South Africa: Fiscal Imbalances and Intertemporal CGE Modelling

Ramos Mabugu[1], Hélène Maisonnave[2], Véronique Robichaud[3] and Margaret Chitiga[4]

Abstract

This paper uses an intertemporal computable general equilibrium to investigate the consequences of an expansive fiscal policy designed to accelerate economic growth in South Africa. A key contribution is made to existing literature on the transmission mechanism of fiscal policy in African economies where to best of our knowledge, no published study has empirically analyzed macroeconomic effects of fiscal policy in the context of an open, middle-income sub-Saharan African economy like South Africa's using an integrated intertemporal model with such disaggregated production structure. Intensified utilization of expansionary fiscal strategies envisaged raises a number of critical policy questions such as composition of spending and how much does it matter whether expanded spending are financed by reductions in government expenditure, or by increases in government's budget deficit or by increased taxation? Results show that an expansive fiscal policy would have short run positive impact on GDP but would translate into a greater debt-to-GDP ratio. Financing increased spending through taxation, direct or indirect, would mitigate this impact but would also have negative short run impact on macroeconomic variables. Increased investment spending would improve long run GDP, under any financing scheme, and would decrease debt-to-GDP ratio as well as deficit-to-GDP ratio. This outcome is driven by the positive impact infrastructure has on total factor productivity. Sensitivity analysis shows that these conclusions are qualitatively similar for a wide value of the elasticity of the total factor productivity to infrastructure. In fact, the conclusions hold even when comparing different financing schemes.

JEL Classification: D58, D92, H54, H59

Keywords: Intertemporal CGE Model: New Growth Path: Infrastructure: Total factor productivity: South Africa.

[1] Financial and Fiscal Commission, South Africa. Corresponding author: Ramosm@ffc.co.za
[2] CIRPEE, Université Laval, and PEP network, Canada
[3] CIRPEE, Université Laval, and PEP network, Canada
[4] Human Sciences Research Council, Economic Performance and Development, South Africa

1. Introduction

Increases in government expenditure can benefit the economy by affecting the level of income and its distribution. This can influence people's wages and returns to capital thereby affecting saving and investment, thus potentially boosting economic growth. However, increased spending, ceteris paribus, will translate into a greater debt, which might not be sustainable in the long run. Indeed, if the government increases its spending, it might need to either reduce them in the future or increase taxes in order to get back to its original debt-to-Gross Domestic Product (GDP) ratio. To evaluate the impact of such policies, an intertemporal model is constructed and applied to South Africa. In such a model, firms and households have a forward-looking behaviour and thus take into account all future prices in their investment and consumption decisions. By taking this approach, major contributions to existing literature on the transmission mechanism of fiscal policy in African economies is made. To the best of our knowledge, no published study has empirically analyzed the macroeconomic effects of fiscal policy in the context of an open, middle-income sub-Saharan African economy like South Africa's using an integrated intertemporal model with such rich production disaggregation. It is believed that this approach can provide important insights on the fiscal constraints and their impact on the economy as a whole.

South Africa experienced a long period of economic decline in the last decades of apartheid (1985–1994). In the immediate post-apartheid period (1995–2003) economic growth rates improved and then picked up substantially from 2004 to 2007. However, in 2008 the global economic crisis resulted in a slowdown in economic growth. Economic recovery and ensuing fiscal consolidation has evolved better than expected. This good performance, however, masks a more complex reality, that of a tepid economic recovery associated with unemployment, poverty and inequality. Poverty remains high, especially among African and female-headed households, despite an unprecedented extension of government social grants that have helped to reduce absolute poverty. Poor educational and health outcomes are similarly skewed against the poor. These social realities, together with the realisation that dates for attaining the Millennium Development Goals are a mere four years away, have galvanised government to seek alternative ways of using public expenditures to grow the economy in order to address poverty and inequality. Ambitious social reforms are being proposed to tackle poverty, growth and inequality problems. The National Health Insurance promises to be the largest reform undertaken in the health sector since the end of apartheid. Government has adopted the New Growth Path for South Africa, which aims to accelerate the creation of decent jobs and reduce inequality and poverty. As government identifies options for public expenditure, the need for reliable assessments of the probable impact of such expenditure becomes critical. Although fiscal authorities intend reducing the high fiscal deficit induced by the 2007-2009 global economic crisis and public debt, intensified utilization of expansionary fiscal strategies in this way may jeopardise fiscal sustainability. A number of critical policy questions such as the composition of spending and how much does it matter whether the expanded spending are financed by reductions in government expenditure, or by increases in government's budget deficit or by increased taxation are raised? As Mountford and Uhlig (2009) note, these questions are critical not only to the science of economics, but also for the practice of fiscal policy alike. Hence, it is an opportune time to reflect on the current state and likely future of South African fiscal policy. This paper provides such reflection, focusing specifically on the impact of the composition of government spending and alternative financing arrangements on the economy in both the short and longer-term developmental sense and impact on the allocation of resources.

The paper proceeds as follows: After the literature review, the data used to implement the model and the model itself are discussed, and then several fiscal policy simulations and their impacts on the economy are analysed.

2. Literature Review

(Neo) economics generally assumes that increasing employment and production does not require an activist fiscal policy. Government expenditure is believed to be consumptive and will crowd out private investment if financed with public debt. Wagner's law assumes that public expenditure is endogenous and hence cannot be used as a policy lever; politicians at best should pursue balanced budget strategies. However, Keynesian economists believe that public expenditure is important for determining the level and distribution of income, as the market mechanism will not be sufficient to restore full employment. The body of empirical literature related to the public expenditure–economic growth is substantial. Moreno-Dodson (2009) contains a review of government spending and economic growth studies. Of direct relevance for this study is the idea that the composition of public expenditures (capital versus current) can have differential impacts on economic growth.

2.1 Public investment and growth

The literature on the effects of public capital spending on output dates back to Arrow and Kurz (1970) and Aschauer (1989). During the 1980s and 1990s, the link between public investment in infrastructure and economic growth was of particular interest (especially in the USA). The research trend has moved from initial headline estimates of a production elasticity of 0.4 in 1989 to the more modest assessments of 0.1 in 1997. When exploring the 'public infrastructure debate', the complexity of the subject matter means that empirical controversies are to be expected. Many of the benefits of public investment (e.g. improved health and a cleaner environment) are difficult to measure and are not always included in the calculation of gross value added. As Gramlich (1994) points out: "it will always be difficult to relate infrastructure investment to its goals, or changes in them".

International Literature

In 1989 Aschauer's seminal paper found that public investment in infrastructure was a very important source of economic growth. Aschauer looked at the relationship between aggregate output and the stock and flow of government spending variables. He concluded that "core" infrastructure (streets, highways, airports and mass transit systems) should be given more weight when assessing the role that government plays in promoting economic growth and productivity improvements.

Aschauer's work suggested that the elasticity of output with respect to government capital was highly positive, within a range of 0.38 to 0.56, which implies extremely high returns. The marginal product of government capital would be in the region of 100% or more per annum, which means that one unit of government capital would pays for itself through higher output in a year or less. Given these results, it is not surprising that Aschauer's work initiated the 'public infrastructure debate'.

Munnell (1992) provides an excellent assessment of the early literature on the public infrastructure debate. She shows that the main problem with Aschauer's work is that his results do not rule out the possibility that the direction of causality runs from growth to infrastructure. In other words, economic growth might lead to an increase in the need for investment and/or an increase in the availability of funding. Munnell provides evidence to suggest the claim – that the wide range of estimates of public capital's impact on output "make the empirical linkages fragile" – is misleading. As Table 1 illustrates, in almost all cases the impact of public capital on private output has been found to be positive and statistically significant.

Table 1: The impact of an increase in the stock of public capital on output

Author	Focus of study	Output elasticity of public capital
Aschauer (1989)	US national	0.39
Holz-Eakin (1988)	US national	0.39
Munnell (1990a)	US national	0.34
Costa, Ellson and Martin (1987)	US states	0.20
Munnell (1990b)	US states	0.15
Duffy-Deno and Eberts (1989)	US metropolitan areas	0.08
Eberts (1986, 1990)	US metropolitan areas	0.03

Source: Table adopted from Munnell (1992)

Munnell concludes that, in addition to providing an immediate demand-side economic stimulus, public infrastructure investment appears to have a significant, positive effect on output and growth. However, in a policy making context, "[a]ggregate results cannot be used to guide actual investment spending. Only cost-benefit studies can determine which projects should be implemented".

In 1994, Gramlich's influential paper begins by defining public sector ownership as the stock of infrastructure capital, but highlights that a broader definition could include private infrastructure capital, human capital investment and research and development spending. This emphasises the importance of definition – what type of investment is being classified as infrastructure and what type is then being linked to economic growth. Gramlich notes that a new highway might provide a very high return, whereas maintenance of rural roads might provide low or even negative economic rates of return; in such areas, investment objectives may be primarily social rather than economic. He shows that Aschauer's claims about infrastructure's major positive influence on economic growth are less plausible, as only two-thirds of the capital stock analysed by Aschauer even purports to raising national output – and to varying degrees.

As research in the field progressed, disputes over the direction of causality between changes in productivity and investment in infrastructure arose. Evans and Karras (1994) analyzed infrastructure and productivity data for seven OECD countries between 1963 and 1988. The study found strong correlations between the two variables, but concluded that the direction of causality was the opposite of that reported by Aschauer and Munnel. That is, increased stocks of public capital were the result, not the cause, of increased productivity and economic growth. In analysing the correlation between average annual gross domestic product and government net capital stock, they concluded, "there is no evidence that government capital is highly productive" [Evans and Karras, 1994: 278]. In support of this view, Aklilu Zegeye (2000) found the output elasticity between public infrastructure and private investment to be just 0.02, concluding that infrastructure is a normal good, where wealthy countries will tend to have more and poor countries less.

Several other authors have attempted to resolve the causality question, refining their methodologies to capture the results of infrastructure investments, not the results of economic growth. A 2000 OECD study by Demetriades and Mamuneas, and a 2003 study by Esfahani and Ramirez handled the causality issue by introducing a "time-lag" between public infrastructure and productivity variables. Investments were compared to the productivity data from several years later afterwards, which allowed time for the benefits of infrastructure investments to manifest in the productivity data and reduced the chance of misrepresenting economic growth impacts as productivity impacts. Using this technique, both studies found that public infrastructure does have a measurable impact on increasing productivity and economic growth, although not of the magnitude reported by Aschauer.

Lau and Sin (1997) published an important econometric paper on public infrastructure and economic growth, which SACTRA (1999) referred to as "the most sophisticated subsequent econometric studies" and commended for circumventing the "causality" and "definition" difficulties highlighted by Munnell and Gramlich among others. Lau and Sin estimate the elasticity of output with respect to public capital to be 0.11, which implies a much lower marginal product of public investment than that indicated by Ashauer's original paper. However, it still suggests that infrastructure investment has a significant impact on output.

South African Literature

The literature on the impact of infrastructure investment on economic growth is still small and relatively recent in South Africa, but it follows a similar path to the trends observed for the international literature. Fourie (2006) offers a good account of the literature, and Table 2 summarises known studies on this topic.

Table 2: The impact of an increase in the stock of public capital on output in South Africa

Author	Infrastructure measure (on economic growth)	Econometric technique	Output elasticity
Abedian and Van Seventer (1995)	Public authorities capital stock	OLS	0.33
	Public sector capital stock	OLS	0.17
Coetzee and Le Roux (1998)	Public sector infrastructure stock	OLS	0.3
DBSA (1998)	Public authorities capital stock	OLS	0.25
		Cointegration	0.3
	Public sector capital stock	OLS	0.15
		Cointegration	0.28
	Public sector infrastructure stock	OLS	0.17
		Cointegration	0.25
Fedderke, Perkins and Luiz (2005)	Electricity generation	VECM	0.1-0.2 and rising to 0.5 after controlling for institutions
Bogetic and Fedderke (2005)	Infrastructure measures on labour productivity	VECM	0.2-0.4
	Infrastructure measures on total factor productivity	VECM	-0.6
Fourie (2006)	Electricity generation	VECM	0.2
	Electricity generation on a measure of equity performance	VECM	0.38
Amusa (2008)	Economic infrastructure	VAR	0.01-0.02
	Social infrastructure	VAR	0.01-0.02

Source: Table adopted from Fourie (2006) and extended by authors.

Early studies relied on classical econometric tools, but later studies use more recent techniques of Vector Error Correction Models (VECMs) and Vector Autoregressions (VARs). In spite of differences in methodology, the studies report a positive output elasticity. Bogetic and Fedderke (2005) find that infrastructure has positive effects on labour productivity but negative effects on total factor productivity. Their explanation for this counterintuitive result is that infrastructure only has direct effects and no indirect effects! This is grossly at odds with predictions from received theory that finds indirect effects are most important. A study by Fourie (2006) finds bi-directional causality between infrastructure and growth and large positive returns to infrastructure on equity. Using sophisticated VAR methodology, the recent study by Amusa (2008) finds that infrastructure on equity has larger positive effects on growth than economic infrastructure.

In brief, irrespective of the methodology used, the South African studies reviewed show that infrastructure spending has favourable effects on growth. Some go further and argue that infrastructure on equity has higher returns than economic infrastructure.

2.2 Current public expenditures and growth

Like for public investment, evidence is mixed concerning the relationship between public expenditures and economic growth. Alm and Embaye (2010) find evidence in support of Wagner's law, while Ansari *et al.* (1997) finds evidence for the Keynesian hypothesis. Ziramba (2008) on the other hand finds bi-directional causality, with no evidence for either the Keynesian or the Wagnerian hypotheses for South Africa. Marinkov (2011) recently constructed elasticity estimates for public expenditure variables for South Africa. Unlike the previous studies mentioned, disaggregated expenditures are employed: GDP, public expenditure, growth rate of total factor productivity, investment output ratio, as well as the marginal product of capital, are used to compute public expenditure GDP elasticities.[5]

Table 3: Summary of revenue elasticities for South Africa

Expenditure category	Elasticity estimate
Agriculture, forestry and fishing	2.41
Defence	0.22
Education	1.51
Fuel and energy	0.61
Health	1.87
Housing and community amenities	0.37
Mining, manufacturing and construction	-1.86
Public order and safety	-1.38
Recreation, culture and religion	-0.25
Social protection	0.39

Source: Marinkov (2011)

In most of the studies reviewed, the output elasticity of public expenditure is positive and significant. However, the magnitudes of the effects vary considerably. This variance may be because of the different econometric estimation methods used and specification of the production function assumed (e.g. Cobb-Douglas or Translog).

Although the original headline elasticity claims of Aschauer (1989) have been reduced over time, more recent research suggests that infrastructure investment still has a significant impact on output. Perhaps the most important message to draw from all of the academic literature covered here is given by Gramlich (1994), "the best approach is not to try and

[5] The data for the variables listed above was obtained from Quantec's quarterly industrial database (www.quantec.co.za).

analyse the numbers and tell how short the supply is and how much national or state spending or grants should be increased. A far more sensible approach is to find the optimal stock".

This suggests that the issue is not simply about increasing the level of public investment, but investing in the right projects and managing this investment better.[6]

3. Data Description

The data used is based on a 57-activity social accounting matrix (SAM) of 2005. However, the SAM needed to be aggregated in order for the model to solve numerically for a long period of time. Indeed, in an intertemporal model where agents have forward-looking behaviour, all periods need to be taken into account and solved simultaneously. Furthermore, such a model needs many periods to allow the economy time to get back onto a steady-state path after a shock has been introduced. Hence, the SAM was aggregated into 19 activities and commodities. The correspondence between the 19 sectors in the aggregated SAM and the 57-activity SAM is shown in Table 4.

Table 4: Activities in the SAM

Sectors	Correspondence
Agriculture, forestry and fishing	Agriculture, forestry and fishing
Mining	Coal, gold, uranium ore and other mining
Food and beverages	Food, beverages and tobacco
Textiles	Textiles, wearing apparel, leather and leather products and footwear
Wood and paper	Wood and wood products, paper and paper products, and printing, publishing and recorded media
Petrochemicals	Coke and refined petroleum products, basic chemicals, other chemicals and man-made fibres, rubber and plastic products
Metals	Basic iron and steel, basic non-ferrous metals, metal products excluding machinery
Machinery and equipment	Machinery and equipment, electrical machinery, television, radio and communication equipment, professional and scientific equipment, motor vehicles,

[6] Ayogu (2005) also surveys the theoretical literature on infrastructure and growth and then reviews the empirical evidence globally and within the African region. Overall, he concludes that the question is not whether infrastructure matters but precisely how much it matters in different contexts. Ultimately, this is an empirical question that the literature has not yet resolved satisfactorily. In contrast, according to Ayogu, the crucial issue—understanding policymaking processes in infrastructure—remains little understood and largely under-researched.

	parts and accessories, other transport equipment
Other industries	Glass and glass products, non-metallic minerals, furniture, and other industries
Electricity, gas and steam	Electricity, gas and steam
Water supply	Water supply
Building construction	Building construction
Wholesale and retail trade	Wholesale and retail trade
Catering and accommodation services	Catering and accommodation services
Transportation	Railway transport, road transport, transport via pipeline, water transport, air transport, and transport support services
Other services	Communication, finance and insurance, business services, medical, dental and other health and veterinary services, and community, social and personal services
Government – education	Primary education, secondary education, and tertiary education
Government – health	Health
Government – other	General administration, defence, law and order, social and economic

In order to appreciate better the relative size of each sector in the South African economy, Figure 1 presents the contribution of grouped sectors to GDP, while Table 5 shows the sectoral contribution. Although South Africa shows a rather diversified economy, the importance of the services sectors is clear; services contribute to more than half of GDP, whereas agriculture represents less than 3%.

Figure 1: Share of grouped sectors in GDP

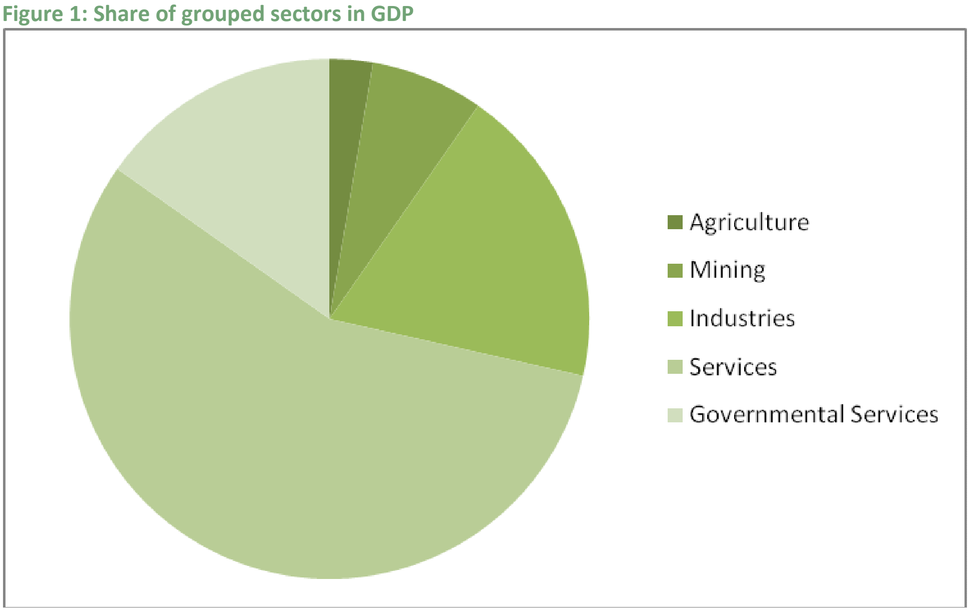


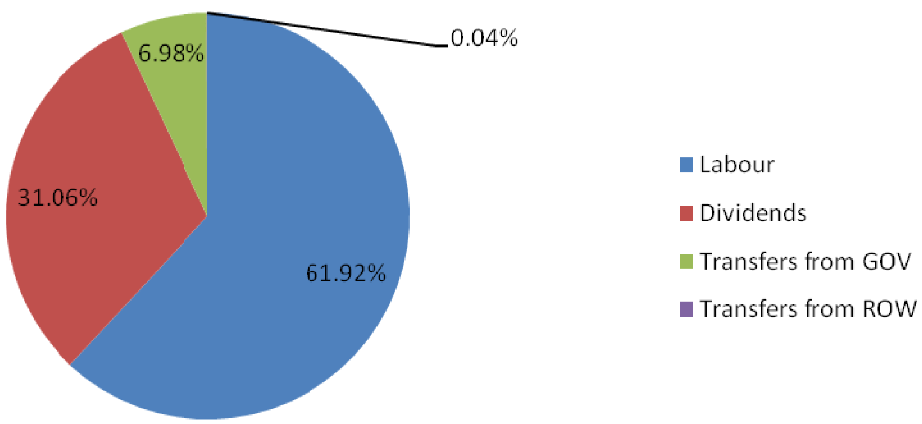
Table 5: Sectoral value added in GDP in 2005

SECTORS	share of VA in GDP
Agriculture, forestry & fishing	2.7%
Mining	7.0%
Food and beverages	3.1%

Textiles	0.8%
Wood and paper	1.6%
Petrochemicals	4.5%
Metals	3.5%
Machinery and equipment	3.5%
Other industries	2.4%
Electricity, gas and steam	0.5%
Water supply	0.2%
Building construction	0.1%
Wholesale & retail trade	13.5%
Catering & accommodation services	1.1%
Transportation	3.2%
Other services	30.7%
Government: education	5.9%
Government: health	2.1%
Government: other	7.3%

The SAM displays four institutional accounts. Households receive payment (for the factors of production they supply to the activities) and receive transfers from other agents. They use their income to consume, save, pay direct taxes and transfer to other agents (government (GOV) and the rest of the world (ROW)). Figure 2 below shows the contribution of each source of revenue to total households' income.

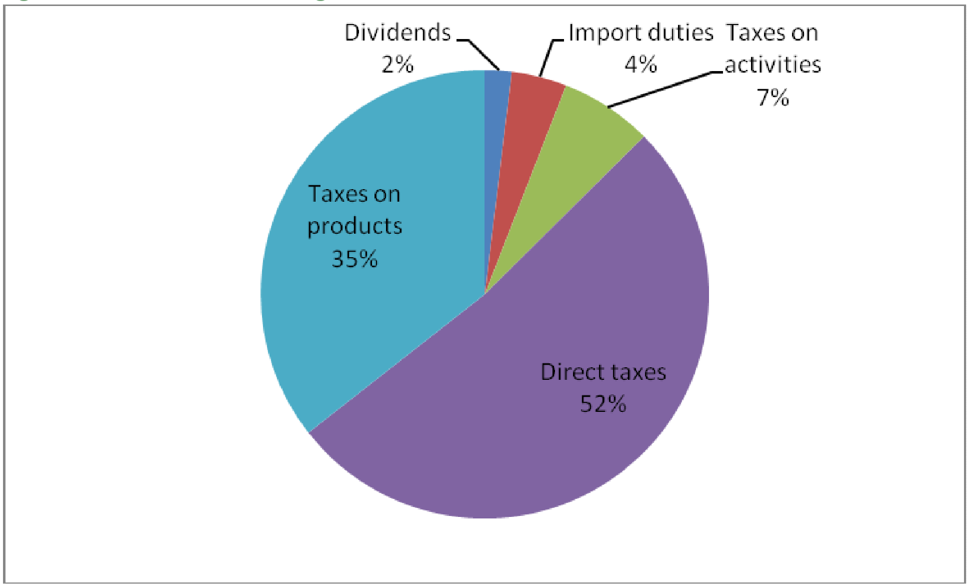
Figure 2: Source of income for households:



Firms' income is mainly composed of capital revenues, as well as minor transfers from other institutions. Firms distribute dividends to other agents, pay direct taxes and save. Firms' savings is a huge component in financing total investment.

Government collects direct taxes (from households and firms) as well as indirect taxes (on products, production and imports). It also receives dividends from the firms and transfers from other agents. Figure 3 displays the relative importance of each income source and highlights the reliance of public receipts on direct taxation.

Figure 3: Sources of income for government



4. Model Description

The multi-sector, forward-looking, dynamic, general equilibrium model for South Africa presented draws largely from the family of PEP standard CGE models developed by Decaluwé *et al.* (2010). It is a neo-classical growth model in which the economy's steady-state growth rate is solely determined by the population growth rate augmented by Harrod-neutral technological progress. South Africa is considered a small-open economy producing tradable and non-tradable goods, which takes world prices and international interest rates as given. As discussed in the previous section, the economy is disaggregated into 19 industries, producing 19 products.

The model is real in the sense that only relative prices affect real variables. The *numéraire* is the nominal exchange rate or, more specifically, the conversion factor between local and foreign exchange units. All real variables are expressed in labour-efficiency units, in order to disentangle the dynamics resulting from the exogenous growth of the population from the dynamics induced by policy shocks.

4.1 Production

The representative firm in each industry combines labour, capital and intermediate inputs to produce composite commodities that can either be sold locally or exported. The firm has access to constant returns, in order to scale technology, and capital installation costs. It operates in a competitive environment in the good markets, as well as in factor markets.

A nested structure is used to represent the production function of each activity. At the first level, output ($XST_{j,t}$) is a Leontief function of value-added input ($VA_{j,t}$) and of the aggregate of intermediate inputs ($CI_{j,t}$):

$$XST_{j,t} = \min\left[\frac{VA_{j,t}}{v_j}, \frac{CI_{j,t}}{io_j}\right]$$

where v_j and io_j are parameters.

Labour ($LD_{j,t}$) is combined with capital ($KD_{j,t}$) using a CES function to produce value added. Total factor productivity is influenced by the level of infrastructures (IND^{INF}) available in the economy. Hence:

$$VA_{j,t} = \left(KD_t^{INF}\right)^{\sigma^{INF}} B_j^{VA}\left[\beta_j^{VA} LD_{j,t}^{-\rho_j^{VA}} + \left(1-\beta_j^{VA}\right) KD_{j,t}^{-\rho_j^{VA}}\right]^{-\frac{1}{\rho_j^{VA}}}$$

where σ^{INF}, B_j^{VA}, β_j^{VA} and ρ_j^{VA} are parameters. σ^{INF} reflects the amplitude of the impact an increase in infrastructures would have on output (elasticity). The value of this elasticity was set to 0.3 (taken from the literature[7]), which can be considered to be in line with South African literature cited above.

The total stock of infrastructure at a given period depends on its depreciated level inherited from the previous period plus the new investment made by the government, IND^{INF},

$$(1+n)\, KD_{t+1}^{INF} = (1-\delta) KD_t^{INF} + IND_t^{INF}$$

Finally, the aggregate of intermediate inputs is a Leontief function of the composite inputs ($DI_{i,j,t}$):

$$DI_{i,j,t} = aij_{i,j} CI_{j,t}$$

where $aij_{i,j}$ is a parameter.

Further, assuming that capital stock at each period is determined by the depreciated stock from the previous period plus investment $IND_{j,t}$,

$$(1+n)\, KD_{j,t+1} = \left(1-\delta_j\right) KD_{j,t} + IND_{j,t}$$

where δ_j is the depreciation rate and n is the rate of growth of the labour force, adjusted to take into account technical progress[8].

The representative forward-looking firm maximizes the actualised value of profits, net of investment expenditures:

$$\max \sum_{t=1}^{T}\left[\frac{1}{1+ir_t}\right]^t \left(r_{j,t} KD_{j,t} - PK_t IND_{j,t}^T\right)$$

Where profits are given by

---

[7] See Dissou and Didic (2011) and Calderón et al. (2009).

[8] The intertemporal model is thus defined per unit of effective worker.

$$r_{j,t} KD_{j,t} = PP_{j,t} XS_{j,t} - w_t (1 + ttiw_{j,t}) LD_{j,t} - \sum_i PC_{i,t} DI_{i,j,t} - ttik_{j,t} KD_{j,t}$$

with $ir_t, r_{j,t}, PP_{j,t}, w_t, ttiw_{j,t},, ttik_{j,t}$ and $PC_{i,t}$ being respectively the interest rate, the rate of return to capital, the price received by the firm for its aggregated output, the wage rate, taxes paid on the labour, taxes paid on capital and the price paid for input *i*.

Following Hayashi (1982), a convex adjustment cost function is considered, which is linear homogeneous in both of its arguments, i.e. investment and capital stock. In mathematical terms:

$$IND^T_{j,t} = \left(1 + \frac{\phi_j}{2} \frac{IND_{j,t}}{KD_{j,t}} \right) IND_{j,t}$$

where ϕ_j is the adjustment parameter.

In maximising a firm's value, managers determine the optimum paths for investment, labour and other intermediate inputs. Apart from investment decisions, the first-order conditions of the firm's intertemporal optimisation problem are the standard ones encountered in static optimisation problems. Firms use the production factor up to the point where its marginal product equals its price.

$$\frac{LD_{j,t}}{KD_{j,t}} = \left[\frac{\beta_j^{VA}}{1 - \beta_j^{VA}} \frac{r_{j,t} (1 + ttik_{j,t})}{w_t (1 + ttiw_{j,t})} \right]^{\sigma_j^{VA}}$$

The optimum level of investment is determined so as to equalise the marginal cost of investment to the shadow price of capital, i.e. the marginal benefit q_j (evaluated in terms of change in firms' value) of changing the capital stock by a unit. The firm's marginal cost of investment includes not only the purchase price of capital goods, but also the additional capital installation costs incurred. This behaviour refers solely to the business sectors, *bus*. In the public sectors, investment does not follow an optimisation process but is rather determined exogenously by the government.

$$q_{bus,t} = PK_t \left(1 + \phi_{bus} \frac{IND_{bus,t}}{KD_{bus,t}} \right)$$

The marginal benefit of the investment takes into account the marginal impact of investment on current and future profits. Thus, the marginal benefit is the discounted sum of present and future marginal gain of physical capital. The marginal gain is the sum of the marginal product and the gain associated with the reduction in installation costs linked to the increase in the capital stock.

$$q_{bus,t+1} (1 - \delta_{bus}) = q_{bus,t} (1 + ir_t) - r_{bus,t+1} (1 - ttik_{bus,t+1}) - PK_{t+1} \left[\frac{\phi_{bus}}{2} \frac{IND_{bus,t+1}}{KD_{bus,t+1}} \right]^2$$

It appears that two main channels can affect firms' investment decisions: the purchase price of capital goods and the marginal product of capital, which depends mostly on the producer price received by the firm. An increase in the purchase price of capital goods has a negative impact, whereas an increase in the producer price has a positive impact, on investment demand.

Assuming that total private and public investment demand is a Cobb-Douglas composite of several commodities, the demand for each commodity entering this composite is a fixed share γ_i (in value) of total gross fixed capital formation (*GFCF*).

$$PC_{i,t} INV_{i,t} = \gamma_i^{INV} GFCF_t$$

It follows that the average price of the capital goods is given by the following equation:

$$PK_t = \frac{1}{A^K} \prod_i \left[\frac{PC_{i,t}}{\gamma_i^{INV}} \right]^{\gamma_i^{INV}}$$

where A^K is a scale parameter.

Finally, total financial wealth at each period is given by:

$$Wealth_t^{TOT} = \sum_{bus} q_{bus,t} KD_{bus,t+1}$$

4.2 Households

Consider an economy populated by a finite number of infinitely lived households. The representative household makes consumption and savings decisions, derives its current income from wages and profits paid by firms, and pays income tax. It maximises an intertemporal utility function subject to a sequence of budget constraints and an intertemporal solvency constraint. The intertemporal utility function, which is additively separable, features a constant rate of time preference (ρ^H) and an instantaneous logarithmic utility function that is weakly separable and defined over aggregate consumption CTH_t,

$$\max u = \sum_{t=1}^{T} \left[\frac{1}{1+\rho^H} \right]^t \ln CTH_t$$

subject to:

$$SH_t = w_t LS_t + \lambda_{HH}^{RK} \sum_j r_{j,t} KD_{j,t} + \sum_{ag} TR_{HH,ag} + INT_t^{DOM} - TDH_t - \sum_{ag} TR_{ag,HH} - CTH_t$$

where SH_t represents savings, LS_t labour supply, λ_{hh}^{RK} the share of capital income received by households, INT_t^{DOM} domestic interest paid on the public debt, TDH_t income taxes and $TR_{HH,ag}$ and $TR_{ag,HH}$ transfers respectively received and paid by households from and to other agents.

By solving its optimisation problem, the representative household determines the optimal paths for consumption expenditures. The first-order condition of this standard optimisation problem is the consumption Euler equation, which specifies the trade-off between consumption in two consecutive periods. This trade-off depends on the ratio of real interest rate (in terms of consumption) and the discount factor. More precisely, an anticipated rise in the real interest rate relative to the rate of time preference induces households to substitute current consumption for future consumption.

$$CTH_{t+1}\left(1+\rho^{H}\right)=CTH_{t}\left(1+ir_{t}\right)$$

Based on the optimal path for aggregate consumption (or consumption expenditures), in each period the representative household allocates these expenditures among the available commodities (C_i). A linear expenditure system (LES) function is used as the aggregator function to specify the relation between aggregate consumption and the quantities of various commodities consumed by the representative household.

$$C_{i,t}PC_{i,t}=\overline{C_{i,t}^{MIN}}PC_{i,t}+\gamma_{i}^{LES}\left(CTH_{t}-\sum_{ij}\overline{C_{ij,t}^{MIN}}PC_{ij,t}\right)$$

where $\overline{C_{i,t}^{MIN}}$ represents the minimum consumption of commodity i and γ_{i}^{LES} the marginal share of commodity i in the household's consumption budget.

4.3 Government

The government's behaviour is simple. It collects direct and indirect taxes, receives and pays transfers, and consumes goods and services. It also pays interest (INT_{t}^{DOM} and INT_{t}^{ROW}) on the public domestic and foreign debt ($Debt_{t}^{DOM}$ and $Debt_{t}^{ROW}$ respectively), for which interests rates $\overline{ir_{t}}^{DOM}$, $\overline{ir_{t}}^{ROW}$ can differ and are exogenous.

$$INT_{t}^{DOM}=\overline{ir_{t}}^{DOM}Debt_{t}^{DOM}$$

$$INT_{t}^{ROW}=\overline{ir_{t}}^{ROW}Debt_{t}^{ROW}$$

The distribution between domestic and foreign borrowings is assumed to be fixed, although different closure could be assumed. The government issues bonds (SG) to finance current and investment expenditures that exceed its revenue.

$$SG_{t}=YG_{t}-\sum_{agng}TR_{agng,GVT,t}-\overline{G}_{t}-INT_{t}^{DOM}-INT_{t}^{ROW}-IT_{t}^{PUB}$$

A positive balance implies that the government would reimburse part of its debt, whereas a negative balance would increase it. Hence,

$$\begin{aligned}(1+n)Debt_{t+1}^{TOT}&=\left(1+\overline{ir_{t}}^{ROW}\right)Debt_{t}^{ROW}+\left(1+\overline{ir_{t}}^{DOM}\right)Debt_{t}^{DOM}-\left(SG_{t}+INT_{t}^{DOM}+INT_{t}^{ROW}\right)\\&=Debt_{t}^{ROW}+Debt_{t}^{DOM}-SG_{t}\end{aligned}$$

A wide variety of taxes have been introduced in the model to allow many tax instruments to be taken into account. Although some of these are not used, the SAM enables users to easily implement new taxes in order to evaluate alternative financing options and their impacts on the South African economy.

5. Simulations and Results

Three sets of simulations are run under three different financing options. In Simulation 1, government current expenditures are increased by 10% in 2011 and 2012, and 2% for the three following years. In Simulation 2, government investment expenditures are increased by the same percentage, i.e. 10% in 2011 and 2012 and 2% in 2013–2015. Both simulations assume that government expenditures would go back to their business as usual (BAU) values from 2016. In Simulation 3, investment spending increases by 10% every year for 10 years (2011–2020) and then, from 2021, stays at the 2020 level.

Different financing mechanisms are envisaged in all these scenarios. The first assumption is that the government cannot run a greater deficit, and therefore taxes will have to be increased in order to compensate for this new spending. To keep the deficit constant, two different taxes are alternatively set endogenous: tax on households' income and tax on commodities. As a third experiment, all taxes are kept constant, and the government increases its deficit. In other words, the public administration finances its additional expenditures through increased debt.

Table 6 presents the impact of increased current public spending under the three financing mechanisms, for three years: 2011, 2015 and 2025.

Table 6: Simulation 1 – Impact of increased current public expenditures on macroeconomic variables (deviation from BAU in %)

	Direct tax financing			Indirect tax financing			Debt financing		
	2011	2015	2025	2011	2015	2025	2011	2015	2025
GDP	1.18%	0.07%	-0.10%	-0.54%	-0.42%	-0.23%	1.14%	0.04%	-0.12%
GDP deflator	1.19%	0.38%	0.11%	-0.56%	0.15%	0.16%	1.15%	0.35%	0.10%
Real GDP	-0.01%	-0.31%	-0.20%	0.02%	-0.57%	-0.39%	-0.01%	-0.32%	-0.21%
Real consumption	-1.07%	-0.71%	-0.24%	-1.65%	-0.81%	-0.40%	-1.09%	-0.74%	-0.27%
Real investment	-5.56%	-0.77%	-0.05%	-2.54%	-1.27%	-0.28%	-5.69%	-0.81%	-0.07%
Debt	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.97%	2.08%
Gov. expenditures	5.92%	1.22%	0.03%	6.23%	1.36%	0.07%	5.91%	1.43%	0.25%
Increase in tax rate	2.65%	0.63%	0.06%	1.01%	0.26%	0.04%	n.a.	n.a.	n.a.

In order to finance its additional expenditures, the government would need to raise the actual income tax by 2.65 percentage points in the short run. However, the increase would be temporary, as income tax rates slowly go back to their original levels, as public expenditures revert to their BAU values. If the government chooses to finance new spending through indirect taxation, an additional tax of 1% on all commodities would be necessary to keep the deficit constant. In the longer run, this new tax would no longer be necessary, for the same reasons as in the direct taxation scenario.

Under all three financing schemes, the impacts on macroeconomic variables are rather small. In the short run, real GDP stays about the same as in BAU, but the impact on investment is greater, which affects the long-run value of GDP. This impact on investment is greater in the income tax scenario and under the debt-financed scheme, as these financing mechanisms have a greater effect on savings from households and public deficit. Although in the short run, an indirect tax affects investment less, its impact is more even across periods, leading to similar decrease of the real GDP in the longer run.

Figures 4 and 5 show the debt-to-GDP ratio and the deficit-to-GDP ratio respectively over the next 60 years for the first scenario (increased government expenditure).

Figure 4: Simulation 1 – Impact of increased public current expenditure on debt to GDP ratio (BAU = 1)

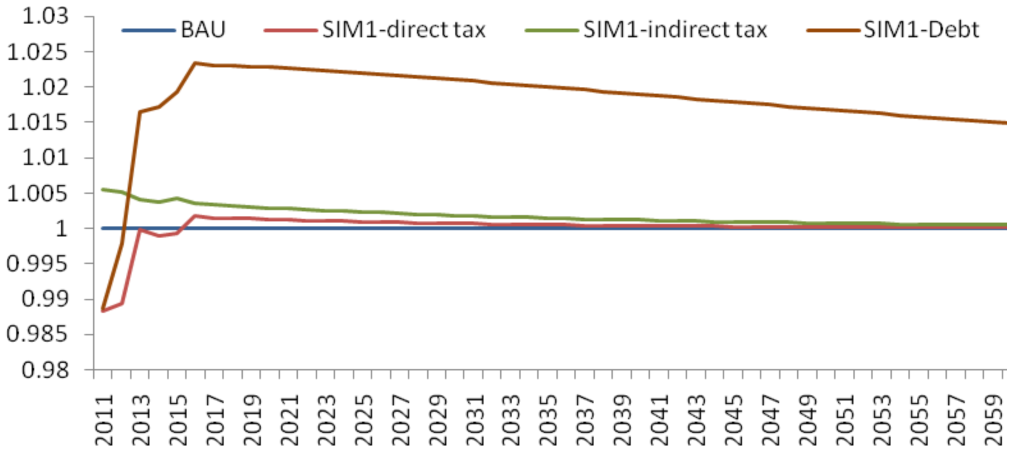
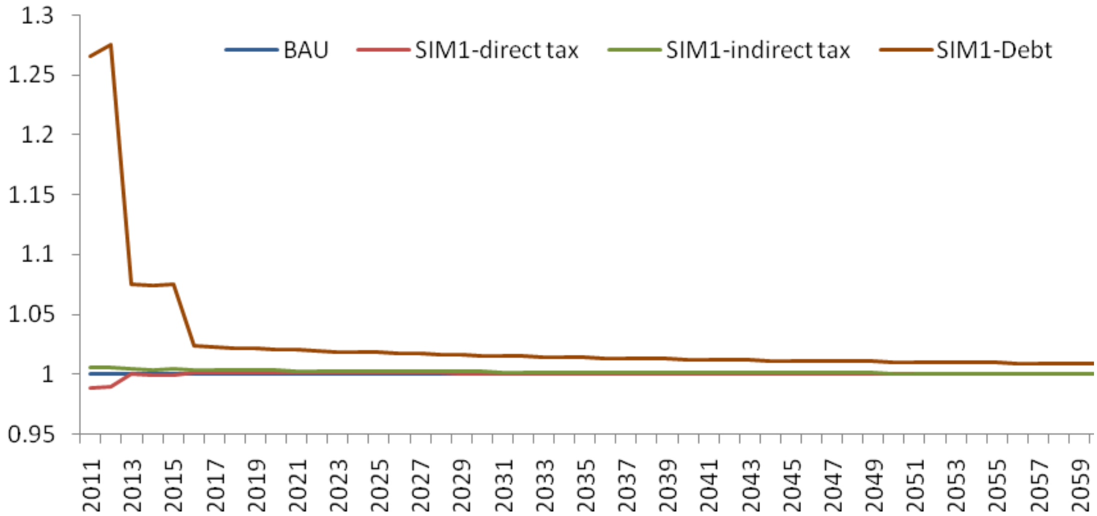


Figure 5: Simulation 1 – Impact of increased public current expenditure on deficit-to-GDP ratio (BAU = 1)



Although the impacts of the three financing mechanisms are about the same for the macroeconomic variables, the two ratios (debt-to-GDP and deficit-to-GDP) do vary. Indeed, in all cases the ratios would be greater than they would have been without the increased current spending. However, the impact is much more important if the government chooses to finance its extra spending through increased debt (SIM1-debt). In the very long run, the debt-to-GDP ratio is 1.5% greater than what it would have been and close to 1% for the deficit to GDP ratio. In other words, increased government spending for a short period of time will have a long-lasting impact on these two indicators.

Increased public spending in education and health would probably have a positive impact on the productivity of the factors of production, as a more educated and healthy work force is more likely to be more productive. However, in its current version, the model does not attempt to capture this impact. Adding this feature into the CGE model would be straightforward, but it would probably not be sufficient to generate such impacts given the relatively short period for which current spending is higher. In any case, the results presented here could be considered as the worst-case scenario, as any positive impact on productivity would generate positive impact on GDP and other economic variables. Furthermore, assuming all else is held constant, a positive impact on GDP would translate into smaller debt-to-GDP and deficit-to-GDP ratios.

In Simulation 2, the government increases its investment spending (see Table 7).

Table 7: Simulation 2 – Impact of increased public investment (2011 to 2015) on macroeconomic variables (deviation from BAU in %)

	Direct tax financing			Indirect tax financing			Debt financing		
	2011	2015	2025	2011	2015	2025	2011	2015	2025
GDP	0.02%	0.15%	0.17%	-0.22%	0.16%	0.26%	0.02%	0.15%	0.17%
GDP deflator	0.02%	-0.34%	-0.27%	-0.22%	-0.33%	-0.25%	0.02%	-0.34%	-0.27%
Real GDP	0.00%	0.49%	0.44%	0.00%	0.49%	0.51%	0.00%	0.49%	0.44%
Real consumption	0.07%	0.30%	0.37%	-0.09%	0.23%	0.37%	0.07%	0.30%	0.38%
Real investment	-0.21%	0.89%	0.51%	0.46%	1.12%	0.79%	-0.25%	0.88%	0.51%
Debt	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.17%	-0.15%
Gov. expenditures	0.73%	0.07%	-0.07%	0.76%	0.06%	-0.10%	0.73%	0.08%	-0.08%
Increase in tax rate	0.34%	-0.03%	-0.11%	0.13%	-0.01%	-0.04%	n.a.	n.a.	n.a.

Although the amplitude of the shock is the same as in Simulation 1 (10% for the first two years, then 2% for the following three years), current expenditures represent a greater part of public expenditures. Hence, in the first simulation, government expenditures increases by about 6% compared to less than 1% here. Therefore, it is not surprising that the required rise in taxes (direct or indirect) is much less than the one presented in Table 6. Similarly, impacts on real GDP in the short run are negligible. However, as these expenditures finance investment, thus increasing total infrastructure and output, the GDP is positively affected in the medium and longer run. In fact, under a rigid deficit, taxes would eventually go down, as a result of greater production in the economy.

Figures 6 and 7 display different trends for the debt-to-GDP and deficit-to-GDP ratios compared to those seen in Simulation 1. In fact, as the GDP grows over time, a constant deficit translates into an improvement of both ratios. More surprisingly, this improvement is the greatest under the debt-financed scenario. In fact, keeping the same tax rates throughout the modelling horizon, would increase government revenues in the longer run and thus allow for a smaller deficit in the future.

Figure 6: Simulations 2 – Impact of increased public investment on debt to GDP ratio (BAU = 1)

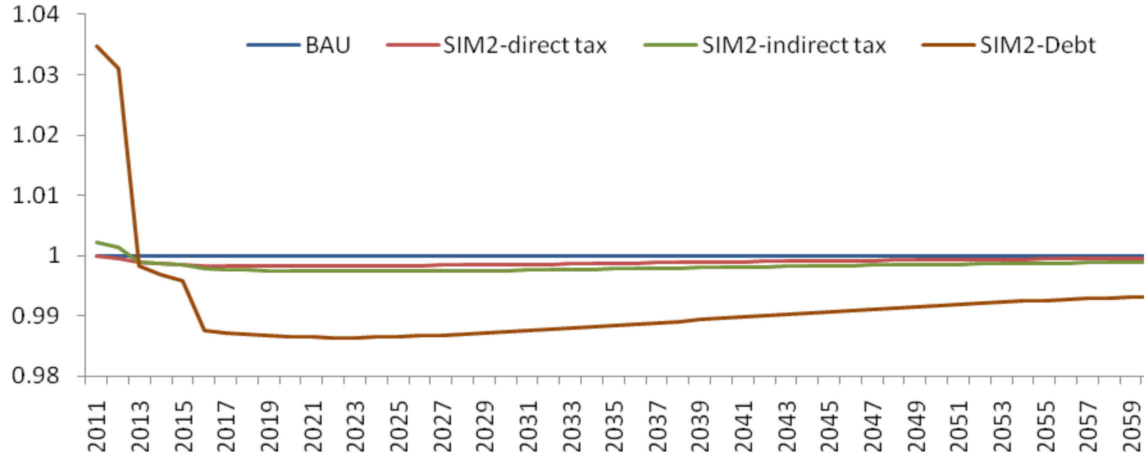
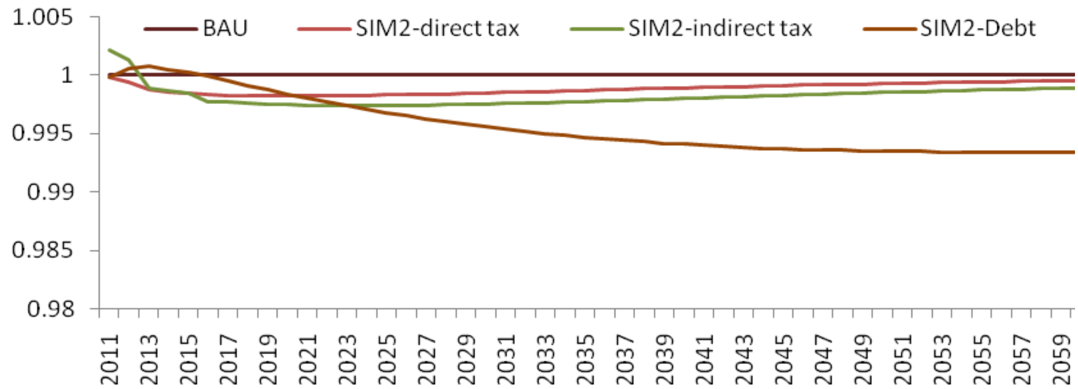


Figure 7: Simulation 2 – Impact of increased public investment on deficit to GDP ratio (BAU = 1)



In order to test the robustness of the model to the elasticity values, Simulation 2 is run under the three different financing mechanisms using the lowest (0.1) and the highest (0.6) values of elasticity shown in Table 2. Figures 8 and 9 present the impact on real GDP and debt-to-GDP ratio respectively. The results are qualitatively similar, whatever the value of the elasticity of the total factor productivity to infrastructure. In fact, the conclusions discussed above still hold when comparing the different financing schemes. As might be expected, the magnitude is a bit different, but impacts are not significantly different, being in a range of less than 1%.

Figure 8: Simulation 2 – Impact of increased public investment on GDP (BAU = 100)

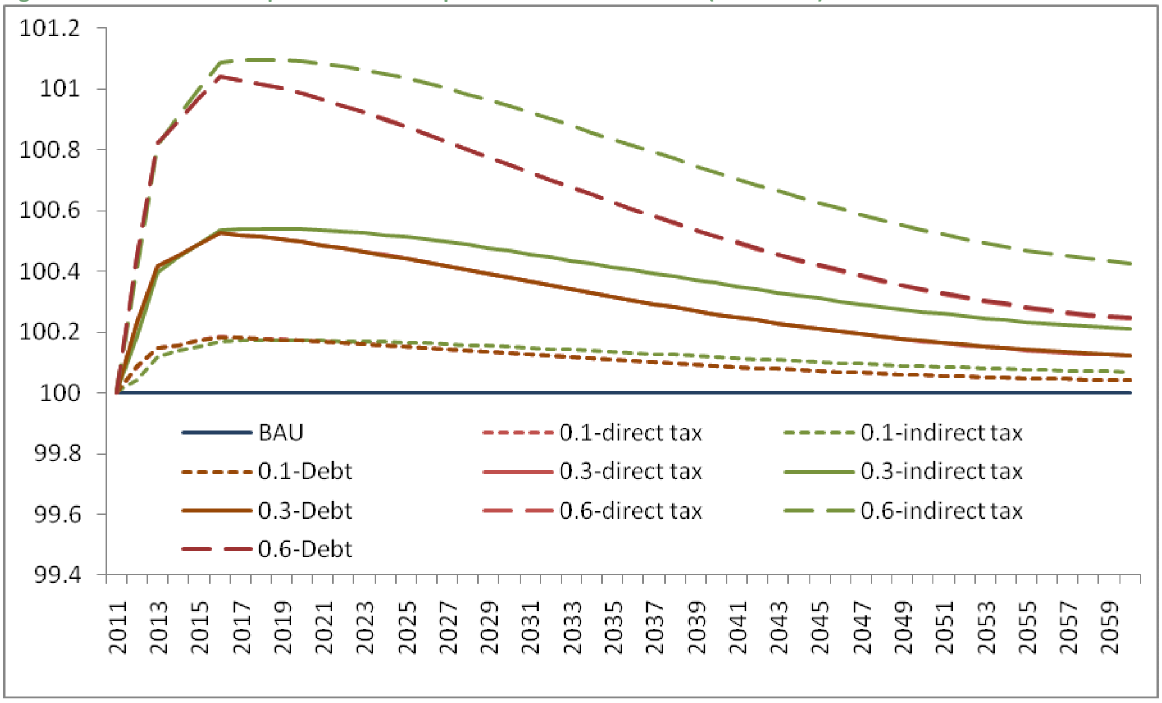
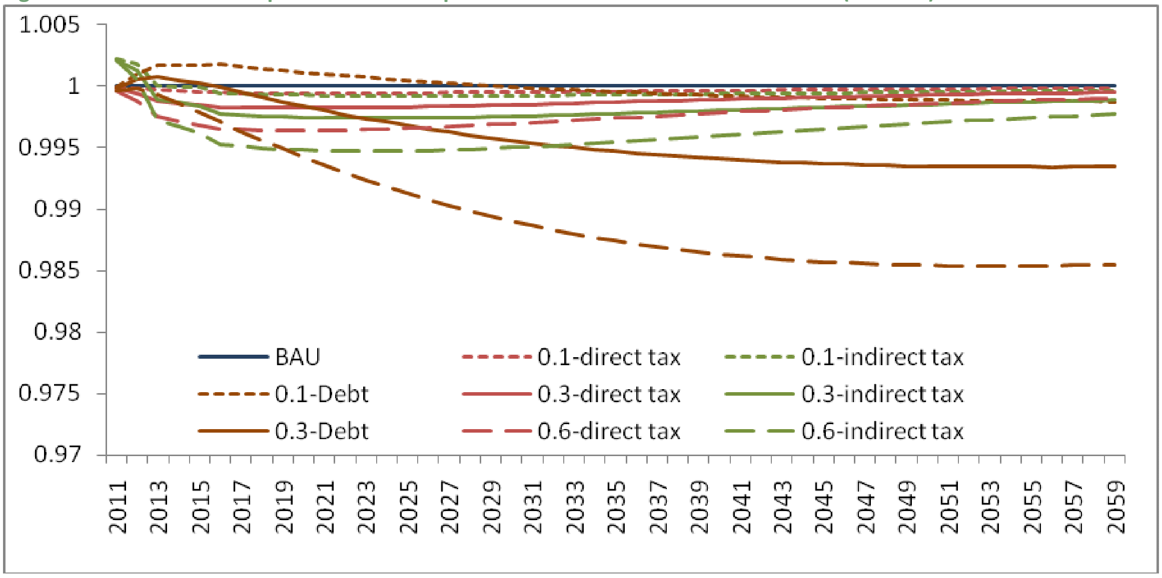


Figure 9: Simulation 2 – Impact of increased public investment on debt-to-GDP ratio (BAU = 1)



6. Conclusion

Using an intertemporal CGE model built for South Africa, with elaborated government features, the simulations focused on the impact of increased current and investment spending. An expansive fiscal policy had a short-run, positive impact on GDP but translated into a greater debt-to-GDP ratio. This impact was mitigated by financing the increased spending through taxation, direct or indirect, but also had a negative short-run impact on macroeconomic variables. Under any financing scheme, increased investment spending improved long-run GDP and decreased debt-to-GDP and deficit-to-GDP ratios. Driving this outcome is the positive impact that infrastructure has on total factor productivity. Without this feature, increased public investment would have almost no impact on the South African economy.

Although the positive impact of infrastructure on growth is well documented, less is known about the effect that current expenditures on education and health may have on total factor productivity. More conclusive econometric work for South Africa would allow for a better modelling of public spending and, therefore, a better understanding of how this spending affects economic growth.

References

Abedian, I and Van Seventer, D. 1995. *Productivity and multiplier analysis of infrastructure investment in South Africa: an econometric investigation and preliminary policy implications.* Mimeo. Pretoria: Ministry of Finance.

Alm, J and Embaye, A. 2010. Explaining the Growth of Government Spending in South Africa. *South African Journal of Economics.* 78(2):152–169.

Amusa, H., (2008). Output effects of public sector infrastructure investment in South Africa. Mimeo. Financial and

Fiscal Commission, South Africa.

Ansari, MI, Gordon, DV and Akuamoah, C. 1997. Keynes Versus Wagner: Public Spending and National Income for Three African Countries. *Applied Economics,* 29(4): 534–550.

Arrow, KJ and Kurz. M. 1970, *Public Investment, the Rate of Return and Optimal Fiscal Policy*. Baltimore: John Hopkins Press.

Aschauer, DA, 1989. Is Public Expenditure Productive. *Journal of Monetary Economics*, 23, 177–200.

Ayogu, M. 2005, Infrastructure and Economic Development in Africa: A Review. Invited Paper for the December 2005 AERC Biannual Plenary Session on *Services and Economic Development in Africa*, Rosebank Hotel, Johannesburg 3–8 December 2005.

Bogetic, Z and Fedderke, J. 2005. Infrastructure and Growth in South Africa: Benchmarking, Productivity and Investment Needs. Presented at the ESSA conference 2005. Available online: http://www.essa.org.za/

Calderón, C, Moral-Benito, E & Servén, L. 2009. *Is infrastructure capital productive? A dynamic heterogeneous approach.* Mimeo. The World Bank and CEMFI, December.

Coetzee, Z. and Le Roux, E. (1998). .Does Public Infrastructure Affect Economic Growth?. Presented at the Annual EBM Conference of the National Productivity Institute.

Costa, J.S., Ellson, R.W., Martin, R.C. (1987). Public capital, regional output, and development: some empirical evidence. *Journal of Regional Science*, 27(3), 419-437

Decaluwé, B, Lemelin, A, Robichaud, V and Maisonnave, H. 2010. *PEP-1-t. Standard PEP model: single-country, recursive dynamic version.* Québec Université Laval, Politique Economique et Pauvreté/Poverty and Economic Policy Network. http://www.pep-net.org/programs/mpia/pep-standard-cge-models/

DBSA (Development Bank of South Africa). 1998. Infrastructure: a foundation for development. Development Report 1998: Pretoria.

Demetriades, P., and Mamuneas, T., Intertemporal Output and Employment Effects of Public Infrastructure Capital: Evidence from 12 OECD Economies. *The Economic Journal*, Vol. 110, Issue 465, July 2000

Dissou, Y and Didic, S. 2011. *Public Infrastructure and Economic Growth A Dynamic General Equilibrium Analysis with Heterogeneous Agents* (to be published).

Duffy-Deno, Kevin T. & Eberts, Randall W., 1991. Public infrastructure and regional economic development: A simultaneous equations approach, *Journal of Urban Economics*, Elsevier, vol. 30(3), pages 329-343, November.

Eberts, R., 1986. Estimating the contribution of urban public infrastructure to regional growth, Working Paper 8610, Federal Reserve Bank of Cleveland.

Eberts, R., 1990. Public infrastructure and regional economic development, *Economic Review*, Federal Reserve Bank of Cleveland, issue Q I, pages 15-27.

Esfahani, Hadi Salehi and Ramirez, Maria Teresa, 2003. Institutions, infrastructure, and economic growth, *Journal of Development Economics*, Elsevier, vol. 70(2), pages 443-477, April.

Evans, P., and Karras, G., 1994. Is government capital productive? Evidence from a panel of seven countries, Journal of Macroeconomics, Elsevier, vol. 16(2), pages 271-279.

Fedderke, J and Vase, P. 2001, The Nature of South Africa's Trade Patterns by Economic Sector, and the Extent of Trade Liberalisation During the Course of the 1990's. *South African Journal of Economics*, Vol. 69, No. 3, pp. 436–473.

Fedderke, J, Perkins, P and Luiz, J. 2005. *Infrastructure Investment in Long-run Economic Growth: South Africa 1875–2001*. Preliminary draft. Available online: http://www.uct.ac.za/economics

Fourie, J. 2006. Some policy proposals for future infrastructure investment in South Africa. Stellenbosch Economic Working Papers: 05/06, Department of Economics, University of Stellenbosch.

Gramlich, E. 1994. Infrastructure Investment: A Review Essay. *Journal of Economic Literature*, 32.

Holzt-Eakin, D (1993), State-Specific Estimates of State and Local Government Capital, *Regional Science and Urban Economics*. 23: 185-209.

Lau, SHP and Sin, CY. 1997. Public Infrastructure and Economic Growth: Time Series Properties and Evidence. *Economic Record*, 73.

Marinkov, M. 2011. *Public Expenditure Economic Growth Nexus: Evidence from South Africa*. Midrand: Financial and Fiscal Commission.

Moreno-Dodson, B. 2009. On the Marriage between Public Spending and Growth: What Else Do We Know? The World Bank PREM Notes in Economic Policy, No. 130.

Mountford, A and Uhlig, H. 2005. What are the Effects of Fiscal Policy Shocks. SFB Discussion Paper No. 649. Berlin: Deutsche Forschungsgemeinschaft.

Mountford A and Uhlig, H. 2009. What are the effects of fiscal policy shocks? *Journal of Applied Econometrics*, Vol. 24(6), pages 960–992.

Munnell, A., 1990a. How does public infrastructure affect regional economic performance?, Conference Series ; [Proceedings], Federal Reserve Bank of Boston, pages 69-112.

Munnell, A., 1990b.. Why has productivity growth declined? Productivity and public investment, New England Economic Review, Federal Reserve Bank of Boston, issue Jan, pages 3-22.

Munnell, AH. 1992. Policy Watch: Infrastructure Investment and Economic Growth. *The Journal of Economic Perspectives* Volume 6 No. 4.

SACTRA. 1999. *Transport and the Economy*, London: DETR (Department of Environment, Transport and Regions). www.dft.gov.uk

Zegeye, Aklilu A. (2000). U.S. Public Infrastructure and its contribution to private sector productivity. Working Paper 329, U.S. Department of Labor, Bureau of Labor Statistics, June.

Ziramba, E. 2008. Wagner's Law: An Econometric Test for South Africa, 1960-2006. *South African Journal of Economics*, 76(4): 596–606.