th}$ eigenvalue and $h_5 \equiv \alpha^* (0) - \alpha$ and $h_6 \equiv 1 - (L^* - L_0)$ are constants determined by the initial conditions. Once again $b_o$ is set to zero for ease of exposition and we have $\alpha_o \leq$

\(^{17}\)The government’s commitment to maintain exchange rate, forces it to ultimately choose the rate of nominal currency depreciation, $\chi$, that is consistent with its fiscal and monetary policies. For simplicity and to abstract from the effects of an anticipated change in the exchange rate, it is assumed that, at the time of the reform, the government sets the rate of nominal currency depreciation to a level consistent with the long-run equilibrium.
\( \alpha (0) \leq \alpha^* \).

### 4.2.1 The Current Account Balance

As before, the discussion the behavior of the real exchange rate and relative price of nontraded good is skipped as it is linked to the behavior of the current account.

Linearization of the external balance condition, (7), gives

\[
CA (t) = \hat{F} (t) = -(1 - \gamma k) \left[ \hat{E} - \hat{\alpha} \right],
\]

which, after substituting for \( E (t) \) and \( \alpha (t) \) from (17) and evaluating the solution at \( t = 0 \), becomes

\[
CA (0) = (1 - \gamma k) \left[ Z_{22} (L^* - L_o) + \{ Z_{23} - E - Z_{13} Z_{22} \} (\alpha^* - \alpha (0)) \right].
\]

Once again, the first term captures the effect of the long-run fundamentals. In addition, as \( Z_{12} \equiv 1 \) and \( Z_{23} = 0 \), it can be shown that \( Z_{22} = (c_{11} - \kappa_2) / c_{12} > 0 \).

Thus, for a reform that delivers entire productivity gain at \( t = 0 \), the current account goes into surplus on impact if agent’s total currency holding, not foreign currency holding, rises across steady states. This is a much weaker condition as domestic real money balances always rise. In fact, one has the following proposition that complements Proposition 1:

**Proposition 5** A productivity-enhancing reform causes total currency holding (denominated in foreign currency) to fall in the long run if and only if

\[
\sigma > \sigma^{**} \equiv \left( 1 + \frac{\rho}{\pi \theta_F} \right) \frac{\mu (\rho + \pi_o) + \tau \theta_m z}{\mu (\rho + \pi_o) + \theta_m z}.
\]

One can easily show that \( \sigma^{**} > \sigma^* \). But, for a wide range of plausible parameter values, \( \sigma^{**} \) is still in the lower range of value of \( \sigma \) found in literature. Hence, a decline in total currency holding, not just foreign currency holding, is quite likely. The first term in (18), therefore, contributes to a current account deficit on impact in majority of the plausible cases.

One can also show that second term in (18) is negative which leads to:

**Proposition 6** If \( \sigma > \sigma^{**} \) and \( \tau < 1 \), then a productivity-enhancing reform under a fixed exchange rate regime leads to a current account deficit at \( t = 0 \).

That this indeed is a very plausible outcome is shown by Figures 4-5. These figures show the response of relevant macro variables for fixed exchange rate regime for illustrative cases.
with $\sigma \leq \sigma^*$ and very representative values of other parameters. Once again, qualitative effects accord with stylized facts, and quantitative responses are significant.

4.2.2 Inflation, Real Interest Rate, Foreign Exchange Reserves, and Fiscal Deficit

The various, conflicting effects that determine the trade off in the flexible exchange rate case between running down the domestic and the foreign currency holdings, to achieve consumption smoothing, also operate in the fixed exchange rate regime. Consumption smoothing again leads to current account deficit, and the real exchange rate appreciates on impact due to the increase in the demand for the nontraded good. In fixed exchange rate regime, however, the tendency to move out of foreign currency does not cause nominal appreciation on impact. So a jump in $E$ raises the price level at $t = 0$ in contrast to the flexible exchange rate where it declines.

The appreciation of real exchange rate on impact is followed by depreciation during transition as the demand for nontraded good rises slowly compared to the increase in its supply. Since, government sets $\chi$ at $t = 0$ at a value consistent with the new steady state, inflation approaches its new steady state level from below and overshoots the new long-run level on impact ($3'$) implies $\pi = \chi - \dot{\nu}/\nu$).

Overshooting of inflation below its new, lower steady state value causes the demand of the real money balances to rise strongly on impact leading to the overshooting of the foreign exchange reserves. Thus, the increase in domestic real money balances during transition ($\hat{m}$ term in (5)) is lower than in flexible exchange rate case and a part of fiscal deficit is financed by running down the foreign exchange reserves ($\hat{F}_q$ term in (5)). A smaller $\beta$ implies a longer duration for which this effect operates leading to a larger decline in reserves. In addition, with fixed nominal exchange rate, agents face an infinitely elastic supply of foreign currency in contrast to an upward sloping supply when exchange rate is flexible. In the latter case, ex ante desire to accumulate foreign currency is partly countered by the consequent nominal depreciation. Thus, with the same pull of long-run fundamentals, the agent starts accumulating foreign currency earlier during the transition (or rather reduce their foreign currency balances slowly during transition) than with flexible exchange rate. A smaller $\sigma$ implies stronger pull of fundamental to increase foreign currency balances earlier during transition leading to a larger decrease in foreign exchange reserves along transition (compare Figures 4 and 5). In empirically relevant cases, it is possible for foreign exchange reserves to either rise or fall across steady states.

For both exchange rate regimes, same factors control the qualitative behavior of the real interest rate during transition. However, as, with fixed exchange rate, rise in price level on
impact lowers real value of domestic currency balances as conventionally measured, agents have to finance both the resulting loss in real value and the desired increase in domestic currency holding.\textsuperscript{18} This tends to restrain the initial jump in $E$ imparting a higher slope to the consumption profile and hence higher real interest rate during transition. The effect is very weak for high values of $\sigma$ but is noticeable when agents want to increase their foreign currency holding across steady states, \textit{i.e.} $\sigma < \sigma^*$, as evident from comparison of paths of real interest rates in Figures 3 and 5, and Figures 2 and 4. A higher real interest rate leads to higher fiscal deficit compared to flexible exchange rate case if $b_o \neq 0$.

5 Numerical Simulations for Uganda and Ghana

Majority of countries in Africa, including Ghana, have suffered from economic mismanagement and political uncertainty for more than three decades. In many of them, such as Uganda, these factors combined with extreme civil and political conflict with disastrous consequences. Besides representing the two broad categories of circumstances facing many African countries, Ugandan and Ghana also adopted different exchange rate regimes during the implementation of the reforms dictating their choice for calibration of numerical simulations. Uganda floated its currency immediately at the onset of reforms whereas Ghana followed fixed exchange rate regime with periodic adjustment. Before turning to numerical simulations, we provide a very brief context to the periods of productivity boom in Uganda and Ghana to which the model is calibrated. The paths of significant macroeconomic variables for Uganda and Ghana for these periods are shown in Figures 6-7.

At the end of the civil war in Uganda in 1986-87, “per capita GDP was estimated to be about 40% below the level of 1970, and the inflation rate, on an annual basis, had risen to 240%.” (see Sharer \textit{et al.}) The Economic Recovery Program (ERP) initiated in Uganda in 1987, therefore, involved widespread economic and political reforms including removal of price controls, restoration of fiscal discipline, and rationalization of parastatal enterprises. For example, as mentioned earlier, latter resulted in removal of 114,000 public sector workers and demobilization of 33,000 soldiers. ERP received wide support from international lending agencies, such as the World Bank and the IMF, and Paris Club donors. Over 1987-94 the annual aid flow to Uganda increased from 0.5% of GDP to 9.0% in 1992-93 before falling to 5.1% in 1994-95. The level of aid was the same as many other African countries have been receiving for an extended period of time (see Younger, 1992) and was therefore expected to

\textsuperscript{18}The rise in price level and real exchange rate appreciation respectively ensure that the real value of both the domestic and the foreign currency therefore falls on impact when exchange rate is fixed. In contrast, the fall in price level with flexible exchange rate raises the real value of domestic currency balances.
persist. Helped by foreign aid, public investment tripled from 2.6% to 7.6% over 1987-94 but private fixed investment increased only marginally from 6.6% to 8.8%. (see Sharer et al.)

Ghana’s problems arose from uncertain political climate with long military interventions and misguided economic policies. When Economic Recovery Program was launched in 1983, per capita income in Ghana was a third lower than its level a decade earlier. Exchange rates were highly overvalued, and extensive controls had distorted the incentives and engendered economic inefficiency. The first phase of economic reforms (1983-86) in Ghana concentrated on macroeconomic stabilization and included realignment of the real exchange rate and removal of the price controls along with the restoration of fiscal balance. The reform was supported by the international agencies and current official transfers rose from .32% of GDP over 1980-83 to 2.79% during 1984-91.

Although it liberalized the price controls and the trade regime, Ghana failed to implement structural reforms in financial, agricultural, and parastatal sectors at an adequate pace. Neither did Ghana face extended civil war like Uganda. Thus, the productivity shock in Ghana was modest compared to Uganda. Private investment at constant prices, also hardly responded to the economic recovery program and remained below 5% of GDP from 1983-88 (see Hadjimichael et al.). In fact the investment was barely, if at all, sufficient to offset the depreciation of capital.

As preceding discussion shows, during the periods under consideration, these countries experienced widespread economic and political reforms. It would be encouraging if the model could roughly match the empirically observed changes in magnitudes of the relevant macroeconomic variables in the data. However, given the simplicity of the model and the variety of shocks assailing the economy, a close quantitative match in values is not be expected. Although, in some cases possible sources of differences between model’s results and data are pointed out.

5.1 Calibration of the Model

The calibration of the model is based on the empirical data for countries in Africa and developing countries in general. In the model, the time preference rate, \( \rho \), discounts future utility and determines steady state return on capital. As Buffie (2001) notes, matching data from LDCs on both these counts is not possible as former implies \( \rho < .05 \) while latter requires it to lie in the range .10-.15. Thus, as in Buffie (2003) and Haltiwanger and Singh (1999), \( \rho \) is set to .1. Most estimates of the elasticity of intertemporal substitution, \( \tau \), for the low- and middle-income countries lie in the range of zero to .5 as in Ogaki, Ostry, and Reinhart (1996). But, many estimates for the United States are .1-.3 which indicates \( \tau \) might be quite
small. Hence, it is given the middle value of .25 and sensitivity analysis is done for $\tau = .5$.

In highly aggregated demand systems with 5-11 goods the estimated compensated own-price elasticities lie in the range .15-.6 (See Buffie, 2001, and references cited therein). Given this, $\zeta$ is given a value of .5. This yields $\eta = .25$ which is quite reasonable as the model has only two goods. To account for the fact that many food items consumed in Africa are effectively nontraded in view of the absence of the world markets, the consumption share of the nontraded good at set at .5, slightly on the higher side of the range of the estimates for value added in this sector for the middle and low-income countries (World Development Report 1996).

The estimates in the literature for the elasticity of substitution between domestic and foreign currency, $\sigma$, for Latin America vary widely from 1.5 to 8 (See Buffie, 2003, and references cited therein). For Egypt, Elkhafif (2002) reports that dollarization ratio fell from 51% to 20% over 1991-99 when it undertook widespread reforms. Thus, foreign currency balances appear to be sensitive to the path of the exchange rate in African economies as well: a fact also noted by Buffie (2003). Accordingly, we set $\sigma = 2$ and do sensitivity analysis for $\sigma = .5$ and 3.

Given evidence of high dollarization in African economies mentioned earlier and noting that in the model, $M$ is high powered money, the results are presented for for $m/F$ ($= M/\tilde{V}F$) = 1/3 and 1/2, latter being the value for Nigeria in Buffie (2003).

Calibration for Uganda.\(^{19}\) The stock of reserve or high powered money in 1986, which stood at 4.86% of GDP, is used to set the value of domestic currency holdings.\(^{20}\) The value of .0585 for consumption tax ($z$) is the ratio of revenue from indirect taxes to GDP for Uganda for four years preceding the reform. The domestic debt excluding that owed to the central bank stood at .71% of GDP which gives $b_0/GDP = .0071$. The economy is subject to a 50% increase in long-run productivity with speed of adjustment, $\beta = .3$. This implies a 45% increase in productivity over 8 years from 1986 to 1994, which is close to the 44.27% increase experienced by Uganda. In Uganda annual inflation was 161.01% in 1986 which implies an instantaneous rate of inflation of 95.94%. Finally, as Ugandan economy was highly demonetized at the onset of reforms, so $m/F = 1/3$ in the benchmark case (see p. 31, Sharer et al., 1995).

\(^{19}\)The data for Uganda and Ghana, unless otherwise stated, have been obtained from International Financial Statistics, IMF, Government Financial Statistics, IMF, and Balance of Payments Statistics, IMF.

\(^{20}\)Data for reserve money supply for Uganda for 1987 are not unavailable. However, as the level of inflation in 1986 and 1987 is quite similar, using 1986 data is acceptable. In order to correct for the bias arising out of very high inflation, I calculate this ratio by dividing the average of reserve money supply at the end of 1985 and 1986 by the GDP for 1986. A similar correction is also applied to domestic debt.
Calibration for Ghana. In case of Ghana, the reserve money was 6.75% of GDP in 1983, and $m/F$ is set to 1/2 in the benchmark case. The indirect tax receipts which set the value of $z$ were 3.47% of GDP over 1980-83. Domestic debt, excluding owed to the central bank, was 5.68% of GDP. Recall that the productivity shock in Ghana was modest compared to Uganda: per capita real GDP in Ghana rose by 12.02% over 1984-87, and increase over 1984-91 was 16.38%. Therefore, the economy is subject to an 18% increase in productivity which with 12.02 increase over 1984-87 where speed of adjustment $\beta = .275$. In Ghana’s case annual inflation stood at 55.14% in 1983 giving instantaneous inflation of 43.92%.

5.2 Simulation Results for Uganda

In earlier sections, we worked with a linearized model to identify basic economic mechanisms operating in the model and how it affects the qualitative and quantitative behavior of variables of interest. However, as shocks hitting the Ghanaian and Ugandan economy were large, to take the model to data, nonlinear structure of the model should not be ignored. To do so, the paper uses shooting methods to solve for the global nonlinear saddlepath. Thus, numerical results are free from errors arising from linearization.

Figure 8 contains the illustrative paths of relevant macroeconomic variables for the benchmark case ($\sigma = 2, \tau = .25, m/F = 1/3$) with flexible exchange rate, and Table 2 shows the results of the sensitivity analysis. Like Figure 8, Table 2 shows the percentage change from the initial steady state for productivity, real consumption, domestic real money balances, foreign currency balances, and real exchange rate, and change in levels from the initial steady state for the rest where levels are specified in percent.

The behavior of the variables matches the stylized facts, and the magnitudes are quantitatively significant. In particular note the large immediate decline in inflation, large immediate and sustained rise in real interest rate and significant worsening of current account accompanied by private capital inflows.

Agents’ desire to smooth consumption drives the macroeconomic outcomes in the model. The three-year consumption response in the model is surprising close to the data: in first three years of reform, real consumption rises by 29.70% compared to a 31.14% increase in data. Changes in $\tau, \sigma,$ and $m/F$ cause the impact response of real consumption to change in intuitive ways but the three-year response does not change much. As consumption smoothing motive operates strongly only during first 3-4 years of the reform when domestic supply is constrained, changes in $\tau, \sigma,$ and $m/F$ merely alter the consumption response within this period.

The behavior of other macroeconomic variables also differs quantitatively in the initial
years of the reform. For example, the path of domestic real money balances is quite sensitive to values of $\tau$, $\sigma$, and $m/F$. Dependence on $\sigma$ and $\tau$ arises as they determine the interest and the inflation elasticity of money demand: higher values leading to a larger response; larger difference in their values also causes a bigger jump in domestic real money balances on impact due to greater substitution towards the domestic currency. If domestic currency holding is already large (high $m/F$), tendency to substitute towards domestic currency is weaker, and response of domestic real money balances and inflation on impact is smaller (Table 2).\footnote{To see this, note $\theta_m$ rises and $\theta_F$ falls as $m/F$ rises (10c-10d). As $\sigma > \tau$, (11*) then shows that $\varepsilon$ falls.} The real exchange rate and the current account also vary with $\tau$, $\sigma$, and $m/F$ in an intuitive manner: being much smaller when $\tau$ is higher, $\sigma$ is lower, and $m/F$ is higher. However, as the qualitative behavior remains unchanged rest of this section concentrates on the benchmark case.

In the model consumption smoothing worsens current account deficit by 7.88% of GDP in the first year of the reform. The cumulative current account deficit amounts to 11.33%. These are big numbers. The worsening of current account is biased towards first year of the reform partly because assumed path of productivity in (2) concentrates productivity rise in the initial period compared to data. It is, therefore, better to compare cumulative current account deficit with data. The relevant data for comparison would depend on the point of view adopted. If one is interested in matching the current account deficit arising out of increase in consumption as in the model, one should look at the trade balance adjusted to exclude imports arising due to project-tied foreign aid and foreign direct investment. Sharer \textit{et al.} provide data on the imports related to the foreign-aid supported projects. Cumulative trade balance excluding project-related imports from 1987-88 to 1990-91 is 19.00% of GDP. The four year horizon is appropriate as consumption smoothing operates during first 3-4 years of the reform. Sharer \textit{et al.} also provide aggregate data on external borrowing by commercial banks and foreign direct investment along with errors and omissions. In absence of further break down, assuming half of this inflows resulted in imports related to investment, cumulative trade deficit induced by consumption smoothing over the same period falls to 12.73% of GDP.

The model produces large private capital inflows and overshooting of private capital inflows during transition. The agent’s pre-reform foreign currency holding at 14.58% of the GDP declines across steady states by 87.20% in the benchmark case with a peak decline of 94.27% at the end of third year. Thus, initial capital inflows are partly reversed later. The decline at the end of the fourth year is 93.88% which implies a cumulative private capital inflow of 17.49% of GDP. Hadjimichael \textit{et al.} (1996) report cumulative private current transfers of $493 mn over first four years (1987-91) which amount to 17.68% of GDP. However,
in the data, there are additional private inflows besides those masked as private current transfers. These private capital inflows total 12.53% of GDP and are not accounted for by the model. In the model, transitory private capital inflows occur even when there are private capital outflows in the long-run. For $\sigma = .5$, $\tau = .25$, and $m/F = 1/3$, there is a peak transitory private capital inflow of 4.72% of GDP even though the economy experiences private capital outflow of 2.34% of initial period GDP in the long run.

The model also produces a substantial immediate decline in inflation. In the model, annual inflation declines from 161.01% to 31.94% during first year of the reform: very close to the new steady state level of 11.21%. The decline is even more when downward jump in price level on impact is included. In Uganda, inflation continued to remain high at 196.11% in 1988 but declined to 61.44% in 1989: a decline of 134.67 percentage points. Substantially lower and delayed decline in inflation in data may be reconciled with model by allowing for downward rigidity of the price level. It will eliminate the immediate downward jump in the price level and also exclude the jump in domestic real money balances on impact delaying the fall in inflation.\(^22\)

For the real exchange rate, data on Real Effective Exchange Rate for Uganda (see Figure 6) from *International Financial Statistics* (IMF) shows strong temporary real appreciation despite a long-run trend for real depreciation due to removal of trade barriers and price controls. In 1987 real exchange rate appreciated by 27.80%: an increase that persisted for about 3 years (Figure 6). The model produces real exchange appreciation of 35.39% on impact with first year average of 22.00%.\(^23\)

The annual real interest jumps by 22.32 percentage points on impact and remains high for an extended period (Figure 8); even after 7 years, real interest rate is 15.13% per year, more than 1.5 times the time rate of preference. The data on the levels of the real interest rate is not entirely reliable as Uganda liberalized interest rates only in early 1990s. Yet, the upward trend in real interest rate after the reform is unmistakable (Figure 6). In 1982-83, the real annual return on treasury bills ranged from -20% to -10% which fell to -50% range during 1984-87 primarily due to high and volatile inflation. It steadily rose thereafter to reach 16.67% in 1990. Since government controlled the interest rate on treasury bills, this may merely reflect the variation in inflation. However, government steadily raised (nominal)

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\(^{22}\)Lower and delayed decline in inflation is also consistent with a smaller decline in fiscal deficit in Uganda than predicted by the model although it is more likely to be a coincidence in view of wide ranging fiscal reforms being undertaken at that time. Against the sustained and immediate decline in fiscal deficit by 3.29% of GDP in the model, fiscal deficit fell from 2.48% in 1987 to .87% in 1988 but rose back to 2.51% in 1989.

\(^{23}\)The *International Financial Statistics* (IMF) defines REER in a manner different from the way that is usual in the economics literature: a rise in REER implies real exchange rate appreciation. This necessitates a correction in the percentage rise in real exchange rate mentioned in Table 3 to match it to the data.
interest rate on treasury bills from 24% in 4th quarter of 1987 to 43% in 2nd quarter of 1989, and it remained at that level for an additional year. That the government had to increase the nominal interest rate indicates that the reform did put a strong upward pressure on the real interest rate. Deposit interest rates and bank rate also show a similar pattern.

5.3 Simulation Results for Ghana

Figure 9 shows the illustrative paths of various relevant macroeconomic variables for Ghana for the benchmark case with $\sigma = 2$, $\tau = .25$, and $m/F = 1/2$ with fixed exchange rate. The behavior of the variables is in accordance with the analysis of subsection 4.2. In particular, at $t = 0$, inflation overshoots its new steady state level. Foreign exchange reserves also overshoot and rise above their long-run level on impact. Agents run down their foreign currency holding beyond the new steady state level during the transition, implying overshooting of the private capital inflows. Large increases in the real interest rate cause a temporary rise in fiscal deficit. Table 3 shows the results of the sensitivity analysis. The response of $\nu$, $P_N$ and the current account to the productivity shock is smaller when $\tau$ is higher, $\sigma$ is lower and $m/F$ is higher as in case of Uganda with flexible exchange rate. Since the results are qualitatively robust to values of $\tau$, $\sigma$ and $m/F$, this section again concentrates on the benchmark case.

The model predicts a 12.21% increase in consumption in first four years of reform compared to 9.96% in data. The model produces a maximum trade deficit of 3.93% of GDP (during the first year) with cumulative deficit of 7.10% over 5.12 years. The trade deficit in Ghana shows hardly any trend over 1983-86 though balance of goods and services shows a cumulative deficit of 7.53% over this period. 24

Private capital inflows during the transition exceed their long-run level. The peak occurs at the end of the third year with foreign currency holding of agents declining by 67.91%. The decline at the end of the fifth year is 64.32% which implies a cumulative private capital inflow of 8.88% of GDP. During 1983-87 cumulative private capital inflows in Ghana amounted to 6.01% of GDP compared to very small levels prior to reform. The reform also immediately raises foreign exchange reserves as agents dump foreign currency to increase consumption and domestic currency balances. In the simulations, they rise by 4.52% of GDP. Ghana’s foreign exchange reserves rose by 3.33% of GDP from .68% in 1983 to 4.01% in 1984. The model also implies overshooting of foreign exchange reserves on impact. The data for Ghana support this strong prediction of the model. Foreign exchange reserves, after jumping from

24Information on the extent of use of official flows for project-related imports is lacking. If one assumes that official inflows were completely used for imports, one may also compare current account deficit in the model to the current account balance excluding private transfers as official inflows on capital account were non-existent for Ghana for the period under consideration. The current account excluding private transfers show a similar cumulative deficit of 6.91% of GDP.
$142.60 mn in 1983 to $511 mn (8.91% of GDP) in 1986, ultimately declined to $179.20 mn (3.69% of GDP) in 1987. Such cycles have been a feature of Ghana’s foreign exchange reserves even during later phases of reforms (Figure 7).

The data also corroborate a smaller decline in inflation in the first year followed by the overshooting of inflation in the next year that is predicted by the model. In the model, inflation during first year stands at 29.35%. It falls to 18.77% in the second year but climbs back to 22.70%. In the data, inflation declined to 28.40% in 1984 (one year after the reform) and to 9.34% in 1985: a cumulative decline of 45.80 percentage points. But, it rose back to 24% over the next two years.

The data on real interest rate pose same problems as it did for Uganda. However, as in that case, there is a gradual upward trend in the nominal interest paid on treasury bills and bank deposits, and the discount rate for banks which points to the pressure arising from rising real interest rates. In case of treasury bills, discount rate was progressively raised from 13% in the third quarter of 1983 to 22.80% in the third quarter of 1987. The ex post real return on treasury bills rose from very low negative levels to reach positive territory in 1984: first time since 1979. It rose to 4.65% per annum before falling to modest negative levels over next several years (Figure 7). Quarterly data on ex post real interest rate shows positive levels in 7 out of 16 quarters over 1984-87. The model produces a rise in instantaneous real interest rate of 6.17 percentage points in the first year with a maximum of 6.42 percentage points. Figure 9 shows that this initial rise is very persistent; the real interest rate is 1.4 times the time rate of preference even after 5 years. In the model, the rise in real interest rate worsens the fiscal deficit due to the increased debt service burden but fiscal balance in Ghana improved substantially after the reforms. Also, note that fiscal deterioration fails to prevent a substantial decline and overshooting of inflation in the model as noted in subsection 4.1.

The model generates a 9.22 % real exchange rate appreciation in the first year. On the contrary, Hadjimichael et al. (1996), report a 40% fall in $P_N$ over 1983-84 and a 70% sustained and permanent fall over 1983-87. This is not surprising as, unlike Uganda where realignment of real exchange rate was almost complete at the onset of the reforms, Ghana was still undertaking significant liberalization of price controls to improve export competitiveness (Figure 7). Resulting large realignments in real exchange rate dominate the impact of the modest rise in productivity.

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25 The inflation in the first year accounts for both the average instantaneous inflation over the year and the jump in the price level on impact; former falls by 29.46% while latter rises by 11.94% due to a 25.31% rise in price on nontraded good.
6 Conclusion

The paper uses a currency substitution model to explain the stylized macroeconomic facts associated with reforms in some countries of Africa that primarily resulted in a rise in productivity. There is a tremendous potential for increase in productivity in many other countries of Africa as peace and economic efficiency make their comeback after decades of economic decline, and political and civil strife. A number of countries have witnessed end of wars and conflict in Africa: Mali (1968-91), Nigeria (1983-98), Somalia (1969-91), and Zaire (1965-97). On the economic front, since the late 1980s, economic decline and balance of payment crises have forced economic discipline on many African countries leading to the opening up of markets, reduction of state intervention, and greater reliance on markets and private sector. The macroeconomic effects of these reforms in forerunners like Ghana and Uganda can inform policy making in the other African countries undertaking or having potential to undertake such reforms.

In accordance with the view of observers on Africa, the model does not appeal to tight integration of these countries into the world capital markets. The calibrated versions of the model match, both qualitatively and quantitatively, important stylized macroeconomic facts associated with the productivity-enhancing reforms in Uganda and Ghana. They reproduce the drastic decline in inflation on initiation of reforms. The decline in inflation, moreover, occurs despite a strong rise in consumption spending. The current literature on currency substitution has focussed mostly on Latin America. However, this paper shows that currency substitution is equally important for understanding macroeconomic dynamics in African countries. It can also explain large private capital inflows in these countries despite their isolation from the world financial markets.

In calibrated models, the real interest rate responds very strongly and positively to the anticipated rise in productivity. Such rise in real interest rates, pursuant to the reforms, has been a major source of concern for policy makers in Africa and international development agencies. It is held partly responsible for the sluggish response of private investment, casting doubt on the sustainability of economic growth in these countries once the gains from rise in productivity are exhausted (see Hadjimichael et al., 1996). While currently African countries have been able to sustain investment despite low, and many times negative, savings rate due to outside financial aid and lending, but they are reaching a point where their debt is becoming unsustainable; foreign aid is tapering off as well. Hence, domestic private savings and investment are essential for sustaining growth. Future research in this direction would include introducing capital in the model and examining if the empirically observed slow response of investment can arise endogenously.
References


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Table 1: Numerical solutions for the path of current account balance for the flexible exchange rate regime.

| π₀ = .5,  τ = .25,  μ = .075,  m/F = 1/2,  ⇒  σ⁺ = .725 |
|---|---|---|---|---|---|
| σ | α(0) = α* | β = 1 | CA(0) | t₀ | CA(5) | β = .5 | CA(0) | t₀ | CA(5) | β = .1 | CA(0) | t₀ | CA(10) |
| 5σ* | .607 | 3.63 | 1.11 | .330 | -2.60 | 1.60 | .436 | -7.794 | 2.91 | .118 |
| σ* | 0 | -4.53 | 1.52 | .355 | -3.47 | 2.22 | .453 | -1.21 | 4.58 | .118 |
| 3σ* | -2.26 | -7.44 | -2.16 | -6.54 | -3.45 | -1.45 | -3.45 | 11.4 | .072 |

| π₀ = .5,  τ = .5,  μ = .075,  m/F = 1/2,  ⇒  σ⁺ = .85 |
|---|---|---|---|---|---|
| σ | α(0) = α* | β = 1 | CA(0) | t₀ | CA(5) | β = .5 | CA(0) | t₀ | CA(5) | β = .1 | CA(0) | t₀ | CA(10) |
| σ* | 0 | -3.40 | 1.48 | .258 | -2.59 | 2.15 | .334 | -0.898 | 4.41 | .084 |
| 3σ* | -7.24 | -11.0 | -1.5 | -10.2 | -2.73 | -6.78 | -5.11 |

| π₀ = 1,  τ = .25,  μ = .05,  m/F = 1/3,  ⇒  σ⁺ = .726 |
|---|---|---|---|---|---|
| σ | α(0) = α* | β = 1 | CA(0) | t₀ | CA(5) | β = .5 | CA(0) | t₀ | CA(5) | β = .1 | CA(0) | t₀ | CA(10) |
| 5σ* | .6 | -3.66 | 1.12 | .112 | -2.63 | 1.62 | .088 | -8.807 | 2.95 | .119 |
| σ* | 0 | -4.59 | 1.54 | .154 | -3.53 | 2.25 | .143 | -1.24 | 4.67 | .123 |
| 3σ* | -1.95 | -7.25 | -1.97 | -6.34 | 5.90 | .113 | -3.21 | 11.7 | .077 |

| π₀ = 1,  τ = .5,  μ = .05,  m/F = 1/3,  ⇒  σ⁺ = .836 |
|---|---|---|---|---|---|
| σ | α(0) = α* | β = 1 | CA(0) | t₀ | CA(5) | β = .5 | CA(0) | t₀ | CA(5) | β = .1 | CA(0) | t₀ | CA(10) |
| 5σ* | .967 | -2.34 | .86 | .282 | -1.65 | 1.24 | .380 | -4.92 | 2.08 | .120 |
| σ* | 0 | -3.39 | 1.48 | .258 | -2.57 | 2.16 | .332 | -0.878 | 4.42 | .082 |
| 3σ* | -6.39 | -10.2 | -1.51 | -9.35 | -1.48 | -5.72 | -6.01 |

Notes:
1. An entry in a cell (except in columns with heading t₀) is the change in the current account (percent of GDP) in response to 10% rise in productivity after years shown in parenthesis.
2. An entry in columns with heading t₀ is years.
3. Second column of the table shows the impact effect on the current account for α(0) = α*.
4. For each value of β, first column contains impact effect on the current account, second column the time when the current account changes sign (if it does), and third column the effect on the current account at a time shown at the top of the column when adjustment is almost complete.

†: Response of the current account after 15 years of the reform.
### Table 2: Simulation results for the nonlinear model calibrated to Uganda.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>( \tau = .25 )</th>
<th>( m/F = 1/3 )</th>
<th>( m/F = 1/2 )</th>
<th>( \tau = .5 )</th>
<th>( m/F = 1/3 )</th>
<th>( m/F = 1/2 )</th>
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</thead>
<tbody>
<tr>
<td>( \nu E \uparrow )</td>
<td>3\textsuperscript{rd} year end</td>
<td>( \sigma = .5 )</td>
<td>23.77</td>
<td>29.70</td>
<td>29.67</td>
<td>29.01</td>
<td>29.62</td>
</tr>
<tr>
<td>( \nu m \uparrow )</td>
<td>Impact</td>
<td>( \sigma = .5 )</td>
<td>13.04</td>
<td>44.41</td>
<td>46.19</td>
<td>9.30</td>
<td>29.45</td>
</tr>
<tr>
<td>( F \uparrow )</td>
<td>Maximum</td>
<td>( \sigma = .5 )</td>
<td>-32.34</td>
<td>-94.27</td>
<td>-99.16</td>
<td>-36.74</td>
<td>-94.59</td>
</tr>
<tr>
<td>( \nu \uparrow )</td>
<td>Impact/Maximum</td>
<td>( \sigma = .5 )</td>
<td>-14.63</td>
<td>-26.14</td>
<td>-27.47</td>
<td>-12.94</td>
<td>-21.88</td>
</tr>
<tr>
<td>( P_N \uparrow )</td>
<td>Impact/Maximum</td>
<td>( \sigma = .5 )</td>
<td>34.28</td>
<td>70.73</td>
<td>75.69</td>
<td>29.72</td>
<td>55.98</td>
</tr>
<tr>
<td>( t^\uparrow )</td>
<td>Impact</td>
<td>( \sigma = .5 )</td>
<td>25.99</td>
<td>22.62</td>
<td>22.32</td>
<td>25.16</td>
<td>22.37</td>
</tr>
<tr>
<td>( \pi \uparrow )</td>
<td>Impact</td>
<td>( \sigma = .5 )</td>
<td>26.22</td>
<td>19.20</td>
<td>18.16</td>
<td>27.02</td>
<td>20.32</td>
</tr>
<tr>
<td>( \chi \uparrow )</td>
<td>Impact</td>
<td>( \sigma = .5 )</td>
<td>26.45</td>
<td>22.62</td>
<td>22.32</td>
<td>28.88</td>
<td>23.50</td>
</tr>
<tr>
<td>( CA_{GDP} \uparrow )</td>
<td>1\textsuperscript{st} year average</td>
<td>( \sigma = .5 )</td>
<td>-3.72</td>
<td>-7.88</td>
<td>-8.33</td>
<td>-3.00</td>
<td>-6.16</td>
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<tr>
<td>( t_0^g )</td>
<td>Cumulative</td>
<td>( \sigma = .5 )</td>
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<td>11.33</td>
<td>11.10</td>
<td>-3.13</td>
<td>-7.45</td>
</tr>
<tr>
<td>( FD_{GDP} \uparrow )</td>
<td>Impact</td>
<td>( \sigma = .5 )</td>
<td>1.64</td>
<td>3.10</td>
<td>2.96</td>
<td>1.46</td>
<td>2.59</td>
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</table>

\( \uparrow \) Each cell in the row shows percentage change with respect to the initial steady state at the time or the point in transition mentioned in the second column.

\( \uparrow \) Each cell in the row shows change in percent level with respect to the initial steady state at the time or the point in transition mentioned in the second column.

\( \uparrow \) Each cell in the row contains the duration (years) of the current account deficit.
Table 3: Simulation results for the nonlinear model calibrated to Ghana.

| | \( \frac{m}{F} = 1/3 \) | | | \( \frac{m}{F} = 1/2 \) | | | |
| | \( \sigma = 0.5 \) | \( \sigma = 2 \) | \( \sigma = 3 \) | \( \sigma = 0.5 \) | \( \sigma = 2 \) | \( \sigma = 3 \) |
| \( \nu E^{\dagger} \) | 4th year end | 11.94 | 12.30 | 12.51 | 12.08 | 12.21 | 12.34 |
| \( \nu m^{\dagger} \) | Impact | 19.10 | 67.61 | 85.17 | 16.51 | 48.22 | 58.70 |
| | Maximum | -14.15 | -65.20 | -85.98 | -17.54 | -67.91 | -86.47 |
| \( \nu^{\dagger} \) | Impact/Maximum | -6.80 | -13.02 | -15.40 | -6.26 | -11.26 | -13.02 |
| | 1st year average | -4.95 | -10.06 | -12.09 | -4.54 | -8.44 | -9.88 |
| \( P_N^{\dagger} \) | Impact/Maximum | 14.59 | 29.95 | 36.39 | 13.36 | 25.37 | 29.92 |
| | 1st year average | 10.49 | 22.61 | 27.82 | 9.57 | 18.65 | 22.20 |
| \( r^{\dagger} \) | Impact | 10.02 | 5.93 | 4.92 | 10.27 | 6.16 | 5.22 |
| | 1st year average | 9.66 | 5.66 | 4.47 | 10.08 | 6.17 | 5.07 |
| | Maximum | 10.02 | 5.93 | 4.92 | 10.27 | 6.42 | 5.78 |
| \( \pi^{\dagger} \) | Impact | -23.75 | -33.95 | -39.99 | -23.27 | -31.10 | -33.59 |
| | 1st year average | -22.45 | -32.41 | -35.48 | -21.90 | -29.46 | -31.98 |
| \( CA^{\dagger} \) | GDP | 1st year average | -2.32 | -4.67 | -5.58 | -2.12 | -3.93 | -4.59 |
| | Cumulative | -3.73 | -8.95 | -11.34 | -3.61 | -7.10 | -8.68 |
| | \( t_0^{\ddagger} \) | 3.62 | 5.05 | 6.31 | 4.62 | 5.12 | 6.58 |
| \( FD^{\dagger} \) | GDP | Impact | .46 | .13 | .03 | .48 | .17 | .09 |
| \( FE^{\dagger} \) | GDP | Impact | 1.88 | 6.26 | 8.02 | 1.64 | 4.52 | 5.56 |
| | 3rd year end | -1.56 | 3.71 | 5.43 | -1.86 | 1.74 | 2.73 |

\( ^{\dagger, \ddagger, \cdot} \): See notes for Table 3
Figure 1: Inflation, Productivity Growth and Foreign Currency Balances.
Figure 2: Response of important macroeconomic variables to 1% shock to productivity for the linearized flexible exchange rate model when $\sigma = .5\sigma^*$ and $\beta = .3$ ($\rho = .1$, $z = .05$, $\tau = .25$, $\pi_o = .5$, $\mu = .075$, and $m/F = .5$).
Figure 3: Response of important macroeconomic variables to 1% shock to productivity for the linearized flexible exchange rate model when $\sigma = 3\sigma^*$ and $\beta = .3$ ($\rho = .1$, $z = .05$, $\tau = .25$, $\pi_o = .5$, $\mu = .075$, and $m/F = .5$).
Figure 4: Response of important macroeconomic variables to 1% shock to productivity for the linearized fixed exchange rate model when $\sigma = .5\sigma^*$ and $\beta = .3$ ($\rho = .1$, $z = .05$, $\tau = .25$, $\pi_o = .5$, $\mu = .075$, and $m/F = .5$).
Figure 5: Response of important macroeconomic variables to 1% shock to productivity for the linearized fixed exchange rate model when $\sigma = 3\sigma^*$ and $\beta = .3$ ($\rho = .1$, $z = .05$, $\tau = .25$, $\pi_o = .5$, $\mu = .075$, and $m/F = .5$).
Figure 6: Some major macroeconomic indicators for Uganda.
Figure 7: Some major macroeconomic indicators for Ghana.
Figure 8: Nonlinear solution for the transition paths for major macroeconomic variables for the model calibrated to Uganda ($\tau = .25$, $\sigma = 2$, and $m/F = 1/3$).
Figure 9: Nonlinear solution for the transition paths for major macroeconomic variables for the model calibrated to Ghana ($\tau = .25$, $\sigma = 2$, and $m/F = 1/2$).