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Understanding the Short-Term Effects of Infrastructure Expenditure on the Gauteng Economy: A Vector Auto-Regression Approach

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ABSTRACT: Infrastructure spending has proven to be pivotal to the social and economic development of a country, region and community. There has been a move globally, to evaluate the effect of infrastructure by investigating its effect on employment, economic growth as well as private investment. This has been done for a number of countries and regions. This study contributes to this literature by analysing the impact of provincial infrastructure spending on the economy of Gauteng. In particular, the paper investigates the short-term impact of provincial infrastructure spending. As indicated also in the literature review, the short-term impact was found to be significant and positive. Due to specific data shortage and unavailability, the long-term impact could not be assessed. Further study and research is still needed to see and quantify the long-term impact on infrastructural spending on the indicated variables.

Executive Summary

In the late 1980s, Aschauer revolutionised policy and decision making in terms of public infrastructure spending. He conducted a study that suggested that the annual marginal productivity of public infrastructure spending was 70 cents to one dollar invested by the United States (US) government. Since then, the analyses of the impact on economic growth, employment and private investment have become critical in deciding how much more public infrastructure investment will be done.

This study focuses on the impact of the Gauteng Provincial Government's (GPG) infrastructure spending on employment, economic growth and private investment in the province from 2010 to 2015. This study uses a Vector Auto Regressive (VAR) model as it allows for dynamic feedbacks in estimation, which improves the results as highlighted in the literature.

The VAR model that was used indicates that there is a positive of public infrastructure expenditure effect on economic growth in the short-run. The effect on employment was not contemporaneous in this model and this could be due to the fact infrastructure projects usually have a long lead-time. Initially there was dis-investment by the private sector in this model, and by the 3rd quarter there is positive impact on private investment. This indicates that the private sector takes time to adjust to new public infrastructure expenditure, but eventually public infrastructure expenditure tended to crowd-in private investment.

Further research is necessary to study the impact of public infrastructure spending in the province over a long period. Current data availability does not allow this. There is also a need to investigate which type of infrastructure spending yields the best results, as well as the impact of regional spill-overs.

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List of Abbreviations

BRICS	Brazil, Russia, India, China and South Africa
BRT	Bus Rapid Transport
CoE	City of Ekurhuleni
CoJ	City of Johannesburg
CoT	City of Tshwane
GDED	Gauteng Department of Economic Development
GDP	Gross Domestic Product
GDP-R	Regional Gross Domestic Product
GPG	Gauteng Provincial Government
LED	Light-Emitting Diode
MEC	Member of Executive Council
NDP	National Development Plan
NMPP	New Multi-Product Pipeline
PICC	Presidential Infrastructure Coordinating Commission
PPP	Public/Private Partnerships
SMMEs	Small, Micro and Medium Enterprises
TMR	Transformation, Modernisation and Re-industrialisation
US	United States
VAR	Vector Auto-Regression

1 Introduction

Infrastructure spending remains at the centre of government's development plans both nationally and provincially. Through the National Development Plan (2012) government aims to address critical infrastructure backlogs in rail, road, ICT, and other social infrastructure. The Transformation, Modernisation, and Re-industrialisation (2014) Program of the Gauteng Provincial Government articulates province specific infrastructure plans, related to the National Development Plan (NDP).

In essence infrastructure expenditure[1] by government constitutes a public investment. Therefore, beyond the development imperatives of infrastructure spending lays its economic imperatives (Aschauer, 1990). Infrastructure spending is a key aspect of most stimulus packages as it has been shown to have positive growth effects (Pereira and Andrax, 2010). However the magnitude of these effects is debatable (Pereira and Andrax, 2010; Sturm, Jacobs and Groote, 1999; Pereira, 2000). Although not the focus of this paper, the role of spill over effects, particularly at a regional level is a key consideration in understanding the regional growth effects of infrastructure spending (Pereira and Roca-Segales, 2003).

Studies on the economic growth effect of infrastructure spending in South Africa are limited (Feddeker and Luiz, 2006) and a search of relevant databases revealed that no such study has been conducted at a regional level. Given the increased focus on infrastructure spending in South Africa as policy priority, it is imperative to understand the effect of infrastructure spending as a whole on the economy. Therefore, with specific reference to Gauteng Province, this research paper seeks to investigate the effect of overall infrastructure spending on the economy. This is with specific reference to the short-term effects of infrastructure spending, which according to literature tend to be larger than the long-term effects (see Bivens, 2014)

To this end, this research paper commences with an overview of the current infrastructure delivery policy environment at a national and provincial level. A review of the relationship between infrastructure spending and the economy is analysed, and a discussion on the methodology, data preparation, and results follows.

[1] Infrastructure expenditure is used interchangeably with public infrastructure investment, public investment, and infrastructure spending in this document.

2 Infrastructure Delivery by the South African Government

2.1 Policy Environment

The NDP is the central policy on infrastructure, among many other aspects of the economy. Other policies concerning the infrastructure that pre-dated it had to be brought in line with the NDP, while policies written after were written to be compatible with it and advance the goals found within. The infrastructure-related goals of the NDP include:

- Improving transport infrastructure to reduce the cost of doing business, especially trade with rest of Africa;
- Improving infrastructure to increase competitiveness of South African products and, therefore, export earnings. This will in turn contribute to job creation;
- Strengthening key services such as commercial transport, energy, telecommunications and water, while ensuring their long-term affordability and sustainability; and
- Lowering the cost of living for poor households in that it can lower the cost of services such as electricity, amongst others.

The fourth goal, in particular, is essential, as some parts of the plan will increase costs in South Africa. For example, the expansion and upgrading of infrastructure is likely to require that higher tariffs be charged for the use of that infrastructure. Some of these increased tariffs will be passed on to the poor because they will affect such areas as the delivery of food, education, health and public transport, especially considering the fact that subsidy levels for transport and energy do not explicitly only benefit the poor or in some cases not in existence. This necessitates that this investment in infrastructure be directed in ways that will improve efficiency and competitiveness and thus reduce costs for the poor. The NDP, in alignment of being pro-poor, advocates for an affordable cost structure for the economy and the promotion of a more efficient public sector.

The NDP has also acknowledged that the current infrastructure has been a limiting factor for the domestic mining operations, the availability of transport such as freight rail, as well as the security of water supply and electricity. It contends on these constraining aspects alongside the need for further clarity on the policy and regulatory framework from an investor's perspective, then the mining sector would prosper in the long run which would in turn enhance economic performance.

The Presidential Infrastructure Coordinating Commission (PICC) was established to fast-track important infrastructure projects (The Presidency, 2015). The PICC was formed to coordinate a multi-billion rand public infrastructure programme and it brings together the national, provincial and local spheres of government. The intention was to use infrastructure as a springboard for economic development as well as to mobilise resources internally and to increase South Africa's tax base. Since the establishment of the PICC in 2011, departments have identified infrastructure projects to which National Treasury made allocations and the PICC monitors the large infrastructure projects. If projects are particularly large, the PICC assists departments with their applications to National Treasury for additional funding.

In South Africa, as in many countries, particularly the emerging & developing economies, there is a significant degree of migration of people from rural areas to urban areas. This is especially noticeable in Gauteng as citizens from other provinces come in search of employment opportunities. This adds to the challenge of providing service delivery infrastructure like water, sanitation and electricity, to the ever-growing population in the province.

Further challenges identified included poor planning at institutional level, slow approval of projects, and the late start of projects, high costs due to collusion and late delivery relating to project completion. In construction, there are also supply and competition bottlenecks in steel, cement, wood, coal, bitumen, as well as machinery and equipment. Responses to these challenges include a programme to coordinate improvement in project related skills, with project management and engineering skills within the state, and a focus was placed on job creation and industrialisation. Training and development are being implemented to address the shortage of skills.

Infrastructure investment can also be directed in ways that serve other goals at the same time, such as challenging the inequalities that remain as a legacy of the past. To this end, the PICC has emphasised the importance of localisation and the need to support the development of black industrialists by procuring their services to manufacture the supplies used in the infrastructure programme.

2.2 Infrastructure Spending in South Africa

According to the Estimates of National Expenditure (2015), R99.5 billion was spent on infrastructure in the 2013/14 financial year, R119 billion was estimated for the 2014/15 financial year and R127.6 billion was forecast for 2015/16.

As of 30 April 2015, over 220 000 jobs were being directly supported by the infrastructure projects that were being overseen by the PICC (The Presidency, 2015). These projects included the building of roads, ports, rail-lines, hospitals, schools and universities, power-plants, dams, pipelines and household infrastructure such as electricity, water and sanitation. As part of this, the 100th school will soon be built through the new national school-build programme that was introduced to address backlogs. Six major dams will be expanded or built over the next decade. As of April 2015, thirty-nine renewable energy plants have been opened with 1 897 megawatts of renewable energy coming onto the grid.

Transnet has recognised the importance of an integrated port system that is effective, efficient and economical, towards promoting economic growth. To this end, they have implemented their Market Demand Strategy from 2012/2013 to 2014/15, during which time they have invested R5.8 billion in port infrastructure (Transnet National Port Authority, 2015). By the end of the 2015/16 financial year, this figure is expected to have increased by R320 million. Over the next ten years, approximately R55 billion or more is to be invested. Transnet's anticipated major port infrastructure projects between 2015/16 and 2021/22 include:

- Creating bulk capacity at the Port of Ngqura through a new 16 megatons per annum manganese terminal and a tank farm at berth A100 supported by roads, port entrance and service;
- A fleet management programme for all ports including the acquisition of tug boats, pilot boats, launchers and dredgers; and
- Operation Phakisa infrastructure developments at the Ports of Durban, Saldanha, Cape Town, East London and Port Elizabeth, aimed at supporting the oil and gas sectors as well as the ship repair and building industries.

3. Infrastructure Delivery in the Gauteng Provincial Government

3.1 Policy Environment

The Gauteng Provincial Government (GPG) has several plans and programmes aimed towards infrastructure delivery; the primary one being the Transformation, Modernisation and Re-industrialisation (TMR) programme, introduced by the Premier, Honourable David Makhura, in his 2015 State of the Province Address. It organises the province into five development corridors that will specialise in economic activities in which they have a comparative advantage. The aim is to make Gauteng a preferred investment destination and develop the provincial economy. This will be supported with infrastructure investment in projects such as the Aerotropolis[2] currently planned around O.R. Tambo International Airport.

The TMR programme is divided into 10 pillars, which are organised as Transformations, Modernisations and Re-industrialisations. The Modernisations include the modernisation of public transport and other infrastructure.

The TMR programme's five development corridors are:

- The Central Development Corridor, which is centred on the CoJ as the hub of the ICT, finance, services and pharmaceutical industries;
- The Northern Development Corridor, anchored around the CoT as the administrative capital and the hub of the automotive sector, research, development, innovation and the knowledge-based economy;
- The Eastern Development Corridor, centred around the economy of the CoE as the hub of the manufacturing, logistics and transport industries;
- The Southern Corridor, which includes the Sedibeng district and is aimed at creating new industries, new economic nodes and new cities; and
- The Western Corridor, consisting of the current West Rand district and focussing on the creation of new industries, new economic nodes and new cities.

[2] An Aerotropolis is a city that is built around an airport, offering its businesses speedy connectivity to their suppliers, customers and enterprise partners both nationally and internationally. It is a new urban format currently developing around many large airports." – City of Ekurhuleni, 2014

Plans for the Central Development Corridor include revitalising the CoJ central business district, establishing the African regional centre of the BRICS Development Bank in the CoJ (The BRICS Post, 2015) and building 140 000 housing units as part of a larger spatial reorganisation. In the Northern Corridor, there will be continued support for the automotive industry, a housing development that will include office and commercial space, and a Business Process Outsourcing Park that will provide training and technical support for Small Micro and Medium Enterprises (SMMEs). The Eastern Corridor will see 29 industrial initiatives as part of the Aerotropolis project, extended coverage by the Bus Rapid Transport (BRT) system and the construction of over 100 000 houses.

There will be diversification of the economy of the Southern Corridor towards tourism, logistics and agro-processing. There will also be 14 new schools and 120 000 new houses will be built in the corridor. In the Western Corridor, there will also be economic diversification into the same sub-sectors as in the Southern Corridor. The Western Corridor will include the proposed site of a new solar power manufacturing plant or a solar farm. Completing all of these projects will require extensive investment in building new and upgrading existing infrastructure.

The revitalisation of the township economy is another objective parts of which may be achieved by infrastructure investment. The Gauteng Department of Economic Development (GDED) has identified that township businesses would benefit from the construction of business parks that would allow entrepreneurs to focus on running their businesses rather than the need to build or find infrastructure before they can begin. Other projects from GDED include a Light-Emitting Diode (LED) production plant and tyre production.

During the Gauteng Provincial Budget Speech for 2016, the Member of the Executive Council (MEC) for Finance, Honourable Barbara Creecy, listed several actions that must be taken in order to meet the goals of the TMR programme. These included ensuring significant investment in infrastructure, as it is key to stimulating economic development and inclusive growth. Lack of infrastructure hampers citizens' search for economic opportunities and their access to services. Honourable Barbara Creecy also highlighted that at this time of fiscal consolidation, public/private partnerships (PPPs) are becoming more prominent in the planning. The PPPs government want to foster include rooftop solar panels, a jewellery manufacturing precinct at O.R. Tambo International Airport and the building of affordable housing. The GPG will spend R41.6 billion on infrastructure over the course of the 2016 Medium-Term Expenditure Framework. This will fund such projects as the construction and upgrading of 7 hospitals and clinics, the building of 12 new schools and housing projects, the

upgrading and rehabilitating of road infrastructure and the rollout and maintenance of the broadband network, with an aim of connecting 300 sites in the 2016/17 financial year.

3.2 Infrastructure Spending in the Gauteng Provincial Government

The cyclical nature of government infrastructure spending is based around budgets and the political cycle. The level of infrastructure spending is also related to the level of economic activity in the provincial economy. The level of infrastructure spending as compared to the level of economic activity is a good indicator of the level of future economic growth.

Table 1: Infrastructure Spending as a Percentage of GDP-R, Gauteng, 2011-2015Q1

Year	% of GDP-R
2011	0.17%
2012	0.22%
2013	0.20%
2014	0.22%
2015Q1	0.34%

Source: Own Calculation, Gauteng Infrastructure Reporting Model, Quantec Research, and Stats SA, 2016

Note: Table 1 shows provincial infrastructure spending as a percent of the Gauteng GDP-R from 2011 to 2014, with the first quarter of 2015 included.

The ratio of infrastructure spending to regional gross domestic product (GDP-R) was on an upward trend from 0.17 to 0.22 percent in 2014. Reflective of a renewed commitment to infrastructure development, this had increased to 0.34 percent in the first quarter of 2015. In the other years under review, the first quarter had the highest percentage but none were as high as that of first quarter of 2015. The second highest was first quarter of 2012, at 0.31 percent. This suggests that the pace of growth of infrastructure spending, is outpacing the pace of growth of the GDP-R. Spending has increased from R6.8 billion in 2011 to R9.4 billion in 2014; R3.6 was already spent in the first quarter of 2015.

4. Literature Review

Infrastructure has the capacity to improve the quality of life for citizens. The Infrastructure that governments are mostly responsible for include water purification, solid waste management, mobility needs and road congestion management. The improvement in the quality of life for the citizens include and are not limited to improvements in health, aesthetics

of the surroundings, increasing economic opportunities and increased leisure as identified by Aschauer (1990). Aschauer lists the benefits of public infrastructure investment as follows:

- Public infrastructure improves the quality of life such as:
  - Health and aesthetics in from infrastructure such as water purification facilities and waste management infrastructure.
  - Economic opportunities grow with the improvement of mobility such as the building of roads, rail systems and other public transportation system.
  - It increases leisure time as less time is spent on inefficient commuting.
- Public infrastructure improves the economic efficiency
  - The building of schools and hospitals increases labour productivity.
  - Roads, rail and other transport infrastructure increases economic activity with improvement of transportation of goods and services
  - The actual building of capital projects is an economic activity in itself adding to domestic output.
  - The provision of communication infrastructure reduces the cost of doing business and supports economic activity.

Aschauer conducted extensive research regarding the importance of public investment infrastructure on output. In *Why Is Infrastructure Important* Aschauer investigated the impact of public infrastructure investment on private capital investment and ultimately on Gross Domestic Product (GDP) using the United States (US) as a case study. In *Public Investment and Productivity Growth in the Group of Seven,* Aschauer measured the productivity of labour when there is a change in public infrastructure investment that was estimated to have a positive relationship with private capital investment. He found that there is indeed a strong relationship with the productivity of labour and public infrastructure investment.

Pereira (2000) investigated the long-term impact of public infrastructure spending on private investment, private employment and private output. He found that investing in public infrastructure spending is a powerful tool to crowd in public investment and private output in the long run. The impact on private employment is not has high in the long run.

Bivens (2014) investigated both the short- and long-term impact of infrastructure investment in the US economy in an effort to highlight the importance of infrastructure investment. In his investigation, he found that where for instance, the US government invests US $18 billion of debt financed money into infrastructure, GDP increases by US $29 billion and 216 000 jobs are created in the short run (or short-term). Furthermore, Bivens (2014) found that the impact was higher in the initial ten years and as time passes, the effects diminish. That is the

impact of infrastructure expenditure was expected to be higher in the short term, and to diminish overtime.

Depending on the stage of development of an economy, the government responsible for that economy will choose accordingly which type of infrastructure to invest in. Demurger (2001) also lists some types of public infrastructures to include; those that impact education, transportation, urbanization and industrial reform. The decision on what kind of public infrastructure to spend on can at time be complex, especially on the more social type as the impact of these type of infrastructure is difficult to measure (Chandra and Thompson, 2000).

The effects of public infrastructure investments are not limited to changes in private investment, employment or output within the region that they have been invested in. Pereira and Roca-sagalés (2003) investigated the externalities of public infrastructure investment in different regions in Spain and the impact that they had in regions outside the area of initial investment. The initial step that they took was to model the aggregate impact of public capital investment in the whole country to set up a benchmark for total impact. This was followed by an analysis on the impact for the 17 regions in Spain. The results for the individual regions combined did no match with the results obtained in the model that aggregated the public capital investment. This suggests that the aggregate model did not capture the full impact of public capital investment and that there maybe spill over effects that can't be accounted for in that region.

5. Methodology

Methods used in the literature vary from simple equation models to complex stochastic macro economic models (Pereira & Andraz, 2010). However the majority of the literature has focused on Vector Auto Regression (VAR) models which has the advantage of being a-theoretical, and overcoming the problem of simultaneity bias experienced with single equation models (examples include Pradahn, Arvin, Norman and Bele, 2014; and Herranz-Loncan, 2007). The simultaneity bias prevents researchers from drawing meaningful conclusions about the positive effects of infrastructure spending and has been a source of great debate in the literature. Therefore, this paper will pursue a VAR method of inquiry.

6. Data and Model Description

6.1 Model Description

In line with Pereira (2000), a VAR model is estimated using Gauteng infrastructure spending, GDP-R, employment, and private investment. The VAR model evaluates the short-tem effects of Gauteng's infrastructure spending on GDP-R, employment and private investment (that is the Gauteng private economy). In the VAR system, this equation is referred to as the policy function.

Prior expectations and literature suggest that infrastructure expenditure is expected to have a positive effect on GDP-R. However this may differ depending on the lag specification of the model as investment may in some instances reduce GDP-R if infrastructure spending is not used productively. Furthermore, the relationship between infrastructure expenditure and employment can be positive or negative depending on the business cycle and the pace of infrastructure project implementation. This is to say that as infrastructure projects are rolled out, employment is expected to increase gradually up to a point, and then it may turn negative. As such infrastructure expenditure can have counter cyclical characteristics as highlighted in Pereira (2000). Private investment is also expected to be positive in cases where infrastructure spending crowds-in private investment, and negative where infrastructure spending crowds-out private investment.

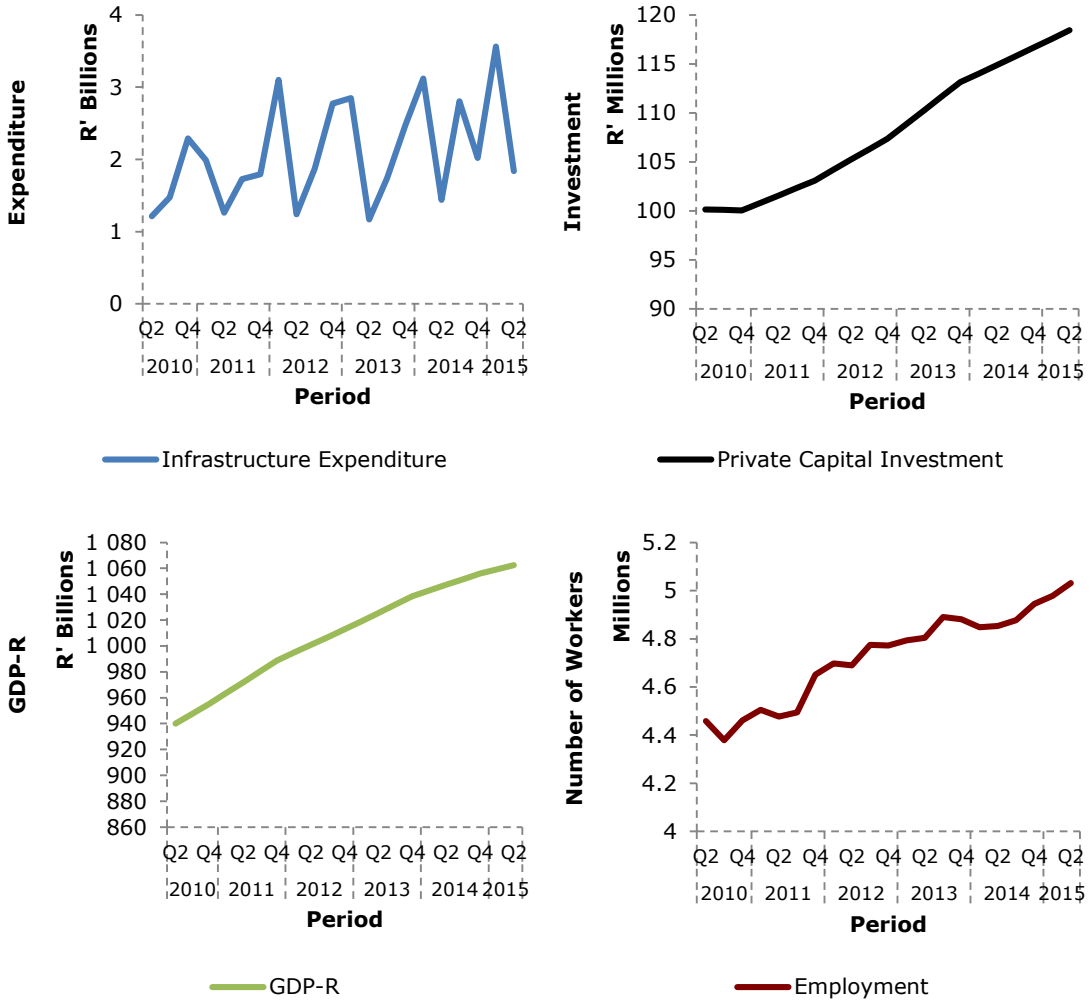
There two main advantages of the VAR model are that it allows for feedbacks (from other variables) in the estimation of elasticities (or coefficients) and furthermore, it captures the dynamic nature of elasticities with the use of lags. This is particularly important in as highlighted above; literature has shown that dynamic feedbacks in the estimation of the short-term and long-term effects of infrastructure spending on the private economy are essential. These dynamic feedbacks also account for the question of whether infrastructure expenditure leads to GDP growth, or GDP growth leads to infrastructure expenditure. In this case we follow Pereira (2000) with the assertion that infrastructure spending is used as a policy variable with which a certain level of growth is targeted.

6.2 Data

Figure 1 shows the data used in the estimation of the VAR model. All variables show an upward trend over the period of estimation, though infrastructure expenditure also displays a

cyclical nature. This would normally suggest a positive relationship between between infrastructure expenditure and economic growth. However, they may simply be increasing over time without influencing one another. An econometric study of their relationship is necessary to arrive at any conclusion. Employment and private investment in capital took longer than the overall economy, represented by GDP-R, to recover from the Great Recession. Since the end of 2010, however, they have both been on an upward trend.

Figure 1: Government Infrastructure Expenditure, Private Capital Investment, Gross Domestic Product & Employment in Gauteng, 2010Q2-2015Q2



Source: Gauteng Infrastructure Reporting Model, Quantec, and Stats SA, 2016

Note: Figure 1 shows the provincial infrastructure expenditure figures, the private investment in capital, the GDP-R for Gauteng and the employment level of the province from the second quarter of 2010 to the second quarter of 2015.

6.3 Data Sources and Transformations

The model is estimated from the second quarter of 2010 to the second quarter of 2015. The GDP-R and private investment data was sourced from Quantec Research (and only available in annual form). The employment data was obtained from Statistics South Africa. The infrastructure expenditure data was sourced in its quarterly format from the Gauteng Infrastructure Reporting Model[3]

Using *Eviews 7*, the GDP-R and Private investment data were transformed into quarterly data using the linear-match last method. All the data was then logged therefore all the VAR model was estimated in log form. Infrastructure spending data showed seasonality and as such was de-seasonalised using the X11 method[4] in *Eviews 7*, which was developed by the US Census Bureau.

6.4 Univariate Characteristics

To establish co-integration the residuals of the model were tested for stationarity using both the Augmented Dickey-Fuller test and the Phillips-Perron tests. The full results are in the appendix. The residuals of all the variables (provincial public infrastructure expenditure, employment, GDP-R, and private capital) spending were all stationary. It is therefore concluded that the VAR model is co-integrated. It was therefore not necessary to ensure that the individual data series were stationary.

7. Results

7.1 VAR Estimation

Table 2 below shows the results of the policy function (see appendix for full VAR). A VAR of order three was estimated after the lag selection criteria tests were conducted (see appendix for results). Furthermore, the VAR model was tested for stability and found to have roots of less than 1 (see appendix for full results).

The results concur with theory that the short-term effects of infrastructure expenditure on the private economy are higher as compared to the longer-term effects. Pereira (2000) for

[3] It is a database of all provincial infrastructure projects.
[4] Method of de-seasonalising data developed by the US Census Bureau.

example found significantly lower effects with a larger dataset. Indicatively, the model reviewed a significant one period lag relationship between GDP-R and infrastructure spending of 180, meaning that a 1 per cent increase in GDP-R required a 180 per cent increase in infrastructure spending. This relationship at the second and third lags was insignificant. This indicates that the effect of infrastructure expenditure is most significant one quarter after the expenditure is made. However this may be different with a longer time series.

Table 2: Infrastructure Expenditure Short-term Policy function

	GDP-R	Employment	Private Investment
One-Period Lag	180.06	-7.33	-98.40
	(2.04)	*(-1.76)*	*(-3.13)*
Two-Period Lag	-145.23	18.55	-34.38
	(-1.58)	*(2.59)*	*(-0.90)*
Three-Period Lag	34.81	7.89	93.62
	(0.53)	*(1.45)*	*(2.64)*

Note: T statistics in parenthesis. A t-statistic of less than or greater than 1.96 is regarded as significant at 5% level of significance.

Employment was significant at a second lag and indicates that infrastructure expenditure had employment effects. Therefore Infrastructure expenditure did not have contemporaneous[5] effects on employment. Table 2 also highlights that in the immediate quarter after the infrastructure expenditure, private investment was crowded out. However in the third quarter after, infrastructure expenditure crowds in private investment. This indicates that private investment takes time to adjust to changes in infrastructure expenditure.

7.2 Infrastructure Expenditure Shock

In this section, the effects of a one-percentage point random shock over 10 quarters to the growth rate of infrastructure expenditure on GDP-R, employment, and private investment are estimated. The effect on the growth rate of infrastructure expenditure is expected to be temporary, whilst those on GDP-R, employment, and private investment permanent. Also as already highlighted in the results, the effects of infrastructure spending on the private

[5] In the context of this study contemporaneously means that the effect of a policy action materializes in the same quarter, in which it was conducted.

economy were not contemporaneous, and therefore the shock could not be contemporaneous.

Table 3: Short-term accumulated elasticities

Variable	GDP-R	Employment	Private Investment
Infrastructure expenditure *(central case)*	0.010885	-0.003055	0.039223

The results of the shock are highlighted in the appendix. Noteworthy is that the response of the private sector economy was in-line with expectations and that in the main the response was positive. Table 3 shows the accumulated short-term elasticities (the final effect over the period of the shock) of the shock. The effect on GDP-R and private investment was positive, and employment slightly negative. This may indicate that employment required a higher shock in order to yield positive results.

7.3 Value of Additional Infrastructure Expenditure for GDP-R

The estimated marginal productivity as shown in Table 4 refers to the total direct and indirect effect of a Rand of infrastructure expenditure on GDP-R. As Pereira (2000:516) puts it "it measures both the direct effects of public investment on output and the indirect effects of public investment on output through the evolution of private inputs". The full calculation of the marginal product is in the appendix.

Table 4: Effect of Infrastructure expenditure on GDP-R

Variable	Marginal productivity
Infrastructure expenditure (2011 average level)	R6,45
Infrastructure expenditure (2012 average level)	R5,52
Infrastructure expenditure (2013 average level)	R6,11
Infrastructure expenditure (2014 average level)	R5,33
Average (over the period of estimation)	**R5,71**

Table 4 shows that the marginal productivity of infrastructure expenditure declining between 2011 and 2014 (on average). This is mainly due to business cycle factors as the ratio of Infrastructure expenditure to GDP-R increases as highlighted in Table 1. The average over the estimation period indicates that for a Rand of infrastructure expenditure, R5.71 of GDP-R was attained. This, of course excludes other adverse factors, which may affect the economy.

As stated above, these are short-term effects and will likely decline in study with a longer estimation period.

8. Discussion

In the wake of the then financial crisis in 2009, government emphasised infrastructure as a key counter cyclical measure and essential for long term economic development. As outlined above, government through the PICC is undertaking a historic infrastructure development drive; and the GPG is part of this drive. From a policy stand point it therefore becomes important to understand the effect of this drive, as expressed in the TMR programme.

The model has shown that in the short-term, infrastructure expenditure has had a positive effect of the economy during the period of analysis. Infrastructure expenditure effect on GDP-R, private investment, and employment is in the main positive (growth inducing, investment attracting and employment creating). This is a strong argument for the maintenance and even improvement of the infrastructure drive.

However, the parameter estimates (for example 180 per cent infrastructure expenditure for one per cent of GDP-R) indicates that efficiency of government infrastructure expenditure may have scope to improve further. As stated above, it must be noted that short-term estimates will always be higher than long-term estimates. In line with the challenges in implementing infrastructure projects as outlined in Section 2.1. above, efficiency in project selection and management will therefore become more important in the future.

Furthermore, the model indicates that timing of the infrastructure expenditure and the response of the economy are not simultaneous. This may erroneously create the perception that infrastructure expenditure does not have positive effects on the economy. A distinction also needs to be drawn between the direct and indirect effect of infrastructure expenditure, in that the indirect effect of infrastructure expenditure is likely to take longer than the direct effects to transmit through the economy. This again may erroneously create the perception that the effects of infrastructure spending are lower than actual when both the direct and indirect effects are taken into account. The estimates in Table 4 indicate are contrary to this viewpoint, with positive combined effects of infrastructure expenditure on the economy.

9. Limitations of the Study

The data used in this study limited the period of analysis to five years. This in effect, meant that the study could not determine the long-term effects of infrastructure expenditure on the economy. This also restricted the analysis in that the data could not allow for more detailed analysis on the different categories (highways and streets, electricity and gas facilities, sewage and water) of infrastructure expenditure and their effect on the economy. The data also ruled out any investigations on the spill over effects of infrastructure expenditure.

These limitations also suggest areas of future research on the effect of infrastructure expenditure on the Gauteng economy. Future studies will need to look at the longer-term effects of public infrastructure expenditure and to investigate the effect that various types of infrastructure spending have on the economy, employment and capital investment. There is also a need for a detailed long period database of infrastructure spending within the province. Current databases are fragmented and only provide a short-term view of infrastructure expenditure.

10. Conclusion

This paper highlighted the importance of infrastructure expenditure by GPG to the Gauteng economy. The literature established the linkages between infrastructure expenditure and the economy; and also highlighted key methodology challenges. Due to limitations in the data and data availability, only short-term effects of infrastructure expenditure could be modelled. The results indicated that indeed infrastructure expenditure had a positive effect on the economy during the period of analysis.

The results therefore advocate for the maintenance and further enhancement of the infrastructure development programs in the province as a catalyst for economic growth. Further studies will be necessary to determine the long-term effects of infrastructure expenditure on the economy.

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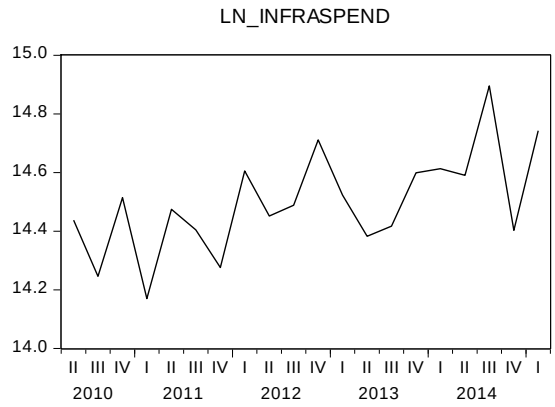
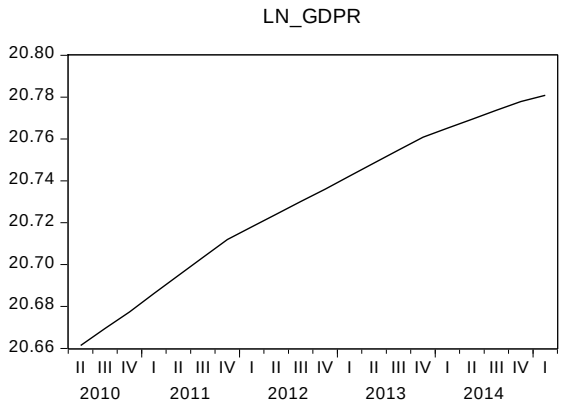
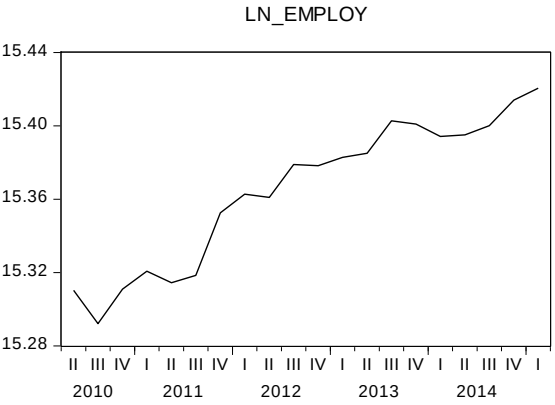
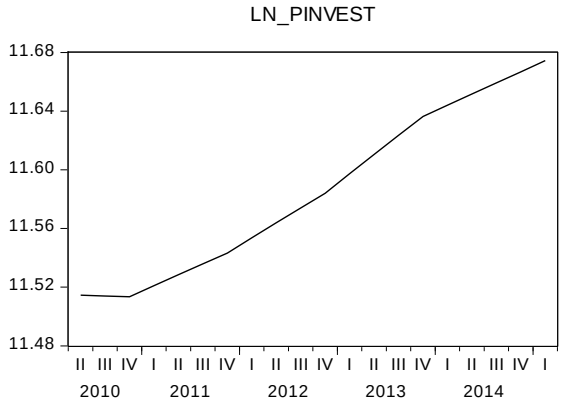
12. Appendix

12.1 Plots of Data Used in the VAR model

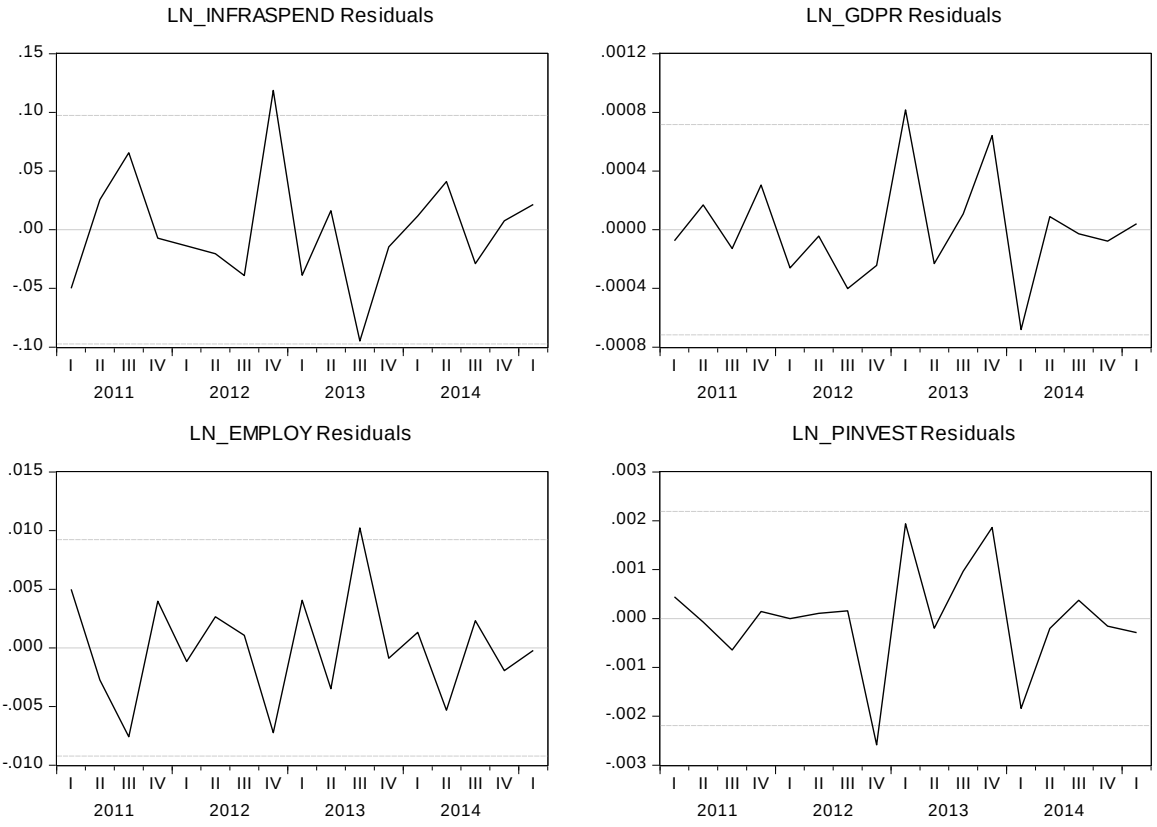








12.2 Residual Plots of the VAR model



12.3 Stationary Tests of Residuals of the VAR model

12.3.1 Ln_Infraspend

Series	Model	ADF			PP	
		Lags	τ_T, τ_μ, τ	φ_3, φ_1	Lags	
Resid01	**Trend & Intercept**	0	-5.162499***	13.55934***	0	-5.247709***
	Intercept	0	-5.352300***	28.64712***	0	-5.442932***
	None		-5.506136***			-5.599541***

Ho: Non Stationary

Ha: Stationary

Given that most of the results were significant indicating stationarity, we can conclude cointegration.

12.3.2 Ln_EMPLOY

Series	Model	ADF			PP	
		Lags	τ_τ, τ_μ, τ	φ_3, φ_1	Lags	
Resid02	**Trend & Intercept**	0	-4.646142***	11.37288***	0	-4.651134***
	Intercept	0	-4.932267***	24.32725***	0	-4.944435***
	None		-5.074069***			-5.085672***

Ho: Non Stationary

Ha: Stationary

Given that most of the results were significant indicating stationarity, we can conclude cointegration.

12.3.3 Ln_GDPR

Series	Model	ADF			PP	
		Lags	τ_τ, τ_μ, τ	φ_3, φ_1	Lags	
Resid03	**Trend & Intercept**	0	-5.893398***	17.37493***	0	-6.890790***
	Intercept	0	-6.100805***	37.21982***	0	-8.131954***
	None		-6.299823***			-8.463121***

Ho: Non Stationary

Ha: Stationary

Given that most of the results were significant indicating stationarity, we can conclude cointegration.

12.3.4 Ln_Pinvest

Series	Model	ADF			PP	
		Lags	τ_τ, τ_μ, τ	φ_3, φ_1	Lags	
Resid04	**Trend & Intercept**	0	-5.598707***	15.67946***	0	-7.198712***
	Intercept	0	-5.784590***	33.46148***	0	-7.351331***
	None		-5.973841***			-7.664565***

Ho: Non Stationary

Ha: Stationary

Given that most of the results were significant indicating stationarity, we can conclude cointegration.

12.4 Lag Length Selection Criteria Test

VAR Lag Order Selection Criteria
Endogenous variables: LN_INFRASPEND LN_GDPR LN_EMPLOY LN_PINVEST
Exogenous variables: C
Date: 02/28/16 Time: 18:21
Sample: 2010Q2 2015Q1
Included observations: 17

Lag	LogL	LR	FPE	AIC	SC	HQ
0	167.2266	NA	5.38e-14	-19.20313	-19.00708	-19.18365
1	274.4566	151.3835	1.26e-18	-29.93608	-28.95583	-29.83864
2	290.1249	14.74661	1.97e-18	-29.89705	-28.13260	-29.72166
3	354.2594	30.18094*	2.95e-20*	-35.55993*	-33.01128*	-35.30659*

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

12.5 Estimated VAR Model

Vector Autoregression Estimates
Date: 02/28/16 Time: 18:16
Sample (adjusted): 2011Q1 2015Q1
Included observations: 17 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	LN_INFRASPEND	LN_GDPR	LN_EMPLOY	LN_PINVEST
LN_INFRASPEND(-1)	-1.625094	0.001507	0.034644	0.004022
	(0.34125)	(0.00251)	(0.03239)	(0.00768)
	[-4.76222]	[0.59910]	[1.06957]	[0.52337]
LN_INFRASPEND(-2)	-1.587182	0.000225	0.048240	0.005640
	(0.42146)	(0.00311)	(0.04000)	(0.00949)
	[-3.76594]	[0.07234]	[1.20589]	[0.59421]
LN_INFRASPEND(-3)	-0.213332	0.000413	-0.004232	0.006132
	(0.25968)	(0.00191)	(0.02465)	(0.00585)
	[-0.82151]	[0.21595]	[-0.17171]	[1.04848]
LN_GDPR(-1)	180.0665	0.764130	-6.903065	0.463401
	(87.9041)	(0.64780)	(8.34363)	(1.97958)
	[2.04844]	[1.17957]	[-0.82735]	[0.23409]
LN_GDPR(-2)	-145.2385	-0.014095	0.175807	-0.040984
	(91.5310)	(0.67453)	(8.68789)	(2.06126)
	[-1.58677]	[-0.02090]	[0.02024]	[-0.01988]
LN_GDPR(-3)	34.81550	0.114313	6.298800	-0.485971
	(64.8391)	(0.47783)	(6.15436)	(1.46016)
	[0.53695]	[0.23923]	[1.02347]	[-0.33282]

LN_EMPLOY(-1)	-7.333594	-0.023303	0.710942	0.108060
	(4.15164)	(0.03060)	(0.39406)	(0.09349)
	[-1.76643]	[-0.76165]	[1.80414]	[1.15579]
LN_EMPLOY(-2)	18.55372	-0.043695	-1.218066	-0.002118
	(7.14712)	(0.05267)	(0.67839)	(0.16095)
	[2.59597]	[-0.82960]	[-1.79553]	[-0.01316]
LN_EMPLOY(-3)	7.890395	0.021003	-0.416410	0.057876
	(5.41576)	(0.03991)	(0.51405)	(0.12196)
	[1.45693]	[0.52626]	[-0.81006]	[0.47454]
LN_PINVEST(-1)	-98.40894	0.362351	2.066311	1.207801
	(31.3551)	(0.23107)	(2.97614)	(0.70611)
	[-3.13853]	[1.56815]	[0.69429]	[1.71050]
LN_PINVEST(-2)	-34.38348	-0.248362	3.954807	-0.282785
	(38.0991)	(0.28077)	(3.61627)	(0.85799)
	[-0.90247]	[-0.88458]	[1.09361]	[-0.32959]
LN_PINVEST(-3)	93.62743	-0.052742	-5.286091	0.002391
	(35.3344)	(0.26039)	(3.35385)	(0.79572)
	[2.64976]	[-0.20255]	[-1.57613]	[0.00300]
C	-1218.561	2.782906	28.80652	-0.586387
	(345.695)	(2.54757)	(32.8125)	(7.78499)
	[-3.52496]	[1.09238]	[0.87791]	[-0.07532]
R-squared	0.924186	0.999857	0.980261	0.999555
Adj. R-squared	0.696743	0.999428	0.921042	0.998219
Sum sq. resids	0.037876	2.06E-06	0.000341	1.92E-05
S.E. equation	0.097309	0.000717	0.009236	0.002191
F-statistic	4.063379	2329.043	16.55333	748.3406
Log likelihood	27.78448	111.2616	67.81519	92.27160
Akaike AIC	-1.739350	-11.56018	-6.448846	-9.326070
Schwarz SC	-1.102187	-10.92302	-5.811683	-8.688907
Mean dependent	14.51429	20.73989	15.37541	11.59814
S.D. dependent	0.176705	0.029974	0.032870	0.051927
Determinant resid covariance (dof adj.)		3.04E-21		
Determinant resid covariance		9.33E-24		
Log likelihood		354.2594		
Akaike information criterion		-35.55993		
Schwarz criterion		-33.01128		

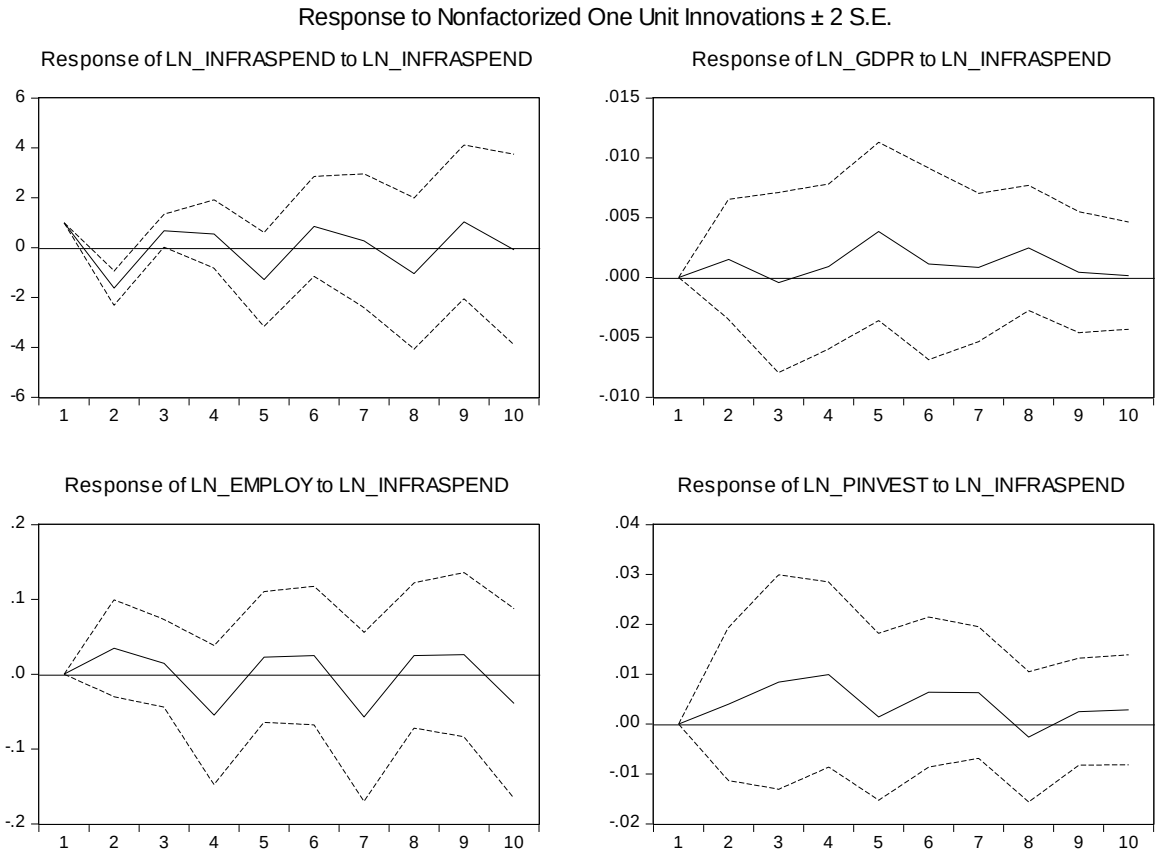
12.6 VAR Model Stability (Roots of the VAR Model)

Roots of Characteristic Polynomial
Endogenous variables: LN_INFRASPEND LN_GDPR LN_EMPLOY LN_PINVEST
Exogenous variables: C
Lag specification: 1 3
Date: 02/28/16 Time: 18:20

Root	Modulus
-0.576038 - 0.814346i	0.997487
-0.576038 + 0.814346i	0.997487
0.935133	0.935133
-0.110963 - 0.887037i	0.893950
-0.110963 + 0.887037i	0.893950
0.656256 - 0.490521i	0.819318
0.656256 + 0.490521i	0.819318
0.761688	0.761688
0.264111 - 0.670286i	0.720443
0.264111 + 0.670286i	0.720443
-0.552887 - 0.267933i	0.614387
-0.552887 + 0.267933i	0.614387

No root lies outside the unit circle.
VAR satisfies the stability condition.

12.7 Impulse Response Plots for One Per Cent, One Time, Random Shock



12.8 Accumulated Impulse Response Elasticities from the Random Shock

Period	LN_INFRASPEND	LN_GDPR	LN_EMPLOY	LN_PINVEST
1	1.000000	0.000000	0.000000	0.000000
	(0.00000)	(0.00000)	(0.00000)	(0.00000)
2	-0.625094	0.001507	0.034644	0.004022
	(0.34125)	(0.00251)	(0.03239)	(0.00768)
3	0.050084	0.001084	0.049124	0.012425
	(0.45661)	(0.00588)	(0.04710)	(0.01733)
4	0.595305	0.002000	-0.005565	0.022353
	(0.58970)	(0.00860)	(0.03538)	(0.02425)
5	-0.683170	0.005848	0.017405	0.023788
	(0.62362)	(0.01151)	(0.02967)	(0.03065)
6	0.165397	0.006971	0.042223	0.030193
	(0.74535)	(0.01455)	(0.04172)	(0.03514)
7	0.437203	0.007807	-0.014801	0.036479
	(0.84606)	(0.01630)	(0.03475)	(0.03715)
8	-0.601871	0.010280	0.010021	0.033889
	(0.91138)	(0.01750)	(0.03157)	(0.04048)
9	0.431436	0.010729	0.036120	0.036360
	(0.97860)	(0.01881)	(0.03687)	(0.04163)
10	0.347876	0.010885	-0.003055	0.039223
	(1.15679)	(0.01983)	(0.03752)	(0.04106)

Nonfactorized One Unit Standard Errors: Analytic

12.9 Calculation of Marginal Productivity

Calculation of the GDP-R/Infrastructure expenditure Ratio

		Infraspend/GDP-R	(Infraspend/GDP-R)*(100)	1\((Infraspend/GDP-R)*(100))
2010	Q2	0,0013	0,1293	7,732866322
	Q3	0,0016	0,1557	6,422081254
	Q4	0,0024	0,2396	4,173567728
2011	Q1	0,0021	0,2064	4,84384859
	Q2	0,0013	0,1300	7,694309579
	Q3	0,0018	0,1762	5,676075211
	Q4	0,0018	0,1814	5,512486402
2012	Q1	0,0031	0,3117	3,208646717
	Q2	0,0012	0,1240	8,061848141
	Q3	0,0019	0,1862	5,371178915
	Q4	0,0027	0,2737	3,653450601
2013	Q1	0,0028	0,2795	3,577644089
	Q2	0,0011	0,1139	8,780270955
	Q3	0,0017	0,1689	5,921486216

	Q4	0,0024	0,2380	4,200832148
2014	Q1	0,0030	0,2990	3,343999317
	Q2	0,0014	0,1374	7,279484399
	Q3	0,0027	0,2665	3,751761479
	Q4	0,0019	0,1915	5,22310045
2015	Q1	0,0034	0,3362	2,974632212

Calculation of GDP-R Marginal Productivity

		(1\((Infraspend/GDP-R)*(100)))*((GDPR Short Term Accumulated Elasicity)*100)	GDPR Short Term Accumulated Elasicity	(GDPR Short Term Accumulated Elasicity)*100	Yearly Average Marginal Productivity
			0,010885	**1,0885**	
2010	Q2	8,417224992			6,650196303
	Q3	6,990435445			
	Q4	4,542928471			
2011	Q1	5,27252919			6,456633621
	Q2	8,375255977			
	Q3	6,178407867			
	Q4	6,000341449			
2012	Q1	3,492611952			5,52281072
	Q2	8,775321702			
	Q3	5,846528249			
	Q4	3,97678098			
2013	Q1	3,894265591			6,117433516
	Q2	9,557324934			
	Q3	6,445537746			
	Q4	4,572605793			
2014	Q1	3,639943256			5,333199809
	Q2	7,923718769			
	Q3	4,08379237			
	Q4	5,68534484			
2015	Q1	3,237887162			

For a full set of research documents produced by the GPT Economic Analysis Unit go to
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