Impacts of Public Infrastructure Investment in South Africa: A SAM and CGE-Based Analysis of the Public Economic Sector

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11 December 2018

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1. Introduction

In 2012, the South African government espoused a National Infrastructure Plan, with the objectives of job creation, improving service delivery and contributing to the growth of the economy (Presidential Infrastructure Coordinating Commission, 2012). This came almost 20 years after South Africa's democratic transition, which had proven unable to bring about the anticipated solutions to the problems of unemployment, inequality and poverty. Thus, prompting much talk in policy circles on how to achieve higher rates of economic growth while simultaneously tackling these three challenges. Infrastructure development, referred to as the first and key jobs driver in the New Growth Path, is believed to be the foundation for the creation of new jobs and improvement in economic growth. It is believed that increased investment in public infrastructure will ensure inclusive growth from which everyone will benefit.

Public economic infrastructure accounts for more than 75% of total public infrastructure in South Africa. Besides accounting for a greater part of public infrastructure investment, public economic infrastructure is important for raising the productivity of other sectors of the economy. Copeland, Levine and Mallett (2011) point out that not all types of public infrastructure investment which add directly to a nation's productive capacity. Public infrastructure expenditures, which enter the production function as inputs for final output, include the provision of roads, railway networks, airports and harbours (Glomm & Ravikumar, 1997). This is supported by Haider et al (2013) who mentioned that the impact of infrastructure is influenced by types of infrastructure as well as by economic conditions. Furthermore, public infrastructure investment is likely to have strong backward and forward linkages, hence the need to assess these. Because of the scale of the public economic infrastructure in South Africa, this paper seeks to assess how shocks to public sector infrastructure spending affect other economic activities and actors.

We carry out an impact analysis of increasing public economic infrastructure investment in South Africa. To do this we use Social Accounting Matrix (SAM) modelling to do multiplier and Structural Path Analyses (SPA), and Computable General Equilibrium (CGE) modelling to assess the economy wide impacts of scaling up public economic infrastructure. Even though these methodologies have been separately used to analyse the impact of infrastructure investment in previous studies (see Mabugu & Mohamed, 2008; Ngandu et al., 2010; Maisonnave et al., 2013; Mbanda & Chitiga-Mabugu, 2017), to the best of our knowledge, no previous study has used multiplier analysis, structural path analysis and CGE analysis jointly to assess the impacts of public economic infrastructure investment. Moreover, because of unavalability of relevant data, the previous study that used SPA to assess the impact of infrastructure investment in South Africa, that of Ngandu et al. (2010), shocked the construction sector as a proxy for the sector that is affected by increased public economic infrasture investment. However, the reality is that the construction sector is impacted on, only indirectly by an increase in public economic infrastructure investment. Taking advantage of a disaggregated SAM that incorporates explicitly a public economic sector, we are able to shock the actual sector that receives public economic infrastructure investment. We are thus able to analyse the multiplier effects of South Africa's public economic infratructure investment, trace the paths through which they are transmitted across the economy and assess the economy wide impacts.

It is important to note that SAM multiplier analysis measures sectoral linkages and quantifies production impacts, SPA goes beyond multiplier analysis and traces the adjustment process of the full network of influence through which an impact is transmitted within a socioeconomic system, while CGE analysis assesses the overall impact of a shock on an economy (Khan & Thorbecke, 1989). This study does not seek to make a comparison of SAM and CGE modelling. It rather uses them in a complementary way by using SAM analysis to measure the sectoral interdependencies and trace the path of influence of increasing public economic infrastructure investment, and CGE analysis to evaluate the economy-wide impact thereof.

SAM modelling is a valuable tool for measuring sectoral interdependencies and effects resulting from quantity change; however, it is often criticised for its restrictive assumptions (Polo & Valle, 2012; Thaiprasert, 2006). A static fixed-price SAM model, which we use in this study, does not take into account resource constraints, assumes no substitution between factors in production and substitution between commodities in consumption and is argued to lack micro-theoretic foundations (Schreiner et al., 1999). Because of the price fixity assumption, the static SAM framework only captures the initial impact, but does not capture the price adjustments of any socioeconomic shock (Nokkala, 2002). For these reasons, CGE modelling becomes a more theoretically sound policy and impact analysis tool which can explicitly assess the impacts resulting from relative price changes and factor input movements, and which assumes prices to be sufficiently flexible to clear the factor and commodity markets (Schreiner et al., 1999; Thaiprasert, 2006).

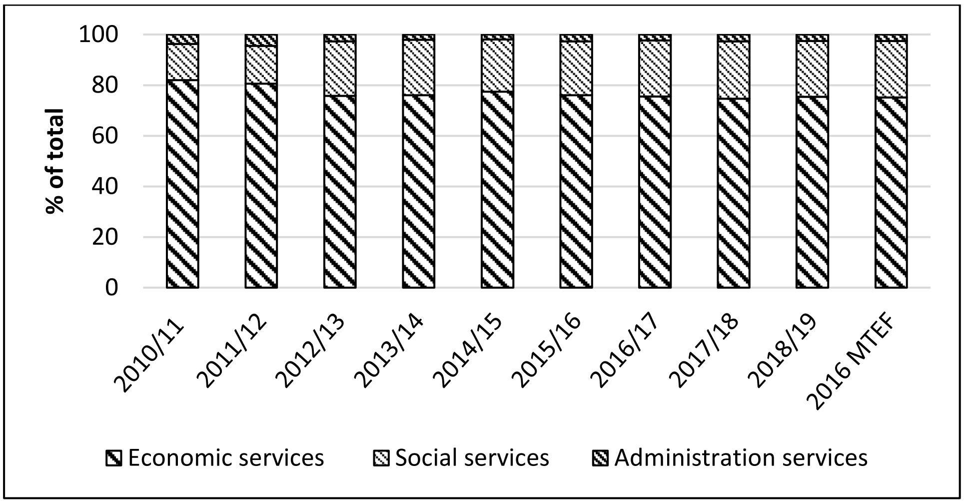
The rest of the paper proceeds as follows. The next section gives the background on public-sector infrastructure expenditure in South Africa. In section 2 related literature is reviewed. Data and methods are discussed in section 3. Section 4 performs multiplier analysis and decomposition, structural path analysis and CGE analysis of increasing final demand for the public economic sector. Section 6 concludes the paper.

1.1. Background on public service expenditure in South Africa

From the 2010/11 - 2012/13 Medium Term Expenditure Framework (MTEF) to the 2015/16-2017/18 MTEF, planned public-sector infrastructure expenditure for investing in new infrastructure and upgrading of existing infrastructure ranged between R606 billion (6.8% of Gross Domestic Product (GDP)) for 2010/11-2012/14 and a planned

R865.5 billion (6.1% of GDP) for 2016/17-2018/19 (National Treasury, 2014:24; National Treasury, 2015:122; National Treasury, 2016:129).

Figure 1: Public-sector infrastructure expenditure and estimates, 2010/11 – 2017/18



Source: National Treasury (2015; 2012)

The bulk of this public infrastructure spending goes to economic services, which accounts for between 75% and 82% of the public infrastructure expenditure over the 2010/11 to 2017/19 period. This is indicated in Figure 1, which shows yearly public infrastructure expenditure data. The impact of public-sector infrastructure investment is thus expected to come largely from economic services through power-generation capacity expansion, upgrading and expansion of the national transport infrastructure network, investment in telecommunications, as well as improvements in sanitation and provision of water (National Treasury, 2015). Economic services, henceforth referred to as the public economic sector, is a public sector which, like all other sectors in the economy, employs both labour and capital. It comprises public sector energy, transport, telecommunications and water and sanitation services.

2. Literature Review

SAM analysis has been used, and continues to be used, to understand the impacts of various socio-economic issues and policies. Previous studies have used the SAM technique to look at issues that include the impact of energy policies and prices (Akkemik, 2011; Doukkali & Lejars, 2015; Hartono & Resosudarmo, 2008), understanding the structure of an economy (Alikaj & Alexopoulos, 2014; Husain, 2006; Lewis & Thorbecke, 1992), investment behaviour and initiatives (Nakamura, 2004; Santos, 2004; Wanjala & Were, 2009), the sectoral impacts of tourism (Cai, et al., 2006; Jones, 2010), and of agriculture (Juana & Mabugu, 2005), the impacts of land reform (Juana, 2006), high prices (Tlhalefang & Galebotswe, 2013) and public investment and infrastructure. In South Africa, studies that have used the SAM methodology include those that have been used to analyse the impacts of sectoral growth on poverty reduction (Khan, 1999), the impacts of agriculture (Eckert et al., 1997; Townsend & McDonald, 1998), the mining sector (Johannes & Leeuw, 2012), manufacturing and services (Tregenna, 2008) and public infrastructure related issues namely the Expanded Public Works Programme (Kim, 2011), 2010 FIFA World Cup related infrastructure (Mabugu & Mohamed, 2008) and the economic impact of infrastructure investment (Ngandu et al, 2010). Previous studies on investment and infrastructure are briefly discussed below, while the works of Mabugu and Mohamed (2008) and Ngandu et al (2010) are discussed in detail, as they are closely related to the current paper.

Nakamura (2004) looked at the investment behaviour of Russian oil and gas versus non-oil and gas industries using SAM analysis, to assess their disinclination to invest in the domestic economy. The results, Nakamura (2004) reported, showed that both oil and gas as well as non-oil and gas companies were inclined to invest financially overseas. Santos (2004) used SAM multiplier analysis and SPA to assess the components of the Portuguese government account that contribute most to an improvement in the country's net borrowing. The capital expenditure of central government, Nakamura (2004) observed, had a significant impact on the economy's net borrowing. In conclusion, Nakamura (2004) recommended a reduction in the central government's capital expenditure components, but acknowledged the effects such a reduction might have on the economy.

Wanjala and Were (2009) used the SAM multiplier analysis to assess the gender differences in employment outcomes of different investment options in Kenya. Wanjala and Were (2009) observed that women were likely to gain more from job creation; however, most of the new jobs would be in the informal sector, which is characterised by low wages. Farag and Komendantova (2014) used SAM modelling to compare the impacts of investment in various renewable energy technologies, largely for export to Europe, versus meeting local demand, in Egypt. Farag and Komendantova (2014) observed relatively higher GDP and income multipliers for the export scenario and relatively higher output multipliers for the local demand scenario. Sassi (2010) carried out a study to understand the impacts of public investment in agriculture on economic growth, poverty and food security in Kenya. Raihan (2011) assessed the economy-wide impacts of investment in infrastructure in Bangladesh using SAM modelling. Investment in both physical and social capital, Raihan (2011) observed, significantly raised gross output, GDP and household consumption.

Mabugu and Mohamed (2008) estimated the economic impacts of financing the preparations for the hosting of the 2010 FIFA World Cup by the South African government. The authors simulated an increase in expenditure for construction and upgrading of stadia amenities and related transport infrastructure. The impacts of the policy intervention were then traced on production and inputs, factor remuneration, household income and government tax revenues (Mabugu & Mohamed, 2008).The increased expenditure for the 2010 FIFA World Cup and related activities, Mabugu and Mohamed (2008: 18) found, impacted positively on the economy as indicated by a 1.2% rise in GDP, and output of the targeted sectors increased. Relatively high multipliers were observed for sectors with strong forward or backward linkages with the targeted sectors. Mabugu and Mohamed (2008) concluded that, based on the SAM analysis, the infrastructure expenditure related to the 2010 FIFA World Cup had a positive impact on the economy as shown by the change in GDP, but had regressive socio-economic impacts as indicated by the differential gains by households.

Ngandu, Garcia and Arndt (2010) assessed the economic impacts on the South African economy of the infrastructure investment that gathered momentum in the years leading to the 2010 FIFA World Cup. In addition, Ngandu et al (2010) carried out an SPA of infrastructural expenditure. The impact of infrastructure investment was evaluated by shocking the construction sector. Assuming that construction and construction-related activities received the entire R845 billion infrastructure investment, Ngandu et al (2010: 7) applied the shock to these sectors, using the 2003 SAM. With a multiplier close to 5 for the construction sector, Ngandu et al (2010: 7) acknowledged that the “numbers are clearly too large” and that the “result highlights the need for appropriate consideration of results and perhaps reconsideration of the magnitude of the package.”

This paper takes a different angle from the study by Ngandu et al (2010). While Ngandu et al (2010) made an invaluable contribution to the debate on impacts of public infrastructure investment in South Africa, they did not shock the actual sector that received the infrastructure investment. Shocking the construction sector cannot fully capture the impact of public infrastructure investment. As pointed out above, the public infrastructure investment drive is in fact directed largely at economic services and only impacts the private sector (which includes construction) indirectly. In addition, the main focus is of this paper is on the impacts on labour accounts, as the government seeks to make an impact on employment (Economic Development Department, 2011; NPC, 2011b).

The 2005 SAM of the South African economy is used to model the economic impact of public economic infrastructure. This SAM has disaggregated public sectors, including a public economic services sector, under which all economic services mentioned previously fall. It thus enables assessing how the recipient of the public infrastructure investment funds (i.e. the public economic sector) interacts with other players in the economy.

3. Methods and Data

3.1 SAM Modelling

A SAM is a money-metric, double-entry economic accounting system that records transactions among economic activities and actors and reflects the socio-economic structure of a country. In essence, it shows the complete circular flow of income from production to distribution and expenditure. It presents data on items that include production inputs and outputs; consumption by households, government and for investment purposes; taxes levied on production, institutions and commodities, subsidies given by government for production, transfers across institutions; and exports and imports (see the SAM in Table 1**Error! Reference source not found.**).

A SAM thus gives the value of flows of an economic system and shows who pays what and who receives it, for all transactions. It not only provides a framework for recording socio-economic data but, as pointed out by the Coordinating Ministry for Economic Affairs and International Labour Organisation (2010), also for analysing the data and its impacts on the economy. For this reason, Civardi, Lenti and Pansini (2008) mention that a SAM is considered a macroeconomic model because it includes data related to production, income distribution and consumption expenditures, which depend on household behaviour. The Coordinating Ministry for Economic Affairs and the International Labour Organisation (2010) concur that a SAM is an important analytical tool that can be used to simulate economic policies, past, present and future, to assess their effectiveness and/or impacts on various economic metrics, which include employment, output, and income distribution.

3.1.1 Multiplier Analysis

SAM analysis uses multipliers to model the links between economic sectors and actors at a point in time. According to Antonopoulos and Kim (2011), it gives a platform that is sufficient to do simulations for analysing policy impacts on households, labour, and industries as well as their subgroups. The multiplier analysis accounts for the impacts triggered by an exogenous demand stimulus. As pointed out by Round (2003), SAM multiplier analysis allows the decomposition of these multipliers into three types of economic impacts: direct, indirect, and induced effects.

IHS Global Inc. (2014) and Oxford Economics (2008) described the three types of economic impacts. According to IHS Global Inc. (2014) and Oxford Economics (2008), direct impacts are created by the activity directly associated with the demand shock. In the present case of an increase in public economic infrastructure, this includes all the impacts caused by increased infrastructure spending. The direct impacts therefore result from total expenditure on inputs for the industry receiving the new public infrastructure. Both IHS Global Inc. (2014) and Oxford Economics (2008) point out that indirect impacts are production changes in backward-linked industries generated through the intermediate goods demanded by all sectors that are directly and indirectly affected by the direct expenditures on inputs linked to the initial infrastructure investment. Induced impacts result from changes in income and arise from the total impact on all consumer demand resulting from both direct and indirect impacts (IHS Global Inc., 2014). That is, induced impacts are created from the additional labour income received from direct and indirect industries (Oxford Economics, 2008), which is then spent on consumer goods by households. The sum of direct, indirect and induced effects gives total impacts (IHS Global Inc., 2014).

In short, when an economy gets an investment stimulus from government, the investment enters the SAM model as a “shock”, which is modelled as a demand stimulus. The stimulus would cause the sector that receives it to purchase intermediate inputs, consequently resulting in a series of expenditures in different sectors of the economy as the producers of those intermediate inputs will also demand inputs from other industries that supply them with intermediate inputs. The basis of this methodology, as Antonopoulos and Kim (2011) mention, is the assumption that technical coefficients of production remain constant.

The SAM model allows assessing the impacts of changes in exogenous and policy-driven variables on other variables that are endogenous to the system (Civardi, et al., 2010). This study uses static SAM modelling to analyse the growth prospects and employment potential resulting from an exogenous demand stimulus on the public economic sector. Multiplier analysis, backward and forward linkages, multiplier decomposition and SPA are applied to assess the linkages of the public economic sector with other economic players, and to trace the main paths of influence of the public economic sector on the economy. Through multiplier decomposition and SPA, the economic adjustment process is traced.

3.1.1.1 SAM Matrices

To help visualise the transactions taking place in the economy, a schematic SAM in Table 1 is presented, showing information on inter-industry transactions, T, final demand components represented by D and total production, X. L and R represent leakages and residual balances. The row totals of endogenous accounts X are the sum of expenditures by endogenous accounts T and expenditures by exogenous accounts D Thus:

$$\boldsymbol{X} = \boldsymbol{T} + \boldsymbol{D} \qquad (1)$$

Table 1: SAM in Symbols

	Endogenous accounts	**Exogenous accounts**	**Total receipts**
Endogenous accounts	T	D	X
Exogenous accounts	L	R	Y
Total payments	X	Y	

Source: Adapted from Defourny and Thorbecke (1984)

The inter-industry data can give one the direct input requirements to produce a unit of output. One can calculate how much inputs a sector requires to produce a unit of its output. To calculate the input requirements, each cell in the industry by industry matrix T is divided by each total column expenditure. This gives what is called matrix A, which is a technical coefficients or direct requirements coefficients matrix, showing the amount of inputs purchased directly to produce one unit of output. In other words, the A matrix is the direct requirements of the inter-sectoral relationships where the rows of A give the amount of output from industry i required as intermediate inputs in order to produce one unit of output of industry j. Introducing the coefficient matrix A, allows one to give the following formulation:

$$\boldsymbol{T} = \boldsymbol{AX} \quad (2)$$

From equations **1** and **2** it emerges that:

$$\boldsymbol{X} = \boldsymbol{AX} + \boldsymbol{D} \quad (3)$$

Rearranging gives:

$$\boldsymbol{X} = (\boldsymbol{I} - \boldsymbol{A})^{-\mathbf{1}}\boldsymbol{D} = \boldsymbol{MD} \quad (4)$$

where I is the identity matrix and M is the Leontief inverse matrix. M_{ij}, representing every cell of M, is a measure of the change in total output of row account i due to a unitary change in the exogenous demand of column account j.

3.1.1.2 Multiplier Decomposition

While multipliers might be useful for informing policy on the before and after scenarios of an exogenous shock, Holland and Wyeth (1993) point out, the multipliers alone provide limited information to understand how the economy adjusts to the exogenous shocks. The economic adjustment process can be traced through multiplier decomposition and through SPA. Multiplier decomposition is discussed first.

The endogenous SAM elements seem like part of a single large matrix, Roland-Holst, Heft-Neal and Chaiwan (2013) mention, but the endogenous part of an A matrix can be divided into a 3x3 matrix of sub-matrices. In Table 2, A_{11} denotes inter-industry transactions, A_{21} payments from activities to factors and A_{32} payments from factors to institutions. A_{13} and A_{33} respectively are payments from institutions to activities and inter-institutional transfers.

Table 2: A Matrix Endogenous Elements

		Payments		
		Activities	Factors of production	Institutions
Receipts	Activities	A_{11}	0	A_{13}
	Factors of production	A_{21}	0	0
	Institutions	0	A_{32}	A_{33}

Source: Adapted from Roland-Holst, et al (2013)

Roland-Holst, et al (2013) point out that removing inter-industry and inter-institutional transfers from Table 2 gives the circular flow of income. We thus remain with payments from activities to factors (A_{21}), factors to institutions (A_{32}) and institutions to activities (A_{13}). The multiplier components can be either multiplicative or additive. According to

Parra and Wodon (2010), for any $n \times n$ non-singular matrix $\tilde{A}$, the multiplier matrix

$$\boldsymbol{X} = (\boldsymbol{A} - \widetilde{\boldsymbol{A}})\boldsymbol{X} + \widetilde{\boldsymbol{A}}\boldsymbol{X} + \boldsymbol{D} \quad (5)$$

$$\boldsymbol{X} = \boldsymbol{A}^{*}\boldsymbol{X} + \left(\boldsymbol{I} - \widetilde{\boldsymbol{A}}\right)^{-\boldsymbol{1}}\boldsymbol{D} \quad (6)$$

where

$$\boldsymbol{A}^{*} = \left(\boldsymbol{I} - \widetilde{\boldsymbol{A}}\right)^{-\boldsymbol{1}}\left(\boldsymbol{A} - \widetilde{\boldsymbol{A}}\right) \quad (7)$$

Multiplying through by A^{*} and replacing $A^{*}X$ on the LHS with $A^{*}X = X - \left(I - \tilde{A}\right)^{-1}D$

$$A^{*}X = A^{*2}X + A^{*}\left(I - \tilde{A}\right)^{-1}D$$

$$X - \left(I - \tilde{A}\right)^{-1}D = A^{*2}X + A^{*}\left(I - \tilde{A}\right)^{-1}D$$

$$X = A^{*2}X + A^{*}\left(I - \tilde{A}\right)^{-1}D + \left(I - \tilde{A}\right)^{-1}D$$

$$X = A^{*2}X + (I + A^{*})\left(I - \tilde{A}\right)^{-1}D$$

$$X = (I - A^{*2})^{-1}(I + A^{*})\left(I - \tilde{A}\right)^{-1}D$$

$$X = A^{*3}X + (I + A^{*} + A^{*2})\left(I - \tilde{A}\right)^{-1}D$$

$$X = (I - A^{*3})^{-1}(I + A^{*} + A^{*2})\left(I - \tilde{A}\right)^{-1}D$$

Thus the general result is:

$$X = (I - A^{*k})^{-1}\left(I + A^{*} + A^{*2} + \cdots + A^{*(k-1)}\right)\left(I - \tilde{A}\right)^{-1}D$$

Decomposition could be done indefinitely, Roland-Holst, et al (2013) point out, but it is normally stopped at $k = 3$, the number of endogenous accounts in the SAM; thus the circular flow of income goes through three steps around the SAM. Therefore

$$\boldsymbol{X} = \underbrace{(\boldsymbol{I} - \boldsymbol{A}^{*3})^{-\boldsymbol{1}}}_{\boldsymbol{M_3}}\underbrace{(\boldsymbol{I} + \boldsymbol{A}^{*} + \boldsymbol{A}^{*2})}_{\boldsymbol{M_2}}\underbrace{\left(\boldsymbol{I} - \widetilde{\boldsymbol{A}}\right)^{-\boldsymbol{1}}}_{\boldsymbol{M_1}}\boldsymbol{D} \quad (8)$$

$\boldsymbol{M_3}$ $\boldsymbol{M_2}$ $\boldsymbol{M_1}$ (**8**) is the multiplicative decomposition of the Leontief inverse matrix with M_1, M_2 and M_3 capturing transfer, open-loop and closed-loop effects respectively (Miller & Blair, 2009).

Transfer or direct effects capture the multiplier effects that result from direct transfers within endogenous accounts, for example within agents or the inter-industry transfers (Defourny & Thorbecke, 1984; Roland-Holst, et al., 2013). Open-loop or cross effects, Defourny and Thorbecke (1984) explain, capture all the interactions among production activities, factors and domestic institutions; that is the three endogenous accounts. Roland-Holst, Heft-Neal, and Chaiwan (2013) point out that circular multiplier or closed-loop effects capture the full circular multiplier effects of an exogenous injection on an account (net of transfer and open-loop effects). While transfer and open-loop effects include both direct and indirect effects, Cohen (2013) states that closed-loop effects capture exclusively indirect effects. Thus multiplier decomposition enables one to assess the extent of direct and indirect impacts of an exogenous shock.

The additive decomposition can be presented in the following format:

$$\boldsymbol{M} = \boldsymbol{I} + \underbrace{(\boldsymbol{M_1} - \boldsymbol{I})}_{\textbf{TR}} + \underbrace{(\boldsymbol{M_2} - \boldsymbol{I})\boldsymbol{M_1}}_{\textbf{OL}} + \underbrace{(\boldsymbol{M_3} - \boldsymbol{I})\boldsymbol{M_2}\boldsymbol{M_1}}_{\textbf{CL}} \quad (9)$$

where TR are transfer effects, OL are open-loop effects and CL are closed-loop effects and have the same interpretation as M_1, M_2 and M_3 above, respectively.

3.1.1.3 Forward and Backward Linkages

When any sector produces output, Miller and Blair (2009) point out, it has two impacts on other sectors of the economy: demand and supply effects. An increase in sector j's output requires sector j to increase its demand for the commodities it uses as intermediates to produce its output. The term backward linkage, Miller and Blair (2009) state, refers to this normal demand-side direction of causation which displays the connection between sector j with the upstream sectors that supply it with intermediates. An increase in sector j's output, conversely, makes available additional supplies of intermediates for sectors that use sector j's commodities to produce their output. Forward linkage, Miller and Blair (2009) further assert, is the term used to refer to this supply-side direction of causation, which indicates the linkage of sector j to the downstream sectors that demand its output. Thus, forward linkages indicate the relative importance of a sector as supplier of intermediate inputs to other industries. On the other hand, backward linkages measure the relative importance of a sector as a demander of intermediate inputs.

The dependency of sector j on intermediate inputs in its production process is the measure of strength of sector j's backward linkage (Miller & Blair, 2009). This measure, which is the column sum of sector j in the direct input coefficients matrix (Miller & Blair, 2009) is given by:

$$\boldsymbol{BL_j^d} = \sum_{i=1}^{n} \boldsymbol{a_{ij}}$$

where BL_j^d is the direct backward linkage of sector j, n is the number of industries and a_{ij} are the elements of the direct coefficient matrix A.

This is referred to as the direct backward linkage because matrix A coefficients only measure direct effects (Miller & Blair, 2009). Farag and Komendantova (2014) mention that these coefficients do not include indirect effects but only take into account first-round effects. The total backward linkages, Miller and Blair (2009) point out, capture direct as well as indirect impacts and are calculated by summing down the columns of the Leontief inverse as follows:

$$\boldsymbol{BL_j^t} = \sum_{i=1}^{n} \boldsymbol{M_{ij}}$$

where BL_j^t is the total backward linkage for sector j, and $\boldsymbol{M_{ij}}$ are the elements of the Leontief inverse matrix M as discussed before.

Forward linkages are calculated as the row sum of direct-output coefficients, which capture the supply of sector i's output used as intermediate inputs across sectors j (Miller & Blair, 2009). The row sum of the direct-output coefficients is calculated as:

$$\boldsymbol{FL_i^d} = \sum_{j=1}^{n} \boldsymbol{a_{ij}}$$

where FL_i^d is the direct forward linkage of sector i, n is the number of industries and a_{ij} are the elements of the direct coefficient matrix

The row sums of the Leontief inverse (Kula, 2008) measure the total forward linkages as defined below,

$$\boldsymbol{FL_i^t} = \sum_{j=1}^{n} \boldsymbol{M_{ij}}$$

where FL_i^t is the total forward linkage of sector i.

Kula (2008) and Miller and Blair (2009) point out that the linkage calculations using the direct coefficients are based on the Chenery and Watanabe method, while calculations based on the Leontief inverse are based on the Rasmussen method. The Chenery and Watanabe approach calculates backward (forward) linkages as column (row) sums of the direct coefficient matrix. The Rasmussen method, on the other hand, measures linkages using the Leontief inverse, which captures direct as well as indirect impacts and gives total forward and total backward linkages. Total forward linkages are calculated by summing the rows of the Leontief inverse (Kula, 2008). Total backward linkages, Farag and Komendantova (2014) explain, are measured by summing down the columns of the Leontief inverse.

3.1.1.4 Identifying key sector(s) using backward and forward linkage indices

Sectors that exhibit both strong forward and backward linkages are classified as key sectors. The major importance of these linkages, Hewings et al (1998) point out, is to identify the sectors with linkage structures that produce an above-average economy-wide effect when they expand. Sonis, Guilhoto, Hewings and Martins (1995: 234) mention that the Hirschman-Rasmussen works of 1958 led to the development of linkage indices which have "become part of the generally accepted procedures for identifying key sectors in the economy." Cai, Leung and Mak (2006) acknowledge that while the concepts of backward and forward inter-industry linkages are widely accepted in literature, there appears to be no consensus on how best to compute them. This argument is supported by Miller and Blair (2009), who mention that several propositions for differing definitions of these linkage and key sector measures have been put forward, and debates continue. This discussion is, however, beyond the scope of our work. See the work of Miller and Blair (2009) for more on the debates and formulations of backward and forward linkages. For the purposes of the current study, the formulations in Hewings, et al (1998) and Parra and Wodon (2010) are used. Hewings et al (1998) and Parra and Wodon (2010) give the derivation for backward and forward linkages as follows:

If the global intensity (sum of all cells) of the Leontief inverse matrix is denoted as V:

$$\boldsymbol{V = \sum_{i=1}^{n} \sum_{j=1}^{n} M_{ij}}$$

and sum of the i^{th} row and the j^{th} column of the inverse matrix are denoted respectively by $M_{i.}$ and $M_{.\boldsymbol{j}}$ where $M_{i.} = \sum_k M_{ik}$ and $M_{.j} = \sum_k M_{\boldsymbol{k}j}$, then the Hirschman-Rasmussen backward linkage index of sector j is calculated as:

$$\boldsymbol{BL_j = {M_{.j}} \Big/ {\tfrac{1}{n}V} = {nM_{.i}} / {V}}$$

and the forward linkage index of sector i as:

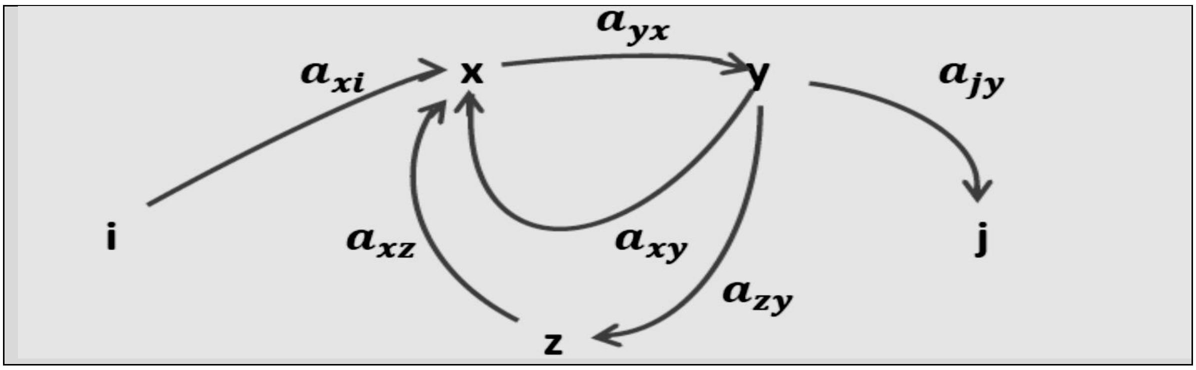
$$\boldsymbol{FL_i = {M_{.i}} \Big/ {\tfrac{1}{n}V} = {nM_{.i}} / {V}}$$

A sector with both backward and forward linkages greater than 1 is referred to as a key sector while a sector with both backward and forward linkages less than 1 is referred to as a weak sector. A sector with backward linkages greater than 1 and forward linkages less than 1 is a backward-oriented sector while one with forward linkages greater than 1 and backward linkages less than 1 is forward-oriented.

3.1.2 Structural Path Analysis

SPA traces how the effect of any exogenous shock on a single account travels through the complete network of a socioeconomic system. SPA according to Defourny and Thorbecke (1984), is an alternative to the traditional multiplier decomposition. In SPA, every endogenous account is likened to a pole, and any two poles i and j are connected by an arc $arc_{i,j}$ and the cell of the average expenditure propensity matrix A (of direct influences), a_{ji} is the intensity of $arc_{i,j}$ (Defourny & Thorbecke, 1984; Shantong, et al., 2004). In other words, a_{ji} is the magnitude of influence of pole i on j. A path is a sequence of successive arcs and its length is measured by the number of its arcs (Defourny & Thorbecke, 1984). There are two types of paths, defined by the way a path interacts with a given pole.

Figure 2: Paths of Influence



Source: Shantong, Ying, and Jianwu (2004)

A path that passes through any pole only once, according to Shantong, et al (2004), is called an elementary path while a path that starts and ends in the same pole is defined as a circuit.
Figure **2** shows the various paths:
i →x →y→ j is an elementary path while *x →y→ x* and x→ *y →z →x* are circuits.
There are three possible effects between accounts or poles i and j namely direct, total and global influence.

3.1.2.1 Direct Influence

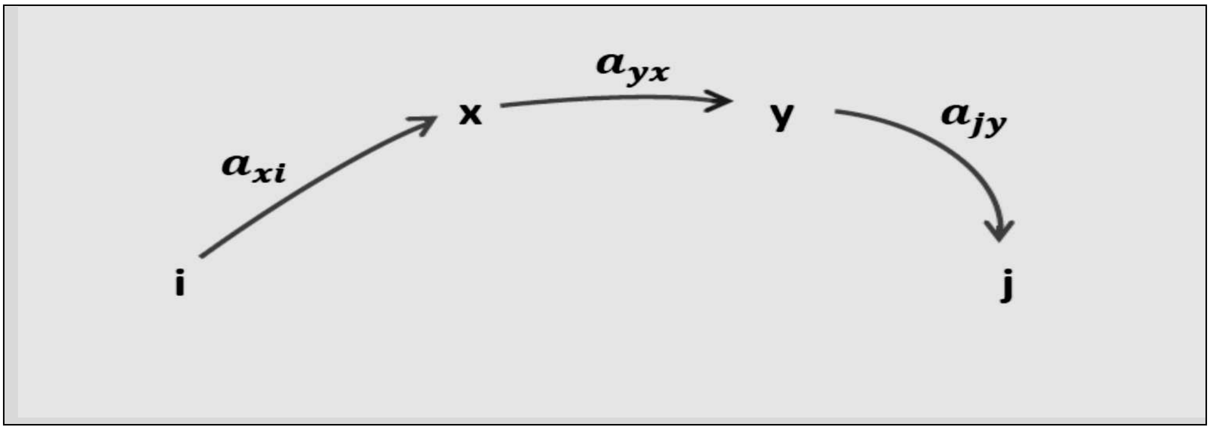
Defourny and Thorbecke (1984) point out that the direct path of i on j is defined as a change in j's production due to a unitary change in i, that is transmitted through an elementary path; holding all other poles constant (i.e. their production remaining constant), other than the ones along the elementary path. The direct influence of i on j, according to Defourny and Thorbecke (1984) and Shantong, et al. (2004), is measured along the arc, $arc_{i,j}$, if there are only two poles, i and j, or along an elementary path if there are other poles between i and j. In a case where the path only has two poles, i and j, the direct influence is:

$$I^D_{(i\to j)} = a_{ji}$$

For an elementary path p as shown in Figure 3, the direct influence is the product of the intensities of all arcs making up the path. The direct influence is thus calculated as:

$$I^D_{(i\to j)p} = I^D_{(i,x,y,j)} = a_{xi}a_{yx}a_{jy}$$

Figure 3: Elementary Path



Source: Defourny and Thorbecke (1984)

3.1.2.2 Total influence

In reality, the notion of elementary paths is very rare given the presence of feedback effects. The existence of feedback effects is well accounted for by the total influence. The total influence of i on j includes all direct effects (transmitted along the elementary path) and indirect effects (triggered by the circuits adjacent to that same path). In Figure **2** the direct influence is $a_{xi}a_{yx}$ through the elementary path *i→ x →y*. However, there are feedback effects transmitted from pole *y* back to pole *x* through circuits *x → y→ x* and *x → y →z→ x*. The indirect influence from pole *x* to pole *y* after one round of feedback is: $a_{yx}(a_{xy} + a_{zy}a_{xz})$. The feedback between poles x and y goes on and on, and after t rounds of feedback the indirect influence becomes: $[a_{yx}(a_{xy} + a_{zy}a_{xz})]^t$ which can be converted, using a geometric series, to: $a_{yx}[1 - a_{yx}(a_{xy} + a_{zy}a_{xz})]^{-1}$. The total impact, including the direct influence between pole i and pole x and between pole y and pole j then becomes:

$$I^T_{(i\to j)p} = a_{xi}a_{yx}a_{jy}[1 - a_{yx}(a_{xy} + a_{zy}a_{xz})]^{-1}$$

The first part on the right-hand side of the equation is the direct influence as defined above. The second part is called a path multiplier M_p, a measure of how adjacent feedback circuits augment the direct influence along the elementary path. Thus the equation can be rewritten:

$$I^T_{(i\to j)p} = I^D_{(i\to j)p}M_p$$

3.1.2.3 Global Influence

The global influence from i to j is given by the accounting multiplier m_{ji}, the element of the inverse matrix M in the j^{th} row and i^{th} column. The global influence is thus given by:

$$I^G_{(i\to j)p} = m_{ji}$$

4.2 Computable General Equilibrium

CGE modelling is a significant tool for policy design because it is one of the most rigorous, quantitative methods available, which is said to have become the most important empirical tool to evaluate the economy-wide impact of economic and policy shocks (Boyer & Schuschny, 2010; Darboe, 2012; Inter-American Development Bank, n.d.). CGE models extend the SAM structure, allowing the adjustment of prices and resource reallocation between production sectors (Wei, et al., 2013). They mimic the structure of the economy, and capture the economic transactions prevailing among different economic actors such as firms, households, government and productive sectors. CGE models can mimic the role of markets because they capture the behavioural content of economic agents explicitly derived from microeconomic optimisation, which allows complex interaction and specification of how economic actors respond to changes in the economy (Rossouw & Saayman, 2011; Wei, et al., 2013; Giesecke, et al., 2015). Thus, as explained by Cohen (2013), CGE models can calibrate quantity and price adjustments better in both product and factor markets. CGE models include feedback between production, demand and income structures and allow all prices to adjust until production decisions are consistent with demand decisions (Rossouw & Saayman, 2011).

4.2.1 Model overview

We use the Poverty and Economic Policy (PEP) single country static model, PEP-1-1, (Decaluwe, et al., 2009) to make some simulations on the South African economy. We use the most basic model, adapted to the South African situation. Following the Walrasian approach, perfect competition is assumed in all markets, thus all markets clear, and only relative prices matter. Firms are assumed to operate in a perfectly competitive setting, maximising profits subject to their production technology. Firms are price takers, as prices of goods and services as well as factors are given.

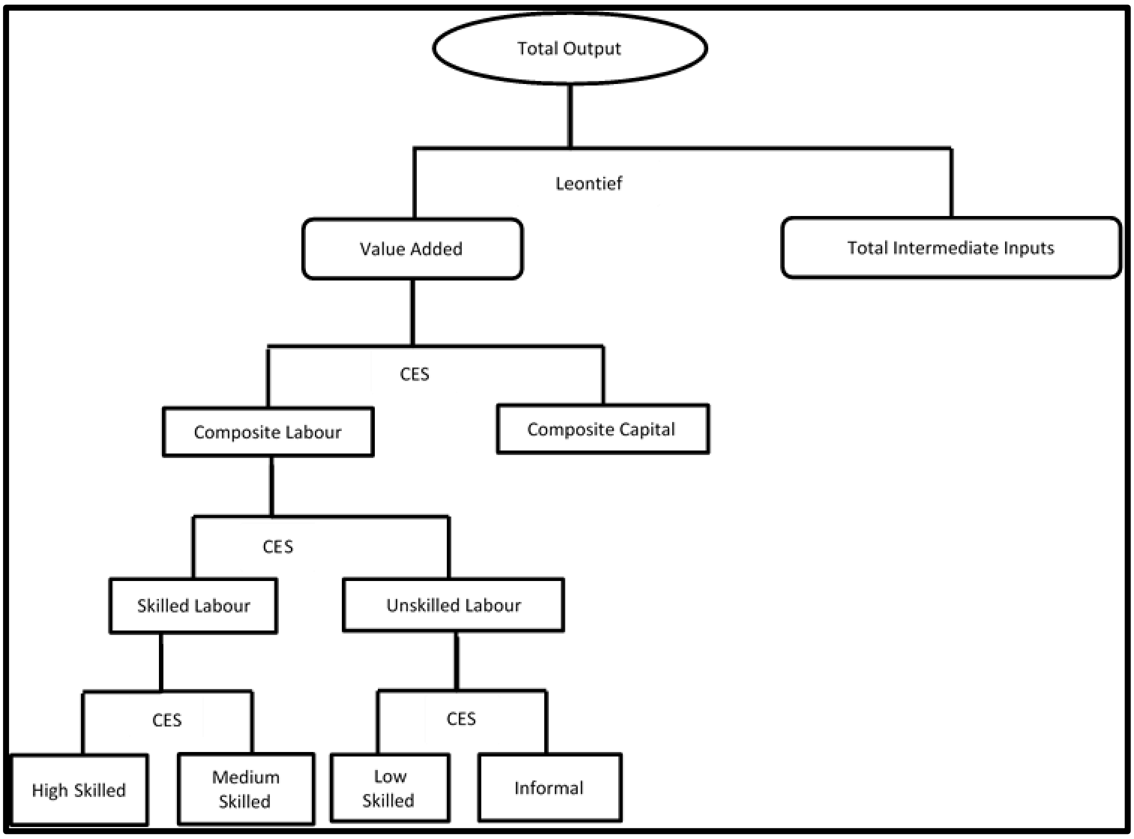
Output in each firm is determined by a nested production function which combines value added and total intermediate consumption in fixed shares through a Leontief function at the upper level as given in The model has four agents: firms, households, government and the rest of the world. Households are disaggregated into deciles, with the 10th decile further disaggregated into three, thus giving a total of 12 household categories. Households supply capital and labour to the productive activities. In return they receive income from the supply of labour and capital as well as transfers from other agents.

Figure 4. At lower levels, CES and Leontief production structures result in value added and composite intermediate consumption respectively. Inputs from different origins are combined to form composite intermediate consumption in a Leontief function. At the top level, the sectoral output of each productive activity combines total intermediate consumption and value added in a Leontief production function, thus there is no possibility of substitution because inputs are strictly complementary.

At the second level, composite labour and capital combine to give value added in a CES function. At the third level of value added side, composite labour is a CES combination of skilled and unskilled labour. Skilled labour is a CES combination of high skilled and medium skilled labour, with a low elasticity indicating the difficulty of substituting skilled labour while unskilled labour is a CES combination of low skilled labour and informal labour, with a high elasticity because it is relatively easier to substitute unskilled labour. Even though sectors are not disaggregated by formal/informal status, informal labour is employed by the informal sector. Firms maximise profit or minimise cost, leading them to hire capital (labour) to the point where the rental rate of capital (the wage rate) equals the value of the marginal product of capital (labour).

The model has four agents: firms, households, government and the rest of the world. Households are disaggregated into deciles, with the 10th decile further disaggregated into three, thus giving a total of 12 household categories. Households supply capital and labour to the productive activities. In return they receive income from the supply of labour and capital as well as transfers from other agents.

Figure 4: Production function



Source: Author's representation

Household income is used to buy goods and services, pay direct taxes to government, pay transfers and to save. Firms receive income from capital payments and transfers from other agents and use the income to pay direct taxes to government, to save and pay transfers to other agents. Government receives income from taxes and uses its income to pay for consumption of goods and services, to pay transfers to other agents and to save. The rest of the world receives income from payments from imports as well as transfers from other agents; and use the income to pay for exports, for transfers to other agents and to save.

Equilibrium between supply and demand is established in the goods and services market as well as in the factor market. Supply equals demand in the export market. A savings-driven closure, where total investment expenditure is equal to the sum of agents' savings, is adopted. Thus, investment is endogenous and depends on available savings. The exogenous variables are the nominal exchange rate, which is used as the *numeraire*, the current account, current government expenditure, labour supply, the world price level and inventories (Robichaud, et al., 2012). It is typically the exogenous variables that are shocked.

3.3 Data

We use the South Africa 2005 SAM for the SAM analysis, to analyse multipliers and trace the paths of impacts on the economy, and for the CGE analysis. The use of the 2005 SAM is largely due to the unavailability of an alternative SAM, a problem not only in South Africa but across the continent and beyond. While later SAMs are available, they do not have the level of disaggregation necessary for this study. On the other hand, the 2005 dataset is rich in that it contains disaggregated government sectors, which makes it possible for us to analyse how the public economic sector relates with other sectors and actors of the economy.

3.3.1 Overview of the SAM

The SAM has five public sector activities and commodities (administration, education, health, social and economic). All the public economic services that receive public economic infrastructure fall within the public economic sector. The factors of production are capital and labour. Labour is disaggregated into formal and informal labour, with the formal labour category subdivided into skilled labour, semi-skilled labour and low skilled labour. Thus there are four labour categories and only one type of capital. The government sectors only employ formal labour. The SAM has 12 household groups (10 deciles with the 10th decile subdivided into three categories) disaggregated by income levels. The other institutions are government, the rest of the world and firms.

4. Analysis of Results

4.1 SAM Analysis

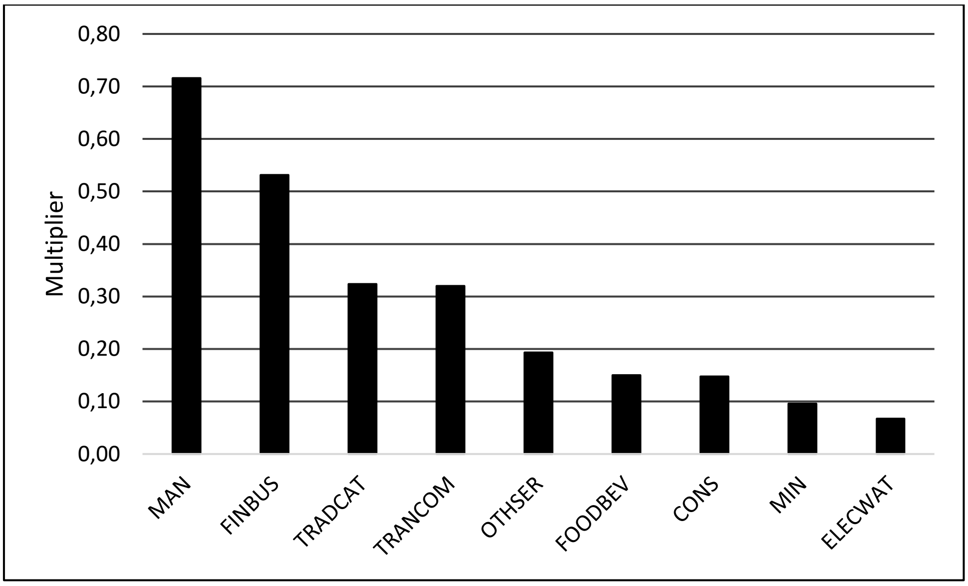
4.1.1 Multipliers

The Leontief inverse matrix for South Africa based on the 2005 SAM is given in Table A1 in the appendix. From the Leontief inverse, one observes that shocks to the public economic sector have the greatest impact on two sectors, manufacturing (MAN) and financial and business services (FINBUS) (other than own impact of the public economic sector) as shown in Figure 5[1]. A one unit increase in final demand for the public economic sector causes manufacturing and financial and business services output to increase by 0.72 and 0.53 respectively. This result is somewhat similar to that of Mabugu and Mohamed (2008) who found the third and fourth largest impact of the 2010 FIFA World Cup and related activities infrastructure expenditure on manufacturing and financial and business services. The difference is due to

[1] The full names of the remaining sectors in are as follows: trade, hotel, catering and accommodation (TRADCAT), transport, storage and communication (TRANCOM), other service activities (OTHSER), manufacture of food products, beverages and tobacco products (FOODBEV), construction (CONS), mining and quarrying (MIN), electricity, gas and water supply (ELECWAT). Table A2 in the Appendix provides a description of abbreviations of all accounts in the SAM.

differences in the types of public infrastructure focused on in their paper and in the current paper.

Figure 5: Multipliers: Impact of the Public Economic Sector on Selected Sectors



Source: Results from SAM Modelling

Next, total multiplier impacts of the public economic sector are analysed, in comparison with other sectors. Total multipliers, which measure the response of the economy to a change in final demand, include all types of linkages for all rounds (Breisinger, et al., 2010).

Table 3: Total Multiplier Effects by Type of Multiplier

	Output	**GDP**	**Income**
GOVECN	3.84	1.47	1.14
GOVSOC	3.71	1.50	1.15
GOVHLTH	3.53	1.63	1.31
CONS	3.47	1.18	0.85
GOVADM	3.47	1.56	1.23
GOVEDUC	3.34	1.78	1.44
ELECWAT	3.13	1.33	0.92
OTHSER	3.07	1.31	0.97
TRADCAT	3.01	1.33	0.94
AGRI	2.93	1.21	0.83
FOODBEV	2.90	1.10	0.77
FINBUS	2.87	1.28	0.88
TRANCOM	2.82	1.15	0.79
MIN	2.48	1.08	0.76
MAN	2.44	0.91	0.64

Source: Results from SAM Modelling

Thus, the multipliers presented in Table 3 give the changes in output, GDP and income resulting from a 1 unit change in final demand. Table 3 shows that the public economic sector (GOVECN) has the biggest impact on aggregate output. Therefore, investing in public infrastructure channelled through this sector indeed has the highest impact on economy-wide increase in output. While it performs relatively less than other public sectors on the impact on value added and income multipliers, public economic sector still has higher multipliers than all the private sectors.

4.1.2 Multiplier Decomposition

Table 4 gives the multiplier effects and their composition. Row 3 indicates that a 1% increase in the final demand for the public economic sector causes a 0.72% increase in output production of manufacturing. The 0.72 total multiplier effect on manufacturing is decomposed as follows: 0.28 emanates from direct or transfer effects resulting from direct transfers within endogenous accounts; 0.02 comes from cross- or open-loop effects, which depict all interactions among endogenous accounts, namely factors, activities and domestic institutions; and 0.42 is from closed-loop or circular multiplier effects, which completes the circular multiplier of an exogenous injection on an endogenous account.

Table 4: Decomposition of Public Economic Sector Multipliers on Selected Sectors

	Multiplier				**Ratio of indirect (closed-loop) effects**
	Total	Transfer	Open-loop	Closed-loop	As a % of multiplier
MAN	0.72	0.28	0.02	0.42	58.5
FINBUS	0.53	0.18	0.02	0.33	61.8
TRADCAT	0.32	0.03	0.07	0.22	68.6
TRANCOM	0.32	0.10	0.02	0.20	61.6
OTHSER	0.19	0.05	0.00	0.14	72.9
FOODBEV	0.15	0.01	0.00	0.14	94.4
CONS	0.15	0.12	0.00	0.02	14.3
MIN	0.10	0.04	0.00	0.05	52.4
ELECWAT	0.07	0.02	0.00	0.05	68.5
LABHI	0.29	0	0.18	0.11	37.8
LABSK	0.36	0	0.25	0.11	30.9
LABLS	0.16	0	0.07	0.08	53.3
LABINF	0.03	0	0.01	0.02	70.4

Source: SAM modelling results

Table 4 shows that the public economic sector largely impacts other industries via indirect impacts, except for the construction sector, judging from column 6, which indicates that only 14.3% of the impacts are exclusively indirect. The public economic sector is involved in infrastructure activities; thus, it is directly linked to the construction sector. In addition, changes in the final demand for the public economic sector have more direct impact on formal than informal labour as indicated in column 6, which shows that 70.4% of the impact of a change in final demand for the public economic sector on informal labour is entirely indirect. This is because the sector does not employ informal labour, and thus impacts on it only indirectly. The economic adjustment process for labour accounts will become clearer under SPA in the following section.

4.1.3 Public Economic Sector Backward and Forward Linkage Indices

Table 5 presents the results of the public economic sector backward and forward linkages with other sectors of the South African economy. Row 3 shows that the backward (forward) linkages of the public economic sector with agriculture (AGRI) are 0.56 (0.32) and 2.97 (1.31) respectively when calculated using the Chenery and Watanabe method and the Rasmussen method. Linkages calculated using the Chenery and Watanabe method are based on the direct coefficient matrix and are smaller than linkages calculated using the Rasmussen method which is based on the Leontief inverse.

Table 5: Linkages of the public economic sector with other sectors in the economy

	Chenery and Watanabe method		**Rasmussen method**	
	Backward	Forward	Backward	Forward
AGRI	0.56	0.32	2.97	1.31
MIN	0.48	0.38	2.85	1.93
FOODBEV	0.76	0.25	3.36	3.45
MAN	0.75	3.01	3.19	16.04
ELECWAT	0.53	0.28	2.93	1.15
CONS	0.77	0.47	3.45	1.11
TRADCAT	0.46	0.18	2.88	4.77
TRANCOM	0.57	0.76	2.95	4.88
FINBUS	0.44	1.56	2.72	8.36
OTHSER	0.49	0.39	3.10	3.46
GOVADM	0.43	0.08	3.24	0.09
GOVEDUC	0.18	0.03	3.07	0.04
GOVHLTH	0.40	0.08	3.31	0.09
GOVSOC	0.61	0.17	3.46	0.20
GOVECN	0.64	0.13	3.56	0.17

Source: Calculations from the 2005 SAM analysis

Table 5 shows that construction and the public economic sector have the strongest direct and total backward linkages of 0.77 and 3.56 respectively, as indicated in the second and fourth columns. The forward linkages of the public economic sector are however quite weak. Manufacturing has the greatest forward linkages (both direct and total), largely because of its size, as well as its function as a supplier of intermediate inputs. Thus, when the public economic sector receives a positive shock in the form of an expansion in infrastructure investment, such a shock triggers expansion in the whole economy through increased demand for intermediate inputs by the sector and subsequently the sectors that supply it with intermediates as they increase their production.

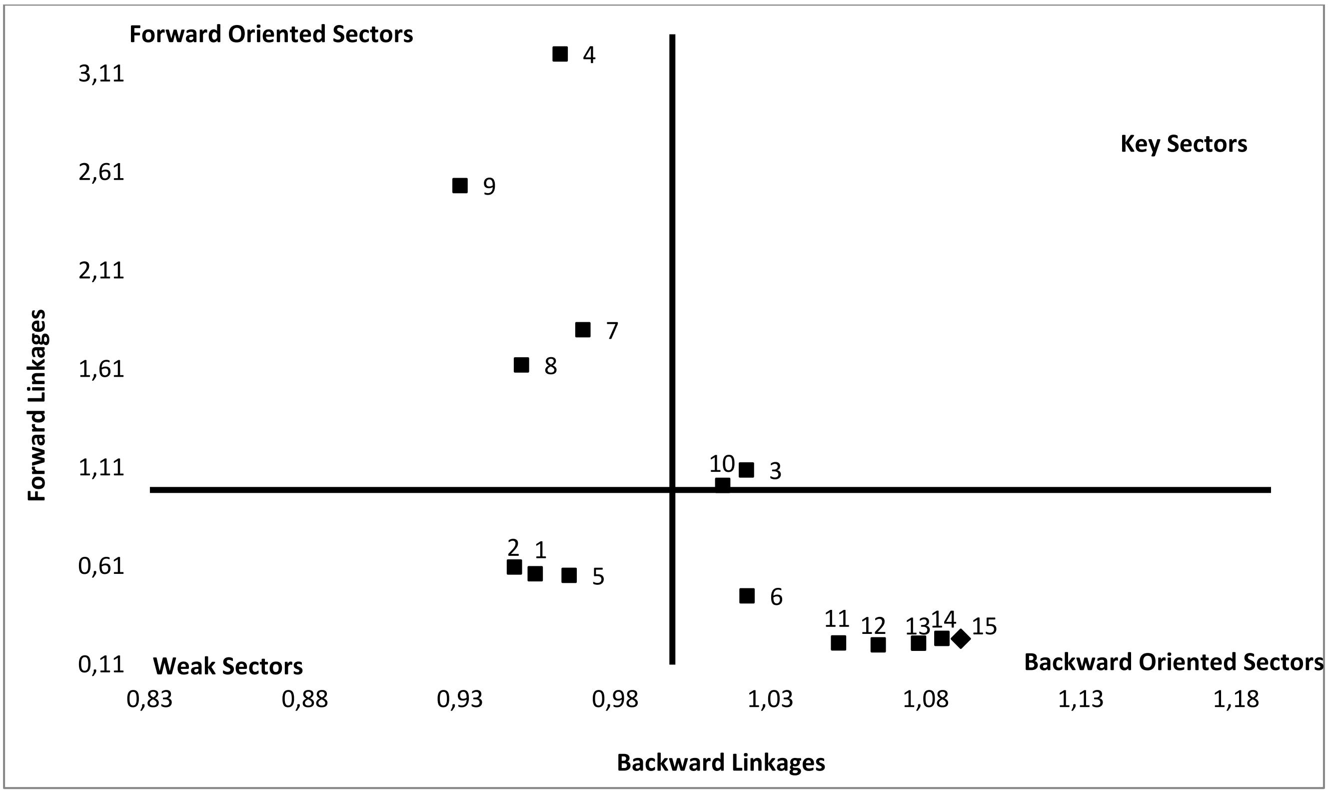
4.1.4 Identifying key sector(s) using backward and forward linkage indices

It is interesting to note that this method, like the Rasmussen approach, shows again that the sector of interest being studied, public economic sector, exhibits the strongest backward linkages. The sector is thus very important in terms of demanding intermediate inputs from other sectors. Hence a shock to this sector significantly impacts the economy through the change in its demand for intermediate consumption. In fact, all the public sectors are backward-oriented, which is not surprising, as they produce for final consumption. Figure 6 gives information on backward and forward linkage indices. The vertical and horizontal lines represent a value of 1. Backward-oriented sectors have a backward linkage index greater than 1 and lie on the right-hand side of the vertical line, while forward oriented sectors have a forward linkage index greater than 1 and lie above the horizontal line. Key sectors have both backward and forward linkage indices greater than 1 and are in the top right quadrant while weak sectors have both backward and forward linkage indices less than 1 and lie in the bottom left quadrant. Figure 6 shows that food and beverages (3=FOODBEV) is a key sector with both forward linkage and backward linkage indices above 1.

The analysis presented in Figure 6 shows that manufacturing; financial and business services; transport and communication; and trade, hotel, catering and accommodation are forward-oriented sectors, in that order from the strongest (manufacturing). This is expected of the manufacturing sector, since it largely uses primary inputs such as agriculture and mining output to produce textiles, wooden products, metals, refined petroleum products, chemicals, plastic and rubber, which in turn are used as intermediate inputs in many other sectors, including manufacturing itself.

Food and beverages and other services are the key sectors, with both above average backward and forward linkages; the two sectors are thus important both as suppliers and demanders of intermediate inputs. Three sectors, agriculture, mining and electricity and water prove to be neither forward- nor backward-oriented. Even though electricity and water is used in all sectors, the sector accounts for only between 0.3% and 4.8% of total intermediate consumption by other sectors. On the other hand, the electricity and water sector consumes only between 0.2% and 8.3% of the total supply of intermediate commodities by other sectors.

Figure 6: Backward and Forward linkages, based on 2005 SAM



Source: SAM modelling results

Key: 1=AGRI, 2=MIN, 3=FOODBEV, 4=MAN, 5=ELECWAT, 6=CONS, 7=TRADCAT, 8=TRANCOM, 9=FINBUS, 10=OTHSER, 11=GOVADM, 12=GOVEDUC, 13=GOVHLTH, 14=GOVSOC, 15=GOVECN

4.2 Structural Path Analysis of the Economic Services Sector

Since in South Africa public economic infrastructure is believed to be key in the creation of the much-needed new jobs, it is worth noting how an exogenous shock on the public economic sector travels through the economy, to labour accounts. SPA is thus used to trace this sector's impact on labour. As discussed above, the account multiplier, which is equal to the global influence, is the corresponding cell of the Leontief inverse matrix. The SPA results give information on the global effect, elementary paths, direct and total influence, path multiplier and the share of the global influence that is carried through the total (direct and indirect) influence of each elementary path. Focusing on the public economic sector, the paths through which an exogenous shock to the sector's final demand influences labour accounts are traced.

The results are given in Table 6, where arrows indicate the channels through which income or output is affected across commodities, activities and factors. The global influence (which is the Leontief multiplier as given in Table 4 Row 12) of the public economic sector on high skilled labour (LABHI) is 0.29, thus a Rand increase in exogenous demand for the public economic sector raises high skilled labour income by R0.29. Table 6 indicates that the influence of the public economic sector on high skilled labour is the main path of influence (Row 2, Column 3), and is the shortest and most direct path, through which 52% (as indicated in Column 7) of the global influence is transmitted. Row 3 to Row 7 down Column 3 in Table 6 represent indirect effects of the public economic sector on high skilled labour.

Table 6: Structural Path Analysis of the Economic Services Sector

Path Destination	Global Influence	Elementary Paths	Direct Influence	Path Multiplier	Total Influence	Total (% of Global)
LABHI	0.2886	AGOVECN→LABHI	0.1164	1.3249	0.1542	52.3324
		AGOVECN→CFINBUS→AFINBUS→LABHI	0.0083	1.9764	0.0165	5.5969
		AGOVECN→CMAN→AMAN→LABHI	0.0044	2.3728	0.0104	3.5441
		AGOVECN→CMAN→TCM→CTRADCAT→ATRADCAT→LABHI	0.0023	2.5365	0.0059	1.9905
		AGOVECN→CCONS→ACONS→LABHI	0.0025	1.7546	0.0043	1.4720
		AGOVECN→CTRANCOM→ATRANCOM→LABHI	0.0020	1.7297	0.0035	1.1858
LABSK	0.3638	AGOVECN→LABSK	0.1801	1.3299	0.2396	65.8466
		AGOVECN→CMAN→AMAN→LABSK	0.0045	2.3787	0.0108	2.9551
		AGOVECN→CFINBUS→AFINBUS→LABSK	0.0049	2.0233	0.0099	2.7315
		AGOVECN→CMAN→TCM→CTRADCAT→ATRADCAT→LABSK	0.0029	2.5305	0.0073	1.9957
		AGOVECN→CTRANCOM→ATRANCOM→LABSK	0.0039	1.7172	0.0068	1.8597
		AGOVECN→COTHSER→AOTHSER→LABSK	0.0024	1.5468	0.0037	1.0118
LABLS	0.1564	AGOVECN→LABLS	0.0284	1.2959	0.0368	23.5044
		AGOVECN→COTHSER→AOTHSER→LABLS	0.0068	1.4900	0.0101	6.4397
		AGOVECN→CMAN→AMAN→LABLS	0.0036	2.3616	0.0085	5.4120
		AGOVECN→CCONS→ACONS→LABLS	0.0046	1.7160	0.0080	5.0997
		AGOVECN→CTRANCOM→ATRANCOM→LABLS	0.0020	1.6948	0.0034	2.1471
		AGOVECN→CMAN→AMAN→CMIN→AMIN→LABLS	0.0011	2.3901	0.0026	1.6800
		AGOVECN→CMAN→TCM→CTRADCAT→ATRADCAT→LABLS	0.0009	2.5374	0.0024	1.5346
		AGOVECN→CFINBUS→AFINBUS→LABLS	0.0010	2.0208	0.0020	1.3044
		AGOVECN→LABSK→HHD8→COTHSER→AOTHSER→LABLS	0.0010	1.6994	0.0018	1.1337
LABINF	0.0307	AGOVECN→CCONS→ACONS→LABINF	0.0014	1.5800	0.0022	7.2886
		AGOVECN→CMAN→TCM→CTRADCAT→ATRADCAT→LABINF	0.0008	2.4332	0.0018	5.9738
		AGOVECN→CFINBUS→AFINBUS→LABINF	0.0008	1.8914	0.0016	5.0876
		AGOVECN→CTRANCOM→ATRANCOM→LABINF	0.0008	1.5866	0.0013	4.1869
		AGOVECN→CMAN→AMAN→LABINF	0.0006	2.2555	0.0012	4.0708
		AGOVECN→CTRADCAT→ATRADCAT→LABINF	0.0004	1.4975	0.0007	2.1561
		AGOVECN→COTHSER→AOTHSER→LABINF	0.0004	1.4329	0.0006	2.0224

Source: SAM modelling results

For skilled labour (LABSK), the global influence is 0.36. The most important path is the impact of the public economic sector on skilled labour: 66% of the global influence is transmitted through this path. The global influence for low-skilled labour (LABLS) is 0.16, and the most important path (the public economic sector) impact accounts for

24% of the global influence. Because the public economic sector does not employ informal labour (LABINF), the most important path of an exogenous demand shock of the former on the latter is public economic sector having an impact on construction, and construction impacting on informal labour. For each of the four labour categories, manufacturing is in two elementary paths, showing its importance in the transmission of income from the public economic sector to the labour accounts. Trade, hotel and catering services is an equally important sector for the informal labour.

4.3 CGE Analysis

4.3.1 Simulations

Despite the investment in public infrastructure over the years, Lombard, Behrens and Viruly (2017) point out that infrastructure backlogs persist in South Africa. Jordaan (2017) complements the argument mentioning that the country needs to invest heavily in economic infrastructure to close the infrastructure investment gap. For example, between 2010 and 2015, the average annual increase in public economic infrastructure was 8%. Thus, substantially more than this is required to meet South Africa's infrastructure needs. In fact, the government at some point planned a rate of growth in public capital budget of between 15% and 20% per year (Kularatne, 2006). We simulate a 20% increase in the public economic sector capital, which is financed by a 10% increase in indirect taxes. We choose to fund the increase in infrastructure investment through taxation to avoid deficit financing which negatively impacts the economy. In addition, we simulate a 5% increase in current government expenditure on goods and services, as increasing infrastructure investment is accompanied by an increase in current spending as the public sector needs to hire more labour and also as it increases consumption of its output.

4.3.2 Closures

A savings-driven closure, where total investment expenditure is equal to the sum of agents' savings, is adopted. Thus investment is endogenous and depends on available savings. The exogenous variables are the nominal exchange rate, which is used as the numeraire, the current account, current government expenditure, capital supply, labour supply, the world price level and inventories. Capital is assumed to be sector-specific, since this is a static model depicting the short run, thus it cannot move across sectors. World prices of imports and exports are assumed to be exogenous because South Africa is a small economy with no influence on global prices and thus takes world prices as given.

4.3.3 Results Analysis

4.3.3.1 Macro Results

The results indicate that increasing public economic infrastructure has overall mixed macroeconomic results on the South African economy. GDP increases by 1.1%, but total investment spending declines by 1.12%, while consumer prices increase by 1.06%, as given in Table 7.

Table 7: Macro Results (% change)

	Percentage change from base
GDP	1.1
Total investment expenditures	-1.12
Consumer price index	1.06

Source: Simulation results

4.3.3.2 Sectoral Results

Raising the indirect tax rate on commodities raises the price at which these commodities are purchased. This is the case for all sectors except mining. The price of mining declines marginally, which is most probably attributable to a very low indirect tax rate on mining. As a result of an increase in prices of goods and services across sectors, the demand for goods and services declines for all private activities, which consequently forces their production to fall. As shown in Table 8, the sectors whose domestic demand is worst affected are construction, manufacturing and mining, which declines by 1.66%, 0.82% and 0.71% respectively. In turn, the first two sectors suffer most in terms of output production, which falls by 1.78% and 0.9% respectively for construction and manufacturing (see Table 9). This is followed by agriculture, whose output declines by 0.52%. These results confirm the findings from multiplier analysis as construction and manufacturing have the greatest backward and forward linkages with the public economic sector.

As output falls, demand for intermediate consumption and for labour correspondingly decline. Even though domestic demand for agriculture does not fall very much relative to other sectors, demand for its output used for as intermediate inputs is the fourth worst affected, declining by 0.52%, after construction, mining and manufacturing with decreases of 0.89%, 0.83% and 0.53% respectively as given in Table 8, column 4. This is largely because food and beverages as well as manufacturing, which together demand 93.78% of agriculture output for intermediate consumption, experience significant decline in their output production. Demand for composite labour declines for all private sectors, the worst affected being construction, manufacturing and agriculture with declines of 3.14%, 1.85% and 1.54% respectively.

However, a different outcome is observed for the public sectors. While the prices of public sector commodities also rise, output production for these sectors increases. This is because there are two transmission channels for the shock for public sectors, an increase in prices and an increase in spending. Hence, the increase in public sector current spending enables government to demand more commodities despite an increase in their prices. In this case, the price increase is outweighed by the increase in current public spending and the net effect is an increase in demand for the public goods and services. Analogous to the case of private activities, as demand for public sector commodities increases, their output production increases which consequently results in an increase in intermediate consumption and labour demand to meet the required increase in output. In addition, a relatively larger impact for public economic sector changes in domestic demand, output production and intermediate input consumption are observed. This is largely because it is the sector that receives the shock, hence the marginal increase in the price of its commodities.

Table 8: Selected Sectoral Results (% change from base)

	Price of composite commodity i	Domestic demand for commodity i produced locally	Total intermediate demand for commodity i	Industry j demand for composite labour
AAGRI	0.80	-0.44	-0.52	-1.54
AMIN	-0.05	-0.71	-0.83	-1.00
AFOODBEV	1.65	-0.42	-0.46	-1.09
AMAN	0.96	-0.82	-0.53	-1.85
AELECWAT	0.51	-0.27	-0.40	-0.65
ACONS	0.93	-1.66	-0.89	-3.14
ATRADCAT	1.02	-0.61	-0.29	-1.24
ATRANCOM	0.68	-0.47	-0.32	-1.27
AFINBUS	0.60	-0.45	-0.33	-1.01
AOTHSER	1.23	-0.30	-0.01	-0.49
AGOVADM	1.72	3.21	3.03	3.74
AGOVEDUC	1.96	2.97	2.61	3.44
AGOVHLTH	1.48	3.45	3.26	3.69
AGOVSOC	1.49	3.44	3.35	4.01
AGOVECN	0.08	4.89	4.73	3.58

Source: Simulation results

Table 9 gives the impact on imports, exports and domestic production. Row 3 shows that the increase in capital for the public economic sector results in a 0.3% decline in imports, 0.85% decrease in exports and 0.52% decline in domestic production for agriculture. The increase in the prices of goods and services makes it more expensive to consume both domestically produced and imported commodities. This is evidenced by the general decline in imports, as shown in Table 9. In addition, an increase in the price level for South African commodities makes them relatively more expensive on the world market. As a result, export demand falls. Overall, export demand falls more than imports which results in a decline in income of the rest of the world, given that savings are assumed to be fixed.

Table 9: Sectoral Production, Exports and Imports

	Imports			Exports			Domestic Production		
	BASE	SIM	VAR (% change)	BASE	SIM	VAR(% change)	BASE	SIM	VAR (% change)
AGRI	4757	4744	-0.30	15889	15753	-0.85	78981	78566	-0.52
MIN	49333	48840	-0.96	99196	98943	-0.26	180443	179683	-0.42
FOODBEV	12787	12778	-0.10	15045	14888	-1.04	170568	169748	-0.48
MAN	292393	291251	-0.36	187115	184952	-1.16	855576	847879	-0.90
ELECWAT	11	11	-0.19	444	443	-0.30	65847	65676	-0.26
CONS	400	397	-0.58	82	81	-1.70	145282	142700	-1.78
TRADCAT	11040	11032	-0.08	10161	10065	-0.94	368501	366287	-0.60
TRANCOM	38785	38851	0.13	27840	27612	-0.82	318767	317172	-0.50
FINBUS	14680	14622	-0.41	21532	21455	-0.36	513039	511084	-0.38
OTHSER	10850	10876	0.20	5523	5471	-0.95	167308	166749	-0.33
GOVADM							130438	134630	3.21
GOVEDUC							95706	98547	2.97
GOVHLTH							46456	48059	3.45
GOVSOC							34263	35443	3.44
GOVECN							28101	29474	4.89
TOTAL	**435036**	**433401**	**-0.38**	**382827**	**379662**	**-0.83**	**3199276**	**3191696**	**-0.24**

Source: Simulation results

4.3.3.3 Factors of Production

The increase in demand for labour by public sectors following increased output production requires the public sectors to pay higher wages to attract additional labour. As a result, other sectors need to increase the wages they pay in order to keep their workers, which causes an overall upward movement in the composite wage rate, as shown in Table 10. For public sectors, demand for labour increases across all labour categories (see column 2 to 3 of Table 10). However, demand for formal labour declines for all private sectors owing to the combined effect of the increase in the cost of labour and the decline in output production. Demand for informal labour, which is employed by private activities only, increases across all sectors with the exception of agriculture, food and beverages, and construction. As production declines in the private formal sectors, some workers are likely to be absorbed by the informal sector. Capital is fixed, as the model is static.

Table 10: Sectoral Labour Results (% change)

	Wage rate of industry j composite labour	Demand for type l labour by industry j			
		High skilled workers	Skilled workers	Low skilled workers	Informal workers
AGRI	0.26	-2.23	-2.83	-1.25	-0.54
MIN	0.03	-1.67	-2.26	-0.68	0.04
FOODBEV	0.25	-2.21	-2.80	-1.22	-0.51
MAN	0.34	-2.08	-2.68	-1.10	-0.39
ELECWAT	0.31	-1.09	-1.69	-0.09	0.63
CONS	-0.30	-2.84	-3.43	-1.87	-1.16
TRADCAT	0.42	-1.48	-2.07	-0.49	0.23
TRANCOM	0.37	-1.65	-2.25	-0.66	0.05
FINBUS	0.56	-1.52	-2.12	-0.53	0.19
OTHSER	-0.16	-0.87	-1.48	0.12	0.84
GOVADM	0.83	4.77	4.13	5.82	
GOVEDUC	0.83	4.65	4.02	5.70	
GOVHLTH	0.83	4.56	3.92	5.60	
GOVSOC	0.83	4.84	4.20	5.89	
GOVECN	0.83	0.62	0.01	1.63	

Source: Simulation results

4.3.3.4 Institutions

Results for institutions are given in Table 11. The overall decline in output across sectors results in a fall in firm income and savings. Household income generally increases mainly because of the increase in wage rates across all sectors. Even though labour demand by private activities declines, this is outweighed by the increase in wages combined by the increase in demand for labour by the public sectors. Thus the net effect is an increase in household income and consequently an increase in household savings. While government income increases, its savings decline (increase in deficit) as the increase in public economic sector's infrastructure investment is partly deficit-financed. Income of the rest of the world declines because of the relatively greater decline in export demand in comparison to the decline in imports. Even though households earn more income following the increase in capital investment by the public economic sector, consumption by households generally declines because of the increase in prices.

Table 11: Results for Institutions

	Savings	Income	Consumption
Firms	-0.67	-0.71	-
Government	8.68	3.62	3.34

Households	0.59	0.64	-0.39
Rest of the World		-0.39	-0.83

Source: Simulation results

5. Conclusion

Public infrastructure investment is widely believed to have a positive impact on the economy. However, the conditions of an economy, as well as the type of infrastructure, play a significant role in influencing the impact of infrastructure investment. Moreover, a job creation policy that is appropriate for the economic conditions of a country is complex and requires detailed analysis of the employment potential of the different sectors of the economy. Using a 2005 South African SAM, this study carried out multiplier analysis and SPA to assess the impact of increasing public economic infrastructure in South Africa to see how the public economic sector relates with other sectors and labour accounts. The SAM has public sectors which include a public economic sector. All the public sector economic infrastructure investment spending goes to services that fall within the public economic sector.

This study carried out multiplier analysis to assess the impact of the public economic sector on the economy in relation to the impact of other sectors. It analysed backward and forward linkages to see the importance of the public economic sector as a demander and supplier of intermediate inputs across the economy. In further carried out an SPA to trace the main paths of influence of the public economic sector on the economy. In addition, a CGE analysis, which captures the feedback effects across production, income and demand structures and calibrates price and quantity changes in product and factor markets better than SAM analysis, was used to assess the economy-wide impacts of an increase in public economic infrastructure investment in South Africa.

An analysis of the multipliers shows that among all sectors, the public economic sector has the greatest impact on manufacturing and financial and business services. A unitary exogenous increase in final demand for the public economic sector triggers an increase in output for manufacturing and financial and business services output of 0.72 and 0.53 respectively; a result comparable to that of Mabugu and Mohamed (2008). On the other hand, a one unit increase in the final demand for the public economic sector results in the following increases in labour income: 0.29 for high skilled labour, 0.36 for skilled labour, 0.16 for semi-skilled labour and 0.03 for informal labour. This is because the public economic sector is directly connected to the formal labour categories. The public economic sector has the highest output multipliers as well as relatively high GDP and income multipliers, compared to other sectors.

Backward and forward linkage analysis reveals that the public economic sector displays the strongest backward linkages and is thus very important in terms of demanding intermediate inputs from other sectors. Hence a shock to this sector significantly impacts the economy through the change in its demand for intermediate consumption. SPA shows that the main and most important path of influence is a direct influence of the public economic sector on each of the formal labour categories. However, because the public economic sector does not employ informal labour, this labour account is only connected indirectly via intermediate consumption of the construction sector output. SAM analysis reveals that the public economic sector is an important sector in the South African economy as a shock to this sector in the form of an increase in infrastructure investment triggers a positive effect on the whole economy in terms of an increase in output. The public economic sector also influences the economy largely via formal labour.

Results from the CGE analysis indicate that increasing public economic infrastructure investment in South Africa has an overall positive impact as measured by an increase in GDP, labour income, government income and household income and savings. However, the increase in public infrastructure investment does not come without costs, as the general price level increases. This has a negative impact on aggregate investment, which declines by 1.12%. This is costly for private sector activities, which are affected negatively, as the private sector investment is crowded out by public investment. As a result, production falls for the private activities, which consequently reduces firm income and savings.

Both the SAM and CGE analyses indicate that increasing public economic infrastructure can be an effective way of stimulating the economy in a way that has a positive impact on labour. The results from CGE modelling confirm results from SAM modelling. This is an important outcome for South Africa, as the results suggest that an increase in public economic infrastructure could help address the problem of unemployment as well as that of low income levels that exacerbate poverty. It is important, however, to note that while the results of this static CGE model give valuable insights, they are limited as they do not capture cumulative impacts of increasing public infrastructure investment. The two methods complement each other in that SAM analysis measures sectoral interdependencies, tracing the transmission of increasing investment in public economic infrastructure through SPA, while CGE analysis captures the economy-wide impacts.

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7. Appendix

Table A1: Leontief Inverse

	AAGRI	AMIN	AFOODBEV	AMAN	AELECWAT	ACONS	ATRADCAT	ATRANCOM	AFINBUS	AOTHSER	AGOVADM	AGOVEDUC	AGOVHLTH	AGOVSOC	AGOVECN
AAGRI	1.083	0.049	0.299	0.052	0.048	0.049	0.054	0.047	0.046	0.059	0.061	0.068	0.064	0.059	0.061
AMIN	0.084	1.077	0.076	0.185	0.214	0.133	0.067	0.079	0.066	0.075	0.082	0.075	0.086	0.080	0.096
AFOODBEV	0.173	0.129	1.228	0.117	0.125	0.121	0.144	0.122	0.123	0.156	0.162	0.183	0.171	0.158	0.150
AMAN	0.680	0.605	0.613	1.771	0.543	0.771	0.544	0.657	0.524	0.612	0.678	0.615	0.687	0.649	0.716
AELECWAT	0.061	0.076	0.063	0.063	1.225	0.057	0.062	0.066	0.055	0.065	0.063	0.065	0.069	0.062	0.067
ACONS	0.032	0.038	0.032	0.029	0.099	1.327	0.052	0.036	0.056	0.043	0.043	0.032	0.036	0.039	0.147
ATRADCAT	0.302	0.265	0.328	0.306	0.252	0.302	1.263	0.288	0.245	0.289	0.313	0.306	0.322	0.304	0.324
ATRANCOM	0.272	0.368	0.260	0.258	0.237	0.247	0.301	1.347	0.251	0.268	0.287	0.277	0.292	0.307	0.320
AFINBUS	0.365	0.397	0.484	0.431	0.376	0.481	0.599	0.446	1.587	0.641	0.496	0.489	0.507	0.667	0.531
AOTHSER	0.145	0.156	0.170	0.143	0.132	0.131	0.144	0.134	0.149	1.173	0.200	0.197	0.207	0.179	0.193
AGOVADM	0.000	0.001	0.001	0.000	0.000	0.000	0.001	0.001	0.001	0.003	1.080	0.001	0.001	0.001	0.001
AGOVEDUC	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.000	1.035	0.000	0.000	0.000
AGOVHLTH	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	1.082	0.000	0.000
AGOVSOC	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	1.199	0.000
AGOVECN	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.001	1.155
CAGRI	0.100	0.059	0.359	0.062	0.056	0.057	0.065	0.056	0.055	0.070	0.073	0.081	0.077	0.071	0.072
CMIN	0.111	0.102	0.101	0.247	0.284	0.162	0.087	0.103	0.085	0.098	0.107	0.099	0.113	0.105	0.121
CFOODBEV	0.268	0.196	0.355	0.175	0.191	0.183	0.220	0.185	0.186	0.237	0.246	0.281	0.261	0.240	0.226
CMAN	1.145	1.009	1.010	1.303	0.905	1.304	0.891	1.102	0.856	1.002	1.121	1.009	1.134	1.064	1.187
CELECWAT	0.063	0.078	0.065	0.065	0.233	0.056	0.064	0.069	0.057	0.067	0.065	0.068	0.071	0.064	0.069
CCONS	0.034	0.040	0.032	0.030	0.107	0.355	0.054	0.038	0.059	0.044	0.045	0.033	0.037	0.039	0.159
CTRADCAT	0.329	0.286	0.356	0.333	0.273	0.330	0.285	0.314	0.264	0.311	0.336	0.328	0.345	0.328	0.349
CTRANCOM	0.309	0.419	0.296	0.293	0.270	0.281	0.342	0.395	0.284	0.304	0.326	0.314	0.332	0.348	0.364
CFINBUS	0.406	0.441	0.539	0.481	0.420	0.538	0.672	0.498	0.657	0.717	0.552	0.544	0.564	0.747	0.592
COTHSER	0.204	0.220	0.240	0.202	0.186	0.185	0.203	0.188	0.210	0.244	0.282	0.277	0.292	0.252	0.272
CGOVADM	0.000	0.001	0.001	0.000	0.000	0.000	0.001	0.001	0.001	0.003	0.080	0.001	0.001	0.001	0.001
CGOVEDUC	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.000	0.035	0.000	0.000	0.000
CGOVHLTH	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.082	0.000	0.000
CGOVSOC	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.199	0.000
CGOVECN	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.002	0.002	0.001	0.152

LABHI	0.150	0.191	0.179	0.181	0.213	0.183	0.227	0.172	0.246	0.207	0.330	0.399	0.362	0.303	0.289
LABSK	0.201	0.178	0.192	0.182	0.183	0.161	0.244	0.212	0.195	0.221	0.438	0.549	0.487	0.378	0.364
LABLS	0.152	0.204	0.153	0.143	0.167	0.182	0.131	0.135	0.106	0.310	0.160	0.174	0.170	0.146	0.156
LABINF	0.037	0.029	0.034	0.031	0.029	0.049	0.054	0.041	0.035	0.040	0.027	0.027	0.028	0.029	0.031
CAP	0.772	0.780	0.718	0.645	0.796	0.641	0.788	0.751	0.818	0.702	0.609	0.626	0.580	0.640	0.603
TCM	0.297	0.249	0.316	0.306	0.236	0.304	0.232	0.263	0.216	0.259	0.284	0.272	0.291	0.271	0.292
ENTRP	0.703	0.710	0.654	0.588	0.725	0.583	0.718	0.683	0.745	0.640	0.554	0.570	0.528	0.583	0.549
HHD0	0.008	0.009	0.008	0.007	0.008	0.009	0.009	0.008	0.007	0.012	0.009	0.010	0.010	0.009	0.009
HHD1	0.009	0.009	0.008	0.008	0.009	0.009	0.009	0.008	0.007	0.013	0.010	0.011	0.010	0.009	0.009
HHD2	0.017	0.019	0.016	0.015	0.017	0.018	0.018	0.016	0.015	0.025	0.020	0.022	0.021	0.018	0.019
HHD3	0.021	0.023	0.020	0.019	0.021	0.022	0.022	0.020	0.019	0.030	0.024	0.028	0.026	0.023	0.023
HHD4	0.037	0.039	0.035	0.033	0.037	0.037	0.039	0.036	0.033	0.051	0.045	0.051	0.048	0.042	0.042
HHD5	0.050	0.053	0.048	0.045	0.050	0.050	0.053	0.049	0.046	0.068	0.064	0.074	0.068	0.059	0.058
HHD6	0.075	0.080	0.073	0.068	0.076	0.074	0.081	0.074	0.071	0.100	0.098	0.113	0.105	0.090	0.089
HHD7	0.110	0.118	0.108	0.101	0.114	0.107	0.121	0.110	0.109	0.143	0.149	0.174	0.159	0.138	0.135
HHD8	0.160	0.171	0.161	0.153	0.173	0.155	0.189	0.165	0.177	0.198	0.252	0.299	0.271	0.230	0.223
HHD91	0.125	0.135	0.127	0.122	0.139	0.122	0.151	0.130	0.146	0.151	0.202	0.240	0.218	0.185	0.178
HHD921	0.089	0.099	0.093	0.089	0.104	0.090	0.111	0.094	0.110	0.109	0.147	0.174	0.158	0.135	0.130
HHD922	0.197	0.207	0.192	0.177	0.213	0.177	0.217	0.197	0.222	0.203	0.215	0.239	0.220	0.212	0.202

Table A2: Description of Abbreviations

Abbreviation	Full name	Abbreviation	Full name
AAGRI/ CAGRI	Agriculture, hunting, forestry and fishing	ENTRP	Enterprises
AMIN/CMIN	Mining and quarrying	HHD0	Household deciles
AFOODBEV/CFOODBEV	Manufacture of food products, beverages and tobacco products	HHD1	
AMAN/CMAN	Manufacturing	HHD2	
AELECWAT/CELECWAT	Electricity, gas and water supply	HHD3	
ACONS/CCONS	Construction	HHD4	
ATRADCAT/CTRADCAT	Trade, hotel, catering and accommodation	HHD5	
ATRANCOM/CTRANCOM	Transport, storage and communication	HHD6	
AFINBUS/CFINBUS	Financial intermediation, insurance, real-estate and business services	HHD7	
AOTHSER/COTHSER	Other service activities	HHD8	
AGOVADM/CGOVADM	Government Administration	HHD91	
AGOVEDUC/CGOVEDUC	Government Education	HHD921	
AGOVHLTH/CGOVHLTH	Government Health	HHD922	
AGOVSOC/CGOVSOC	Government Social Services	IMPTAX	Import tax
AGOVECN/CGOVECN	Government Economic Services	INDTAX	Indirect tax
LABHI	High Skilled Labour	ACTTAX	Activity tax
LABSK	Skilled Labour	INSTAX	Institutional tax
LABLS	Skilled Labour	GOV	Government
LABINF	Informal Labour	S-I	Savings-Investment
CAP	Capital	DSTK	Changes in inventories
TCM	Margins	ROWTOT	Rest of the World