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Assessing the Economy-wide and Sectoral Impacts of Public Infrastructure Investment in Benin: A Dynamic General Equilibrium Approach

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of the econometric hurdles imposed by the macroeconomic (panel and/or time series) methods of estimating Cobb-Douglas production functions. Using more robust techniques, later empirical studies have tended to find smaller estimates of the magnitude of infrastructure's contribution, but nonetheless confirm the positive, statistically significant effect of infrastructure on the level or the growth rate of key variables, such as "output, efficiency, productivity, private investment, and employment" (see Romp & de Haan, 2007). In fact, Estache and Fay (2009) conclude, that at the empirical level, there exists an increasing consensus on the growth-enhancing effect of infrastructure, with its impact being higher in countries at lower levels of income.

However, the production-function approach of most of the econometric regression studies do not provide an adequate framework for tracing in detail the multiple means or channels through which infrastructure investment influences economic growth and, thereby poverty alleviation in developing countries. As pointed out by Escobal (2005), a lack of a more thorough understanding of the transmission mechanisms that brings about increased growth and reduced poverty undermines our ability to make specific policy recommendations that are targeted at easing the key bottlenecks that affect this transmission mechanism. What is more, studies based on the econometric methodology, though successful in providing empirical evidence as to the importance of infrastructure to poverty and growth, do not allow for an analysis of "important general equilibrium feedback effects among variables and for out-of-sample experiments" (Rioja, 2001). To address this concern, a subset of the empirical research on the relationship between infrastructure and growth has been conducted within a general equilibrium framework (e.g. Rioja 2001, 2004; Salas, 2007). Yet, these macro models are too aggregate to track down the more disaggregate sectoral and factor market impacts necessary to analyze the distributive consequences as well as the driving forces behind the aggregate results.

A more suitable methodology for accomplishing this task is that of Computable General Equilibrium (CGE) models. The existing CGE studies, such as those of Lofgren and Robinson (2004), Adam and Bevan (2006), Estache, Perrault, and Savard (2007), Perrault, Savard, and

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authors attempt to quantify the effect of infrastructure on output or productivity by measuring infrastructure either as an investment spending flow variable (see for example, Fosu, Getachew & Ziesmar (2009)), or as a stock variable constructed through accumulated investment (see for example, Arslanalp, Bornhorst, Gupta & Ze, (2010)). Yet, other authors construct an aggregate index of different types of infrastructure stocks (see for example, Calderon, Moral-Benito, & Serven (2010); Calderon (2009); Calderon and Serven (2004); Calderon and Chong (2004)).

proportion behave in a forward-looking manner maximizing utility and profit over an infinite horizon, respectively.

As a numerical example, we apply our model to Benin, which has so far not been studied separately within an intertemporal CGE model that incorporates public infrastructure stock and differentiates between firms and households according to their access to world capital markets. In addition, Benin constitutes an interesting case study due precisely to the recent emphasis placed by international financial institutions on the country's pressing need to raise public investment in the development of its infrastructure stock as a crucial step toward meeting the goals of continuous growth and poverty reduction (IMF, 2010; World Bank, 2009).

The paper is organized as follows. The second section reviews the relevant general equilibrium literature as well as the associated endogenous growth literature. The third section describes the model at hand, while the fourth section provides an overview of Benin's economy. The fifth section analyzes and interprets the simulation results. Lastly, the sixth section concludes.

2. Review of the Literature

Before delving into the details of the general equilibrium literature studying the effects of infrastructure investment on the economy, it is useful to first provide context for the review of literature that follows by highlighting the various transmission mechanisms through which infrastructure affects growth.

The most common conventional channel, first brought to attention by Aschauer (1989) is that public infrastructure investment enhances the productivity of the private sector. In fact, Aschauer (1989) attributed the U.S. productivity slowdown of the 1970's to the lack of infrastructural investment. This direct productivity effect of infrastructure investment captures the idea that an increase in the stock of public capital raises, at a decreasing rate, the marginal product of all factor inputs thereby reducing the cost of inputs into the production process and increasing the level of private production (Agenor & Moreno-Dodson, 2006).

starting with Futugami, Morita and Shibata (1993) who modified Barro's (1990) framework by considering productive public expenditure to be a stock rather than a flow variable.

As a result, subsequent theoretical studies that attempt to model the role of infrastructure may be grouped into two approaches: one that treats government infrastructure expenditure as a flow variable and the other that treats public infrastructure as accumulated capital. Despite the approach employed, however, these theoretical infrastructure-led endogenous growth studies share a common interest: to determine whether public investment increases the long-term steady state growth rate of the economy. The general view seems to be that public investment on physical infrastructure can indeed enhance per capita growth via its positive effect on increasing the marginal product of private inputs, but that the disincentive effects linked to financing public infrastructure by taxing income might also retard per capita growth. Moreover, public investment financed through taxation may discourage private investment, thereby affecting economic growth negatively. The conclusion is that the overall effects of increasing public investment in infrastructure will depend on the trade-off between the productivity of public investment and the distortionary effects of taxes. Consequently, the theoretical infrastructure-led endogenous growth literature also shares a common goal: to determine the optimal tax rate that will maximize the growth rate of the economy and social welfare.

For example, Barro (1990) models infrastructure in the context of a simple AK endogenous growth model. The two building blocks of his model are a production function in which public capital treated as a flow of government's expenditure on infrastructure is added as an additional factor input to private production, and a Ramsey equation which captures the optimizing behaviour of the representative consumer. Production is assumed to exhibit constant returns to scale in the factors that can be accumulated – that is private capital stock and public capital taken together. He finds that public investment in infrastructure can raise the long-run rate of economic growth, but only if its positive effect on private investment outweighs the negative impact of the increased tax rate needed to pay for the public outlay. The maximization of the national growth rate, which Barro (1990) finds to be equal to the maximization of social welfare as well, requires the government to set the optimal tax rate that is financing public services to equal the elasticity of the public services in the aggregate production. This result is crucially dependent upon the

Motivated by the findings of emerging econometric evidence suggesting that public infrastructure may have different effects in different sectors[8] coupled with the recognition that single-sector models cannot capture the various indirect effects of infrastructure investment, such as spillover effects among the different sectors of the economy, the applied general equilibrium literature has extended the theoretical one-sector growth models by incorporating either two or more sectors to analyze the effects of higher budget allocations for infrastructure.

One of the first contributions in this direction has been Rioja's (2001) study. Rioja (2001) develops a simple two-sector neoclassical general equilibrium model of a small open economy to study the effects of raising public investment in infrastructure on output, private investment and welfare in three Latin American countries. An interesting feature of the model is contained in Rioja's (2001) specification of the 'effective' aggregate stock of public capital, which as in Hulten (1997) is modeled to take account of the idea that infrastructure use in developing countries may not be as effective as in developed countries. This 'effective' stock of capital is incorporated as an input into a Cobb-Douglas production function. In line with theoretical expectations, his findings indicate that infrastructure investment can produce net increases in output, private investment and welfare. However, raising infrastructure investment beyond a certain threshold can be detrimental to welfare due to increased taxation needed to fund it.

In a later work, Rioja (2004) extends his previous model to a three-sector model that is solved for seven Latin American countries. In this study, however, Rioja (2004) defines the effective stock of infrastructure as a function of the raw stock of infrastructure, which is deflated by a 'congestion' parameter. He seeks to answer the question of whether the sampled countries would have recorded larger gains in GDP, sectoral outputs and consumptions, private investment and welfare had they raised public investment in 1960s as opposed to 1990s. He finds a positive answer to this question suggesting that infrastructure has higher potential payoffs at an early stage of development.

8 For example, see Feltenstein & Ha (1995), Sturm, (2001), Morrison & Schwartz, (1996), Nadiri & Mamuneas (1994).

Using a static CGE model calibrated to Chad, Levy (2006) studies the impact of using this country's annual oil revenue for public investment in road and irrigation infrastructure. Production is modeled separately for the agricultural and the road sector. For the former sector, Levy (2006) incorporates public investment multiplied by its growth rate into the efficiency parameter of a CES production function. For the latter, Levy (2006) enters total capital stock considered to be a composite good made of private and public capital as a factor input in a CES production function. Her findings indicate that investment in the development of roads and irrigation infrastructures has a positive impact on growth (up to 14%) and household income of the poorest part of the population (up to 27%). Both of the policies are also shown to positively affect productivity and the capital stock, leading the author to conclude that the Dutch Disease may not be an unavoidable consequence of natural resource booms in developing countries.

Such a conclusion is further evidenced by the work of Adam and Bevan (2006). Their recursive-dynamic two-sector CGE model applied to Uganda analyzes the possibility of Dutch disease effects in the presence of aid-financed infrastructure investment. Their model features two main characteristics. First, the authors consider the existence of two sectors: the tradeable and the non-tradable sector where production in each sector is specified as a Cobb-Douglas production function that has labor, private capital, and infrastructure as arguments. Second, the model specifies a learning-by-doing externality for the spillover (tradeable) sector, considered to be the manufacturing sector. This sector benefits from higher spillover effects such that a higher level of infrastructure generates a Hicks-neutral shift in the scale production parameter, which represents a positive change in TFP. The increase in TFP depends upon the size of the spillover effects of exports in the manufacturing sector. The results of the paper indicate that foreign aid indeed generates Dutch Disease effects. However, if the initial conditions of a country are such that it starts from a low level of public infrastructure, higher infrastructure funded by aid generates productivity effects in manufacturing through spillover effects. This results in large welfare gains in the medium term which mitigates the effects of the Dutch disease.

A series of studies conducted by Estache et al. (2007), Perrault et al. (2010), and Savard (2010) have focused on examining the robustness of Adam and Bevan's (2006) conclusions to different economic structures. Their analyses abandoned Adam and Bevan's (2006) dichotomous demonstrates that in Philippines VAT funding is the most favourable funding option for infrastructure investment in terms of both its poverty and macroeconomic impacts. The VAT funding option is followed by the foreign aid option. The income tax funding option is most favourable in terms of its aggregate impacts, but least favourable in terms of its poverty impact. With the exception of Perrault et al. (2010), CGE studies analyzing the effects of infrastructure investment on the economy of Benin are non-existent at this moment. In fact, literature on CGE modeling of infrastructure investment is scarce compared to the large body of literature on CGE modeling in general. The CGE studies reviewed here, with the exception of Levy (2006) who used a static CGE model, all used recursive-dynamic models which themselves are a simple extension of static models. They are solved as a sequence of separate optimization problems – one for each chosen time period. Agents in these models solve their respective optimization problems only for the current time period without any regard to the implications of their actions for their welfare in future time periods. On the other hand, agents in intertemporal models solve their respective optimization problems spanning all the future time periods under consideration. This paper develops an intertemporal model applied to the Beninese economy to provide a more complete assessment of the impacts of infrastructure investment. The model thus allows us to capture the dynamic causal linkages across the aggregate and sectoral variables of main interest. Understanding these dynamic feedbacks is important to better understanding the relationship between economic performance and public capital, particularly because of the direct (demand-led) and indirect (supply-led) effects of public capital.

3. Theoretical Framework

3.1 Model Overview

We consider a small open economy model comprised of four types of institutions: households, firms, the government, and the rest of the world, and three factors of production: labour, private capital, and public capital (infrastructure). We partition the household sector into forward-looking households who enjoy access to capital markets at which they may accumulate or deaccumulate assets at the world interest rate, r^*, and myopic households who are restricted from doing so. Without any allusion to irrationality, we attribute the source of myopic household behavior to a lack of access to financial markets, which given the presence of a liquidity twelve different production sectors,[9] with four of these industries[10] consisting solely of myopic firms, and the remainder consisting solely of forward-looking firms.

As is typical of intertemporal general equilibrium models, the economic behavior of each forward-looking agent in the economy is derived from the agents' objective and intertemporal constraints. Namely, forward-looking households seek to maximize the utility they receive from full consumption of goods over an infinite horizon, while managers of forward-looking firms maximize the market value of their firms. On the other hand, myopic households optimize intratemporally, and not intertemporally as is the case with forward-looking households. This is because myopic households behave as hand-to-mouth or rule-of-thumb consumers in the sense of Campbell and Mankiw (1989). However, unlike Campbell and Mankiw's (1989) model in which the rule-of-thumb consumers are limited to fully consuming their current disposable income, our model features a saving component to the myopic households' consumption decision that allows them to save a fixed proportion of their disposable income. The savings made available by myopic households to the myopic firms determines the latter's investment decision in private capital stock. As part of its static profit-maximizing solution, myopic firms use labour and private capital services up to the point where the marginal product of each of these two factors is equal to its wage.

As pointed out by Sheih (2006), the stock specification of infrastructure implies that the impact of government spending is not instantaneous and temporary but is instead gradual and durable. By modeling decision-making within an intertemporally consistent setting and taking adjustment dynamics into account, the model is able to describe the important dynamic transition to the long run equilibrium point following a shock to infrastructure development while paying particular attention to the differing responses of myopic and forward-looking agents in the economy. The economy achieves a general equilibrium through each agents' optimizing behavior which adjusts to changing product and private factor prices. The wage rate adjusts to clear the labour market, as do prices to clear the domestic goods market. Intertemporally, the model adjusts through changes

[9] *Food Agriculture, Cash Crops, Agricultural Industry, Cotton, Agricultural Handicrafts, Other Modern Industries, Utilities, Industrial Textiles, Other Handicraft Industry, Transportation-Communication, Bank Services,* and *Other Business Services.*

[10] Namely *Food Agriculture, Agricultural Handicrafts, Other Handicraft Industry, and Other Business Services*

with share (1 – φ), own the myopic firms and are unable to borrow against future income to smooth consumption reflecting their inability to access world markets.

3.2.1 Forward-Looking Households

We model an aggregate representative forward-looking household with infinite time horizon and perfect foresight into the future that derives utility from goods consumption. Not portraying preferences for leisure, the forward-looking household supplies its one unit of time endowment inellastically in return for which it receives a competitive compensation in the form of wages. The household's additional sources of income include returns on foreign assets, dividends, lump-sum transfers received from the government and the rest of the world as well as pure profits generated by the contribution of public capital in the private production function. After paying taxes on its dividends and labour, the forward-looking household allocates its disposable income to saving and to the purchase of goods and services.

Under homothetic preferences, the forward-looking household's optimization process can be decomposed in two stages. Such decomposition allows us to distinguish between the intra-temporal consumption/savings decisions and the intertemporal decisions on spending. In the first stage, the objective of the representative household is to maximize an additively separable intertemporal utility function over an infinite horizon in order to optimally allocate income between aggregate consumption and savings in each period (1.1) subject to an intertemporal budget constraint and the transversality condition. In doing so, the household takes its starting financial wealth and the rate of time preference as given. The household's objective function and intertemporal budget constraints can be expressed as follows:

$$Max\, U_0 = \sum_{t=0}^{\infty} \left[\frac{1+n}{1+\rho}\right]^t \ln\left(C_t^f\right)$$

$$s.t.\; F_{t+1}(1+n) = r^* F_t + \left(1-\tau_y^f\right)YL_t^f + TRG_t^f + ER_t TROW_t^f + KG_t \sum_j \xi_{jt} - PC_t^f C_t^f -$$

$$\tau_k \sum_j Div_{jt}^f \;\; \forall\, t$$

$$with\, YL_t^f = \varphi_{\mathrm{YL}} W_t LS_t \qquad (1.1)$$

In the second stage, the representative forward-looking household further allocates its full consumption of the aggregate goods, C_t^f over varieties of commodities by maximizing its sub-utility function at period *t*, given the full consumption already determined in the first stage. The maximization problem for the Constant Elasticity of Substitution (CES) sub-utility function in period *t* is given as follows:

$$Max\ U_t = AC^f \sum_i \left[\propto_{C,i}^f \, c_{i,t}^{f\ -\rho_C^f} \right]^{\frac{-1}{\rho_C^f}}$$

$$\text{s.t. } PC_t^f C_t^f = \sum_i Pc_{i,t} c_{i,t}^f \qquad (1.4)$$

where $\propto_{Ci}^f$ denotes the share parameter for the forward-looking household , and ρ_C^f is defined by the elasticity of substitution for forward-looking consumers, σ_c^f as $\rho_C^f = \frac{1-\sigma_c^f}{\sigma_c^f}$.

Thus, the forward-looking household's demand, $c_{i,t}^f$ for each commodity *i* and its index price of consumption goods, PC_t^f can be solved from the first order condition as:

$$c_{i,t}^f = AC^{f^{\sigma_c^f - 1}} C_t^f \left[\frac{\alpha_{c,i}^f PC_t^f}{Pc_{i,t}(1+\tau_i^C)} \right]^{\sigma_c^f} \qquad (1.5)$$

$$PC_t^f = \frac{1}{AC^f} \left[\sum_i \alpha_{Ci}^{f\ \sigma_c^f} [Pc_{it}(1+\tau_i^C)]^{1-\sigma_c^f} \right]^{\frac{1}{1-\sigma_c^f}} \qquad (1.6)$$

where Pc_{it} is the consumption price of commodity *i*, and τ_i^C is the consumption tax rate.

3.2.2. Myopic Households

As is the case with forward-looking households, myopic households also derive utility from goods consumption and do not value leisure. However, myopic households do not receive dividends nor do they receive returns from foreign assets. Instead, their income sources are comprised of labour income, returns to capital (both to the myopic firms' capital stock and public capital), and transfers from the government and the rest of the world. Hence, their disposable income can be expressed as follows:

$$XTS_{jt}(1 - \tau_{jt}^{p}) = AP_j \left[\alpha_{Pj}(VAG_{jt})^{1-\frac{1}{\sigma_{Xj}}} + (1 - \alpha_{Pj})INT_{jt}^{1-\frac{1}{\sigma_{Xj}}}\right]^{\frac{\sigma_{Xj}}{(\sigma_{Xj}-1)}} \quad (1.10)$$

$$VA_{jt} = AV_j \left[\alpha_{Vj}(K_{jt})^{1-\frac{1}{\sigma_{VAj}}} + (1 - \alpha_{Vj})LD_{jt}^{1-\frac{1}{\sigma_{VAj}}}\right]^{\frac{\sigma_{VAj}}{(\sigma_{VAj}-1)}} \quad (1.11)$$

$$VAG_{jt} = AG_j VA_{jt}^{\alpha_i^g} KG_t^{1-\alpha_i^g} \quad (1.12)$$

$$INT_{jt} = Min\left[\frac{V_{ijt}}{aij}\right] \quad (1.13)$$

Following previous literature, we make public capital, KG_t as a separate argument of the private production function in order to take account of the external effect of infrastructure on production. As noticed by Barro (1990), it is this productive role of infrastructure that creates a potentially positive linkage between government and growth. In other words, public investment in infrastructure raises the stock of public capital, which, in turn, raises firm's output and thereby growth. Firm managers of both myopic and forward-looking firms do not decide on the level of public capital, but its level is rather set by past government decisions to invest in infrastructure. Firms do, however, determine residually the implicit return to public capital that is distributed to households in each time period. Since the stock of public capital is fixed, the rate of pure profit generated by the introduction of public capital in the private production function, $\xi_{jt}KG_t$ is endogenously determined and varies by industry.

Production exhibits constant returns to scale in all the three production factors taken together. Labour is assumed to be homogenous and inter-sectorally mobile. Also, the private capital stock of forward-looking firms is assumed to be sector-specific in the short-run, such that it cannot move from one sector to another within the period after the installation. However, firm managers are still able to alter the long-run level of the private capital stock through a change in investment, which is financed through the firm's retained earnings. On the other hand, the private capital stock of myopic firms is mobile across the myopic industries.

3.3.1 Forward-Looking firms

As is the case with forward-looking households, forward-looking firms optimize both intertemporally and intratemporally. Under the neoclassical assumption of perfect competition, firm managers, in each forward-looking sector, choose the quantity of labour, the path of on the optimal level of $VA_{jt}$and INT_{jt}. The investment decision is the only decision that involves intertemporal considerations, all other decisions are made in a static manner.

Solving the firm maximization problem and rearranging we obtain the following first order conditions as expressed in Equations (1.20) to (1. 34):

$$PXTS_{jt}(1-\tau_{jt}^{p}) = \frac{1}{AP_j}\left[(\alpha_{Pj})^{\sigma_{Xj}}PVAG_{jt}{}^{(1-\sigma_{Xj})} + (1-\alpha_{Pj})^{\sigma_{Xj}}PINT_{jt}{}^{(1-\sigma_{Xj})}\right]^{\frac{1}{(1-\sigma_{Xj})}} \quad (1.16)$$

$$VAG_{jt} = AP_j{}^{(\sigma_{Xj}-1)}XTS_{jt}\left[\frac{\alpha_{Pj}PXTS_{jt}(1-\tau_{jt}^{p})}{PVAG_{jt}}\right]^{\sigma_{Xj}} \quad (1.17)$$

$$INT_{jt} = AP_j{}^{(\sigma_{Xj}-1)}XTS_{jt}\left[\frac{(1-\alpha_{Pj})PXTS_{jt}(1-\tau_{jt}^{p})}{PINT_{jt}}\right]^{\sigma_{Xj}} \quad (1.18)$$

$$PVAG_{jt} = \frac{1}{AG_j}\left[(\alpha_{Gj})^{\sigma_{Gj}}\xi_{jt}{}^{(1-\sigma_{Gj})} + (1-\alpha_{Gj})^{\sigma_{Gj}}PVA_{jt}{}^{(1-\sigma_{Gj})}\right]^{\frac{1}{(1-\sigma_{Gj})}} \quad (1.19)$$

$$VA_{jt} = AG_j{}^{(\sigma_{Gj}-1)}VAG_{jt}\left[\frac{(1-\alpha_{Gj})PVAG_{jt}}{PVA_{jt}}\right]^{\sigma_{Gj}} \quad (1.20)$$

$$KG_t = AG_j{}^{(\sigma_{Gj}-1)}VAG_{jt}\left[\frac{\alpha_{Gj}PVAG_{jt}}{\xi_{jt}}\right]^{\sigma_{Gj}} \quad (1.21)$$

$$W_t = PVA_{jt}(1-\alpha_{Vj})AV_j{}^{-\rho_{VAj}}\left[\frac{VA_{jt}}{LD_{jt}}\right]^{\left(\frac{1}{\sigma_{VAj}}\right)} \quad (1.22)$$

$$PINT_{jt} = \textstyle\sum_i Pc_{it}a_{ij} \quad (1.23)$$

$$V_{ijt} = a_{ij}INT_{jt} \quad (1.24)$$

Due to constant returns technology, the dual price of sectoral output may be expressed as in Equation (1.16). Conditional demands for the index of intermediate inputs and for the index of value added with public capital are expressed in Equations (1.17) and (1.18). The dual price of the value added with public capital, $PVAG_{jt}$ is depicted in Equation (1.19), while the demand for value added, VA_{jt} is expressed in Equation (1.20). Equation (1.21) enters in the calculation of this implicit return to public capital. Demand for labour is determined by Equation (1.22) implying that the firms hire labour until its marginal product is equal to the wage rate. . The dual price of the index of intermediate inputs can be determined as in Equation (1.23), where Pc_{it} stands for the price of each intermediate input. Based on the marginal cost for Leontief

3.3.2 Myopic firms

As mentioned earlier, the myopic firms do not decide about the level of the investment in their private capital stock. This decision is driven by the saving decision of myopic households, which in turn determines the total capital stock of myopic firms. Equations (1.31) and (1.32) determine the myopic household's investment demand and the motion law of myopic firms' capital stock:

$$Inv_t^m = \frac{Sav_t^m}{Pk_t} \tag{1.31}$$

$$K_{t+1}^m(1+n) = Inv_t^m + (1-\delta^m)K_t^m \tag{1.32}$$

where Sav_t^m is as expressed in equation (1.8), and δ^m is the depreciation rate of the private capital stock of myopic firms.

Myopic firms, rather, decide on the desired level of the capital stock, while taking the level of the total capital stock supplied by the myopic household to the myopic firm as given. The myopic firms solve the static problem of maximizing their current profits. The problem's solution is identical to the intratemporal conditions of the forward-looking firms' problem, with the exception that the rental rate of private capital for myopic firms is expressed as in Equation (1.33) implying that the myopic firms will hire capital up to the point at which the value of its marginal product equals its rental price:

$$Rentk_t^m = PVA_{jt}^m(\alpha_{Vj}^m)(AV_j^m)^{-\rho_{VAj}^m}\left(\frac{VA_{jt}^m}{K_{jt}^m}\right)^{\frac{1}{\sigma_{VAj}^m}} \tag{1.33}$$

3.4 Supply of Exports and Domestic Goods

Once output is determined, it can be destined for local demand or be exported. The fact that both export output and domestic output are imperfect substitutes is depicted by a constant elasticity of transformation (CET) function which aggregates exports, EX_{jt} and domestic sales, XSD_{jt} into a composite good, XTS_{jt}:

$$XTS_{jt} = AX_j\left(\delta_{Xj}EX_{jt}^{\frac{1+\sigma_{Xj}}{\sigma_{Xj}}} + (1-\delta_{Xj})XDS_{jt}^{\frac{1+\sigma_{Xj}}{\sigma_{Xj}}}\right)^{\frac{\sigma_{Xj}}{1+\sigma_{Xj}}} \tag{1.34}$$

goods of sector j and the relative differential of the price of exports and the price of total supply of goods. Equation (1.39) represents the sectoral supply of goods for sale in domestic market.

3.5 Demand for Imports and Domestic Goods

On the other hand, aggregate domestic demand is determined by a constant elasticity of substitution function (CES) between the demand for locally produced goods, XDD_{jt} and demand for imports, M_{jt}:

$$XTD_{jt} = AM_j \left(\delta_{Mj} M_{jt}^{-\sigma_{Mj}} + \left(1 - \delta_{Mj}\right) XDD_{jt}{}^{-\sigma_{Mj}}\right)^{\frac{-1}{\sigma_{Mj}}} \quad (1.40)$$

where AM_jdenotes the shifting parameter of the consumption function; δ_{Mj} represents a share parameter which relates to the different consumption goods; and σ_{Mj} is the substitution elasticity between the imported consumption goods and the domestic good. This Armington aggregation function for composite goods, XT_{jt} shows an imperfect substitutability between imported and domestically produced goods.

In this case, the consumer's task within each period is to minimize expenditures by choosing the optimal mix of domestic goods and imported goods subject to imperfect substitutability:

$$Min_{\{XDD_{jt}, M_{jt}\}} Pc_{jt} XT_{jt} = Pd_{jt} XDD_{jt} + Pm_{jt} M_{jt} \quad (1.41)$$

Such that Equation (1.40) holds.

where the value of the total demand for goods of sector j, $Pc_{jt}XT_{jt}$ is the sum of local demand and imports, multiplied by their respective prices, Pd_{jt} and Pm_{jt}. The first-order condition of this minimization problem states that the import composition of domestic demand is influenced by the ratio of domestic and import prices:

$$\frac{M_{jt}}{XDD_{jt}} = \left[\frac{\delta_{Mj} Pd_{jt}}{(1 - \delta_{Mj}) Pm_{jt}}\right]^{\sigma_{Mj}} \quad (1.42)$$

indirect taxes from firms levied on sectoral output, $\sum_j \tau_{jt}^p PXTS_{jt}XTS_{jt}$ and on imported, $\sum_i \tau_i^M Pwm_{it}M_{it}$, and exported goods, $\sum_i \tau_i^{EX} Pex_{it}EX_{it}$. From households, the government collects personal income taxes that consist of a proportional tax on labour earnings of forward-looking and myopic households, $\tau_y^f YL_t^f$ and, $\tau_y^m YL_t^m$, respectively and of a proportional tax on the capital income of forward-looking households, $\tau_k \sum_j Div_{jt}^f$. In addition, the government receives transfer payments from the rest of the world, $TROWG_t$, which are a part of government income. The expenditures of the government are composed of three items: public investment in infrastructure, $Invg_t$, government consumption of goods, GC_{it}, and transfer payments to forward-looking and myopic households, $TRGH_t^f$ and $TRGH_t^m$, respectively. For simplicity, all government tax rates and transfers distributed by the government to households as well as those received from abroad are set to be exogenous. Government's consumption of goods, GC_{it}, is also set to be exogenous. Hence, the government's budget constraint is given as follows:

$$GSAV_t = YG_t + TROWG_t - \sum_i Pc_{it}GC_{it} - Pk_tInvg_t - TRGH^f - TRGH^m \tag{1.48}$$

where

$$YG_t = \sum_j \tau_{jt}^p PXTS_{jt}XTS_{jt} + \sum_i[\tau_i^C Pc_{it}c_{it} + \tau_i^{INV} Pcinv_{it}DINV_{it} + \tau_i^M Pwm_{it}M_{it} + \tau_i^{EX} Pex_{it}EX_{it}] + \tau_y^f YL_t^f + \tau_y^m YL_t^m + \tau_k \sum_j Div_{jt}^f \tag{1.49}$$

The government balance specified in Equation (1.48) requires that government savings, $Gsav_t$ equals government expenditure less the revenue generated by the government The government is restricted to keeping its balance, $GSAV_t$ balanced in each period. The government's balance adjustment can take place either through a uniform proportional increase in the sectoral tax rates on production or through increased transfers from the rest of the world to the government in the form of foreign aid. Furthermore, the simulated policy change of increased investment in infrastructure is represented by the exogenous variables, γ_{Gt}, which is defined as the ratio of the value of spending on infrastructure to GDP at market cost, $GDPM_t$:

$$Pk_tInvg_t = \gamma_{Gt}GDPM_t \tag{1.50}$$

where, $GDPM_t = \sum_i Pc_{it}c_{it}^h + Pcinv_{it}Dinv_{it} + Pc_{it}Dstk_{it} + Pc_{it}GC_{it} + Pwex_{it}EX_{it} - Pwm_{it}M_{it}$ (1.51) by sector of destination, TJ_t is specified as a sum of public investment in infrastructure, investment made by myopic firms (as determined by the myopic households' saving decision), and forward-looking firms' investment in private capital inclusive of adjustment costs:

$$TJ_t = \sum_i J_{it} + Inv_t^m + Invg_t \quad (1.56)$$

where $J_{it} = Inv_{jt}\left(1 + \frac{\beta_{KVj}}{2}\frac{Inv_{jt}}{K_{jt}}\right)$ (1.57)

On the other hand, an increase in investment demand by sector of origin stimulates current production from the demand side. Demand for investment by sector of origin, $Dinv_{it}$ has the following expression:

$$Dinv_{it} = \beta_{Ki} TJ_t \quad (1.58)$$

where β_{Ki} is a Leontief parameter.

The price of the investment good by sector of origin is specified as follows:

$$Pcinv_{it} = Pc_{it}(1 + \tau_i^{inv}) \quad (1.59)$$

The composite price of the investment good is specified as follows:

$$Pk_t TJ_t = \sum_i Pc_{it}(1 + \tau_i^{inv}) Dinv_{it} \quad (1.60)$$

where τ_i^{INV} is tax on the investment good.

3.8 Other Demand Components

Total final sectoral demand of goods (composite demand), XT_{jt} is defined as the sum of demands for household and government final consumption, c_{it}^m, c_{it}^f and GC_{it}, firms' demand for intermediate use, $\sum_j V_{ijt}$ and for investment by sector of origin, $Dinv_{it}$, including inventory changes, $Dstk_{it}$:

$$XT_{it} = c_{it}^m + c_{it}^f + GC_{it} + Dinv_{it} + Dstk_{it} + \sum_j V_{ijt} \quad (1.61)$$

equal to the difference between the sum of total financial assets of the forward-looking firm, VF_{jt}^{f} and external debt, BF_t:

$$F_t = \sum_j VF_{jt}^{f} - BF_t \tag{1.65}$$

Based on this definition, we may transform the forward-looking household's budget constraint into an economy-wide budget constraint as follows:

$$F_{t+1}(1+n) = F_t(1+r^*) + \left(1-\tau_y^f\right)\varphi W_t LS_t + TRG_t^f + ER_t TROW_t^f + KG_t \sum_j \xi_{jt} + Gsav_t - \tau_k \sum_j Div_{jt}^f - PC_t^f C_t^f - \sum_i Pc_{it} Dstk_{it} \tag{1.66}$$

According to Walras' Law, saving is equal to investment:

$$(1-\tau_y^f)\varphi W_t LS_t + KG_t \sum_j \xi_{jt_t}^f + TRG_t^f + ER_t TROW_t^f - \tau_k \sum_j Div_{jt}^f - PC_t^f C_t^f + Gsav_t = \sum_i Pc_{it} Dstk_{it} \tag{1.67}$$

where on the left hand side of (1.67), total national savings consist of the savings of the forward-looking household and of the government. This national savings is used to finance total investment bearing in mind that the saving of the myopic households are used to fund myopic firms' investment needs must equal total investment.

Since the model equations fulfill Walras' Law, either of the four equations above (that is, Equations 1.62, 1.63, 1.64, and 1.65) has to be dropped from the model or a variable has to be added in order to equilibrate the number of equations with the number of variables. Here, we drop the commodity market equilibrium condition. Additionally, we index the nominal exchange rate (the conversion factor between currencies) to the model's numeraire.

Finally, the economy's sustainable balanced-growth equilibrium path is characterized as a path where all variables remain constant:

$$q_{jt}^f\left(\delta_j^f + r^*\right) = PVA_{jt}^f RK_{jt}^f + Pk_t\left(\frac{\beta_{KVj}^f}{2}\right)\left(\frac{Inv_{jt}^f}{K_{jt}^f}\right)^2 \tag{1.68}$$

This production structure has hardly changed since 1991.[16] In 1991, Benin embarked on a structural adjustment program (SAP) supported by the World Bank and the IMF after nearly two decades of state-led development. As observed in *Figure 1*, until 1991, Benin experienced lower and quite irregular growth rates characterized by periods of both positive increase and persistent decrease in GDP growth. Structural adjustment reforms coupled with the 1994 devaluation of the CFA Franc[17] helped the economy sustain a positive growth rate averaging 4.4% over the 1991-2009 period. Notwithstanding the improved growth performance, Benin's GDP growth rate has not been uniform during this period. While Benin achieved relatively high growth rates between 1991 and 2000 (fluctuating in the range of 4 to 6%), its economic growth performance began to decline steadily as of 2001. Growth, however, did pick up in 2007 and 2008 thanks to the improved performance of the tertiary sector and higher cotton production (World Bank, 2009).

Against the background of an appreciating real effective exchange rate[18] and deteriorating terms of trade, the protracted decline in Benin's growth performance over the 2001-2006 period highlights the extent of Benin's vulnerability to exogenous shocks. Benin's dependence on re-export activities and a single cash crop render the country highly vulnerable to external shocks and changes in the trade policy of its main trade partner, Nigeria. More recently, and partly a result of the fall in world commodity prices and in the demand for its only main export - cotton, Benin saw its growth rate decline to 2.7% in 2009 compared to 5.1% in 2008.

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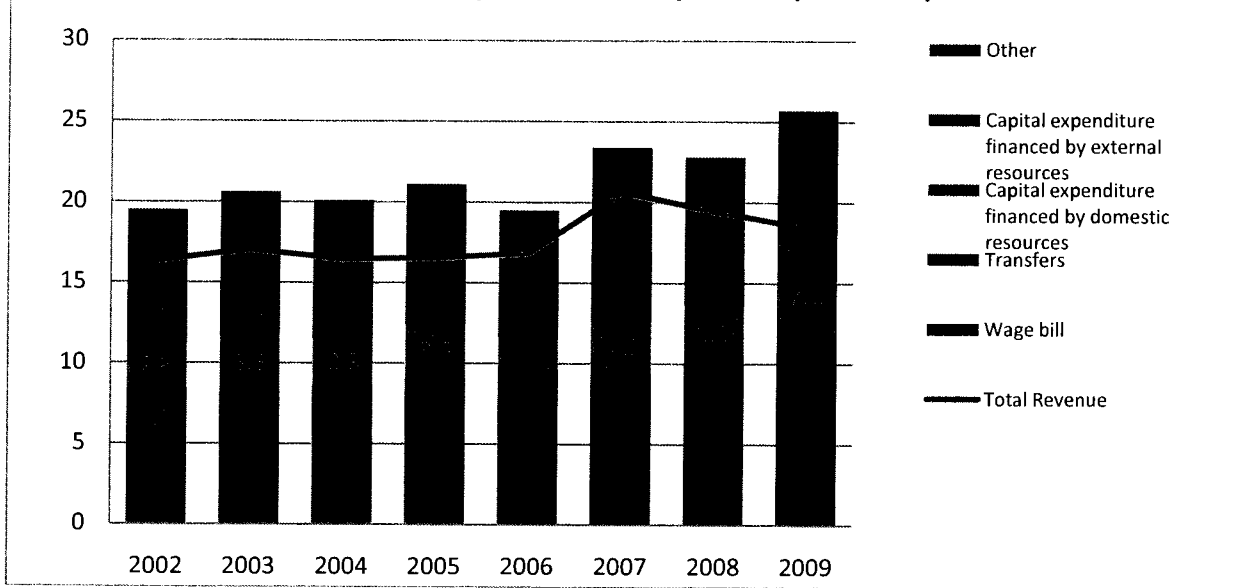
[16] In 1991, the primary sector, the secondary sector and the tertiary sector accounted for 36.3%, 12.7% and 46.2% of GDP, respectively. See IMF. (1998). Benin: Selected Issues and Statistical Appendix. IMF Staff Country Report No. 98/88. Washington, D.C.

[17] In 1994, the CFA franc was devalued to 100 CFA francs per French franc from its initial peg rate of 50 CFA Francs per French Franc. Since 1999, the currency has been pegged to the euro at a rate of 655.96 CFA per euro.

[18] The 1994 CFA Franc devaluation lead to the appreciation of the real effective exchange rate (REER) for all WAEMU member states, with Benin's REER increasing the most (41%) since 1994-2007 (IMF, 2008).

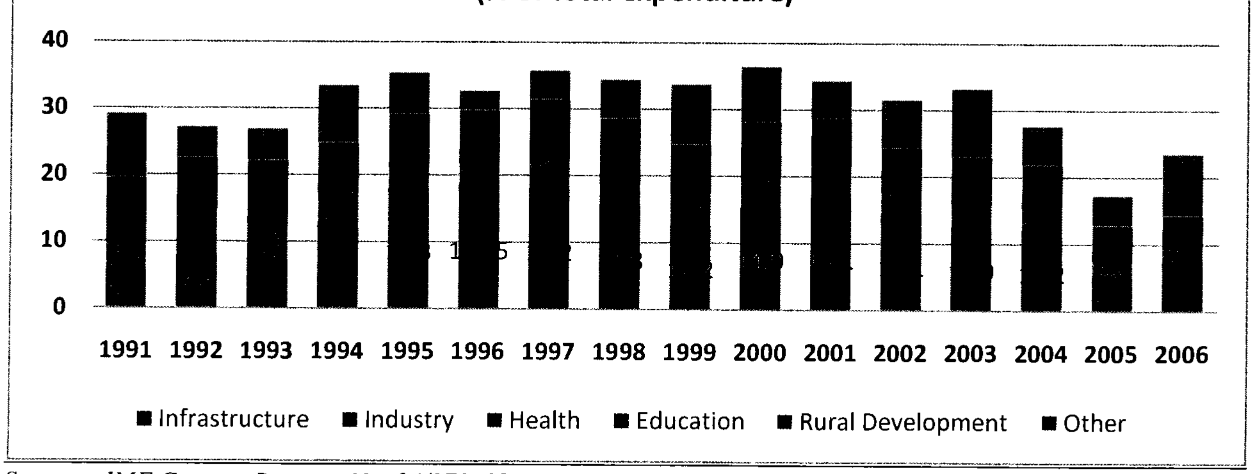
Figure 2: Expenditure Composition (% of GDP)



Sources: IMF Country Reports, Nos. 10/195, 09/252, 07/213, 05/288, and 07/6.

While government investment expenditure tended to slowly trend upward since 1991 reaching 36.4% of total expenditure in 2000, it started to wane beginning in 2001 (before slightly picking up in 2006) in accordance with the fluctuations in the real GDP growth rate. However, as depicted in *Figure 3*, public investment in infrastructure has for the most part constituted the bulk of total government expenditure throughout the 1991-2006 period.

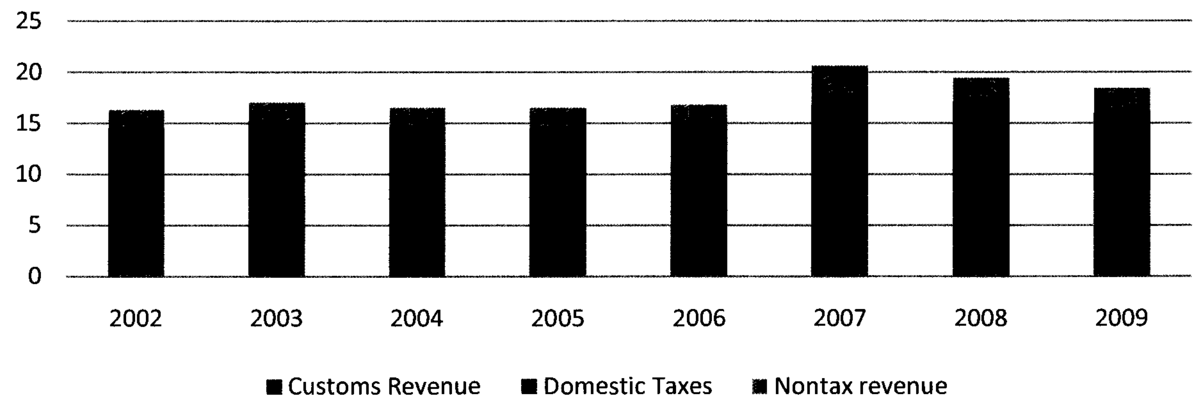
Figure 3: Government Investment Expenditure (% of total expenditure)



Sources: IMF Country Reports, No. 04/370, 02/164, 08/287, and 98/88.

Accordingly, the share of domestic revenues financing public investment increased, whereby the national budget provides the chief source of funds. Domestic revenues, in turn are largely drawn from direct and indirect taxes and taxes on international trade. *Figure 5* indicates that customs receipts comprise a key financial source of domestic revenue.

Figure 5: Revenue Composition (% of GDP)



Sources: IMF Country Reports, Nos. 10/195, 09/252, 07/213, 05/288, and 07/6.

5. Data and Calibration

We calibrate our dynamic CGE model to the benchmark equilibrium dataset as reflected in the SAM (Social Accounting Matrix) of 2006 for the economy of Benin. The 2006 SAM was built on 2006 national accounts data and 1999 Input-Output table, which was updated using the RAS technique. Before simulating any counterfactual infrastructure policy, we first simulate the "base case" or "business as usual" scenario to establish a benchmark to use in our comparisons with the infrastructure policy case. Table 2 presents the characteristics of the Beninese economy in the base case scenario, which is used to show the magnitudes of changes in the variables of interests (e.g. percentage changes) compared to the counterfactual case. For numerical purposes, we assume that the economy reaches a steady-state through a convergence process in about 60 years. The model was simulated using the GAMS software package.

Some parameters of the model were exogenously determined. Upon our review of the literature that estimates the public capital output elasticity for a variety of developing countries, including Sub-Saharan Africa, it was found that the estimated public capital output elasticity averages at around 0.30. This is not substantially different from the Benin-specific value of 0.29 obtained by

6.1 Simulation 1: Increase in public infrastructure investment under production tax financing

In this policy experiment, a 10% increase in the ratio of public investment in infrastructure to GDP is simulated assuming that this increase in government spending is financed by a uniform percentage increase in the production tax imposed proportionally on all myopic and forward-looking firms. The results of the macroeconomic impact of the policy are summarized in Table 4. Tables 5 and 6 present the sectoral impacts on selected volume and price variables, respectively. The corresponding sets of Figures 6 to 8 depict the transitional dynamic paths. We focus our analysis of the macroeconomic effects induced by the increase in public infrastructure on the differing economic choices that myopic and forward-looking firms make, notably with respect to the level of their private capital investment despite being subject to the same productivity shock.

In the period when government investment in infrastructure increases, myopic household's disposable income falls by 0.14% owing to a drop in the wage rate that decreases the myopic household's labour income. The myopic household reacts to this shortfall in disposable income by reducing its demand for consumption goods in the first period. The shortfall in disposable income further implies a proportional decrease in the myopic household's saving. This negative saving effect directly affects the short-run investment spending of myopic firms, which is cut by 0.92% thereby reducing their private capital stock by 0.15%.

In contrast, the forward-looking households do not act as abruptly as myopic households in terms of their short-run consumption decision. The forward-looking households feel a desire to smooth consumption, and hence, choose to increase their consumption spending by 0.77%. This, in turn, implies that private investment of the forward-looking firms is reduced. However, the negative short-run investment reaction of the forward-looking firms is less accentuated than that of the myopic firms. This is not surprising given the fact that forward-looking firms are able to anticipate the increases in future capital productivity created by the higher stock of public capital. In addition, the forward-looking firms fund their investment through retained earnings and are thus not constrained by the savings provided by the forward-looking household as is the run level of forward-looking firms' investment compared to that of the myopic firms is reflective of their ability to anticipate enhanced future capital productivity.

Thus, public infrastructure investment starts to crowd in private investment in the medium and the long-run through an indirect complementarity effect. Clearly, this supply-side effect of public investment in infrastructure on the marginal products of private capital and labour comes into operation only gradually as additional public capital is accumulated. In the short-run, however, it is the direct effect of public investment in infrastructure on the stock of public capital that stimulates output as the distortionary production tax used to finance the public outlay counteracts the productivity enhancing role of public capital. This is exemplified by the fairly low short-run rate of return on myopic household's private capital stock.

Nonetheless, rising private investment, in turn, stimulates the accumulation of the private capital stock over time (rising by 2.05% in the long-run); this, combined with the gradual increase in the stock of public capital stimulates greater output gains over time. The ongoing expansion of output, in turn, entails that the price of the investment good gradually falls, thus adding a further impetus to firms to increase private capital demand. Additionally, the higher stock of public capital allows for a gradual decrease in the production tax rate needed to finance the public infrastructure investment thereby contributing to greater output expansion over time. Government revenue falls steadily, but still remains higher than in the benchmark scenario.

The importance of the productivity enhancing effect of public infrastructure is further highlighted when we analyze Benin's external economic performance. Public investment in infrastructure produces a short-run appreciation of the real exchange rate, whereby imports increase by 0.41% and exports decrease by 1.29%. However, as public capital gets installed and begins to generate positive productivity effects on private inputs, the appreciation effect on the real exchange rate weakens in the medium-run, but nonetheless remains present. It is precisely due to this gradual rise in marginal productivity that exports are able to increase in the medium-run despite the presence of an appreciated real exchange rate, although not as much as imports.

Services are most negatively affected in terms of output, which falls in the short-run by 0.80%, 0.66% and 0.47% respectively. These contractionary effects, which are somewhat attenuated in the medium-run, but nonetheless persist, are mainly attributable to the distorting fiscal mechanism used to finance government infrastructure investment that in turn lowers domestic production in these sectors, but also to the non-tradable nature of these sectors implying that all negative shocks on industries are translated onto them. Output on the manufacturing side of the economy also does not expand in the short-run. This is due largely to decreased export supply as well as domestic production, whereby the increases in the total domestic demand of these industries, such as *Agri-Industry*, *Other Modern Industries* and *Industrial Textiles* are mainly met by increased imports. This suggests that the short-run marginal productivity effects of public capital may be higher in the agricultural sectors of the economy than in the services and the manufacturing sectors.

Consequently, resource allocation will flow from the contracting manufacturing and service sectors of the economy towards the expanding agricultural sectors of the economy. The shadow price of capital increases in all sectors during the early phase of transition but gradually decreases over time, eventually falling below its initial steady state value. However, the ratio of shadow price to purchase price of capital increases in only three sectors in the short-run, namely *Cash Crop*, *Cotton* and *Other Modern Industries*. Accordingly, investment in these sectors rises, particularly in the *Cotton* sector where it increases by 2.4%, while there is a crowding-out of investment in the other sectors in the short-run. Lower private investment in the other sectors, however, reduces the marginal product of labour thereby driving down employment in those sectors.

As the supply-side effects of public capital expansion strengthen over time, output expansion takes place over the medium and the long-run in every sector. The higher productivity of private inputs drives down the prices of domestic goods in all sectors over time and raises the ratio of shadow price to purchase price of capital over the medium-run, eventually stabilizing at around zero in the long-run. One the one hand, falling domestic prices contain the initial onset of the Dutch Disease by promoting greater exports through their depreciating effect on the real exchange rate and by boosting total domestic demand in all sectors. On the other hand, the

In contrast to the production tax financing scenario, myopic households increase their short-run consumption spending by 1.56%. The increase in consumption reflects the rise in the myopic household's disposable income brought about by the aid transfer and by the increased capital and wage income realized in the absence of a distortionary tax. However, following the initial impact period, myopic households slowly decrease their consumption spending to its long-run level of 1.25% owing largely to the gradual reduction in the aid inflows needed to finance new infrastructure. Nonetheless, the myopic households are able to attain higher consumption throughout the entire adjustment process to the long-run in comparison to the case in which the production tax financed the public investment in infrastructure.

Although the forward-looking households also increase their consumption spending in the short-run they do so by a lesser magnitude than in the production-tax financing scenario (0.65% vs. 0.77%). However, having the ability to smooth consumption, the forward-looking households increase their medium and long-run consumption spending by 1.11% and 1.8% respectively – more so than under the production tax funding option.

An important qualitative difference from the previous simulation is that public investment in infrastructure results in a short-run crowding-in effect on private investment. Both myopic and forward-looking firms increase their short-run investment spending by 0.29% and 0.47%, respectively, which, in turn allows them to expand their respective private capital stocks by 0.05% and 0.07%. This greater private capital accumulation, although somewhat attenuated by a steeper rise in the price of the investment good, is largely made possible by the fact that the foreign aid financing mechanism does not play against the productivity enhancing role of public capital in the short-run. For example, the short-run rental rate of capital of myopic household rises by 1.76% as opposed to 0.02% in the production tax financing scenario. Cognizant of future enhanced private capital productivity, the increase in the investment made by forward-looking firms in the initial stages of the transitional period is even steeper than that of the myopic firms as illustrated by Figure 10.

Ultimately, aid-financed infrastructure investment produces a more favourable effect on long-run private sector investment that, in turn, results in a larger expansion of the long-run private short-run domestic prices, and thus a larger appreciation of the real exchange rate. The higher total domestic demand, in turn, is accommodated by greater sectoral imports at all time periods.

In the absence of a distorting fiscal mechanism, aid-financed infrastructure investment works in favour of domestic production in the short-run for most of the sectors. The exception to this are certain manufacturing industries, such as the *Agri-Industry*, *Other Modern Industries* and *Industrial Textiles* where domestic sales decline, although generally less than in the production-tax financing case. In conjunction with the negative export supply response, these sectors experience the greatest output losses in the short run ranging from -0.27% to -0.42%. While the export-oriented sectors of Benin's economy, particularly *Other Business Services* and *Cotton* benefit from increased domestic production, they too record a decrease in their short-run output owing to a sizeable fall in their exports.

In the longer-run, however, the productivity effects stemming from productive public investment and increased accumulation of both types of capital contribute to further increasing domestic supply and reversing the Dutch Disease effects present over the short to medium-run period. In the long-run, exports increase across the board, although by slightly less than in the previous simulation. This has a bearing on Benin's most important export sector, *Cotton* where long-run output increases by 6.18% - which is some 0.15 percentage points lower than in the production tax financing scenario. *Cash Crops* sector is also slightly affected, with its long-run output being 0.02% percentage points lower than in the earlier simulation. For other sectors, however, the lower increase in exports is mainly offset by greater long-run domestic production as well as greater long-run investment levels. Ultimately, all sectors, apart from *Cotton* and *Cash Crops* are able to realize greater long-run output gains that in the production tax financing scenario.

7. Conclusion

This paper has developed a multisector, intertemporal CGE model with public capital that features liquidity-constrained and non-liquidity-constrained households and firms. Using this model, we have analyzed the aggregate and sectoral effects of externally and domestically-financed public investment in infrastructure on the economy of Benin from both the demand and supply sides. The simulation results analysis shows that the two fiscal instruments - production

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Table 4: Simulation 1 - 10% increase in the ratio of public investment in infrastructure to GDP
Production tax financing
Aggregate results (Percentage deviation from base run, unless otherwise mentioned)

	Short run	**Medium run**	**Long run**
Rental rate of capital of myopic household	0.02	2.07	0.73
Wage rate	-0.23	0.92	3.35
Price of investment good	0.79	0.43	-0.42
Real GDP	0.49	0.82	1.39
Total household consumption	-0.06	0.22	1.04
Myopic	-0.14	0.05	0.61
Forward looking	0.77	0.92	1.35
Total investment	1.87	3.23	4.60
Public investment	9.68	10.43	12.00
Private investment	-0.74	0.83	2.13
Myopic	-0.92	-0.38	1.04
Forward looking	-0.63	1.54	2.77
Total capital stock	0.35	1.39	4.72
Public capital stock	1.61	5.19	11.99
Private capital stock	-0.12	0.00	2.05
Myopic	-0.15	-0.36	1.04
Forward looking	-0.09	0.25	2.75
Total exports	-1.29	0.26	3.62
Total imports	0.41	0.74	1.24
Real exchange rate	-0.53	-0.29	0.37
Foreign saving	-3.79	-3.89	-4.16
Total income of myopic households	-0.14	0.05	0.61
Labour income	-0.23	0.92	3.35
Capital income	0.02	1.70	1.78
Wealth of forward looking households (as % of base GDP)	0.00	-0.56	-1.97
Firm value (as % of base GDP)	0.30	0.62	1.25
Foreign debt (as % of base GDP)	0.30	1.18	3.22
Government revenue	3.35	3.20	2.86
Increase in production tax rate (%)	22.96	18.52	6.82

Table 6: Simulation 1 - 10% increase in the ratio of public investment in infrastructure to GDP
Production tax financing
Sectoral impact on prices for selected variables (Percentage deviation from base run)

	Food Agric.	Cash Crops	Agri-Industries	Cotton	Agri-Handicrafts	Other Modern Industries	Utilities	Industrial Textiles	Other Industrial Handicrafts	Transport-Comm.	Bank Services	Other Business Services
Price of gross output												
Short run	-0.12	0.31	-2.39	0.33	-0.21	0.40	-7.59	-1.16	-4.77	-9.14	-10.48	-5.54
Medium run	-0.29	-0.04	-2.52	-0.08	-0.64	0.05	-7.18	-1.66	-5.07	-8.75	-9.96	-5.64
Long run	-0.31	-1.06	-3.24	-1.09	-1.42	-1.01	-7.72	-2.99	-5.76	-8.90	-10.16	-5.79
Price of domestic good												
Short run	-0.09	0.34	0.31	0.70	0.09	0.42	0.70	0.31	1.22	0.93	0.56	0.78
Medium run	-0.26	-0.01	0.12	-0.08	-0.35	0.07	0.97	-0.23	0.77	1.15	0.90	0.49
Long run	-0.28	-1.04	-0.77	-2.08	-1.15	-0.99	-0.08	-1.66	-0.29	0.41	0.04	-0.10
Price of composite consumption good												
Short run	-0.08	0.34	0.11	0.70	0.09	0.08	0.57	0.08	1.22	0.92	0.56	0.75
Medium run	-0.24	-0.01	0.04	-0.08	-0.35	0.01	0.79	-0.06	0.77	1.14	0.90	0.48
Long run	-0.26	-1.04	-0.26	-2.08	-1.15	-0.20	-0.06	-0.44	-0.29	0.40	0.04	-0.10
Shadow price of capital												
Short run		1.18	0.47	1.40		0.83	0.07	0.67		0.20	0.21	
Medium run		0.89	0.63	1.05		0.82	0.54	0.76		0.54	0.55	
Long run		-0.42	-0.42	-0.42		-0.42	-0.42	-0.42		-0.42	-0.42	
Ratio of shadow price to purchase price of capital												
Short run		0.39	-0.32	0.61		0.05	-0.71	-0.12		-0.58	-0.58	
Medium run		0.47	0.20	0.62		0.39	0.11	0.34		0.11	0.12	
Long run		0.01	0.00	0.01		0.01	0.00	0.00		0.00	0.00	

Figure 7: Simulation 1 – 10% increase in the ratio of public investment in infrastructure to GDP
Production tax financing
Transitional Dynamic Paths of Selected Sectoral Volume Variables

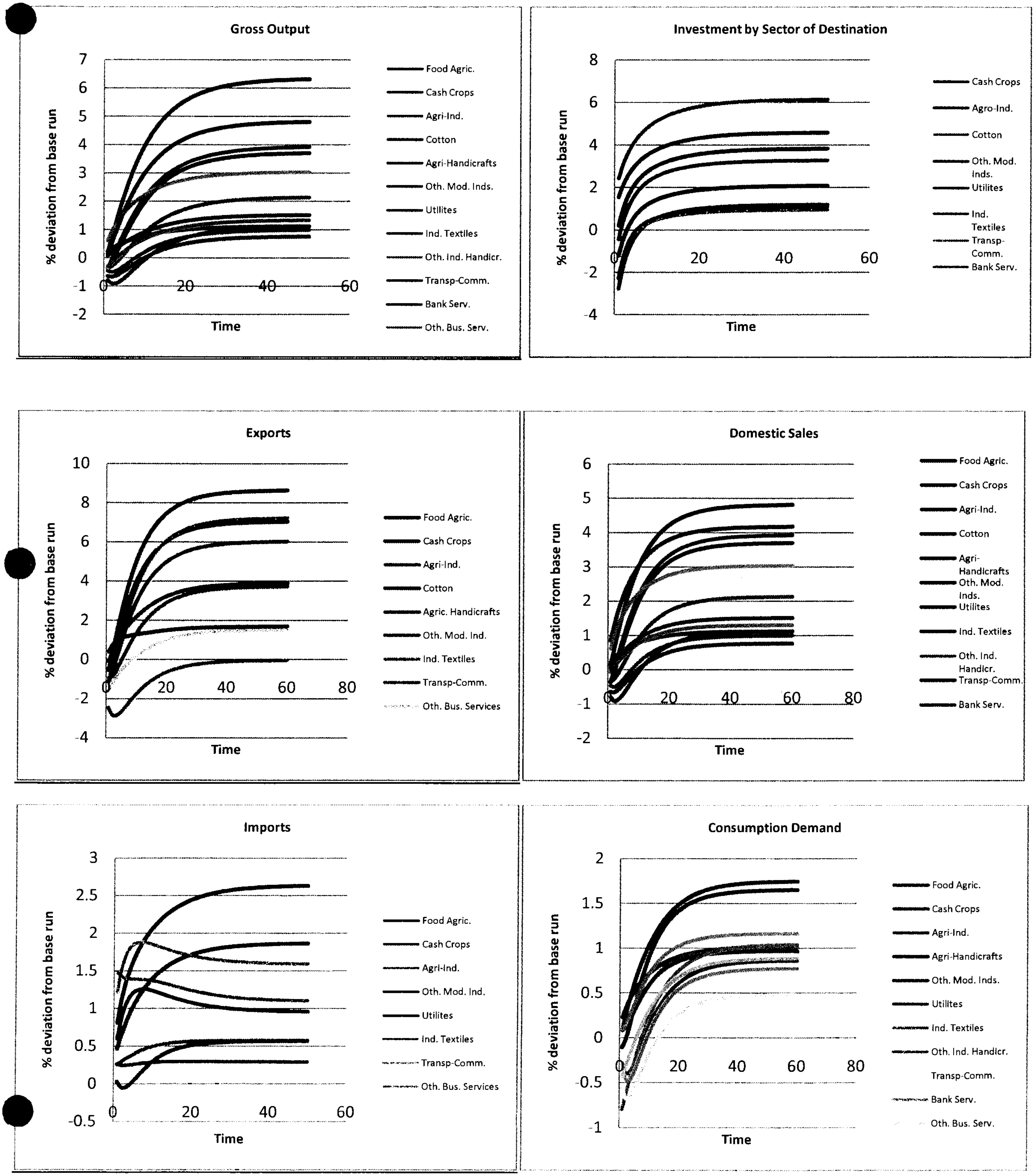

Table 7: Simulation 2 - 10% increase in the ratio of public investment in infrastructure to GDP
Foreign-aid financing
Aggregate results (Percentage deviation from base run, unless otherwise mentioned)

	Short run	**Medium run**	**Long run**
Rental rate of capital of myopic household	1.76	2.19	0.39
Wage rate	1.48	2.56	4.25
Price of investment good	1.27	0.68	-0.28
Real GDP	1.52	1.62	1.84
Total household consumption	0.52	0.86	1.45
Myopic	1.56	1.38	1.25
Forward looking	0.65	1.11	1.80
Total investment	2.87	3.98	4.96
Public investment	10.26	11.03	12.34
Private investment	0.40	1.64	2.49
Myopic	0.29	0.69	1.53
Forward looking	0.47	2.19	3.06
Total capital stock	0.50	1.83	5.09
Public capital stock	1.71	5.50	12.34
Private capital stock	0.06	0.48	2.43
Myopic	0.05	0.24	1.53
Forward looking	0.07	0.65	3.05
Total exports	-2.64	-0.56	3.20
Total imports	1.87	1.91	1.87
Real exchange rate	-1.50	-0.86	0.08
Foreign saving	-3.87	-3.97	-4.13
Total income of myopic households	1.56	1.38	1.25
Labour income	1.48	2.56	4.25
Capital income	1.76	2.43	1.92
Wealth of forward looking households (as % of base GDP)	0.00	-0.38	-1.01
Firm value (as % of base GDP)	0.78	1.03	1.49
Foreign debt (as % of base GDP)	0.78	1.41	2.50
Government revenue	4.43	3.88	3.23
Additional foreign aid as percentage of base GDP	0.57	0.43	0.16

Table 9: Simulation 2 - 10% increase in the ratio of public investment in infrastructure to GDP
Foreign Aid financing
Sectoral impact on prices for selected variables (Percentage deviation from base run)

	Food Agric.	Cash Crops	Agri-Industries	Cotton	Agri-Handicrafts	Other Modern Industries	Utilities	Industrial Textiles	Other Industrial Handicrafts	Transport-Comm.	Bank Services	Other Business Services
Price of gross output												
Short run	1.47	0.89	-1.47	0.84	1.14	0.95	-6.35	-0.30	-3.82	-7.66	-8.45	-4.16
Medium run	0.88	0.49	-1.92	0.40	0.23	0.42	-6.65	-0.99	-4.53	-7.97	-8.92	-4.70
Long run	0.24	-0.84	-2.98	-0.89	-1.06	-0.84	-7.52	-2.70	-5.52	-8.56	-9.74	-5.37
Price of domestic good												
Short run	1.50	0.92	0.98	1.67	1.42	0.97	1.14	1.04	1.57	1.44	1.58	1.72
Medium run	0.92	0.52	0.52	0.83	0.50	0.44	0.81	0.33	0.82	1.11	1.06	1.04
Long run	0.27	-0.82	-0.58	-1.68	-0.80	-0.82	-0.13	-1.40	-0.22	0.45	0.15	0.19
Price of composite consumption good												
Short run	1.39	0.92	0.33	1.67	1.42	0.19	0.92	0.27	1.57	1.42	1.58	1.67
Medium run	0.85	0.52	0.17	0.83	0.50	0.09	0.65	0.09	0.82	1.09	1.06	1.01
Long run	0.25	-0.81	-0.20	-1.68	-0.80	-0.17	-0.11	-0.37	-0.22	0.44	0.15	0.19
Shadow price of capital												
Short run		1.53	1.12	1.61		1.32	1.20	1.17		1.31	1.35	
Medium run		1.19	0.96	1.34		1.14	0.89	1.08		0.86	0.87	
Long run		-0.28	-0.28	-0.28		-0.28	-0.28	-0.28		-0.28	-0.28	
Ratio of shadow price to purchase price of capital												
Short run		0.26	-0.15	0.34		0.05	-0.07	-0.10		0.04	0.08	
Medium run		0.50	0.27	0.66		0.45	0.21	0.39		0.17	0.18	
Long run		0.00	0.00	0.00		0.00	0.00	0.00		0.00	0.00	

Figure 10: Simulation 1 – 10% increase in the ratio of public investment in infrastructure to GDP
Foreign aid financing
Transitional Dynamic Paths of Selected Sectoral Volume Variables