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Abstract

This paper presents an analysis of the public investment scaling-up strategy for Togo using a dynamic macroeconomic model that explicitly analyzes the links between public investment, economic growth, and debt sustainability. In the model, public capital is productive and complementary to private capital, generating positive medium and long-run effects to increases in public investment. The model application indicates that a very large increase in public investment would have positive macroeconomic effects in the long-run, but would require unrealistic increases in the tax burden to cover recurrent costs and ensure debt sustainability. More modest increases in public investment would require more feasible increases in the tax burden, particularly if the efficiency of tax collection is improved. The model simulations also emphasize the importance of improvements in the efficiency of public investment to reap welfare gains. However, even if the macroeconomic implications of public investment scaling-up can be favorable in the long-run under certain assumptions on rates of return and efficiency of investment, the transition period is challenging and exposes the country to increased risk of unsustainable debt dynamics. The model was also used to assess the growth projections underlying the standard Excel-based debt sustainability analysis for Togo.

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I. Introduction

This paper presents an evaluation of public investment scaling-up strategies in Togo using the model constructed by Buffie and others (2012), which aims to complement the standard IMF-World Bank debt sustainability framework for low-income countries (LICs) by explicitly modeling and analyzing the links between public investment, economic growth and debt sustainability. The consideration of these links in a coherent analytical framework is especially important in the case of Togo, because the country neglected its infrastructure needs for more than a decade, during its protracted social and political crisis, which led to public investment collapsing. This situation provides a strong rationale for a policy debate on the appropriateness of a rapid investment scaling-up to accelerate the catch-up process. Moreover, Togo successfully reached the completion point under the HIPC initiative in December 2010, bringing down external debt to about 17 percent of GDP. The fiscal space thus created made it an opportune time for Togo to re-examine its debt and investment policies.

In the model, public capital is highly productive and complementary to private capital, generating positive medium and long-run effects to increases in public investment. Nevertheless, additional public investment does not necessarily lead to a growth takeoff that would ensure debt sustainability by itself. The model also allows us to analyze the risks associated with different financing options for the surge in public investment (namely, concessional loans, external commercial loans, and domestic borrowing) and quantifies the required trade-offs and fiscal adjustments over the medium term in order to ensure debt sustainability. This framework assesses sustainability in terms of whether the path followed by debt is explosive in the medium run. Furthermore, several of the model features are suited to the Togolese and other low-income, low-capacity economies, including the modeling of worker's remittance flows and the presence of inefficiencies in public investment that imply that investment does not fully translate into effective public capital because of leakages and capacity constraints.

This paper uses the model to analyze scaling-up scenarios and their implications for debt sustainability and fiscal policy. The model can also be used to interpret data and projections. For a given parameterization the shocks that generated any given set of data can be inferred. While one such application would be a test of the model by interpreting historical data for Togo, such data is scarce and of poor quality, and structural change in recent years would make it difficult to interpret the results. An alternative application, presented here, uses the model to assess IMF staff's 20-year projections that underlie the staff's debt sustainability analysis (DSA) for Togo. An examination of the resulting estimated shocks helps assess whether the assumptions and results of this DSA are consistent with the model, which may have implications for the DSA, the model, or both.

The paper is organized as follows. Section II sets out the evolution of public investment, infrastructure needs, and debt policy in Togo, describing recent trends and achievements. Section III presents a brief description of the model and the calibration to the Togolese economy, and Section IV discusses main results of model simulations. We consider applications of the model with different types of financing: concessional loans exclusively; both concessional and commercial external debt; and domestic borrowing. Furthermore, Section V considers alternative scenarios that include more realistic features of fiscal policies and variations in the efficiency of public investment. Section VI discusses alternative simulations that consider more modest surges in public investment and a gradual path for the acceleration in public investment. In Section VII, we use the model to interpret projections underlying the "standard" DSA for Togo to assess whether its assumptions and results are compatible with the model. Finally, Section VIII concludes with policy implications and avenues for further research.

II. Public Investment and Infrastructure Needs in Togo

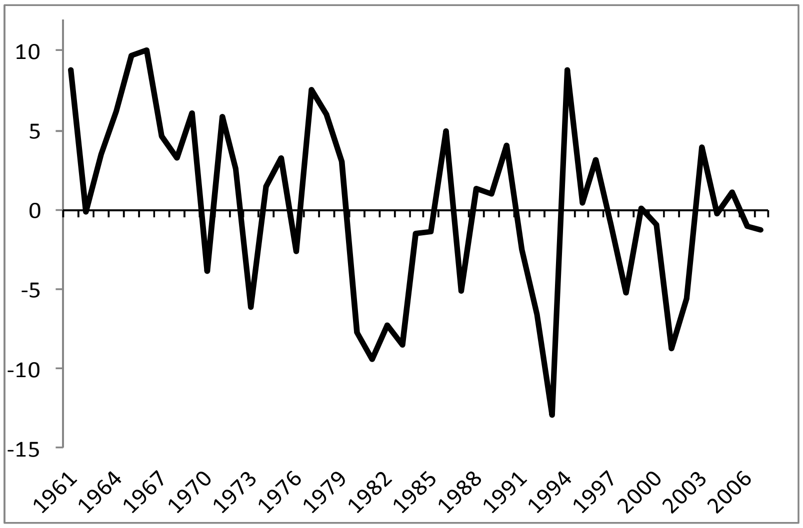
Togo neglected its infrastructure needs during its prolonged domestic social and political crisis, which lasted from the 1990s until the mid-2000s. The 1990s were marked by political instability as the rule of President Eyadéma, in power since 1967, was increasingly contested. This crisis period was characterized by weak fiscal and economic governance, lack of international assistance, and declining per capita income (average real GDP per capita growth in the period 1991-2005 was -1.7 percent[2], see Figure 1).

After the death of President Eyadéma in 2005 and ensuing political turmoil and violence, a national reconciliation and political reform process was initiated, eventually leading to multiparty parliamentary elections in 2007 and re-engagement with the international community. During the crisis, public investment lagged far behind other countries in the sub-region (Figure 2). Only recently, with the implementation of sound macroeconomic policies under an IMF-supported program, have levels of public investment begun to pick up, but without closing the past gap in investment spending.

As public investment sank to low levels for several years, administrative capacity for investment spending also atrophied, leading to low execution rates once budgeted investment spending began to recover. Beginning in 2008, the authorities began to address this problem with an action plan to improve public investment management capacity at the same time as the amount of domestically financed investment was increasing.

[2] Calculations based on Penn World Tables Data (annual growth rate of series rgdpch over the period), see Alan Heston, Robert Summers and Bettina Aten, Penn World Table Version 6.3, Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania, August 2009.

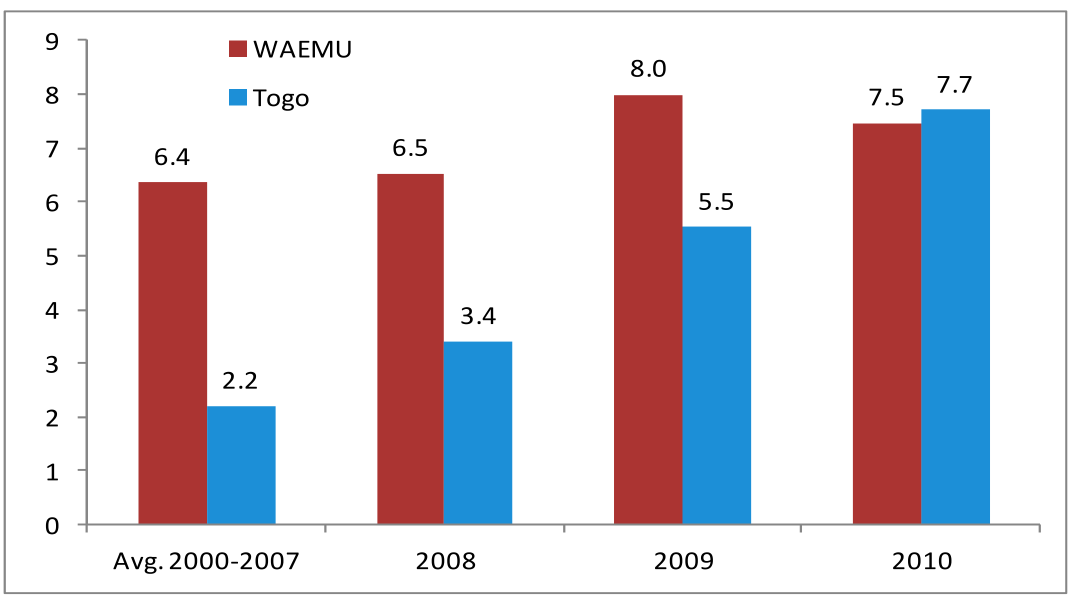
Figure 1. Togo: Real GDP per Capita Growth (1961-2007)



Source: Penn World Tables

The authorities' plan intends to build investment capacity primarily by improving project planning and streamlining procurement rules and spending processes, to speed up project execution without jeopardizing control and quality. Recently completed actions to increase the efficiency of public investment spending include simplifying the expenditure chain by removing redundant control points, which reduced the period for executing spending to a maximum of five weeks, and installing an integrated public financial management system. As a result of these efforts, execution rates for planned public investment increased considerably in 2009 and 2010 compared with previous years, in particular, for investment in infrastructure (Figure 3).

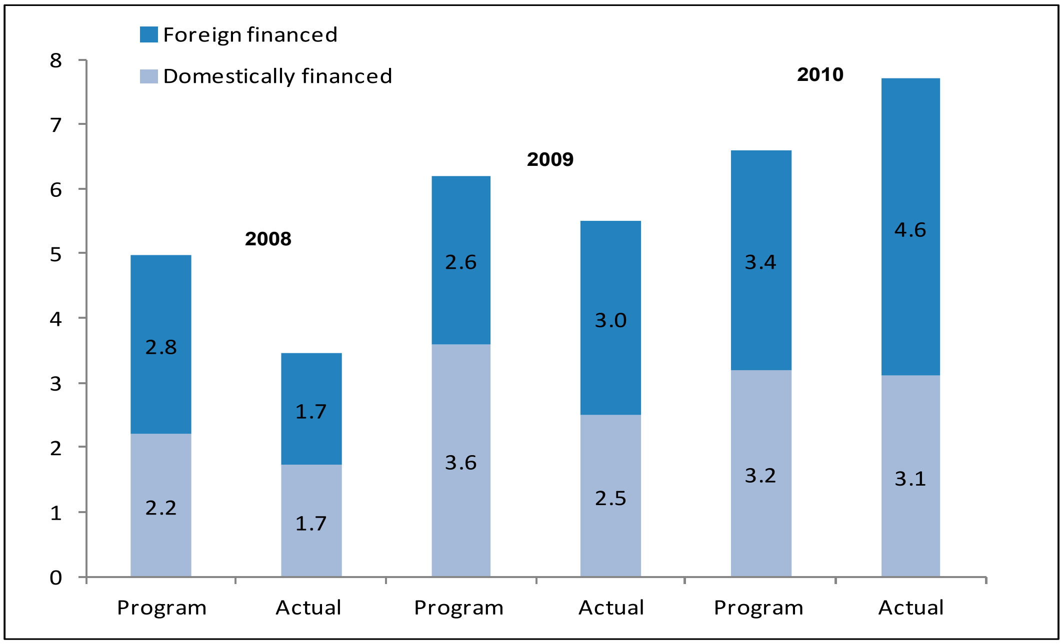
Figure 2. Public Investment As a Share of GDP (percent)



Source: IMF staff estimates and country authorities.
WAEMU= West African Economic and Monetary Union.

In addition to significant improvements in public financial management and administrative capacity over the last three years, Togo also successfully reached the completion point under the enhanced HIPC debt reduction initiative and advanced on the debt management front. Significant challenges remain, however, in particular concerning the elaboration of a comprehensive debt management strategy that follows international best practices. Areas where significant improvement was observed include enhancements in debt service projections and analytical capacity at the public debt management unit, and better coordination among entities involved in debt management (although considerable room for improvement in coordination still exists).

Figure 3. Togo: Public Investment—Programmed and Executed, 2008-2010
(percent of GDP)



Source: IMF staff estimates and country authorities.

As illustrated in Table 1, the stock of external public debt has fallen dramatically since 2007, owing to debt relief from the HIPC, MDRI, and other initiatives involving bilateral, multilateral and commercial creditors. The stock of domestic debt also decreased as more sustainable fiscal policies were implemented and arrears to commercial creditors were cleared. Moreover, re-engagement with the international community after the end of the social-political crisis led to increases in external grants (both budget support grants and grants for specific projects) that are projected to reach 6 percent of GDP in 2011. The IMF-supported program covering the period 2008-2011 included a zero ceiling on the government contracting or guaranteeing non-concessional external debt, with external borrowing therefore limited to loans with a grant element of 35 percent or more for these years. Thus, the terms of external borrowing strongly promoted debt sustainability.

Table 1. Togo: Public Debt and External Financing Profile

	2007	2008	2009	2010 (est.)	2011 (proj.)
			(% of GDP)		
External Public Debt-Stock	81.4	60.9	52.7	17.2	16.0
Domestic Public Debt-Stock	19.3	22.2	15.1	15.1	11.4
Grants (excl. debt relief)	1.7	3.7	4.3	4.7	6.0
External Loans	0.2	0.5	1.4	2.9	1.5

Source: Togolese authorities and IMF staff estimates.

In this context of economic recovery and re-engagement with the international community, the Togolese authorities are planning to rapidly increase public investment in infrastructure in the next 10 years or so (2011–2021). In fact, inadequate infrastructure continues to be a binding constraint on growth. According to a recent World Bank report on competitiveness (World Bank, 2010), Togo's growth will depend on its ability to exploit its central geographic location and relatively attractive port. Given its potential as a transport hub, the economic impact of infrastructure bottlenecks—or conversely, advantages—will be magnified.[3] Moreover, transportation infrastructure investment tends to be large and lumpy with significant network-related synergies. Therefore, there is little doubt that the country has large infrastructure needs that could justify a surge in public investment. The challenge is to ensure that this increase is affordable, consistent with public debt sustainability, and effectively translates into an increase in the stock of effective public capital and sustainably higher GDP levels.

The Togolese authorities' ambitious plans focus on a number of areas including transportation (roads, expansion of the port, railway construction, rehabilitation of airport, among others); energy (for example, the Adjarala dam); telecommunications; water and sanitation; and agriculture. Based on information provided by the authorities, IMF staff estimates that over the 10 year period, the total cost of these investment projects would exceed 192 percent of initial period (2010) GDP. In addition, this investment plan envisages public investment expenditures frontloaded over the next two to three years (notably, 1.3 billion euros over the first two years). It is important to bear in mind that some of the projects considered are expected to be financed through public-private partnerships, although details of the arrangements are not available, and therefore might not necessarily engender a direct and immediate fiscal burden.

[3] Accurate and up-to-date data on the stock of infrastructure, relative to comparable countries in the region, are difficult to obtain, partly owing to the impact of the crisis.

III. FEATURES OF THE MODEL AND CALIBRATION TO THE CASE OF TOGO

The model elaborated by Buffie and others (2012) that is applied to Togo in this paper is a two-sector open economy dynamic general equilibrium model with three types of public sector debt (external concessional, external commercial and domestic debt) that attempts to capture some of the features of a typical low-income country.[4] This model is intended for long-run analysis and therefore does not include money or nominal rigidities.

An interesting feature of the model is that public capital (infrastructure) enters the production function for both tradable and non-tradable goods (Section A- Equation 1). Nevertheless the extent to which public investment produces additional infrastructure depends on a parameter measuring the efficiency of investment (Equation 5).

Another useful feature of the model is that it allows comparison of the implications of a range of financing options. Concessional loans by official creditors and grants from donors are both considered to be determined exogenously and are therefore fixed. Since they are the cheapest forms of financing, policy makers are assumed to use them as much as possible. In addition, the model can simulate governments borrowing under non-concessional terms at home and abroad.

Meanwhile, governments can also modify tax policy and user fees in the model. The tax burden (modeled as a tax rate on consumption) is a crucial policy variable, and changes in the speed and size of the fiscal adjustment (i.e., increases in the tax burden) eventually required to pay for the investment scaling-up are important for determining whether debt will follow a sustainable path.

The main lesson of the model is the need to consider the dynamic interactions of public investment, growth, recurrent costs, and fiscal policy. In addition to servicing the debt, the government needs to pay for depreciation, if it desires a sustained increase in public capital. Therefore, even when investment has a high rate of return, it may not fully pay for itself from the point of view of the fiscal authorities if tax rates and user fees are low and the benefits initially accrue mainly to the private sector. There may also be a transitional fiscal problem if the benefits of the public investment do not fully materialize before the debt needs to be repaid.

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[4] It does so by, for example, taking into account the importance of grants and workers' remittances in the model, by introducing imperfect access to international capital markets and by incorporating "hand-to-mouth" consumers who do not save and therefore allow for non-Ricardian effects. See Buffie and others (2011) for details.

A. The Structure of the Model

In this section, we present a simplified version of the model focusing on some key features, such as inefficiencies in public investment and fiscal reaction functions. Further details are discussed in Buffie and others (2012). There are two productive sectors in the economy, one that produces non-tradable goods, denoted by q_n, and one that produces tradable goods, denoted by q_x. In addition to these domestically produced goods, agents can import a traded good (m), which can be consumed or used to build capital. The production function is outlined in Equation 1. For each sector *i* (with *i* = *n* , *x*), a representative firm uses a Cobb-Douglas technology to convert labor ($L_{i,t}$), private capital ($k_{i,t-1}$), and productive infrastructure (z^e_{t-1}), into output ($q_{i,t}$). Note that infrastructure is a public good in this set-up[5].

$$q_{i,t} = A_{i,t}(z^e_{t-1})^{\psi_i}(k_{i,t-1})^{\alpha_i}(L_{i,t})^{1-\alpha_i} \tag{1}$$

Firms in both sectors operate in a competitive environment and maximize profits, such that the marginal value of each input is equal to its factor price. Thus, they maximize the following objective function, where $\mathrm{p}_{i,t}$ denotes the price of the output of the relevant sector, w_t refers to wages, and $r_{i,t}$ is the rental rate of capital in each sector:

$$\mathrm{Max}\ \mathrm{p}_{i,t}q_{i,t} - w_t L_{i,t} - r_{i,t}k_{i,t-1} \tag{2}$$

There are two types of consumers in the model: "savers" and "non-savers" (who consume all of their income in each period, i.e., live "hand-to-mouth", which allows for non-Ricardian effects). The "non-savers" budget constraint is given by Equation (3), where *a* is the labor ratio of "non-saver" consumers to "savers". These consumers derive income from wages, remittances (R) and transfers (T). Remittances and transfers are assumed to be proportionate to the consumers' share in aggregate employment. P is the consumer price index derived from a Constant Elasticity of Substitution (CES) basket that includes a domestic traded good, a foreign traded good, and a domestic non-traded good such that $P_t^{1-\varepsilon} = [\rho_x P_{x,t}^{1-\varepsilon} + \rho_m P_{m,t}^{1-\varepsilon} + \rho_n P_{n,t}^{1-\varepsilon}]$. Furthermore, nominal consumption is subject to a tax. The tax rate *h* is a summary of the tax burden (there are no other taxes in the economy):

---

[5] Given the properties of the Cobb-Douglas production function, holding other factors constant there are decreasing returns to public effective capital. Therefore, if the stock of public capital is relatively low (perhaps because a large part of public investment undertaken in previous years has been wasted), returns to public capital are likely to be higher. In this context, assumptions about the efficiency of public investment (i.e. how public investment translates into effective public capital, see the detailed discussion below) will have implications for the rate of return on effective public capital (i.e. the marginal product of public capital net of depreciation). In fact, steady-state efficiency of public investment and the marginal product of effective public capital are inversely related (Buffie and others, 2012).

$$(1+h_t)P_t c_t^{\mathrm{H}} = w_t L^{\mathrm{H}} + \frac{a}{1+a}(R_t + T_t) \tag{3}$$

"Savers" behave differently and can invest in private capital in both the tradable and non-tradable sectors ($I_{i,t}^S$ in Equation 4 denotes investment in each of the sectors). They also pay user fees for infrastructure services (μz^e), can buy domestic bonds (b_t^S), and can contract foreign debt (b_t^{S*}). Therefore they solve the maximization problem described in Equation 4, subject to three constraints. In Equation 4, r denotes the real interest rate on domestic bonds and r^* the interest rate on foreign debt, τ is the intertemporal elasticity of substitution (and 1/τ is the coefficient of relative risk aversion), β is the discount factor, δ is the depreciation rate, Φ_t^S are profits for domestic firms, and g is the trend growth rate. The $AC_{i,t}^S$ terms refer to capital adjustment costs in each of the sectors, and Υ_t^S are portfolio adjustment costs linked to foreign liabilities, capturing the degree of financial account openness. The model is rescaled by a permanent component of sector-wide total factor productivity, growing at a rate (g).

$$\text{Max} \sum_{t=0}^{\infty} \beta^t \frac{(c_t^S)^{1-1/\tau}}{1-1/\tau}$$

subject to

$$P_t b_t^S - b_t^{S*} = r_{x,t} k_{x,t-1}^S + r_{n,t} k_{n,t-1}^S + w_t L_t^S + \frac{R_t}{1+a} + \frac{T_t}{1+a} - \frac{1+r_{t-1}^*}{1+g} b_{t-1}^{S*}$$

$$+\frac{1+r_{t-1}}{1+g} P_t b_{t-1}^S - P_{k,t}(I_{x,t}^S + I_{n,t}^S + AC_{x,t}^S + AC_{n,t}^S) - P_t\, c_t^S (1+h_t) - \mu z_{t-1}^e - \Upsilon_t^S - \Phi_t^S, \tag{4}$$

and

$$(1+g)k_{x,t}^S = I_{x,t}^S + (1-\delta)k_{x,t-1}^S,$$

$$(1+g)k_{n,t}^S = I_{n,t}^S + (1-\delta)k_{n,t-1}^S$$

One of the key features of the model is its ability to capture inefficiencies in public capital creation. In this context, public investment (I_z) produces additional public capital or infrastructure (z^e) according to Equation 5, where $\overline{I}_z$ is public investment at the initial steady state. Because the parameter (*s*) takes a value between zero and one, this equation implies that one dollar of additional public investment (the second term of the right-hand-side of Equation 5) does not necessarily translate into one dollar of effective public capital.

$$(1+g)z_t^e = (1-\delta)z_{t-1}^e + s(I_{z,t} - \overline{I}_z) + s\overline{I}_z \tag{5}$$

Furthermore, the model allows one to quantify the fiscal adjustment required to ensure debt sustainability. In order to do so, it uses the government's budget constraint defined by Equation 6. The left-hand-side of Equation 6 is financing ("below the line") and the right-hand-side is the government revenue and expenditure ("above the line). The first positive terms on the right-hand-side of the equation refer to expenditure on debt service (domestic debt, external commercial debt, concessional debt), infrastructure investment, and government transfers, respectively. The negative terms are "revenue" items, namely tax revenue on consumption, grants (exogenous, obtained from donors), and revenue from user fees on infrastructure. When revenue falls short of expenditure, the deficit is financed by borrowing domestically or abroad (on commercial and/or concessional terms).

$$
\begin{aligned}
P_t \Delta b_t + \Delta d_{c,t} + \Delta d_t &= \frac{r_{t-1} - g}{1+g} P_t b_{t-1} + \frac{r_{d,t-1} - g}{1+g} d_{t-1} + \frac{r_{dc,t-1} - g}{1+g} d_{c,t-1} \\
&+ P_{z,t} I_{z,t} + T_t - h_t P_t c_t - G_t - \mu z_{t-1}^{e}
\end{aligned}
\tag{6}
$$

With the path for public investment and concessional loans taken as given (exogenous to the model), the government uses all concessional resources available and the fiscal gap before policy adjustment is defined by Equation 7. This ex ante gap corresponds to the gap when taxes and transfers are kept at initial values (h_o and T_o)[6].

$$
GAP_t = \frac{1+r_d}{1+g} d_{t-1} - d_t + \frac{r_{dc,t-1} - g}{1+g} d_{c,t-1} + \frac{r_{t-1} - g}{1+g} P_t b_{t-1} + P_{z,t} I_t + T_o - h_o P_t c_t - G_t - \mu z_{t-1}^{e} \tag{7}
$$

Nevertheless, debt sustainability requires that taxes and transfers eventually adjust to cover the gap. Throughout the paper, we assume in the experiments that transfers are exogenous and all the burden of adjustment falls on taxes. The target for the debt-stabilizing level of the tax rate is defined by $h_t^{target} = h_o + \dfrac{Gap_t}{P_t c_t}$. In a given year, taxes are determined according to the reaction function outlined in Equation 8, where h^u represents a ceiling on taxes and h_t^r is the tax level determined by the fiscal rule[7]. y_t is the output level or GDP in a given year (defined as $y = P_n q_n + P_x q_x$). Note also that the debt target (d_c^{target}) is exogenously given.

[6] Using Equation 7, it is possible to redefine the budget constraint for any given year as
$Gap_t = P_t \Delta b_t + \Delta d_{c,t} + (h_t - h_o) P_t c_t - (T_t - T_o)$

[7] Note that this equation presents the case where the fiscal rule responds to external commercial borrowing. In the case where it responds to domestic borrowing, dc should be replaced by b.

$$h_t = Min\{h_t^r, h^u\}$$

$$h_t^r = h_{t-1} + \lambda_1 (h_t^{target} - h_{t-1}) + \lambda_2 (\frac{d_{c,t-1} - d_c^{target}}{y_t}), \text{ with } \lambda_1, \lambda_2 > 0 \qquad (8)$$

B. Model Calibration

The model's parameters were calibrated to match data for the Togolese economy. When Togo-specific estimates were not available, the parameters were set to fit a "generic" low income country, as described in Buffie and others (2012). Table 2 presents the calibration of the main parameters of the model. We assume a trend growth rate of 4.1 percent (around 1.6 percent in per capita terms), which is in line with the average real GDP growth used in the standard DSA exercise for Togo.

Debt Dynamics Parameters

The key parameters for the dynamics of debt are the return on investment, the share of public investment spending that is eventually installed as physical capital ("investment efficiency") and the user fees that allow recouping recurrent costs in the use of public capital. The return on infrastructure was set at 25 percent based on the literature regarding infrastructure investment in Africa, but it is important to note that existing estimates of the rate of return on infrastructure vary significantly (ranging from 15 to 30 percent), as discussed in Buffie and others (2012)[8]. Unfortunately, information permitting a precise assessment of rates of return of planned public investment projects in Togo was not available; this is an issue that should be further investigated in future applications of the model.

In the baseline model, we also assume public investment is not fully efficient, implying that every dollar invested by the government creates less than one dollar in public "effective" capital. The relevant parameter is set at 0.5 based on the estimates of Pritchett (2000) for sub-Saharan Africa[9]. Togo's relatively low efficiency of public investment also underlies our assumption that the rate of return to installed public capital is relatively high. If a large share

[8] Note that in the context of the model, the rate of return on public capital is the marginal product of effective public capital minus the depreciation rate on this capital.

[9] Togo ranks in the bottom quartile of the distribution of the index for public investment management quality (PIMI) developed by Dabla-Norris and others (2011). This index comprises measures of the quality of appraisal, selection, management and evaluation of public investment projects. Nevertheless, it is important to note that there is no direct mapping between the PIMI index (which is a relative measure) and the efficiency parameter discussed in the model. The results presented in this paper are broadly unchanged when one sets the efficiency parameter at 0.4, but when efficiency is very low (for example when s=0.2) the conclusions are significantly altered, as discussed below. It is also important to note that Pritchett's estimates were based on data from before 2000. A number of sub-Saharan African countries, including Togo, have made considerable progress in public financial management since then, as evidenced in improving assessments by international organizations.

of prior investment spending has been effectively wasted, then the stock of public capital would accordingly be small, which in turn increases the scope for new installed public capital to be highly productive. Furthermore, user fees are assumed to allow recouping about 50 percent of recurring costs, which is in line with the average for sub-Saharan Africa, as discussed in Briceno-Garmendia, Smits, and Foster (2008). Similarly to data on rates of return, information that would permit an estimation of this critical parameter for the model was not available; this issue merits further attention in future applications.

Macroeconomic Parameters

The public investment-growth nexus also depends on a set of macroeconomic parameters that determine the reaction of the economy to debt and public capital accumulation. The portfolio adjustment cost parameter calibrates the sensitivity of interest rates on external borrowing to debt accumulation. Intuitively, one would expect that a higher stock of debt would entail higher interest rates. This parameter was set at a relatively high level, reflecting a low degree of international financial integration for the private sector.

The ratio of non-savers to savers matters as it influences the sensitivity of domestic interest rates and of domestic consumption decisions to fiscal policy (i.e. it calibrates the extent to which the model is non-Ricardian). It was set to match the poverty rate for Togo, which was estimated to be close to 62 percent in the last PRSP, based on data from household surveys. We also used recent data for Togo (mostly from 2009 and 2010) to set the initial values for the tax rates on consumption, private consumption and trade/GDP shares, the share of remittances to GDP, the share of grants to GDP, the initial public investment to GDP ratio, as well as the initial external and domestic debt to GDP ratios.

Moreover, the parameters for capital's share in value added in the traded and non-traded sectors were chosen based on the social accounting matrix for the Togolese economy constructed by Agbodji and others (2010). National accounts in Togo are of poor quality and seem to underestimate the capital share in the tradable sector. This share was increased in our calibration, to 0.25. The parameter on the cost share of non-traded inputs in the production of capital was chosen based on data on the ratio of imported capital goods to aggregate gross fixed capital formation in Togo in the period 2007-2009.

The distribution parameters for traded goods and for imported goods (γ_x and γ_m) were selected to match the share of the non-tradable sector in GDP and the share of imports to GDP (note that γ_x=1- γ_n - γ_m)[10]. Finally, fiscal reaction function parameters, Tobin's q-elasticity of investment spending parameter, the ratio of the elasticity of the traded sector to

[10] Also note that the share of imports to GDP is equal to gama_m multiplied by initial consumption plus initial investment in the tradable and non-tradable sectors as well as initial public investment (Imports/GDP = γ_m*co+i_{no}+ i_{xo} +i_{zo}).

infrastructure, and the elasticity of the non-traded sector to infrastructure were set at the same values used in Buffie and others (2012) because of lack of Togo-specific data.

Table 2. Calibration of Main Parameters (Base Case)

Parameter	Value	Definition
τ	0.34	Intertemporal elasticity of substitution
ε	1.50	Intratemporal elasticity of substitution across goods
α_x	0.25	Capital's share in value added in the traded sector
α_n	0.30	Capital's share in value added in the non-traded sector
α_k; α_z	0.48	Cost share of non-traded inputs in the production of capital
δ_x; δ_n; δ_z	0.05	Depreciation Rates
γ_x	0.32	Distribution parameter for traded goods
γ_m	0.44	Distribution parameter for imported goods
f	0.50	User fees for infrastructure services (% of recurrent costs)
g	0.015	Trend per capita growth rate
ro	0.051	Initial real interest rate on domestic debt
r_{dco}	0.051	Real interest rate on external commercial debt
R_{zo}	0.25	Initial return on infrastructure
b/Y	0.15	Initial public domestic debt to GDP ratio
d/Y	0.18	Initial external concessional debt to GDP ratio
G/Y	0.05	Grants to GDP ratio
R/Y	0.08	Remittances to GDP ratio
i_z/Y	0.08	Initial ratio of infrastructure investment to GDP
s	0.50	Efficiency of public investment
h_o	0.196	Initial consumption taxes
λ_1	0.25	Fiscal reaction parameter (policy instrument)
λ_2	0.02	Fiscal reaction parameter (debt terms)
a	1.50	Ratio of non-savers to savers
η	1.00	Portfolio adjustment cost parameter
Ω	2.00	Tobin's q-elasticity of investment spending
$\Psi x/\Psi n$	1.00	Ratio of the elasticity of the traded sector to infrastructure and the elasticity of the non-traded sector to infrastructure

IV. Simulation Results Under the Base Case

The main experiment undertaken in this section is an increase in public investment frontloaded in the early years, from an initial value of 8 percent of GDP to a peak of 17.6 percent of GDP after three years. The increase in public investment simulated amounts to 32.3 percent of initial GDP during the first 10 years (with an increase of 13.1 percent of initial GDP over the first 3 years). The public investment to GDP ratio would eventually go back to 11.3 percent after 10 years. Although such a scaling-up in public investment might seem large, it is less ambitious than the identified public investment plans/needs discussed in previous sections, where total public investment could exceed 192 percent of initial GDP over 10 years.[11]

A. Long-run Effects of Scaling Up

We focus first on the long-run effects of the investment scaling up. We assume there are no limits imposed on the size or speed of fiscal adjustment and therefore tax rates increase to finance this additional investment (expenditure cuts are not considered). As expected, the assumptions regarding the returns on public capital and the efficiency of public investment affect significantly the long-run impacts of the public investment increase, as illustrated in Table 3.

Remarkably, even under optimistic assumptions, the scaling-up is not quite self-financing, reflecting the low rate of overall tax collection. Under the "optimistic" parameterization (alternative 1 in the table below), where the return on public capital is set to 35 percent and the efficiency of investment is set at 0.8, real GDP, consumption, the stock of public effective capital, and the private capital stock increase by more than 12 percent in the long-run. The investment scaling-up is very nearly self-financed in the long run and would only require a small increase in the consumption tax rate in the steady state. This should be compared with a required increase in the tax burden by over two percentage points under the baseline calibration. It is important to note that in both the baseline and optimistic cases, the model results suggest that, a temporary deviation from the debt-stabilizing fiscal balance (i.e., that ensures debt stabilization over the long run) that is linked to the increase in public investment can under certain circumstances increase GDP levels with only a moderate rise in risk levels.

Inversely, under the "pessimistic" parameterization (Alternative 2 in the table), which takes the lower bound estimates of return to public capital (10 percent) and of efficiency of public investment (0.2), real GDP grows by less than 2 percent relative to the initial steady state, consumption falls by 3 percent, which implies that with this calibration an investment scaling up is undesirable. In addition, the tax burden must be increased by around 5 percentage points to repay debt, an unrealistic adjustment for a low-income country like Togo. We return to this point later.

[11] This number overestimates public borrowing linked to the scaling-up because the identified public investment plan includes a large number of public-private partnerships, notably in transport infrastructure and telecommunications.

Table 3. Long-run Effects Under Different Choices of Parameters

	Baseline	Alternative 1	Alternative 2
	R=0.25, s=0.5	R=0.35, s=0.8	R=0.10, s=0.2
Taxes (%)	22.3	20.1	24.4
Crowding-in coefficient	0.8	1.0	0.4
Public Effective Capital	48.1	76.9	19.2
Private Capital	8.7	18.1	1.7
Real GDP	8.5	18.0	1.5
Real Wages	8.4	17.9	1.5
Consumption	3.6	12.5	-3.0
Output in tradable sector	7.6	17.6	0.2
Output in Non-tradable sector	10.3	18.7	4.1

The effects are measured in percent change between the steady states, except for taxes and the crowding-in coefficient. The crowding-in coefficient is defined as the change in private capital following a change in public capital ($\Delta k/\Delta z$).

B. Fiscal Adjustment with Concessional External Debt

We now describe the dynamics of a scenario where the government has access to a limited amount of concessional external debt to finance the increase in public investment. We also assume an exogenous path of external grants that would finance part of the fiscal deficits in addition to concessional loans; the rest of the financing needs would have to be covered by domestic taxation. The responses over a 30-year horizon of some of the key variables are presented in Figure 4.[12] By the end of the period (year 30), both real GDP and private investment increase by 7 percent relative to the initial steady state, even though the scenario embeds some crowding-out of private investment in the early years. Concessional and total public debt also increase as a percentage of GDP, reaching a peak of 41.6 and 55.9 percent respectively, but start decreasing after 10 years. Public debt stabilizes by year 30 (below 45 percent of GDP). In general, increases in total public debt are compatible with so-called "speed bumps" of the IMF's debt sustainability framework of 5 percent of GDP increases in any given year.

The short-term macro-economic consequences of the scaling-up are relatively standard. As investment increases demand for non-tradable resources, the relative price of non-traded goods (i.e., the real exchange rate) appreciates during the initial years, drawing resources from the tradable sector to the non-tradable sector. The appreciation in the real exchange rate contributes to a marked deterioration in the current account deficit over the first three years, with a gradual narrowing down of the deficit thereafter as the exchange rate depreciates.

[12] Note that the long-term effects discussed in Table 1 are not fully reflected over the 30 periods presented in this figure.

It is important to note that the rather benign trajectory for debt requires highly optimistic or even unrealistic increases in tax rates over extended periods of time (see discussion in Section V). It is also important to bear in mind that we focus the simulations on the case where the burden of fiscal adjustment falls exclusively on taxes and government transfers remain constant as a proportion of GDP. This is an admittedly strong assumption, but it could be justified by considering the large share of recurrent spending (e.g., public sector wages) in total expenditure. In fact, tax rates on consumption would increase from 19.6 percent of GDP to 22.9 percent after five years. Given the profile of debt repayment and assumptions regarding the availability of concessional financing, taxes would eventually surpass 24 percent of GDP in the medium term, before eventually decreasing to 22.7 percent in year 30.

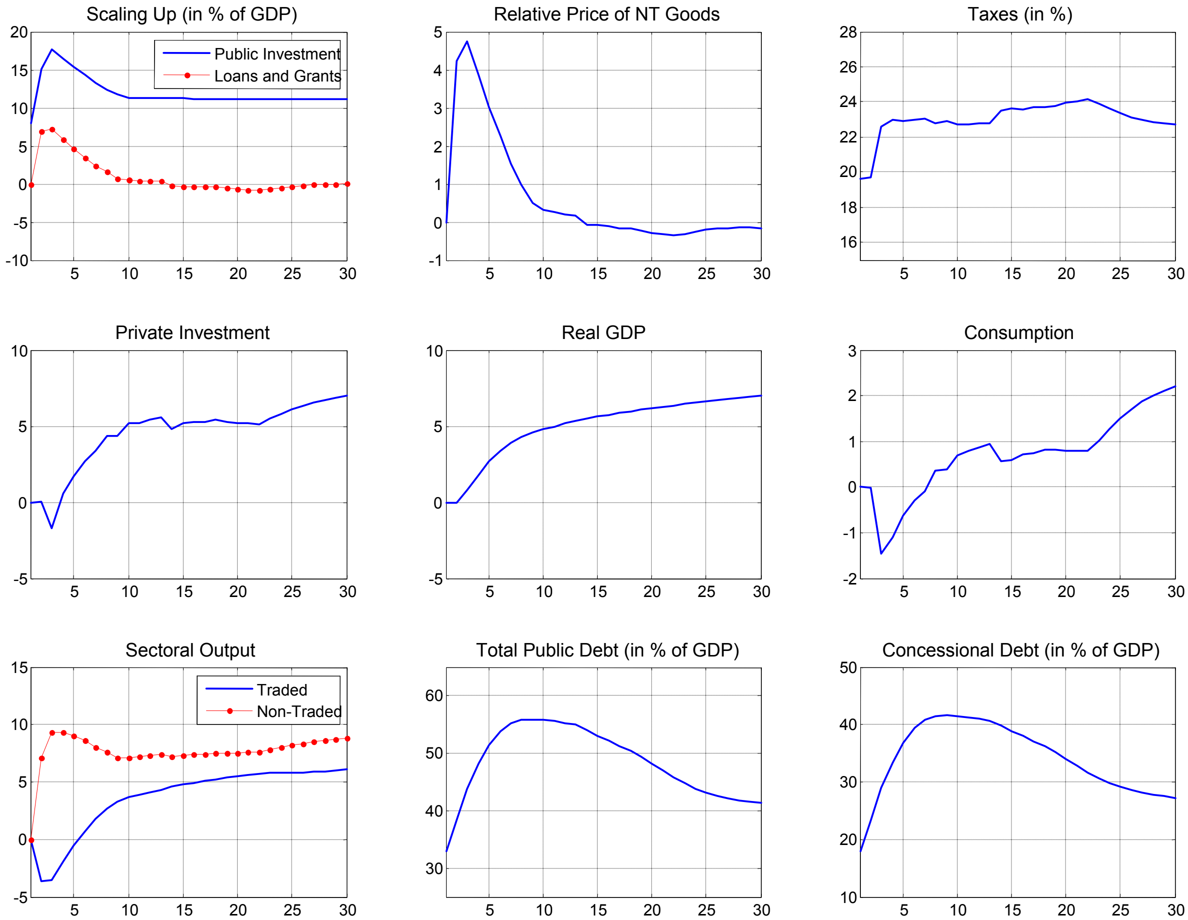
Even without considering issues related to administrative capacity constraints for tax increases, it is difficult to say whether such fiscal adjustment would be politically feasible. Not only are tax increases of this magnitude politically and administratively challenging, but keeping current spending constant as a proportion of GDP also poses challenges. In particular, real wages are projected to increase during the investment surge, putting pressure in turn on current spending. It is also possible to modify the fiscal reaction functions that will govern the distribution of adjustment between taxes and transfers (spending), as well as the speed of adjustment of taxes and transfers to target levels. This could allow for more realistic patterns of the fiscal adjustment required to repay debt. The next sub-section will discuss how access to commercial external borrowing could help to smooth the fiscal adjustment.

C. Introducing External Commercial Borrowing

As expected, crowding-out is dampened when additional commercial external borrowing is available. As the government accesses additional external resources, fiscal adjustment is made easier (first panel in Figure 5) and the rise in domestic interest rates is muted. This in turn smoothes the paths of consumption and investment, which are not crowded-out. However, the real exchange rate appreciates further in the initial years compared to the concessional borrowing-only case, because the availability of external financing also pushes aggregate demand and demand for non-tradables.

As a result, output in the traded sector contracts further, although the difference is marginal (-4.2 percent after three years compared to –3.5 percent in the concessional borrowing-only case). Indeed, the negative effect of the real exchange rate appreciation is compensated by a lower real interest rate and lower taxes, which contribute to higher investment and higher output.

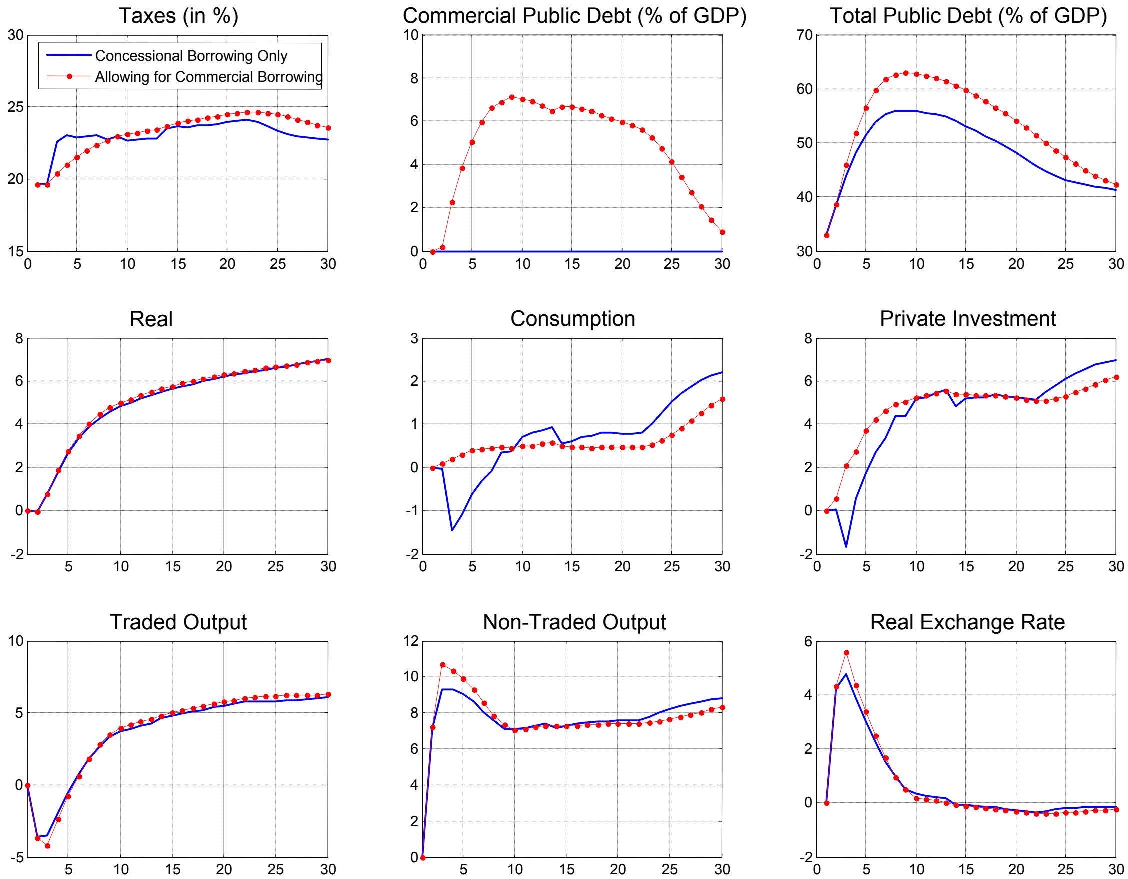
Figure 4. Key Results of Model with Concessional External Debt



Note: GDP, consumption, sectoral output, and private investment are expressed as percent deviations from the initial steady-state.

Debt dynamics continue to be favorable, because commercial public debt peaks at 7.1 percent of GDP after 9 years and gradually decreases thereafter; whereas total public debt peaks at around 63 percent of GDP, eventually returning to around 42 percent of GDP in "year 30". Tax rates still have to increase rapidly, exceeding taxes in the previous scenario after 8 years.

Figure 5. Model Allowing for Commercial External Debt Compared to Model with Concessional Borrowing Exclusively



Note: Real GDP, consumption, and private investment are expressed as percentage deviations from the initial steady state. The burden of fiscal adjustment falls exclusively on taxes in this specification.

D. The Role of Domestic Borrowing Versus External Commercial Borrowing

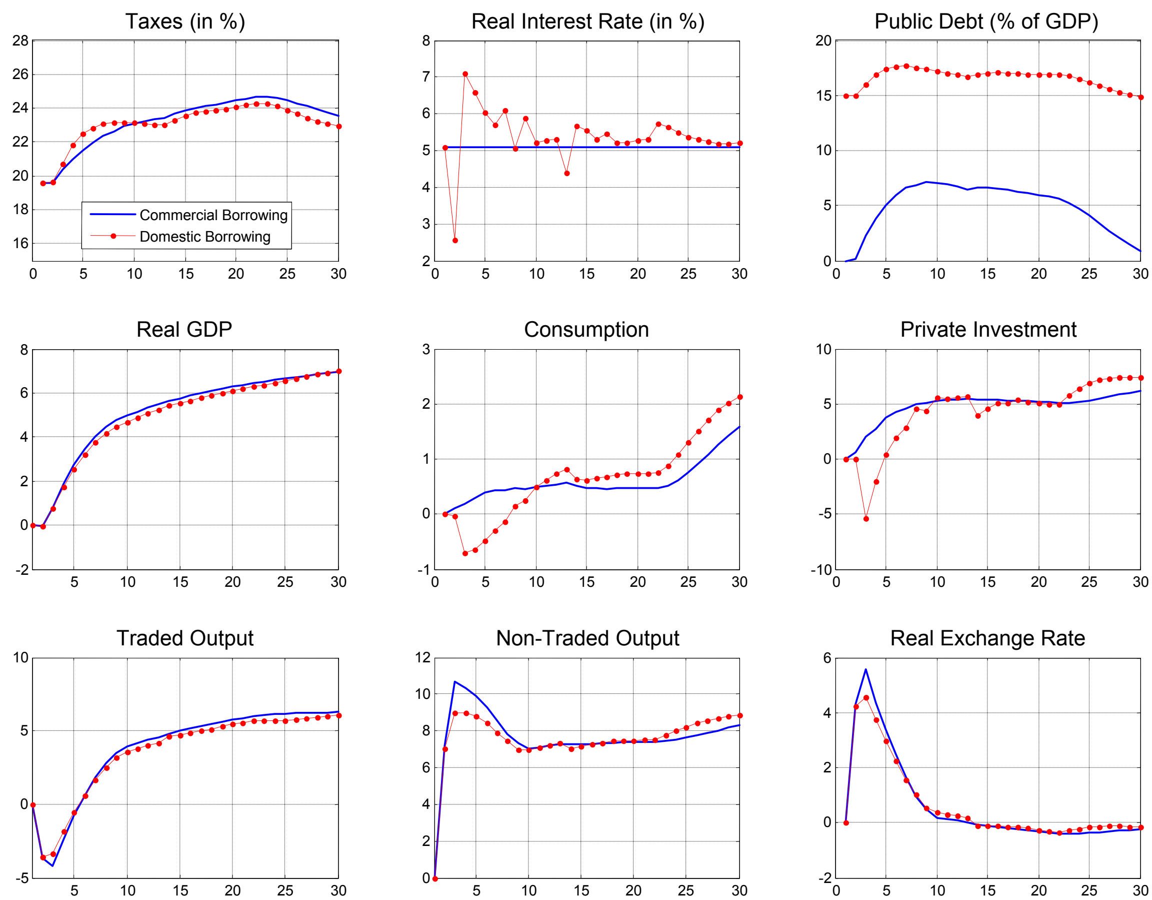
Domestic debt is typically less effective than commercial external debt in smoothing the fiscal adjustments required to finance the increase in public investment. This occurs because domestic debt cannot reduce crowding-out of private investment because no “additional” resources are brought to the economy. In addition, domestic borrowing has a distortive effect on investment decisions as it adds volatility to domestic interest rates (see also the discussion in Buffie and others, 2012).

Figure 6 broadly illustrates these results for Togo. When the government borrows on domestic markets, domestic interest rates rise and private investment is crowded-out, especially for the first four years (investment declines by more than 5 percent in year three). In addition, public debt is higher and declines more slowly over time because financing terms are more expensive for domestic borrowing than for external concessional borrowing.

Two factors specific to Togo that might affect the results need to be examined further. First, like all member countries of the WAEMU, Togo issues "domestic" (local currency) debt in a regional bond market, which might dampen the crowding out effect on private investment. In fact, as much as two-thirds of local currency debt arguably could be considered external commercial debt. Second, there is generally excess liquidity in Togo's banking system. As a result, crowding-out might be reduced if borrowing simply shifts funds from deposits at the central bank to loans to the government. However, if many WAEMU countries were to resort to larger local currency borrowing at the same time, crowding-out effects could surface.

Finally, it is important to note that the results presented in Figures 4 through 6 are based on a specification where the tax burden can reach any level. We discuss in the next section an alternative specification in which fiscal policy is constrained.

Figure 6. Domestic Borrowing Versus External Borrowing



V. Realistic Assumptions for Fiscal Policy and Investment Efficiency

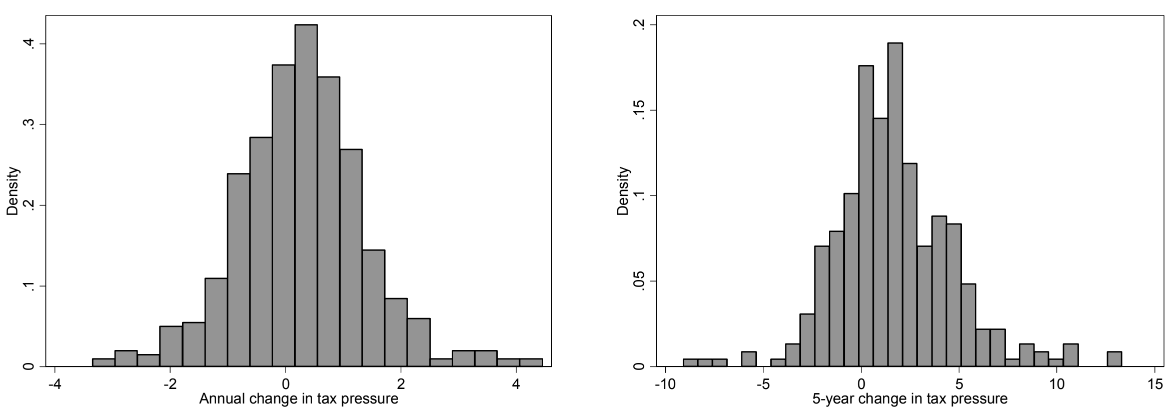
The previous sections presented baseline results where the public sector is assumed to work efficiently. In particular, tax revenues can be raised at any time and reach any required level, and public investment is as efficient in generating productive capital as in a typical sub-Saharan African countries. In this section we explore how changing these assumptions affects the analysis of debt sustainability in Togo. The previous section discussed the limited role played by domestic debt in smoothing fiscal adjustments and therefore we will now focus on the scenario of the model that includes commercial external debt and compare results to the case including only concessional debt.

A. Fiscal Policy

The rather benign trajectories for debt obtained in the previous section require optimistic increases in taxes over extended periods of time, with the tax burden exceeding 24 percent in the medium term.[13] Even abstracting from capacity constraints in tax collection, it is difficult to argue that such fiscal adjustment would be politically feasible.

For low-income countries, over the period 2000-2010 annual increases in the tax burden exceeded 2 percentage points of GDP in only 5 percent of country-years (Figure 7). In addition, the probability of sustaining large adjustments with taxes is only 10 percent (i.e., only 10 percent of country-years witnessed increases in the tax burden by more than 5 percentage points of GDP over 5 years). Togo has been performing well on that account, with increases in tax revenue exceeding 4 percentage points between 2002 and 2010, but the question remains whether the country could strengthen revenue further.

Figure 7. Distribution of Changes in the Tax Burden (PRGT-eligible countries, 2000-2010)



Source: Authors' calculations based on *World Economic Outlook* data.

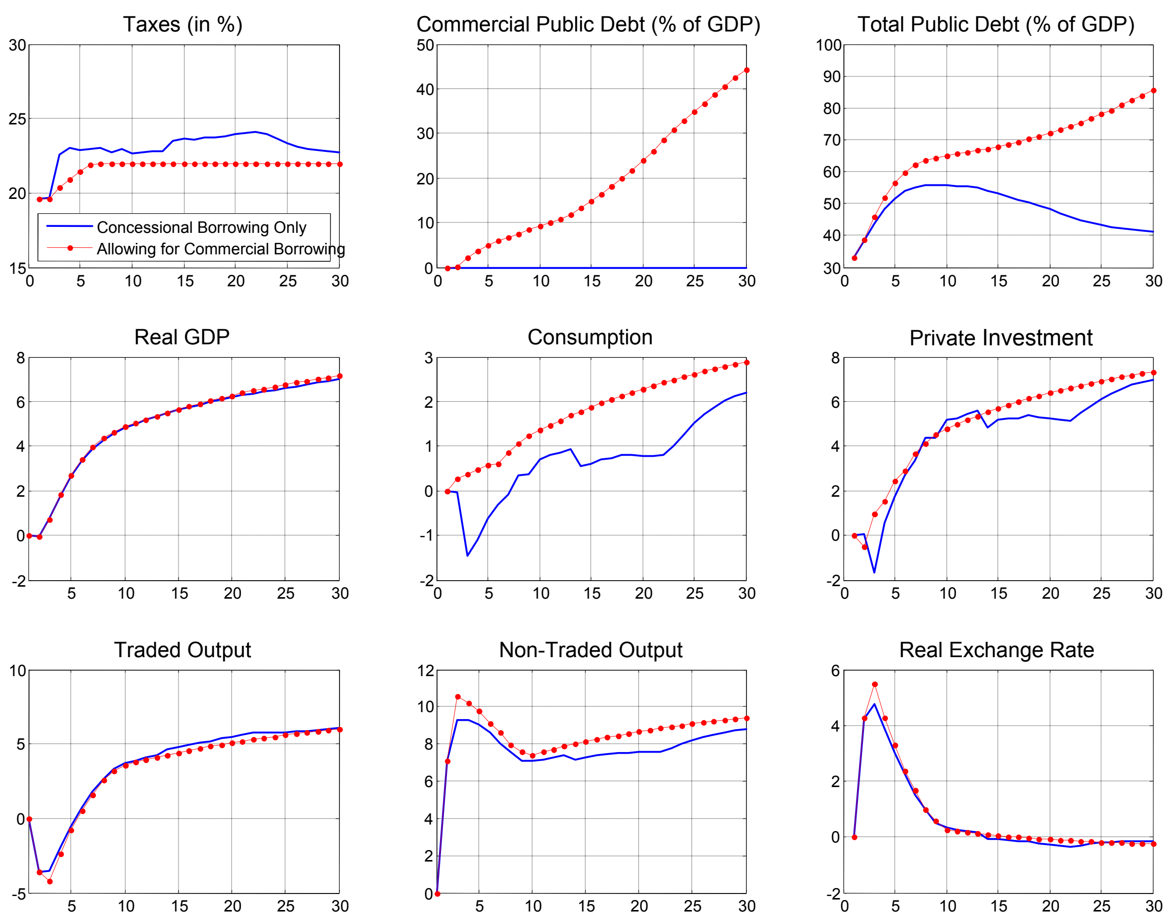
[13] Because our focus is on simulations where the burden of fiscal adjustment falls exclusively on taxes (government transfers are kept constant), this scenario, arguably, overestimates the required tax burden. The assumption that current spending is constant is nonetheless predicated by the large share of recurrent spending (e.g., public sector wages) in current expenditure. In the model, it is possible to modify the fiscal reaction functions that govern the distribution of adjustment between taxes and transfers (spending) to capture the difficulty of revenue mobilization in LICs. This allows for more realistic patterns of fiscal adjustment.

We investigate the impact of constraints on the size of the fiscal adjustment by capping the consumption tax rate at 22 percent. Under these conditions, the trajectories for commercial and total public debt become explosive over the 30-year horizon and look unsustainable, as illustrated in Figure 8. Of course, if the cap imposed is high, say 24 percent, trajectories are similar to the ones in Figure 5.

B. Efficiency of Investment

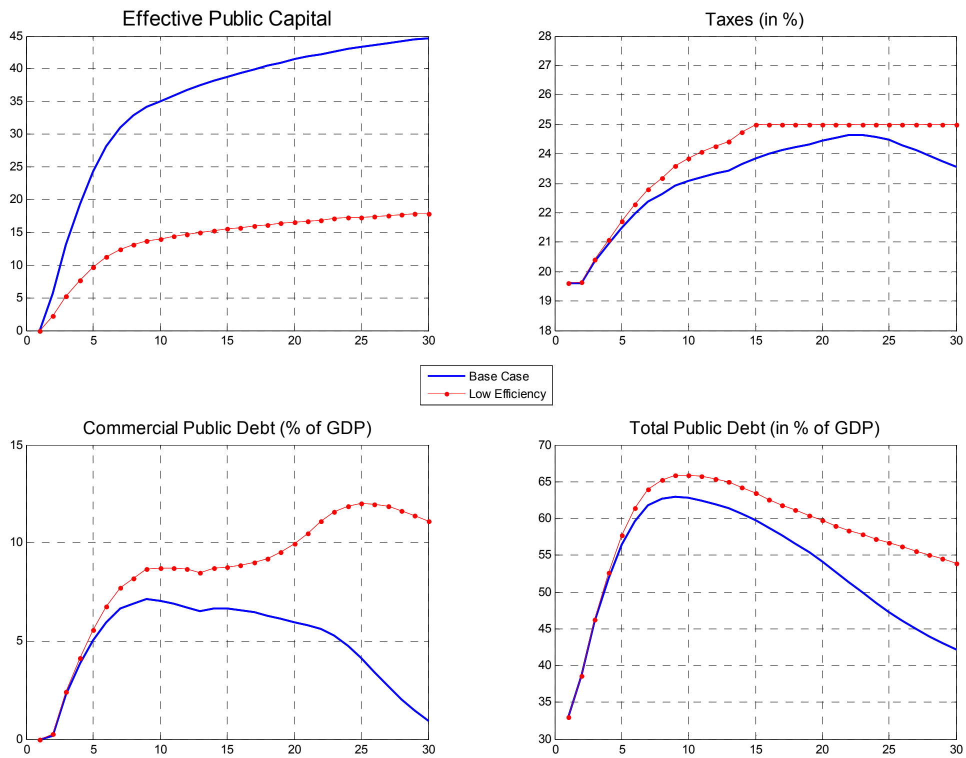
The baseline specification of the model assumes that every dollar invested by the government creates 50 cents in public "effective" capital. This assumption, underpinned by analysis by Pritchett (2000), implies that the rate of return on public investment is relatively high, thereby contributing to the optimistic results discussed earlier. However, Togo ranks in the bottom quartile of the distribution of the index for public investment management quality (PIMI), suggesting that the ratio of public capital accumulation to public investment spending could be lower than Pritchett's "mean" estimate. We therefore explore a scenario where public investment is extremely inefficient, assuming the efficiency parameter is lowered to 0.2. We also maintain the assumption that tax rates are capped at 22 percent.

Figure 8. Cap of 22 Percent on the Consumption Tax Rate (Model with Concessional Borrowing Exclusively Versus Model Allowing for External Commercial Borrowing)



The results presented in Figure 9 show that in this set-up, the stock of effective public capital is lower compared to the baseline parameterization. Commercial debt and total public debt increase rapidly through the period and remain elevated, forcing a sharp fiscal adjustment (in terms of required increases in tax rates). Therefore, in addition to the deleterious long-run effects presented in Table 3, low investment efficiency also negatively affects the trajectories for debt and the fiscal adjustment.

Figure 9. Variations in the Efficiency of Public Investment in Models Allowing for Commercial External Debt



VI. Size and Dynamics of Scaling-up

The experiments conducted so far have considered a large and front-loaded increase in public investment while beneficial in the long-run, require difficult fiscal adjustments to ensure debt sustainability. In this section, we quantify the size of the required tax increase under more modest surges in public investment.[14] Moreover, we also present simulations that consider the relative merits of the frontloaded investment scaling-up considered so far in the paper, compared to a more gradual investment path.

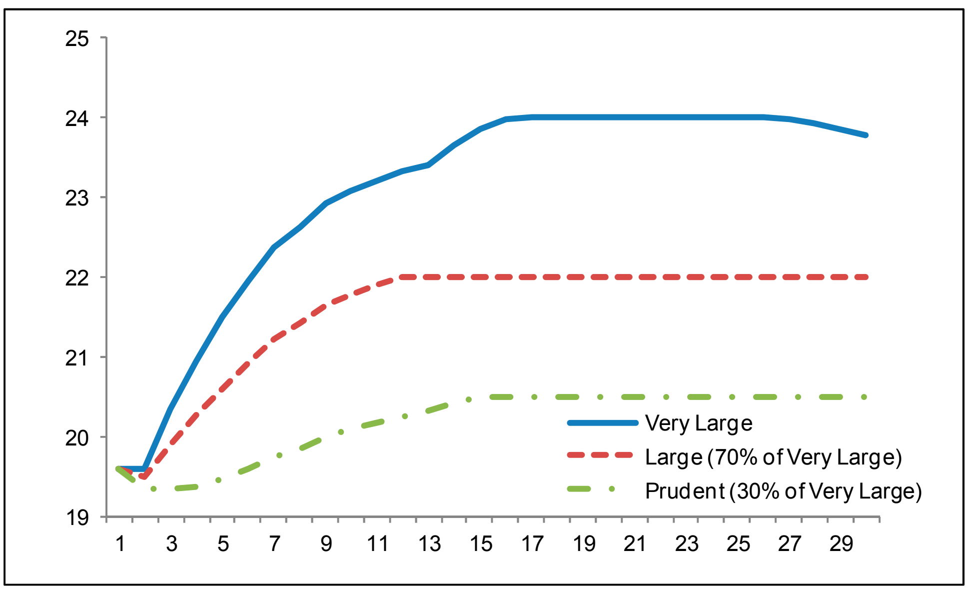
[14] Note that we continue to assume that all the burden of fiscal adjustment falls on consumption taxes.

A. Varying the Size of the Investment Scaling-up

We compare the increase in investment considered in the paper so far (which we label "Very Large"), with a surge 30 percent smaller (denoted "Large") and an increase 70 percent smaller than the original increase ("Prudent"). We focus on the specification that includes concessional borrowing, allows for commercial external debt to smooth the path of fiscal adjustment, and includes caps on tax rates. The availability of concessional loans is assumed to remain proportional to the level of public investment. The paths for grant financing are assumed to be the same across the three different "investment surge" exercises.

As expected, more modest increases in public investment lead to smaller adjustments in tax rates, but the relationship is not linear. In the "Large" scaling-up, taxes gradually increase to 20.6 percent within the first five years (compared to 21.5 in the "Very Large" scenario), reach 22 percent by year 12 and remain at that level until the end of the 30-year period (in the "Very Large" scenario taxes reach 24 percent before dropping back to 23.8 percent by the end of the period). In the "Prudent" scaling-up, taxes on consumption reach 20.5 percent by year 15 and remain at the level until the end of the simulation period.

Figure 10. Tax Adjustment Under Different Investment Scaling-up Scenarios in Models Allowing for Commercial External Debt

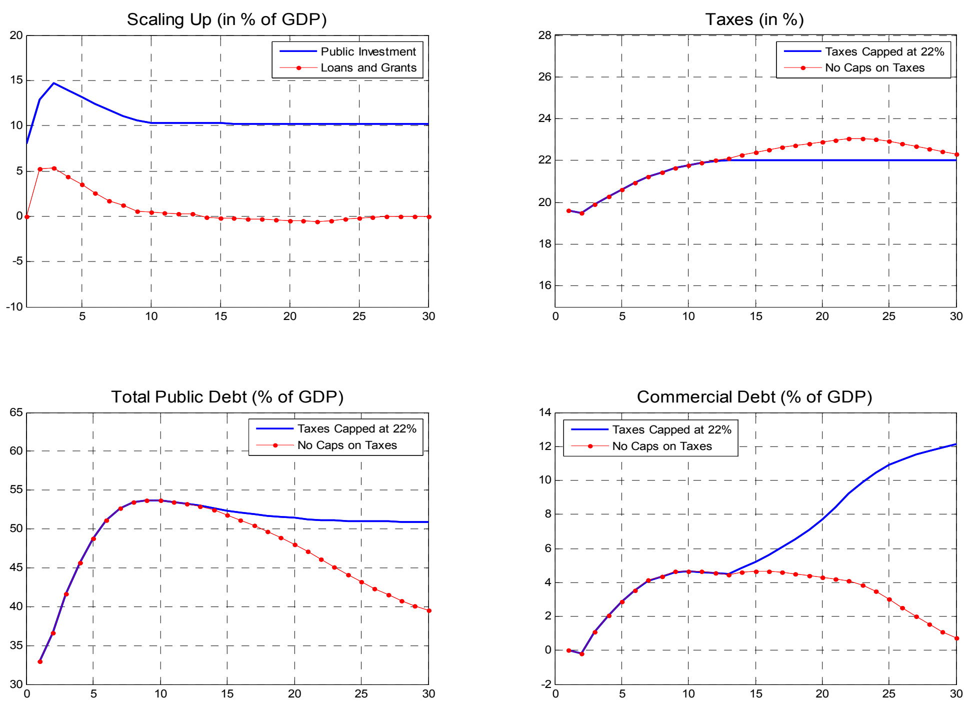


Note: a cap on taxes of 24 percent was imposed in the "Very Large" case. In the "Large" and "Prudent" cases the tax caps were 22 and 20.5 percent, respectively.

B. Assessing the Sensitivity to Limits on the Tax Burden

In addition to the unconstrained path of fiscal adjustment, we also investigate the importance of the level of the tax cap by comparing scenarios with different limits. Figure 10 presents the trajectories for the tax rates that would ensure debt sustainability[15] over the 30-year horizon for the three different investment scaling-up cases. In the "Very Large" scenario we assume a cap on the tax rate of 24 percent.[16] The different caps imposed in these experiments (20.5 and 22 percent for the "Prudent" and "Large" scenarios respectively) do not seriously undermine the sustainability of total debt, as illustrated for the "Large" scaling-up case in Figure 11 and for the "Prudent" scaling-up in Figure 12– although commercial debt is increasing fast when taxes are maintained below 20.5 percent.

Figure 11. "Large" Scaling-up with Caps on Taxes in a Model Allowing for Commercial External Debt

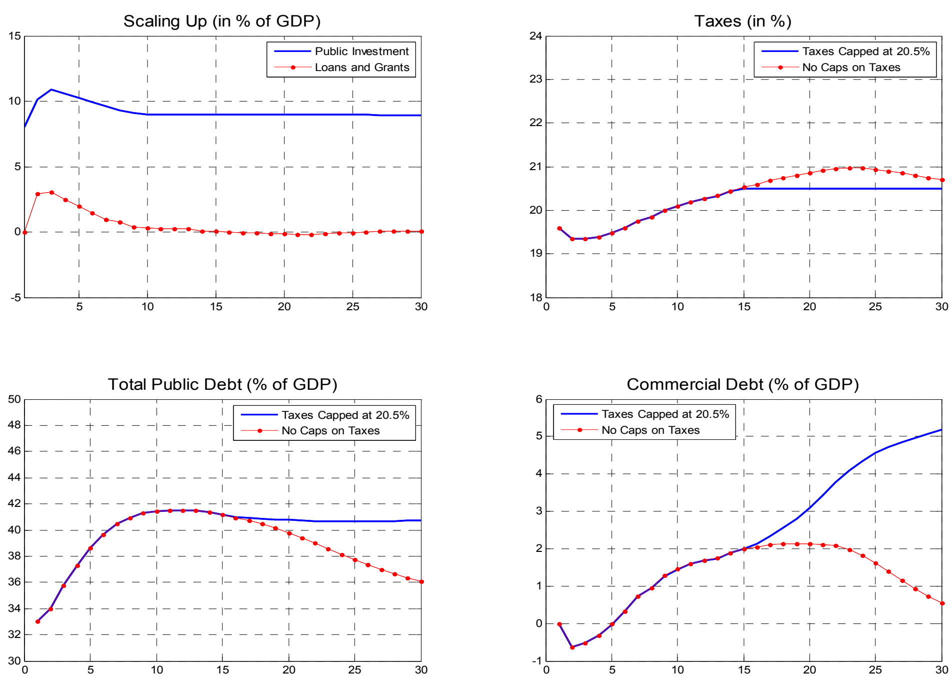


[15] Note that a debt trajectory is deemed to be sustainable if it is not explosive over the 30 period horizon considered.

[16] Note that in this case, debt dynamics were not favorable with a cap of 22 percent (as shown in Figure 8) or even with a cap of 23 percent.

To put the feasibility of such fiscal adjustment in practical perspective, it is important to bear in mind that the current VAT rate in Togo, which is set at 18 percent, is broadly in line with other WAEMU countries, but remains relatively high compared to other sub-Saharan African countries, according to the analysis in Grigg and Petit (2010). The tax to GDP ratio reached 15.4 percent of GDP in 2009, putting Togo at the same level as the median low-income country. Nevertheless, the results presented by Grigg and Petit (2010) suggest that there is significant room for improvement in revenue collection in terms of increasing efficiency. For instance, C-efficiency, defined as the ‘effective’ VAT rate (VAT revenue/consumption) divided by the ‘nominal’ VAT rate is in Togo among the lowest in Africa. The relatively low VAT C-efficiency in Togo is confirmed by the estimates presented in IMF (2011). At 19.5 percent, C-efficiency in Togo is only higher than C-efficiency in Chad among the low-income countries considered in the study. IMF (2011) estimates that if C-efficiency in Togo is raised to 80 percent of the median level for low-income countries, this would imply an increase in the tax revenue to GDP ratio of 1.7 percentage points. Excise duties (on alcohol, tobacco or petroleum products, for example) are in particular an important source of potential revenue.

Figure 12 . “Prudent” Scaling-up with Caps on Taxes in a Model Allowing for Commercial External Debt



C. A Frontloaded Increase in Public Investment Versus a Gradual Approach

The simulations presented in this section address the issue of the path of the acceleration in public investment. In particular, they consider the relative merits of the frontloaded[17] investment scaling-up considered so far in the paper, compared to a more gradual investment path. In this section, we focus on the scenario where only concessional loans are allowed.

When designing the two experiments (frontloaded versus gradual), we assume the same "amount" for the increase in investment in the first 12 years (32.3 percent of initial GDP), but the increase is distributed differently over time for each experiment. In addition, we also assumed that the same total amount of concessional loans is available, but their distribution over time varies according to the experiment, with the amount available to finance each year depending on how much is invested in a given year.

We also assume that under the gradual investment increase scenario, the efficiency of public investment increases over time. This could occur, for example, because as policymakers take more time to pick and define investment projects, the quality of the projects chosen improves. In addition, many LICs have made progress in governance in the last 10 years. Assuming that this trend continues, projects implemented later rather than sooner will benefit from improved governance. Finally, improvements in efficiency could also be achieved by a type of "learning by doing," as investment administrative capacity (in terms of management and execution, for example) improves as public investment gradually increases. Thus, we assume for illustrative purposes that efficiency of public investment gradually increases over time, eventually reaching 0.7 percent after 10 years.[18]

The trajectories of key variables over 30 periods under the two experiments are presented in Figure 13. As illustrated in the first panel, public investment eventually reaches 16 percent of GDP after 8 years under the gradual scaling up. Intuitively, the results of the simulations show that both taxes and total debt increase more gradually over the first 8 years under the gradual scaling-up case. Taxes also reach a peak of 23.4 percent after 8 years, and total public debt reaches 56.3 percent of GDP after 11 years, falling gradually after that. For the first 10 years, the country is less vulnerable to liquidity shocks, because total debt is lower under the gradual scaling-up.

More interestingly, crowding-out of private consumption is less pronounced in the early years of the investment scaling-up under the gradual approach, yielding higher consumption in the first 5 years. However, private investment is higher under the fast scaling up (until

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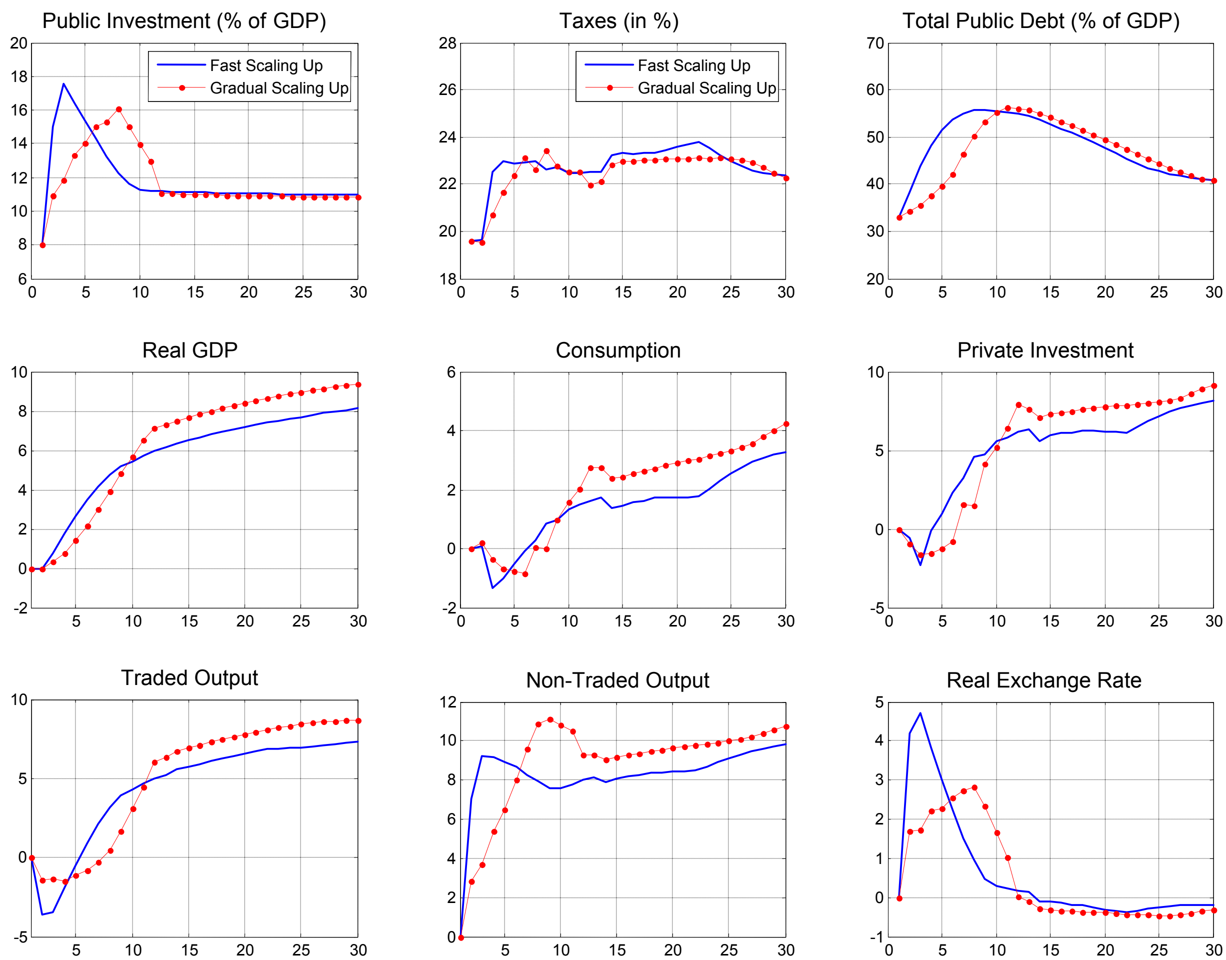
[17] In other words, there is a rapid and earlier increase in public investment, which peaks within the first few years.

[18] Due to lack of available quantitative empirical evidence on improvements in efficiency of public investment in developing countries, the change in the efficiency parameter from 0.5 to 0.7 over 10 years is rather ad-hoc.

year 10) as public investment increases the rate of return on private capital. Overall, welfare (measured as the present discounted value of consumption—PDC) is 0.8 percent higher in period 2 under the gradual approach than under the frontloaded approach.

Figure 13. Frontloaded Versus Gradual Scaling-up in Public Investment in a Model with Concessional Debt Exclusively and Improving Efficiency



VII. Using the Model to Interpret the Projections Underlying the DSA

The model described in this paper has, until now, been used to carry out simulations, in which one or more variables (usually public investment) is `shocked' or the path set exogenously, and the (calibrated) model produces the effects on the rest of the endogenous variables. In this section, we use the model for a somewhat different purpose: to interpret and study the underlying projections of the 2011 DSA for Togo. We treat these projections as if they were actual data, and then interpret them in terms of the model. In this way, we can learn both about these projections and also about the model and its calibration.[19] We first describe some of the main assumptions and data projections of this DSA and then proceed to explain how we use the model to interpret the projections.

A. Main Features of the 2011 DSA for Togo

We use actual data for the Togolese economy starting in 2005 and the Excel-based projections for key macroeconomic aggregates until 2031 that were elaborated by IMF staff in the context of the 2011 DSA exercise for Togo. In these projections, per capita real GDP growth is assumed to gradually increase toward 1.5 percent, with long-run steady-state inflation around 2.5 percent. Assuming 2 percent long-run inflation in the United States, the projection implies a real exchange rate appreciation of 0.5 percent per annum. The DSA projections assume constant terms of trade for Togo in the long run, as well as a stable share of international trade to GDP.

The scaling-up of public investment is assumed to continue at a rapid pace. From 2008 to 2013, the share of public investment to GDP increases from 2 percent to 10 percent. Thereafter the speed of public investment increases gradually slows down to keep up with GDP growth and settles at 9 percent of GDP. Total external debt also increases over the projection period from 17 percent of GDP in 2011 to 29 percent of GDP by 2030. The income from remittances and grants is assumed to stabilize at 7 percent and 4 percent of GDP, respectively. Although these are not investigated in this paper, they are non-negligible sources of income. The ratio of government transfers (current spending) to GDP drops from 16 percent in 2007 to 14.5 percent in 2013 and in the long run, although historically this ratio is rather volatile.[20] The ratio of tax revenue to GDP is projected to increase from 17 percent in 2010 to 18.5 percent in the long run. The major increase in the tax revenue to GDP ratio occurred in the period from 2007-2011, corresponding to a time of acceleration in public investment.

B. Using the Model to Interpret and Analyze the DSA Projections

The model we have using can also carry out counterfactual simulations using the projections of the standard Excel-based DSA.[21] Given the projected paths of selected macroeconomic variables, the model can back out the implied paths for the structural macroeconomic shocks that would produce such a set of projections. Of course, the implied shocks depend on the

[19] If there were extensive historical data for Togo, and if we were willing to assume that the basic economic structure was reasonably stable, a similar exercise would be to apply the model to this historical data. In the case of Togo, however, neither condition applies.

[20] Note that transfers are defined as: -(primary balance) + (fiscal revenue) – (investment spending).

[21] Formally these projections are from the macroeconomic framework underlying the standard Excel-based DSA.

structure of the model and its calibration. Thus, this exercise provides a plausibility/consistency check on the projections, given the model. At the same time, it is a way to examine the reasonableness of the model and its calibration. If the resulting sequence of structural shocks seems unreasonable, for example, it could be because the judgmental projection failed to take into account some of the economic relationships embedded in the model, but it could also be that the model is badly calibrated or ignores some key features. Substantial judgment is required in this exercise, as we will see, and the results thus need to be interpreted with care.

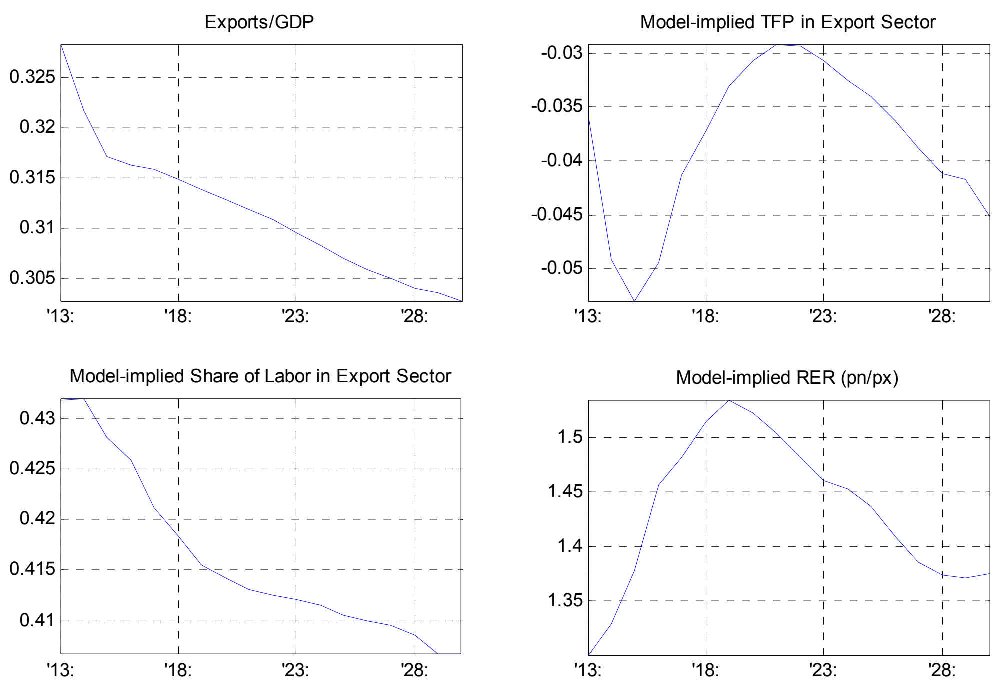
There are several ways of calculating model-implied structural shocks. In this paper we explore two approaches. The first one consists in specifying the stochastic properties of shocks and applying a Kalman filter/smoother to a linearized version of the model. In this method, structural shocks can be added to many of the equations of the model (e.g. to a process for public investment, to TFP, to remittances, and so on). The calibrated model is then used to “filter” the data (in this case, the judgmental Excel-based projections), finding the set of one-step-ahead forecast errors or shocks required for the model to match the data. The second approach maintains the assumption of perfect foresight in the deterministic model and inverts the non-linear model as we explain below. The trajectories of the endogenous variables (output, investment, and so on) are treated as known, both future and past, and we can solve for the trajectories of shocks required for the model to reproduce these values.

There are two major differences between these two approaches.

First, with the Kalman filter, there are many different combinations of shocks that could produce the observed data. The procedure finds the set of shocks that minimizes the overall sum of squared shocks, through a maximum-likelihood approach. In other words, the procedure recognizes that there are many ways to rationalize the data given the model, and it produces the most likely. The model-inversion approach, on the other hand, does not invole a least squares problem and maps N shocks to N observed variables.

Second, the Kalman filter is most natural when the shocks are unanticipated. That is, agents in the economy do not know what will happen to e.g. future output, and the shocks that are required to match the data are treated as unexpected. This would be appropriate, for example, when thinking for example about the effects of oil price shocks. The model-inversion method is set up such that the agents in the model foresee correctly the future values of the data, such as output and investment. This would be appropriate, for example, when a judgmental forecast implies high overall growth—presumably something that would be widely understood in the economy—and the question becomes one of understanding what kind of shocks are required for the model to reproduce this forecast. Both methods can be implemented in the DYNARE or IRIS toolboxes, which are compatible with Matlab.[22]

Figure 14. Kalman Filter Application to an Earlier Preliminary DSA for Togo



The Kalman Filter Approach

First, we illustrate how the model can be used as a consistency check on judgmental forecasts. Specifically, we apply the Kalman filter to back out the implied shocks in a set of judgmental forecasts used in an earlier preliminary, draft version of 2011 DSA.[23] Applying the filter reveals that these forecasts implicitly assumed that the share of exports to GDP would fall gradually over the long run (see Figure 14). This assumption triggered a reduction in the labor force employed in the exportable sector. Part of the decline in exports seemed to reflect an appreciated real exchange rate (which could have been triggered by the investment scaling-up), but the model showed that the assumed decline in exports could only be fully

[22] The Dynare and IRIS toolboxes can be downloaded from the following websites, respectively, http://www.cepremap.cnrs.fr/dynare and http://code.google.com/p/iris-toolbox-project/. In fact, the Kalman filter can be used to produce perfect-foresight shocks; this goes beyond the scope of this section, however.

[23] To apply the Kalman filter, we need to assume some stochastic properties for the shocks, which are not present in the original model, and linearize the model. Future versions of the Buffie et al. (2012) model will introduce uncertainty more systematically while keeping the non-linear structure.

explained assuming negative productivity shocks in the exportable sector (see again Figure 14). Based on these findings, this negative shock was corrected in the latest version, finalized of the 2011 DSA, which we use below to run some further counterfactual simulations.

The Inverting the Model Dynamics Approach

To explain the meaning of "inverting" the model, let express it in the implicit form: F(X,Y) = 0, where X=[X1 X2] are the exogenous variables (the shocks, typically) and Y=[Y1 Y2] are the endogenous variables (such as output and investment). Solving the model means to solve for Y given assumptions on X. However, one can also make assumptions about a subset of endogenous variables Y1—using the historical data and projections from the Excel-based DSA—and then apply the model to back out the subset of exogenous variables X1 consistent with Y1. This is what we called "inverting" the model.. The inverting procedure is general and intuitive. If the number of exogenous variables X1 is the same as the number of endogenous variables Y1, as we assume here, then the procedure reduces to inverting a system of equations, and the solution is independent of the probability of distribution of X1.[24]

When inverting the model, the choice of exogenous variables X1 to pair with endogenous variables Y1 is a choice and is not unique. To see this, consider a simple model consisting of a simple production function, which maps public capital into output, and the accumulation equation, which transforms public investment into public capital. Assume that the exogenous shocks are TFP and public investment shocks, while the endogenous variables are public capital and output. It is perhaps natural to associate the TFP shocks with output and public investment shocks with capital, but this is not a unique one-to-one mapping. A shock to public investment also affects output (through having capital in the production function) and therefore can be in principle associated with output dynamics. (TFP shocks cannot affect the path of public capital in this simple example.).

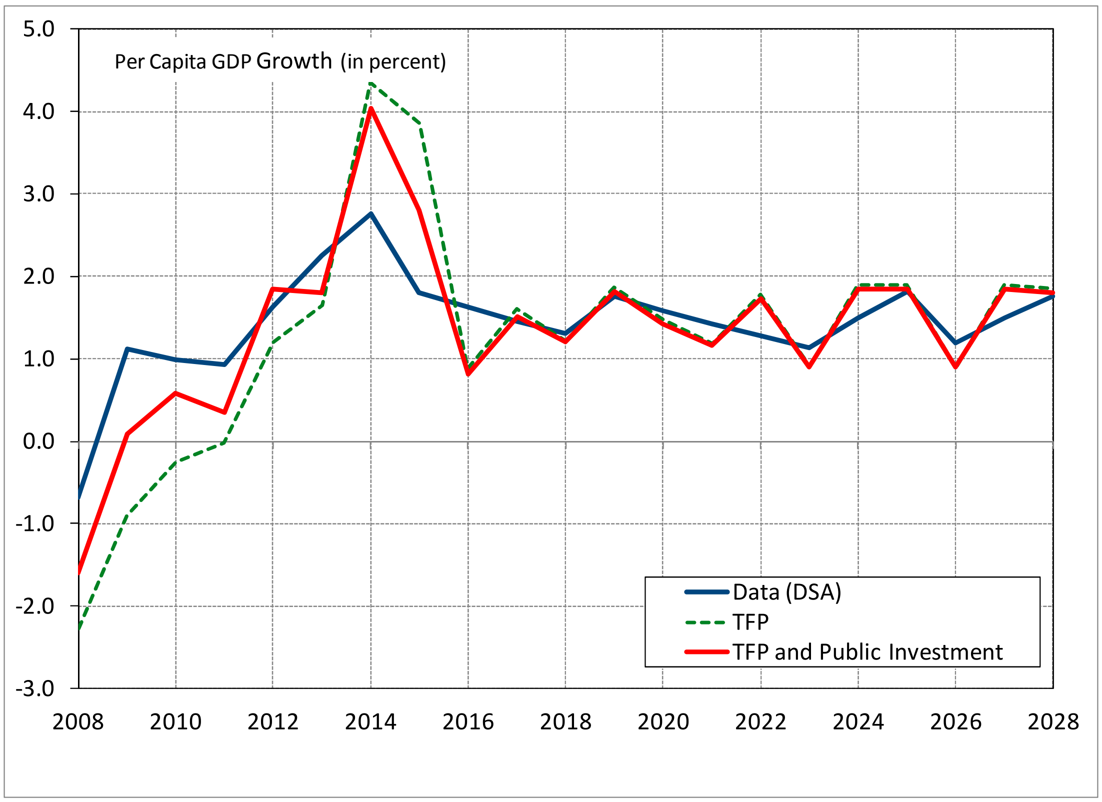
We now use the model to inspect the role of TFP and public investment shocks in explaining observed and projected per capita GDP (pcGDP) growth from the 2011 DSA. To do so, we first invert the model to obtain the implied shocks to TFP and public investment—as well as to other variables such as remittances, grants and concessional borrowing, among others—to match a selected set of macroeconomic endogenous variables. In other words, we deduce the shocks that allow the model to match the 2011 DSA paths for GDP per capita growth, public investment, external concessional and non-concessional debt, transfers, grants, and

[24] Formally this condition means that dim (X1)=dim(Y1), where dim(.) stands for space dimension. If, on the other hand, dim(X1)>dim(Y1) the problem is over-determined, then one has to rely on other methods such as least squares and use the Kalman filter.

remittances, among others.[25] The initial conditions of the simulation are calibrated to match the state of the Togolese economy in 2007.

We know that if we apply the full set of shocks, we retrieve the judgmental projections. By applying only some of the shocks, we are conducting counterfactual simulations that reveal how these specific shocks drive the forecast. Specifically, calculate the pcGDP growth implied by simulating the model with (i) the implied TFP shocks only and (ii) the implied TFP and public investment shocks only.

Figure 15. Inverting the Model Dynamics: Counterfactual Simulations for Per Capita GDP Growth

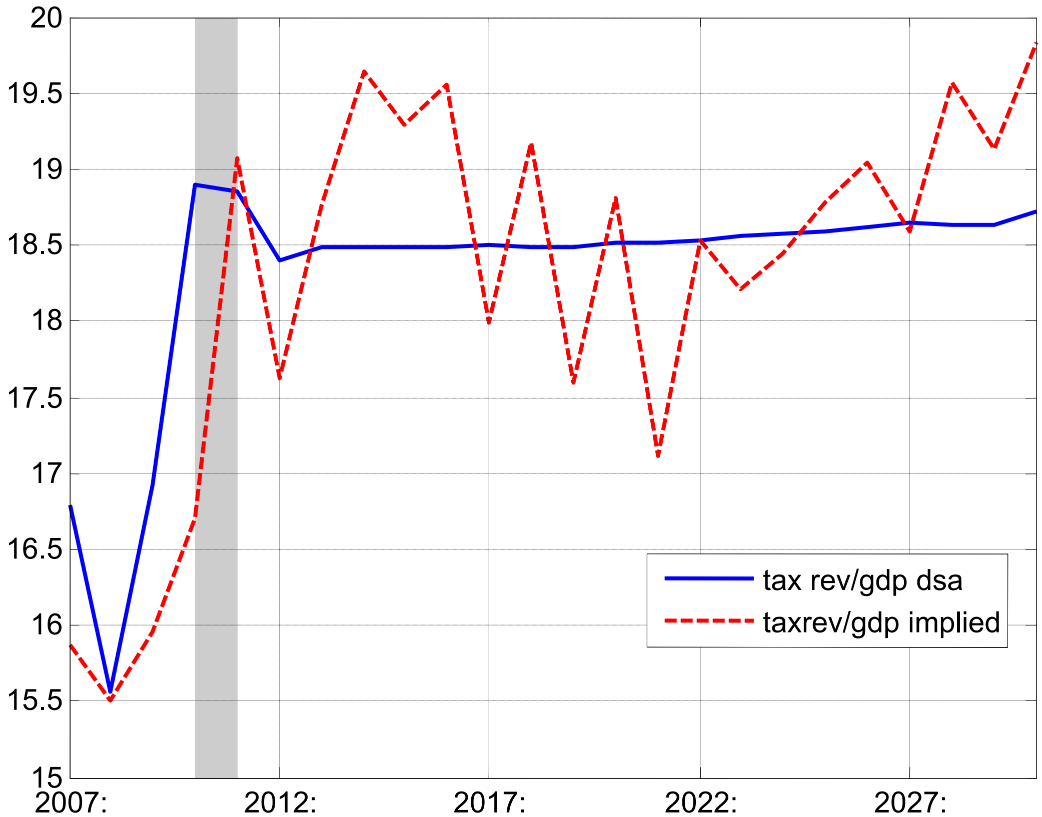


Note: The blue line (Data) corresponds to the pcGDP growth from the 2011 DSA. The red line is the pcGDP growth from the model with both TFP and public investment shocks. The green dotted line corresponds to the pcGDP growth from the model with only TFP shocks.

[25] In this exercise, GDP growth is measured in real terms. All other variables are measured as shares of GDP. In order to accommodate trends, the model is augmented with a common stochastic trend in technology productivities in the traded and non-traded sectors. The policy instrument is the consumption tax rate. Debt paths are taken as given. Apart from shocks to technology, to the terms of trade and to the share of imported goods in consumption, we also introduce shocks to external and domestic debt, real public investment, grants, and remittances.

The results are presented in Figure 15. The blue line corresponds to the pcGDP growth from the 2011 DSA (and, by construction, the forecast of the inverted model with the full set of shocks). The green dotted line corresponds to the pcGDP growth from the model with only TFP shocks. The red line is the pcGDP growth from the model with TFP and public investment shocks. During 2008-2014, TFP and investment shocks both drive the dynamics of output. TFP shocks alone help explain low and rising growth through 2014, as the the green line broadly matches the trajectory of the blue line. However, the assumed increase in public investment plays an important role as well. To match the increase in public investment in the DSA requires shocks to public investment; when these shocks are included as well as TFP, the resulting model projection of growth (the red line) is much closer to the DSA projection, particularly during 2008-2013. The remaining pcGDP growth—i.e., the difference between the blue and red lines—is explained by essentially "income shocks" (remittances, grants and transfers shocks, debt policy, among others, working for example through private investment). In 2014 and 2015, these other shocks are negative. After 2016, TFP shocks are the major driver of pcGDP growth dynamics in the medium to long run, which is not surprising.

Figure 16. Inverting the Model Dynamics: Counterfactual Simulations for Tax Revenues (Tax Revenue /GDP in %)



Along the same lines, we can invert the model to study whether the path of tax-revenues implied by the model corresponds to tax revenue assumed in the DSA. Figure 16 presents the results. Here, the exercise is somewhat different. The key direct determinants of tax revenues in the model are the tax rate and the rate of user fees on public capital (assumed parameters), private consumption, and the stock of public capital. In inverting the model, we do not choose to treat private consumption as exogenous, so that we find the shocks that match it perfectly (as we did before with growth). Rather we ask the question: if we shock the model so as to reproduce the other main variables (real growth, public investment, and so on), do we also match revenues? And the main reason we might not would be if the model-implied consumption trajectory was very different from the consumption trajectory in the DSA, given the values of the other variables.

As the figure shows, the model-implied path of the ratio of tax revenue to GDP follows fairly closely the ratio in the judgmental projections. It is more volatile, largely because consumption is more volatile in the model than in the DSA projection. The grey area of Figure 14 marks year 2011 (the first projection year), so the period of 2007-2011 contrasts the model simulation with actual DSA data. Because there were significant increases in both public investment and the tax revenue to GDP ratio in this period, it seems that our simulation is capable of mimicking the general evolution of the tax revenue and the increase in the tax burden as well. In fact, a substantial divergence between simulated tax revenue ratios and the ratios projected in the DSA would have indicated some inconsistency in the analysis.[26]

VIII. CONCLUSIONS

The model-based analysis of debt sustainability in Togo suggests that scaling up public investment could significantly increase GDP under certain conditions,[27] but would also increase vulnerabilities to adverse debt dynamics over the medium term. A very large increase in public investment would have positive macroeconomic effects in the long-run, but would require unrealistic increases in tax rates to ensure debt sustainability (with a given path for external grants and concessional loans). In light of these results, the Togolese authorities should envisage more moderate increases in public investment and/or would need to obtain additional external resources in the form of grants to finance such increases in investment.

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[26] Note that in the context of the simulation presented here, there is no difference between actual and "DSA projected" data. The simulation is an attempt to replicate the data (both actual and projections) with the model and check the implications for other variables.

[27] These conditions include a good rate of return on infrastructure projects (25 percent); efficiency in public investment at the level of a typical sub-Saharan African country (50 cents in public capital for every dollar spent); increased efforts in revenue collection, particularly on consumption taxes, possibly by a combination of increases in tax rates and improvement in efficiency in collection of these taxes.

More moderate increases in public investment would require increases in tax rates that appear to be feasible (between 1 and 2.5 percentage points) over the medium-run, particularly if the efficiency of tax collection is improved. Nevertheless, the speed and size of the fiscal adjustment would have to be carefully managed to mitigate risks of unsustainable debt dynamics. For example, in the case of the "very large" investment scaling-up, constraints on increases in taxes that would not permit them to reach to up to 24 percent would generate unsustainable trajectories for public debt.

The model also suggests that external commercial borrowing on reasonable terms could be a useful complement to concessional loans and would allow for some smoothing of the fiscal adjustment path. However, the risks of unfavorable debt-dynamics are heightened when interest rates are high and liquidity shocks are more frequent with commercial debt. Alternatively, domestic borrowing would normally play only a limited role in this framework, in part owing to crowding-out effects. However, the extent of crowding-out needs further examination in the specific context of Togo, because borrowing occurs in a regional bond market.

Moreover, the importance of the efficiency of public investment raises the issue of the appropriate timing and pace in the scaling-up in public investment. For example, a question arises about the extent to which countries should frontload increases in investment in infrastructure, even in the presence of significant inefficiencies in public investment, as opposed to proceeding more gradually to reap greater benefits from improving the efficiency of investment through reforms in governance and/or learning by doing. At the same time, given the enormous infrastructure needs and bottlenecks to growth, a sense of urgency in investment is understandable. The simulations of the model indicate, however, that there are welfare gains from increasing public investment gradually rather than having "big bang" increases.

The model was also used to carry out counterfactual simulations using the projections underlying the macroeconomic framework used for the standard Excel-based DSA. These simulations provide a useful check on the plausibility and internal consistency of the projections made in the DSA. This application shows that public investment and TFP shocks are important drivers of economic growth in the recent past data and the projections of the standard Excel-based DSA for Togo.

Extensions of the model could be used to quantify the impact on public debt of unexpected negative shocks. This would allow one, for example, to assess the vulnerability of debt dynamics to a deterioration in the terms of new financing. In fact, shocks are central to debt sustainability, and as articulated by Buffie and others (2012), large scaling-up in public investment tends to be more risky in the face of shocks such as terms of trade shocks or shocks to the country risk premium. Moreover, it would be useful to consider model scenarios that introduce learning externalities to capital accumulation that will reduce some of the crowding-out of private investment and boost the long-run impact of public investment increases.

It is important to bear in mind that the conclusions obtained in the application of the model are sensitive to the set of assumptions made, in particular regarding the returns to public capital, the efficiency of investment, and the availability of external concessional resources and grants. These assumptions can be viewed as the conditions necessary for the success of scaling up investment that are simply made more explicit by the model. The analysis also highlights the need to design clear public investment plans with better information on expected rates of return, user fees and recurring costs, as well as careful reflection on the feasibility of fiscal adjustment. Therefore, the results of the model should be used with care. This framework constitutes one of several useful policy tools to be used in an ongoing, iterative fashion to guide assessments regarding the feasibility of investment surges.

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