

# GROWTH AND EMPLOYMENT IMPACTS OF PUBLIC ECONOMIC INFRASTRUCTURE INVESTMENT IN SOUTH AFRICA: A DYNAMIC CGE ANALYSIS

**Vandudzai Mbanda\***

*University of Johannesburg*

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**Margaret Chitiga-Mabugu\***

*University of Pretoria*

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## Abstract

Public infrastructure investment is believed to be one of the key factors in addressing South Africa's main socio-economic challenges of high unemployment, income inequality and poverty. The country's economic growth has not been able to create enough jobs to reduce these ills. The South African government believes that a labour-absorbing growth path can be realised by improving public infrastructure investment. This study uses a dynamic CGE analysis to quantify the impacts of increasing public economic infrastructure investment on economic growth and employment. The results indicate that increasing public infrastructure investment is in general beneficial for the South African economy. GDP increases while the price level declines. Aggregate labour demand increases across all formal labour categories resulting in a decline in unemployment.

## Keywords

Public infrastructure, economic growth, Employment, Dynamic CGE, Spillover effects, South Africa

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\*Ms V Mbanda is a PhD candidate in the Department of Economics and Econometrics, University of Johannesburg, South Africa. [[vee.mbanda@gmail.com](mailto:vee.mbanda@gmail.com)]

\*Prof M Chitiga-Mabugu is Director and Head of School of Public Management and Administration, University of Pretoria, South Africa.

## **1. INTRODUCTION**

Since the attainment of democracy in 1994, South Africa continues to battle with socio-economic problems of high levels of unemployment, poverty and income inequality. The country's economic growth has not been able to generate enough jobs, which are necessary for the reduction of unemployment as well as for reducing poverty and inequality. Poorly located and insufficient infrastructure is interlinked to the challenges facing the economy. The government believes that a more labour-absorbing growth path will be achieved by focusing on improving infrastructure and network services. It is against this background that policy efforts in South Africa continue to emphasise scaling up public infrastructure investment. The government infrastructure drive gained momentum in the years leading up to the 2010 Federation of International Football Association (FIFA) World Cup. The government's plan has been to focus on capital investment in infrastructure projects. National Treasury (2012) pointed out that the main priority of budgets in future years will continue to be provision of financing for public infrastructure development with the aim of strengthening economic infrastructure in particular.

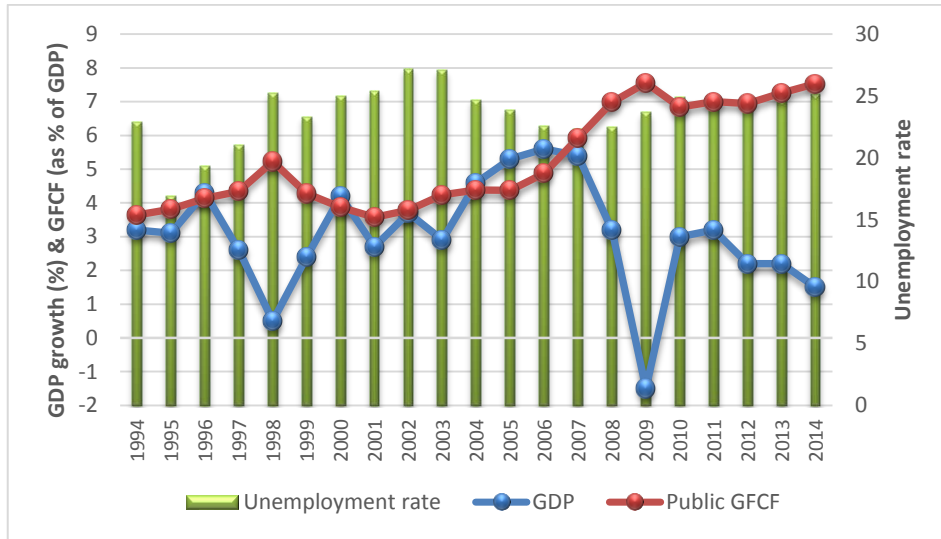
Our study quantifies the short- and long-run impacts of increasing public infrastructure investment in South Africa, mainly focusing on economic growth and employment impacts. We use a Computable General Equilibrium (CGE) analysis to assess the impacts. The model is dynamic to account for accumulation effects and it incorporates externalities to capture the spillover effects of public infrastructure investment. Unemployment is modelled to reflect the South African labour market. The rest of the paper is structured as follows: section 2 gives a background to the South African infrastructure investment initiatives and reviews government policy, section 3 reviews related literature, section 4 describes the methodology used, section 5 covers simulations and results while section 6 concludes.

## **2. BACKGROUND**

### **2.1 Economic growth and unemployment**

From 1994 the South African economy has been achieving positive economic growth rates, with an average Gross Domestic Product (GDP) growth of about 3.3%. Despite this positive growth of the economy, unemployment has remained persistently high, above 20% for the whole period except for 1995 and 1996 as shown in FIGURE 1. From FIGURE 1 it seems when public investment (as measured by Gross Fixed Capital Formation (GFCF)) is high, GDP is low. This however, is an indication of the lagged effect of public infrastructure on economic growth. High unemployment levels in the presence of relatively high levels of economic growth imply that the jobs being created are inadequate to absorb new entrants into the labour market.

According to the National Planning Commission (NPC) (2011), inadequate investment in new infrastructure and failure to maintain existing infrastructure are responsible for inadequate job creation and for holding back development in the country. Inadequate rail, port and electricity infrastructure capacity is a key factor in explaining South Africa's failure to take advantage of the opportunity to achieve high rates of economic growth during the commodities boom between 2001 and 2008 (Joffe, 2009; Baxter, 2011).



**FIGURE 1: GDP growth, public GFCF as % of GDP, and unemployment rate**

Source: South African Reserve Bank (online)

Public infrastructure investment which leads directly to growth affects the productivity of other sectors. This includes public infrastructure investment in energy, transport and logistics, water and telecommunications. The commitment of the South African government to promote growth, and thus creation of jobs, is evidenced by the proportion of productive infrastructure, in comparison to social infrastructure, which does not directly support productive activities. According to National Treasury (2012:103), the breakdown of the R844.5 billion budgeted for the 2012 medium-term expenditure framework (MTEF) from 2012/13 to 2014/15 is as follows: economic services 80.2%, social services 16.6% and administrative and financial services 3.3%.

## 2.2 Infrastructure investment initiatives

Expanding infrastructure investment, according to National Treasury (2012), forms the basis of the national growth and development strategy of South Africa. The country has critical infrastructure needs partly as a result of two decades of underinvestment in economic infrastructure (National Treasury, 2012). Since the 1960s public sector capital investment (as a percentage of GDP) fell below the 10% mark from 1986 (8.6%) to an all-time low of 3.7% in 2001 and remained below the 8% level up to 2012, only reaching 8.1% in 2009 (South African Reserve Bank, online). The 2009 peak, according to the Development Bank of Southern Africa (2012), was due to the 2010 FIFA World Cup preparations. In response to the inadequacy in infrastructure investment, the government continues to set up various economic infrastructure (energy, transport, water and telecommunications) projects with the intention of improving the provision of the different types of infrastructure services. According to National Treasury (2013), the target is for public sector investment to reach 10% of GDP with gross fixed capital formation reaching 30% of GDP by 2030.

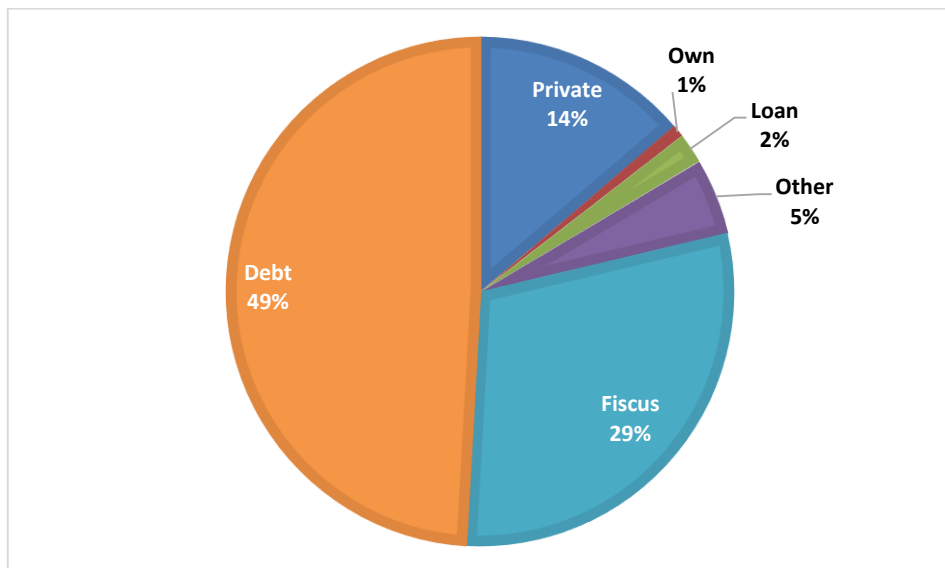
### 2.3 South African government policy

A review of the policies from 1994 shows that the government has been implementing policies which point to the importance of infrastructure in improving economic growth and consequently people's welfare. This is true from the Reconstruction and Development Programme (RDP) in 1994 through the Growth, Employment and Reconstruction (GEAR) in 1996 and Accelerated Shared Growth Initiative of South Africa (ASGI-SA) in 2006 to the recent 2010 New Growth Path (NGP) and the National Development Plan (NDP) of 2011. The latter three spoke of infrastructure investment as one of the means for achieving growth and development in the country.

Under ASGI-SA, infrastructure investment was identified as one of the six key factors needed to achieve economic growth and reduction in unemployment and poverty. The NGP strategy cites infrastructure development as the number one job driver to address the challenges of unemployment, poverty and inequality through creating 250 000 jobs a year up to 2015 from the construction, operation and maintenance of new infrastructure. The NGP strategy as a whole is expected to create 5 million jobs by 2020 (Economic Development Department, 2011:23). According to NPC (2012), under the NDP, public infrastructure investment facilitates economic activity that is conducive to achieve economic growth and job creation and to eliminate income poverty and reduce inequality. South Africa continues to invest substantially in public infrastructure, which increased as a percentage of GDP from 4.6% in 2006/07 to 6.8% in 2014/15 (National Treasury, 2010:35; 2015:122&183).

### 2.4 Financing of public infrastructure projects

While it is important to invest in infrastructure, Giesecke, Dixon and Rimmer (2008) pointed out that the impact of public infrastructure on economic development outcomes essentially depends on how the infrastructure projects are financed.



**FIGURE 4: Financing of major infrastructure projects**

Source: National Treasury (2013:104-105)

*Debt: bonds and government guaranteed corporate debt; Private: private sector funding repaid through tariffs; Loan: World Bank and other government guaranteed loans; Fiscus: fully funded by fiscus; Own: State-owned Enterprise's own revenues; Other: all other forms of finance (includes: public-private partnerships, combined debt and fiscus, project finance, combined project finance and own revenue, other partnerships)*

It is thus important to understand the composition of infrastructure investment financing. An analysis of major infrastructure projects in South Africa, detailed in National Treasury (2013), gives an indication of how public infrastructure is financed in South Africa. The shortcoming of the main two forms of financing of major long-term public infrastructure projects, debt and allocations from the fiscus, as shown in FIGURE 2, is their potential to place a downward pressure on economic growth.

### 3. LITERATURE REVIEW

A number of studies analysed the impact of public infrastructure investment using CGE analysis, both in South Africa and internationally. We discuss studies that inform our paper. Giesecke et al. (2008) used a dynamic multi-regional CGE model to examine the macroeconomic effects of regional public infrastructure provision in Australia. Their study evaluated the impact of infrastructure provision under four financing arrangements, namely the use of developer charges, debt, payroll tax and residential rates. Based on their findings, Giesecke et al. (2008) pointed out that the relationship between economic development outcomes and public infrastructure largely depends on how the infrastructure projects are financed.

Similarly, Boccanfuso, Joanis, Richard and Savard (2014) applied a dynamic CGE model to compare different funding schemes for public infrastructure spending in Quebec. Public infrastructure was financed through debt and through a combination of debt and an increase in taxes (income tax, business tax and sales tax). Boccanfuso et al. (2014) concluded that the different funding options did not result in large differences in terms of growth in Quebec; however, they found household income tax to have the best results on growth.

Savard (2010) used a 'top-down bottom-up' CGE microsimulation analysis to assess the Dutch disease, productivity externalities, job creation and crowding out impacts of an increase in infrastructure investment. Like Giesecke et al. (2008) and Boccanfuso et al. (2014), Savard (2010) also intended to capture funding issues, among other things. Savard (2010) compared the financing of infrastructure expenditure through fiscal policy (value-added tax (VAT) and income tax) and foreign aid. At the macro level, Savard (2010) concluded, there were no major differences from the funding mechanisms used to increase infrastructure.

Bahan, Montelpare and Savard (2011) applied a dynamic CGE model, which captures public infrastructure externalities, to assess the impact of infrastructure investment in Quebec. They compared scenarios with and without positive external effects of public infrastructure. Bahan et al. (2011) found that not accounting for gains in productivity emanating from public capital investment causes an increase in prices, resulting in a deterioration of household income and the current account. When the externality is accounted for, Bahan et al. (2011) pointed out, the results indicate that productive investments are beneficial for the whole economy.

Mabugu, Rakabe and Chitiga (2009) used a static CGE analysis to investigate the impact of increasing public infrastructure investment in South Africa. Mabugu et al. (2009) simulated increases in each of the following infrastructure sectors: water, health, electricity, roads and communications. The results confirm that increases in infrastructure spending are beneficial to

the economy as consumption and investment increase, resulting in an increase in GDP. While an increase in capital for the affected sectors caused output for the respective sectors to increase, Mabugu et al. (2009) pointed out, the fall in the overall price of capital caused a general decrease in employment. Wages increase in the capital-intensive sectors (attributed to the relative scarcity of labour that results from the increase in capital) but decrease in labour-intensive sectors, according to Mabugu et al. (2009).

Although infrastructure investment is found to be beneficial for the wellbeing of the economy and of households in the Mabugu et al. (2009) study, it is useful to have a detailed study to see its economy-wide effects over time. This can be done by using a dynamic CGE analysis. Dynamics are important because infrastructure is a long-term investment. Go (1994) argues that the effects of adjustments in infrastructure investment are dynamic and might not be adequately analysed by static CGE models. Dynamic CGE models, according to Paltsev (2004), are important tools for economic policy evaluation because they enable economists to provide answers for the future and they help policy makers to make decisions about the future. These models are therefore best suited to assess the long-run infrastructure investment impacts.

The South African government believes that a labour-absorbing growth path can be realised by improving public infrastructure investment. Our study uses a dynamic CGE analysis to assess how public infrastructure investment impacts growth and employment creation. The success of investment in public infrastructure in achieving targeted economic growth with unemployment reduction will be welfare-enhancing in South Africa. Of interest is to analyse the differential impacts of different financing options. Quite a number of studies have assessed the impacts of infrastructure investment using CGE analysis as discussed above. Our study thus borrows the modelling techniques applied in the previous studies on South Africa and on other countries.

## **4. METHODOLOGY**

### **4.1 CGE model**

The Poverty and Economic Policy (PEP-1-t) standard dynamic CGE model by Decaluwé et al. (2010) is adapted for use in our study. It is a recursive dynamic CGE model, which means each period is solved as a static equilibrium. Firms are assumed to maximise profits (in a perfectly competitive environment) subject to their production technology. Because of profit maximisation, firms employ capital and labour until the rental rate of capital and the wage rate, respectively, each equals the value of its marginal product. Firms do not determine prices, as they are price takers for goods and services and factors of production.

There is imperfect substitution of the different types of labour, which combine in a constant elasticity of substitution (CES) production function to form composite labour. The sectoral output of each productive activity follows a Leontief production function, combining value added and total intermediate consumption in fixed shares. Value added is a CES combination of composite labour and composite capital. Investment is driven by savings and savings are exogenous. Capital is industry-specific; thus the rental rate of capital is not uniform. New capital in year  $t + 1$  is from the investment made in year  $t$ . Total investment is made up of private and public investment. The level of public investment is determined exogenously, and private investment is a residual of public investment and changes in inventories. That is, private investment is what remains of the total investment after the levels of public investment and inventories have been decided.

Households receive income from supplying their labour and capital and from transfers from other agents (firms, households, government and the rest of the world). They use their income on taxes, transfers to other agents, for consumption and to save. Firms receive income from capital and from other agents. They pay taxes and save. Government receives income from household and business income taxes, payroll taxes, indirect taxes on local commodities, production taxes and import and excise duties. The government uses its income on current expenditure on commodities to pay transfers to other agents and for savings. The rest of the world receives income from import payments and from capital and uses it to pay for exports and transfers to domestic agents.

## 4.2 Incorporating unemployment

The original model assumes full employment of labour, which is not the reality in South Africa. To reflect the South African labour market, we incorporate unemployment in the model. The South African economy is characterised by high unemployment levels. To incorporate unemployment, we introduce a wage curve equation in the model and apply an unemployment elasticity of the wage equal to  $-0.1$  as found by Kingdon and Knight (2006). The wage curve shows a trade-off between unemployment and the wage rate, and is of the form:

$$W_t = f(\theta_l UN_t^{\sigma_l} P) \quad (1)$$

where  $W_t$  is the wage rate,  $\theta_l$  is the scale parameter,  $UN_t$  is the unemployment rate,  $\sigma_l$  is unemployment elasticity of the wage and  $P$  is the price level. Thus labour supply is the sum of labour demanded by sectors and the number of unemployed as given below:

$$LS_t = \left( \sum_j LD_{j,l} \right) + LU_t \quad (2)$$

where  $LS_t$  is labour supply of type  $l$  labour,  $LD_{j,l}$  is demand for type  $l$  labour in industry  $j$  and  $LU_t$  is the number of unemployed for type  $l$  labour. Labour is disaggregated into formal (high skilled, semi-skilled and low skilled) and informal labour. Formal labour unemployment rates, as calculated from the 2005 Labour Force Survey (LFS) data, are 4% (high skilled), 29% (semi-skilled) and 25% (low skilled). There is no unemployment for informal labour. According to Statistics South Africa (StatsSA) (2005) of the 4.48 million unemployed people in 2005 77% had secondary education, technical education or diplomas (semi-skilled), 23% had at most primary education (low skilled) and 1% had degrees (high skilled). This explains the higher rate of unemployment for semi-skilled workers than for low-skilled workers.

## 4.3 Capturing spillover effects

To capture externalities that emanate from increasing infrastructure investment, we incorporate spillover effects, a feature not in the original PEP-1-t model. Additional public spending in the form of infrastructure is believed to make available a factor of production in the form of a positive externality on the total productivity of the private factors of production (Dumont & Mesplé-Somps, 2000). The externality, Dumont and Mesplé-Somps (2000) pointed out, triggers a direct positive effect on sectoral production. Total factor productivity increases due to the public infrastructure investment externality. We built the externality into the model by adjusting the value-added function following Boccanfuso et al. (2014), Bahan et al. (2011), Savard (2010) and Estache, Perrault and Savard (2012) and by using the total factor productivity elasticity with respect to aggregate infrastructure. In addition, we take the cumulative effect of public infrastructure investment into account. Thus the sectoral value-added function is specified as:

$$VA_{j,t} = \prod_{t=1}^T \sigma_{j,t} [A_j LD_{j,t}^\alpha KD_{j,t}^{1-\alpha}] \quad (3)$$

where  $LD_j$  and  $KD_j$  are sector  $j$  demand for composite labour and composite capital respectively.

$\sigma_{j,t}$  (a function of the ratio of new public investment  $ITPUB_t$  over past public investment  $ITPUB_{t-1}$ ) is the sectoral productivity effect of public infrastructure spending and is specified as:

$$\sigma_{j,t} = [ITPUB_t / ITPUB_{t-1}]^{\rho_j} \quad (4)$$

and  $\rho_j$  is the sector-specific elasticity of public infrastructure spending. This specification guarantees that, even after the shocks, the positive externalities will still be present. When infrastructure is built in year  $t$ , it will still be present in year  $t + 1$  and beyond; hence at any point in time we need to account for the effect of infrastructure that was constructed in previous years. It is important, however, to note that the externality is permanent but its effect decreases over time. Currently, the available econometric studies provide the externality parameters of infrastructure investment for South Africa for manufacturing sectors; hence our study applies the externality on manufacturing sectors only for which data is available.

#### 4.4 Data

The main dataset used in our study is the StatsSA 2005 South Africa Social Accounting Matrix (SAM), modified by Quantec. The SAM has 53 activities and 53 commodities, six of which are public sector activities and commodities, a feature not available in SAMs for later and more recent years. This makes it possible for us to simulate the impact of economic infrastructure, as the public economic sector is one of the public sectors. There are two types of production factors: labour with four categories and capital with one category. The SAM has 12 household groups (10 deciles with the 10th decile subdivided into 3 categories).

Other relevant data and elasticities are from StatsSA, South African Reserve Bank, National Treasury and previous studies. These include investment demand elasticity of 0.5 (Fedderke & Luiz, 2008), elasticity for composite labour of 2 (Rattsø & Stokke, 2005), Constant Elasticity of Transformation between exports and local sales of between 0.7 and 1.3 (Behar & Edwards, 2004), Armington elasticity between imports and domestic goods (De Wet & van Heerden, 2003), elasticity for value added, price elasticity of the world demand for exports, Frisch parameter for the Linear Expenditure System (LES) function of -3.34 (Chitiga et al., 2011) and population growth rate (StatsSA, 2010; 2011).

#### 4.5 Closures

The current account balance, minimum consumption of commodity  $i$  by household type  $h$  government current expenditure, capital demand, new capital investment in public sectors, inventory changes and labour supply are exogenous. World price of imports and exports are also exogenous because South Africa is a small economy with no influence on world prices. The exchange rate is the numeraire. For simulation 1 government current expenditure is endogenous. Thus government spending is reallocated from current to capital spending and, because of the savings-investment equality, capital is reallocated from the private to the public sector following the increase in public infrastructure investment. The government global deficit (the difference



between government income and government expenditure (current and investment) is exogenous for simulation 2 and the tax rate on firm income is endogenous.

## **5. SIMULATIONS AND RESULTS**

### **5.1 Simulations**

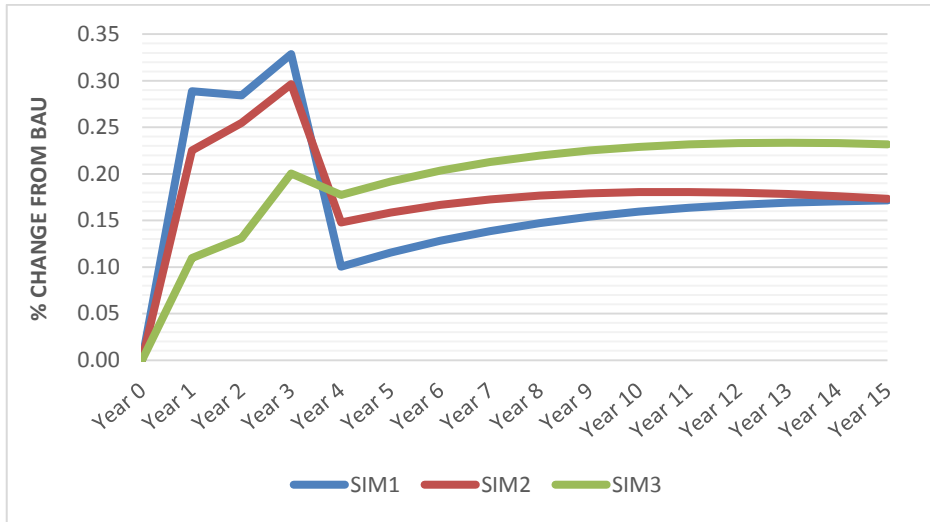
To assess the impact of public infrastructure investment in South Africa, we carry out the following simulations, only on the public economic sector. We introduce shocks in three consecutive years to capture the continued increase in public infrastructure investment and carry out three simulations to assess the impact of different forms of financing. In the business as usual (BAU) scenario, the population grows at 1.13%, the average estimated population growth rate for South Africa, as calculated from StatsSA (2010; 2011) figures. We assume labour supply to grow at the same rate as the population index. The current account balance, the minimum consumption of commodities in the LES demand equations, government current expenditures, public investment by public sector industry and changes in inventories also grow at the population rate. This assumption for these variables growing at the same rate as labour supply is made so that the model simulates a regular growth path.

Our calculations, based on South Africa's investment plans of the 2012 MTEF, outlined by National Treasury (2012), show that capital investment of the public economic sector increases in real terms by 10% in 2012 (year 1), 0.8% in 2013 (year 2) and 8% in 2014 (year 3). These increases are the basis of the simulations, which mimic actual policy in South Africa. Simulated increases in infrastructure investment are financed through an adjustment in government deficit (simulation 1), taxation (simulation 2) and a combination of government deficit and taxation (simulation 3). It is important to note that financing public infrastructure investment through government deficit cannot be done for an extended time period, as it is only a means of deferring payment. In simulation 2 the increase in public infrastructure is financed solely by an increase in tax rate on firm income. Thus the tax rate on firms adjusts to provide enough funds to finance the increased infrastructure. Financing is by both an increase in the tax rate on firm income and an increase in government budget deficit in simulation 3.

### **5.2 Macro results**

The macroeconomic results indicate that increasing public infrastructure investment has a positive growth impact on the economy for the three scenarios. GDP increases relative to the BAU level for all three simulations as shown in FIGURE 3. Deficit financing gives relatively better short-run results (year 1 to year 3).

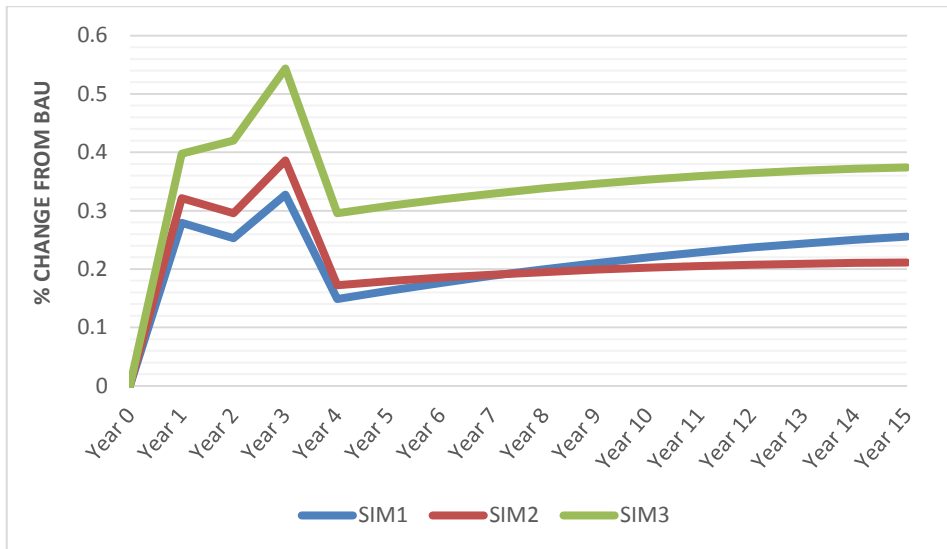
However, there is no permanent option of public spending without raising commensurate revenue, and it is unsustainable for South Africa to have a continuously uncontrolled deficit (as evidenced by deficit financing results beyond the short run). The least favourable outcomes in the medium- and long-run periods result from financing infrastructure investment through budget deficit and taxation. For the tax financing option, adjusting the tax rate on firm income requires firms to save even more in order to contribute to their investment needs. Indeed, the medium- (year 6) and long-run (year 15) savings results confirm that firms save more under this scenario.



**FIGURE 3: Impact of increasing public infrastructure on GDP (% change from BAU)**

Source: Authors' calculations from simulation results

Our study indicates that increasing public infrastructure investment benefits labour for all three scenarios. Results for aggregate demand for labour are higher than the BAU scenario as shown in FIGURE 4. The public economic sector is very labour-intensive, with a capital/labour ratio of 0.1. Thus when capital supply for this sector increases, its labour demand consequently increases. The mixed financing scenario appears the most beneficial funding option for labour demand.



**FIGURE 4: Changes in aggregate formal labour demand (% from BAU)**

Source: Authors' calculations from simulation results

The results for the Consumer Price Index (CPI) indicate that increasing public infrastructure investment has an overall positive impact on the economy, as shown in TABLE 1. This result is

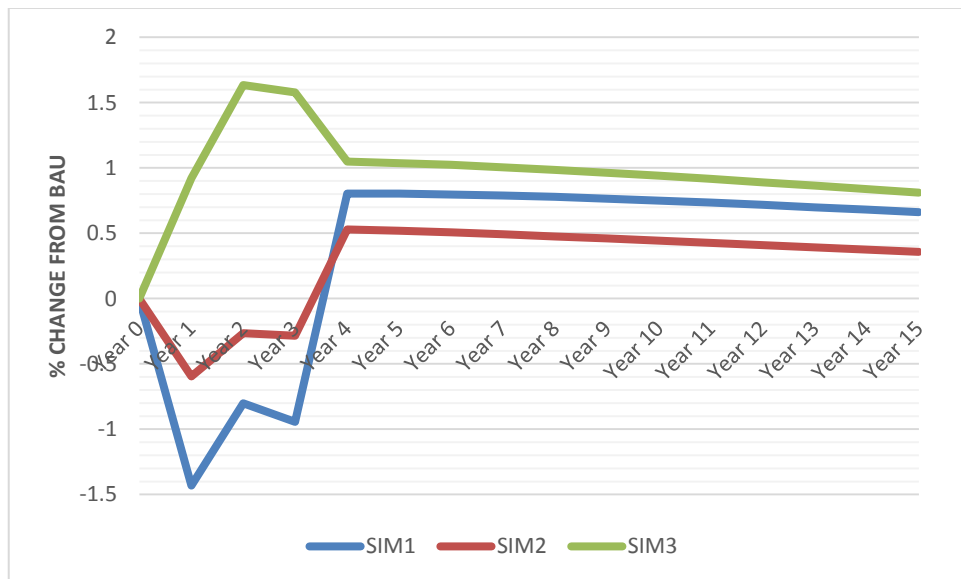
similar to that of Bahan et al. (2011), who found that improving infrastructure investment has a downward pressure on prices after accounting for positive externalities. CPI declines relative to the BAU scenario in all time periods. Financing the increase in public infrastructure investment through a combination of an increase in the tax rate on firm income and an increase in government budget deficit gives the strongest impacts in terms of CPI in all time periods.

**TABLE 1: Impact on Consumer Price Index (% change from BAU)**

Simulation	Year 1	Year 2	Year 3	Year 4	Year 15
1	-0.09	-0.06	-0.21	-0.28	-0.25
2	-0.19	-0.14	-0.31	-0.26	-0.22
3	-0.38	-0.39	-0.57	-0.38	-0.35

Source: Authors' calculations from simulation results

Overall, private investment expenditure grows at a higher rate relative to the BAU situation. The increase in public infrastructure investment in simulations 1 and 2 has a dampening effect on private investment during the shock periods. This indicates some degree of crowding out of private investment. The observed negative impact for simulation 2 confirms the finding by Ferede and Dahlby (2012) that higher tax rates depress investment.



**FIGURE 5: Impact on private investment expenditure (% change from BAU)**

Source: Authors' calculations from simulation results

FIGURE 5 indicates that funding infrastructure through mixed financing yields the most favourable outcome for private investment. Despite these short-run outcomes, the results for the medium and long run show that private investment benefits from increased infrastructure investment.

## **5.3 Sectoral analysis**

### **5.3.1 Output production**

An increase in new capital investment for the public economic sector triggers an increase in both capital and labour demand. Since our model assumes a Leontief production function, it means demand increases for intermediate inputs as well. Public sectors require additional commodities produced by other sectors in order to produce more output following the increase in infrastructure investment. Thus increased government spending on economic infrastructure impacts other sectors through increased intermediate demand. This is true especially for sectors with the strongest forward linkages with the public economic sector, particularly construction, other transport equipment, and professional and scientific equipment. However, the results indicate that indirect linkages are stronger than direct linkages in terms of intermediate consumption. It is the sectors that supply intermediate inputs to construction and other transport equipment that record the highest increases in output. These include wood and wood products, nonmetallic minerals, basic nonferrous metals, metal products excluding machinery, and electrical machinery. This is because a greater proportion of these commodities is consumed for intermediate use as follows: wood and wood products (87%), nonmetallic minerals (91%), basic nonferrous metals (62%), metal products excluding machinery (67%), and electrical machinery (55%).

The results generally indicate that increasing public infrastructure leads to an increase in sectoral output production. The impacts on output production are fairly positive for almost all the sectors, because the improvement in economic infrastructure benefits all sectors through a reduction in margin costs. In addition, even though private investment slightly suffers in the period when shocks are applied, the sectors do not suffer the total crowding-out effect. In fact, private sector investment recovers in the short run, as shown in FIGURE. Almost all sectors increase production relative to the BAU scenario, because the reduction in margin costs contributes to the decline in the cost of production. However, very few sectors experience a negative impact in their production. This emanates from the negative impact on investment which compels these sectors to reduce their demand for capital and labour, resulting in the decline in production in the short run. In subsequent periods, however, the results for sectoral output production show that there are no outright losers in all simulations.

TABLE 2 gives results for sectoral output production for selected sectors for the mixed financing scenario, which has the highest percentage changes in sectoral output production relative to BAU levels (results for the deficit and taxation scenarios are similar but with lower magnitudes).

### **5.3.2 Factors of production**

Under factors of production we first discuss the impact on capital demand, followed by labour demand impacts and lastly effects on unemployment and wage rate. For simulation 1, capital demand generally falls over the assessment period for about 10 sectors. The decline in capital demand is due to the crowding out of private investment. For the other sectors capital demand generally increases in all time periods relative to BAU values. Simulation 2 results are more or less similar to the deficit-financing scenario above.

**TABLE 2: Change in output for mixed financing scenario, selected sectors (% change from BAU)**

<i>Year</i>	<i>Basic non ferrous metals</i>	<i>Construction</i>	<i>Community social services</i>	<i>Public general admin</i>	<i>Public social services</i>	<i>Public economic sector</i>
1	1.59	1.83	-0.33	1.17	1.12	1.26
2	1.63	1.87	-0.29	1.18	1.13	1.30
3	2.81	2.80	-0.28	1.28	1.18	1.45
4	2.59	2.02	0.08	0.23	0.13	0.39
5	2.39	1.88	0.15	0.22	0.14	0.37
6	2.21	1.75	0.20	0.21	0.15	0.35
7	2.04	1.63	0.25	0.20	0.16	0.34
8	1.88	1.52	0.28	0.19	0.17	0.33
9	1.74	1.41	0.32	0.18	0.18	0.31
10	1.60	1.32	0.35	0.18	0.18	0.30
11	1.48	1.23	0.37	0.17	0.19	0.29
12	1.37	1.14	0.39	0.17	0.19	0.28
13	1.26	1.06	0.41	0.17	0.20	0.28
14	1.17	0.99	0.42	0.16	0.20	0.27
15	1.07	0.92	0.43	0.16	0.20	0.26

*Source: Authors' calculations from simulation results*

However, when compared to deficit financing, financing through taxation gives better short-run results but less favourable results in the long run in terms of changes in capital demand relative to BAU levels. Simulation 3 (mixed financing) yields better results for changes in capital demand than simulations 1 and 2. In simulation 3, capital demand declines relative to the BAU values only in seven sectors. As a result, comparatively better sectoral outcomes for output production are observed for this simulation 3.

Besides the additional intermediate inputs required by the public economic sector to produce output subsequent to the increase in infrastructure investment, more labour is also needed. In addition to getting labour from the pool of the unemployed, the public sector attracts formal labour from other sectors by increasing its wage rate. Across all formal labour categories, aggregate demand for labour for each skill increases in all time periods for all simulations. However, this is not the case for sectoral labour demand. Some sectors experience an increase in demand for labour while others record a decline. The model assumes that labour categories can be substituted (imperfectly) for one another. Mixed financing largely gives relatively better outcomes for the changes in sectoral labour demand when compared to the other two scenarios. This is also true for total labour for each of the three formal labour categories as well as for aggregate formal labour demand. Thus increased investment in public infrastructure has positive impacts on labour demand.

Labour demand increases, relative to BAU levels, for the government economic sector as well as other public sectors for all formal labour categories. In general, labour demand increases relative to the BAU situation in agriculture forestry and fishing, all mining sectors, all services sectors and all public sectors. The increase in demand for labour reduces the level of unemployment. As the unemployment rate changes, the wage rate is expected to move in the opposite direction because of the trade-off between unemployment and wages.

**TABLE 3: Changes in wage rate and unemployment rate, formal labour (% change from BAU)**

	<i>Simulation</i>	<i>Year 1</i>	<i>Year 2</i>	<i>Year 3</i>	<i>Year 4</i>	<i>Year 15</i>
Unemployment Rate						
High-skilled labour	1	-2.60	-2.36	-3.12	-1.54	-2.31
	2	-2.95	-2.73	-3.62	-1.75	-0.72
	3	-3.60	-3.79	-4.95	-2.83	-3.32
Semi-skilled labour	1	-1.28	-1.18	-1.52	-0.68	-0.86
	2	-1.41	-1.32	-1.71	-0.76	-0.72
	3	-1.66	-1.73	-2.23	-1.17	-1.24
Low-skilled labour	1	-0.33	-0.24	-0.32	-0.14	-0.98
	2	-0.51	-0.42	-0.57	-0.24	-0.80
	3	-0.84	-0.95	-1.23	-0.75	-1.51
Wage Rate						
High-skilled labour	1	0.17	0.18	0.10	0.1	0.01
	2	0.11	0.14	0.06	0.06	0.02
	3	-0.01	0.00	-0.07	-0.07	0.04
Semi-skilled labour	1	0.04	0.06	-0.06	-0.06	-0.1
	2	-0.05	-0.01	-0.14	-0.14	-0.1
	3	-0.21	-0.21	-0.35	-0.35	-0.18
Low-skilled labour	1	-0.06	-0.04	-0.18	-0.18	-0.12
	2	-0.14	-0.10	-0.25	-0.25	-0.09
	3	-0.29	-0.29	-0.45	-0.45	-0.14

Source: Authors' calculations from simulation results

The short- and long-run changes in the unemployment rate and the wage rate are given in TABLE 3. The base-year unemployment rates, calculated from 2005 LFS, are 0.04, 0.29 and 0.25, respectively for high-skilled (LABHI), semi-skilled (LABSK) and low-skilled (LABLS) labour. We have indexes of the wage, and all wages are equal to 1 at the base year. As unemployment is not modelled for informal labour, there is substitution of informal labour for formal labour, particularly in the period when shocks are introduced. Informal, low-skilled, semi-skilled and

high-skilled labour are assumed to be imperfect substitutes following Rattsø and Stokke (2005). Thus, the wage rate does not respond to changes in unemployment as expected in some instances.

## 5.4 Impact on households and firms

The public infrastructure investment policy impacts positively on households as evidenced by the increase in their consumption as given in TABLE 4. Increase household consumption is attributed to the reduction in unemployment and the decline in the price level. In the short run, deficit financing produces the most favourable results. In the long term, however, the results show that it is not the best financing option for infrastructure investment. Our results show that the mixed financing option produces better long-run results.

**TABLE 4: Household consumption and firm income (% change from BAU)**

	<i>Simulation</i>	<i>Year 1</i>	<i>Year 2</i>	<i>Year 3</i>	<i>Year 4</i>	<i>Year 15</i>
Household consumption	1	0.35	0.31	0.45	0.28	0.36
	2	0.15	0.22	0.34	0.41	0.37
	3	-0.20	-0.17	0.02	0.46	0.50
Firm income	1	0.21	0.22	0.29	0.16	0.10
	2	-0.62	-0.29	-0.32	0.51	0.35
	3	-2.13	-2.12	-2.05	0.18	0.10

*Source: Authors' calculations from simulation results*

Results for firm income show that the increase in the tax rate (in simulations 2 and 3) adversely affects firms in the initial periods. This is because firms have to pay more direct taxes. In the subsequent years improved infrastructure helps the firms to recover, as investment improves and the cost of production goes down, improving production and profitability.

## 6. CONCLUSION

We analysed the growth and employment impacts of increasing public economic infrastructure investment in South Africa, financing the infrastructure investment in three different ways. In the first scenario the government deficit adjusts to fund the increase in public infrastructure investment. There will thus be reallocation of capital from the private sector to the public sector. The results show that financing public infrastructure investment through government deficit cannot be a permanent choice. This option will require commensurate revenue to be raised, as it is unsustainable for a country to have a continuously uncontrolled deficit. In the second scenario infrastructure investment is financed by letting the direct tax rate on firm income adjust to create enough revenue to finance the infrastructure investment. In the third and final scenario, a combination of an increase in the direct tax rate on firm income and an increase in government deficit is used to finance the public infrastructure investment increase. As was found by Giesecke et al. (2008), we also find, for the South African case, that the impact of infrastructure investment is influenced by how it is financed.

Based on the results we obtained, our study concludes that increasing public infrastructure investment has positive impacts on economic growth and employment in South Africa. GDP increases while the price level declines in comparison to the BAU path for all time periods in all scenarios. Unemployment falls relative to the BAU path as labour demand increases. The results indicate that financing public infrastructure investment through a combination of tax and government deficit yields better results, especially in the short and long run.

The results of our study provide an important and interesting contribution to the South African public infrastructure debate, given the government drive for infrastructure development. The study offers evidence to support the expected positive effects of this strategy in South Africa. While public infrastructure investment does impact positively on the economy, the way the investment is financed is of the utmost importance. Thus the current policy, particularly deficit financing of infrastructure investment, might need to be reviewed in the light of other financing options, especially mixed financing and maybe increased private sector involvement. We do acknowledge that our study is limited by the use of one form of tax. We intend to extend this study by including other forms of taxation and funding (value-added tax, individual income tax, import duties, user charges and foreign borrowing) in order to offer even more information to this debate.

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