Infrastructure development and population growth on economic growth in South Africa

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INFRASTRUCTURE DEVELOPMENT AND POPULATION GROWTH ON ECONOMIC GROWTH IN SOUTH AFRICA

CROSS-SECTION SEEMINGLY UNRELATED REGRESSION

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Abstract: The objective of this study is to examine the correlation between infrastructure development and population growth on economic growth in South Africa. The study employed Cross-section Seemingly Unrelated regression to analyze the relationship between infrastructure development and population growth on economic growth using an annual panel data collected from nine provinces for the period 2006-2019. The results showed that infrastructure is not an effective instrument to stimulate economic growth. Provincial government expenditure was found to have a positive and significant relationship with economic growth. The study found that unemployment and economic growth have a negative and significant relationship. Moreover, the results revealed that population has a positive and statistical impact on economic growth. The granger causality test found that there is a causality running from population growth to infrastructure unidirectionally, meaning that population growth has an impact on infrastructure development in South Africa. To correct the problem of having harmful infrastructure on economic growth, South African policy makers should ensure that there is no lack of clarity about national objectives and standards and lack of coordination in the development of natural instruments and inconsistent implementation of national objectives. There is a need to invest more on infrastructure in South Africa.

Key words: Infrastructure, Population, Economic growth, Cross-section Seemingly Unrelated Regression South Africa

JEL Specification: C1, H54, H76, O18

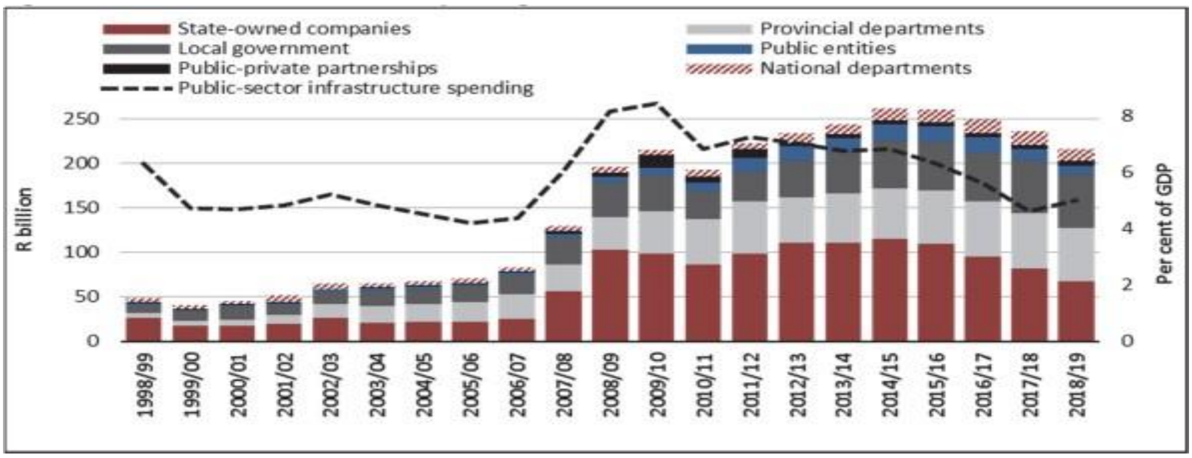
1 INTRODUCTION

Infrastructure is a requirement for the growth of any economy. Transportations, energy, health, housing, and educational facilities have all become essential components of human life. It is crucial for a country to have these facilities since they are critical to home life as well as economic operations. Infrastructure is critical in supporting economy progress and, as a result, contributing to the elimination of economic inequality, poverty, and hardship in a society (Srinivasu & Rao, 2013). The purpose of this study is to investigate the empirical relationship between infrastructure, population, and economic growth. In the empirical literature, some studies found a positive relationship between infrastructure, population and economic growth, like Esfahani and Ramírez (2003), Sridhar and Sridhar (2007), Weinhold and Reis (2001), Beyzatlar and Kustepeli (2011), Batuo (2015).

There are related studies in South Africa, but they did not access the whole infrastructure and pollution on economic growth in one paper. To best of our knowledge, no study has been done in South Africa to analyze the relationship between infrastructure, population, and economic growth using Cross-section Seemingly Unrelated Regression. This study is conducted to close the gap and open a platform for further research. The paper is structured as follows: Section 2 focused on the review of the empirical literature. Section 3 present research method. Section 4 presents empirical results of the study. Section 5 presents a conclusion of the study.

Overview of the study: Improving infrastructure in South Africa is one of the important things to focus on as it has a positive influence towards economic growth by creating employment, attracting tourists, and encouraging foreign direct investment.

Figure 1: Public-sector infrastructure spending



Source: National Treasury

Figure 1 demonstrates trends in public infrastructure spending in South Africa over the period of 1998/99 to 2018/19. The public sector spent R3.2 trillion in infrastructure between 1998/99 and 2018/19. Expenditure has risen from R48.8 billion in 1998/99 to 216.2 billion in 2018/19. For the period 1998/99 through 2006/07, the average actual increase in spending was 8%. Spending on building projects for 2010 FIFA World Cup suddenly increased, resulting in an average real growth of 50% between 2007/08 and 2008/09. Since then, spending growth has been decreasing with an average real growth of 2 percent (Treasury, 2020).

This downward tendency is primarily due to municipalities and state-owned enterprises significantly increasing their spending in recent years. Several big state-owned enterprises have struggled to gain access to financing markets in order to fund infrastructure projects. most municipalities have underspend on conditional grants and are not collecting enough money to find they are capital budgets. Furthermore, as the budget deficit and debt have increased, the national government has cut infrastructure conditional grants two provinces and municipalities (Treasury, 2020).

Figure 2: Public-sector infrastructure expenditure and estimates

R billion	2016/17	2017/18 Outcomes	2018/19	2019/20 Revised estimate	2020/21	2021/22 Medium-term estimates	2022/23	MTEF total
Energy	67.0	55.1	39.9	49.7	52.4	52.4	45.3	150.0
Water and sanitation	30.8	26.8	27.1	33.5	37.0	39.6	40.6	117.1
Transport and logistics	70.9	75.4	74.4	90.5	97.8	105.4	105.1	308.3
Other economic services	14.3	17.1	13.5	13.1	11.8	12.2	12.5	36.5
Health	10.4	9.7	11.3	12.0	12.3	12.3	12.6	37.3
Education	17.8	17.6	17.2	19.5	18.7	19.7	20.7	59.1
Human settlements[1]	18.3	14.3	15.0	18.8	16.6	13.4	13.9	43.9
Other social services	10.3	11.2	10.1	10.5	10.2	9.8	10.2	30.2
Administration services[2]	10.1	9.1	7.7	9.4	10.3	11.0	11.2	32.5
Total	**249.9**	**236.3**	**216.2**	**257.0**	**267.1**	**275.9**	**272.0**	**815.0**
National departments	15.8	14.9	13.6	15.8	16.1	16.9	17.3	50.4
Provincial departments	62.6	62.3	59.5	60.8	59.9	57.1	59.9	177.0
Local government	54.4	58.8	61.0	61.7	62.3	65.7	68.7	196.8
Public entities[3]	17.1	13.2	9.6	18.7	19.0	19.6	20.6	59.2
Public-private partnerships	4.8	4.8	4.9	5.6	5.7	6.1	5.9	17.8
State-owned companies[3]	95.2	82.2	67.5	94.2	104.0	110.5	99.5	314.0
Total	**249.9**	**236.2**	**216.2**	**257.0**	**267.1**	**275.9**	**272.0**	**815.0**

Source: National Treasury

The government's infrastructure spending plans for the next three years as summarized in Figure 2. The data combines nationally, provincially, and local funded infrastructure with estimates of expenditure received from state owned enterprises and other public institutions. Over the medium-term expenditure framework (MTEF) period, public sector infrastructure investment is expected to total R815 billion. State owned continue to be the greatest contributors to capital investment, with R314 billion expected to be spent over the next three years. Over the same time period, provinces are anticipated to spend R177 billion on infrastructure, while municipalities are slated to spend R196.8 billion. The overall cost of public housing and bulk infrastructure developed in provinces under the human settlement's development grants is projected to be R43.9 billion. Despite the fact that these assets are passed to householders, this spending represents a significant government contribution to the built environment (Treasury, 2020).

Figure 3: Population growth rate in South Africa

South Africa - Historical Population Growth Rate Data		
Year	Population Growth Rate	Growth Rate
2021	60,041,994	1.24%
2020	59,308,690	1.28%
2019	58,558,270	1.33%
2018	57,792,518	1.37%
2017	57,009,756	1.43%
2016	56,207,646	1.48%
2015	55,386,367	1.54%
2014	54,544,186	1.60%
2013	53,687,121	1.62%
2012	52,832,658	1.59%
2011	52,003,755	1.54%
2010	51,216,964	1.47%

Source: United Nations - World Population Prospects (macrotrends)

Figure 3 shows the population growth rate in South Africa over a period of 2010 to 2021. The population in South Africa has been increasing gradually from 1950 to 2021, there is no year the population showed a decline since 1950 in South Africa. The population of South Africa in 2018 was 57 792 518 which is 1.37 increase from 2017. In 2019 the population of South Africa further showed an increase to 58 558 270 that is 1.33% increase from 2018. Furthermore, in 2020 population number was standing at 59 308 690 which is 1.28 increase from 2019. However, the current population of South Africa is 60 041 994 which is 1.24% increase from 2020. According to the Kremer (1993) model, South Africa should anticipate more scientist and engineers, geniuses and a quick technological advancement in the long run.

2 LITERATURE REVIEW

Theoretical literature

This section of the study presents the theoretical framework underpinning the study. This paper focuses on more on growth theories. Malthus (1798) argued that population growth will outstrip the Earth's ability to produce food, leading to the impoverishment of humanity. Solow (1956) on the study contributing to economic growth theory emphasized that a country with higher population growth rates will have lower levels of capital and income per worker in the long run. Kremer (1993) argued that population growth leads to economic growth. More people in the country means more geniuses, scientists, and engineers, leading to faster technological progress.

Empirical literature

There is a large on the relationship between population, infrastructure, and economic growth. Different studies found different results on country specific and cross-country studies, most studies found a positive relationship between population, infrastructure, and economic growth. This section is divided into two subsections such as studies found positive relationship and studies found negative relationship

Studies found a positive relationship: Weinhold and Reis (2001)examined the relationship between infrastructure growth and population growth in the Amazon using a panel of 293 municipalities over the period from 1975 to 1985. Employed contemporaneous cross section analysis and it confirmed a strong positive correlation between infrastructure and urban population, but it does not indicate direction of causality. They applied traditional grander causality test to examine the short run relationship, the results indicated that urban populations lead to more infrastructure development. Esfahani and Ramírez (2003) conducted a study examining institutions, infrastructure, and economic growth for a period of three decades, 1965-1975, 1975-1985, and 1985-1995. Standard estimate of the model indicated that the contribution of infrastructure service to GDP is substantial and in general, exceeds the cost of provision of these services.

Using a data from developing countries, Sridhar and Sridhar (2007) investigator at the relationship between the telephone penetration and economic growth. Their study employed 3SLS To estimate a system of equations that endogenizes economic growth and telecom penetration. Their study obtained that the traditional economic factors explained demand for mainline and mobile phones, even in developing countries. The study obtained a positive impact of mobile and landline phones on national output when they controlled for the effect of capital and labor. Perkins et al. (2005) analyzed the long run trends in the development of infrastructure of South Africa's economic infrastructure with the country's long term economic growth. Their study employed PSS (Pesaran, Shin and Smith, 1996, 2001) F-tests are used to identify directions of relationship between economic infrastructure and economic growth. The results indicated that there is bidirectional relationship between economic infrastructure and economic growth in South Africa.

Beyzatlar and Kustepeli (2011) conducted this study to investigate the relationship between railway infrastructure and economy growth, and also between railway infrastructure and population density Turkey. Using an annual data from 1950 to 2004 both the tangible and intangible effects of railway infrastructure were estimated. The results from cointegration and causality test indicated about there is a positive long run relationship between railway length and population density and between railway length and real GDP per capita. The results from granger causality revealed that railway length causes real GDP per capita to increase only in the long run but it causes population density to increase both in the long run and in the short run. Czernich et al. (2011) investigated a broadband infrastructure and economic growth in the panel of OECD countries from 1996-2007. The study employed fixed effect model for the empirical analysis of the study. They found that at 10%-point increase in broadband penetration raised annual per capita growth by 0.9 to 1.5% points. The results a robust two country and year fixed effects and controlling for linear second stage effect of their instruments.

Sahoo and Dash (2012) used panel cointegration techniques to investigate the output elasticity of infrastructure in four South Asian nations, namely India, Pakistan, Bangladesh, and Sri Lanka, from 1980 to 2005. The study discovered that output and infrastructure have a long run equilibrium connection. South Asian production growth is largely influenced by infrastructural development. In addition, the panel causality analysis revealed that total production and infrastructure development had reciprocal feedback.

Cheteni (2013) investigated the influence of transportation infrastructure investment and transportation sector productivity in South African economic development from 1975 to 2011. As empirical techniques, they employed a vector error correction model and Bayesian vector autoregressive model. Through impulse response, the models gave insight into the dynamic shocks on economy growth. The vector error correction model indicated that economy growth is impacted by domestic fixed transport investments and real, whereas it was influenced by domestic fixed transport investments in the BVAR model.

Pradhan and Bagchi (2013) investigated the effect of transportation (road and rail) infrastructure on economic growth in India over the period 1970 to 2010. Using vector error correction model, the study obtained bidirectional causality between road transportation and economic growth and unidirectional causality from rail transportation to economic growth. Batuo (2015) studied how telecommunications infrastructure is related to economic growth in a panel a data set covering 44 African countries for the period from 1990 to 2010. A dynamic panel data approach model which suggests that telecommunications contribute in a major way to the economy development of the continent, after controlling for a number of other variables, the results further revealed that investment in telecommunication infrastructure is subject to increase the returns, demonstrating that an increase in telecommunication investment produces further growth.

Kodongo and Ojah (2016) employed System GMM to estimate an economic growth model enhanced by an infrastructure variable for a panel of 45 Sub-Saharan African nations from 2000 to 2011. They discovered that infrastructure spending and increases in access to infrastructure had an impact on economic growth and development in Sub-Saharan Africa.

Ward and Zheng (2016) found that telecommunications services contributed to economic growth in three ways. They devised a way to address the endogeneity of telecommunications in terms of growth. They discovered that mobile services contribute much more to growth, but that the benefit reduces as the provincial economy grows.

Moeketsi (2017) studied the link between road infrastructure investment and economic growth, as well as Adam macroeconomic factors including ICT investment and labor input. This doctoral thesis makes use of annual time series data from 1960 to 2013. The vector autoregressive model was employed by the study. The study's findings demonstrated the influence of road infrastructure investment, ICT stock, and labor input, all of which continue to have a favorable relationship with economic growth.

Saidi et al. (2018) examined the influence of transportation energy consumption and transportation infrastructure on economic development using panel data from MENA nations (the Middle East and North Africa area) from 2000 to 2016. They discovered, using the Generalized Method of Moments (GMM), that transportation energy use contributes considerably to economic development in the MENA, N-GCC, and MATE areas. Transportation infrastructure boosts economic growth in all locations.

Ng et al. (2019) investigated the relationship between infrastructure development and economic growth. They employed and annual panel data from 1980 to 2010 using fixed effects model for empirical analysis of the study. The results showed that the growth in road length per thousand population, per capita exports, per capita education expenditure, physical capital stock per worker contributed positively to economy growth.

Over a 20 period of fast income development, Banerjee et al. (2020) examined the influence of access to transportation networks on regional economic outcomes in China. Their findings indicated that proximity to transportation networks has a somewhat large positive causal influence on per capita GDP levels across sectors but has no effect on per capita GDP growth.

Studies found a negative relationship: Fedderke et al. (2006) analyzed the relationship between investment in economic infrastructure and long run economic growth in South Africa . The results revealed that investment in infrastructure does appear to lead economic growth in South Africa. There is weak evidence of feedback from output to infrastructure, while the finding of an infrastructure growth impact is robust.

3 RESEARCH METHODOLOGY

This present study examines the empirical relationship between infrastructure, population, and economic growth in South Africa across provinces. There are three possible to be used in the present study such Fixed Effects model, Random effects, and Cross Seemingly Unrelated regression. Therefore, in this case the Durbin Watson test is used to trace for serial correlation, then the model with large Durbin Watson statistics which is very close to 2 will be used for regression analysis for infrastructure, population, and economic growth in South Africa. The variables under the study are exposed to unit root test using Levin et al. (2002) , Im et al. (1997) and ADF-Fisher unit root tests. The normality in the variables will be tested using Jarque-Bera statistics and the study also use cross section dependence test to detect the cross-sectional dependence between the disturbances. The study further employed granger causality test to examine the short run causality between the variables.

3.1 Model specification

The model specification to investigate the relationship between infrastructure, population, and economic growth through their potential determinants is based on the simple multivariate framework where the correlation is presented as follows:

$$LNGDP_t = B_0 + B_1 LNPGE_{it} + B_2 LNINFRA_{it} + B_3 LNUNEMP_{it} + B_4 LNPOP_{it} + e_{it}$$

Where:

LNGDP = Logged gross domestic product

LNPGE = Logged provincial government expenditure

LNUNEMP = Logged unemployment rate

LNIFRA = Logged infrastructure (municipalities with infrastructure to provide services)

LNPOP = Logged population

e_{it} = Error term

All the variables in the model are transformed into logarithmic form to reduce the variation in data set, and to ensure that outliers are removed in the data points. The variables under the study are adopted from different studies in the existing empirical literature, studies like Weinhold and Reis (2001), Esfahani and Ramírez (2003), Beyzatlar and Kustepeli (2011), Ng et al. (2019), etc.

3.2 Data source

The present study uses an annual panel data to scrutinize the relationship infrastructure, population, and economic growth in South Africa from 2006 to 2019. The data set for the variables is collected from different sources, such as GDP, infrastructure, population, and provincial government expenditure are collected from StatsSA, and unemployment is collected from Quantec. Table 1 below present the description of the variables, and table 2 presents the unit roots tests.

Table 1: description of the variables

Variables	Description	Unit of measurement	Frequency	source
$LNGDP_t$	gross domestic product	R million	Annual	StatsSA
$LNPGE_t$	provincial government expenditure	R million	Annual	StatsSA
$LNUNEMP_t$	Unemployment rate	Percentages	Annual	StatsSA
$LNINFRA_t$	Infrastructure	Units	Annual	Quantec
$LNPOP_t$	Population	Million	Annual	StatsSA

Source: Quantec & StatsSA

Table 2: Unit root test

	LLC		IPS		ADF - Fisher	
	Constant	Constant& Trend	Constant	Constant& Trend	Constant	Constant& Trend
	Level	Level	Level	Level	Level	Level
$LNGDP_t$	-7.17833***	-1.41980*	-2.24753**	2.33160	0.0187**	10.0531
$LNPGE_t$	-10.2808***	-1.07683	-4.36742**	1.91616	53.7788***	6.76124
$LNUNEMP_t$	2.65891	-5.20517***	3.06815	-1.45770*	8.77390	26.0121*
$LNINFRA_t$	-2.54660***	-3.59538***	0.70841	0.3856	18.1801	19.3745

$LNPOP_t$	-5.40557***	-3.81920***	0.15013	-1.78337**	21.8793	33.3970**

Source: Authors' computation: The variables are statistically significant at (*), (**), (***) represent 10%, 5%, 1% respectively

Table 2 shows the results from Levin, Lin, and Chu and Im, Pesaran, and Shin panel unit root tests and ADF - Fisher performed and the null hypothesis for both tests was rejected at 10% level of significant level. All the variables are stationary at level I(0). The study carried this test to confirm if the variables are integrated of the same order. Therefore, in this paper the variables are integrated at level I(0).

4 EMPIRICAL RESULTS

4.1 Panel Cointegration test

Table 3: Pedroni Cointegration test on infrastructure, population, and economic growth in SA

Method		(t-statistic) Probability
Within dimension/panel statistics	Panel v-statistics	-1.428834
	Panel rho-statistics	1.156862
	Panel PP-statistics	-5.071187***
	Panel ADF-statistics	-3.929897***
Between dimension/group mean statistic	Group rho-statistics	2.798282
	Group PP-statistics	-6.893439***
	Group ADF-statistic	-6.995814***

Source: Authors' computation: The variables are statistically significant at (*), (**), (***) represent 10%, 5%, 1% respectively

Table 3 presents the results from Pedroni (1999) cointegration test, this test is divided into two parts such as within dimension and between dimensions. The null hypothesis of Pedroni cointegration is that there is no cointegration between the variables. The within dimension shows that PP-statistics and ADF-statistics are both significant at 1% level of significant. Therefore, the null hypothesis of no cointegration cannot be accepted and conclude that there is cointegration. V-statistics and rho-statistics are both not significant at any selected significance level. Therefore, there is on cointegration between the variables since the null hypothesis is not accepted. The study cannot conclude that there is a cointegration without testing for between dimension, since the four tests played a draw. The between dimension value of group rho- statistic(2.798282) is statistically insignificant, so there is no cointegration. While Group PP-statistics and ADF-statistics are both significant at 1% level of significant. Therefore, two of three are significant, then we can conclude that there is cointegration between the variables. Aggregating two parts applying majority rule, then the study concludes that there is cointegration since the majority of statistics are significant.

Table 4: Kao cointegration test (Engle Granger Based)

Method		(t-statistics) Probability
	ADF statistics	(-6.519957) 0.0000***
	Residual variance	0.001373

Source: Authors' computation: The variables are statistically significant at (*), (**), (***) represent 10%, 5%, 1% respectively

The results for Kao cointegration test is presented in table 4. The null hypothesis for Kao test is that there is cointegration between the variables. The Kao (1999) cointegration test fails to accept null hypothesis at 1% level of significant. Therefore, the study concludes that there is cointegration between the variables.

4.2. Durbin-Watson Test

The study begins by using DW statistics to check for autocorrelation of the residuals sequence of Fixed effects model (FEM), Random effects model (REM), and Cross section Seemingly Unrelated regression (SUR). The results are presented in table 5. The results reveals that the DW statistic for FEM and REM are far from 2, therefore, this implies that there is autocorrelation exists in the residuals sequence when FEM and REM are used for regression analysis infrastructure, population, and economic growth in South Africa. Whereas the DW statistic for SUR is close to 2, implying that autocorrelation does not exist in the sequence of residuals. Therefore, the study should use SUR technique to investigate the relationship between infrastructure, population on economic growth in South Africa assessing all nine provinces. The Cross section seemingly unrelated regression is a powerful model since it caters for heterogeneity, biasness, and cross-sectional dependence issues.

Table 5: Heteroscedasticity test of OLS models in the provincial level in South Africa

Estimated models	DW-statistics	Conclusion
Random Effects model	DW = 0.652009	Autocorrelation exists
Fixed Effects model	DW = 1.047064	Autocorrelation exists
Seemingly Unrelated regression	DW = 1.564146	Autocorrelation does not exist

Source: Authors' computation: The variables are statistically significant at (*), (**), (***) represent 10%, 5%, 1% respectively

4.3 Model Estimation

Table 6: Cross-section Seemingly Unrelated regression on infrastructure, population, and economic growth in SA provinces

Variables	Coefficients	Std. Error	t-Statistics	Prob.
LNINFRA	-0.338224	0.013447	-25.15224	0.0000
LNPGE	0.514192	0.009033	56.92186	0.0000
LNPOP	0.389975	0.011071	35.22370	0.0000
LNUNEMP	-0.013260	0.000775	-17.11586	0.0000
Intercept	-0.799445	0.122353	-6.533914	0.0000

Source: Authors' computation: The variables are statistically significant at (*), (**), (***) represent 10%, 5%,1% respectively

The long run marginal impacts are presented in Table 6 by Cross-section Seemingly Unrelated regression with LNGDP as a dependent and LNINFRA, LNPGE, LNPOP, and LNUNEMP are the explanatory variables. The results show that infrastructure services has a negative statistically significant effect on gross domestic product in South Africa at 1% level of significant. When keeping other variables constant, a 1% increase in infrastructure services leads to 0.34% decline in gross domestic product. These results are consistent with the results found by (Fedderke et al., 2006). The results further revealed that provincial government expenditure has a positive significant relationship with gross domestic product in South African provinces at 1% level of significant. A 1% increase in provincial government expenditure leads to 0.51% increase in gross domestic product. Nonetheless, the results from Cross-section Seemingly Unrelated regression demonstrates that population at provincial level in South Africa has a positive and statistical relationship with gross domestic product at 1% level of significant. A 1% increase in population leads gross domestic product to increase by 0.39%. These results are consistent with the results found by Beyzatlar and Kustepeli (2011) and with the Kremer (1993) model. Furthermore, the results showed that unemployment has a negative and statistical relationship with gross domestic product in the long run. A 1% increase in unemployment leads to 0.80% decrease in gross domestic product.

4.4 Cross Section Dependence Test

When the number of cross-sectional units is large, it is more likely that the model will have an existence of panel cross sectional independence between residuals. The presence of cross-sectional dependence could severely impact the model leading to high level of inefficient estimators and misleading results. The null hypothesis for cross-section dependence test is that there is no cross-sectional dependence between the residuals. The present study uses Breusch-Pagan LM (Breusch & Pagan, 1980) because it is good and powerful when the time period (T) is greater than the cross-sectional dimension (N), while Pesaran CD by Pesaran (2004) is perfect when either N is big or small (Sarafidis et al., 2009). The results indicate that the null hypothesis cannot be rejected since the probability of Breusch-Pagan LM and Pesaran CD are greater than 5%. Therefore, the study concludes that there is a cross-sectional independence between the cross-sectional units. Meaning that South African provinces are functioning independently of each other.

Table 7: Cross section dependence on SA provinces

Test	Statistics	d.f	Prob
Breusch-Pagan LM	13.32157	36	0.9998
Pesaran scaled LM	-2.672678		0.0075
Pesaran CD	0.439237		0.6605

Source: Authors' computation: The variables are statistically significant at (*), (**), (***) represent 10%, 5%, 1% respectively

4.5 Panel Causality

Table 8: Pairwise Granger causality test

Null Hypothesis	Obs	F-Statistics	P-Value
LNINFRA does not granger cause LNGDP	108	0.17416	0.8404
LNGDP does not granger cause LNINFRA		2.06571	0.1319
LNPGE does not granger cause LNGDP	108	4.19614	0.0177
LNGDP does not granger cause LNPGE		7.65236	0.0008
LNPOP does not granger cause LNGDP	108	21.9138	0.0000
LNGDP does not granger cause LNPOP		7.19153	0.0012
LNUNEMP does not granger cause LNGDP	108	0.15460	0.8570
LNGDP does not granger cause LNUNEMP		8.98444	0.0003
LNPGE does not granger cause LNINFRA	108	1.94440	0.1483
LNINFRA does not granger cause LNPGE		0.25594	0.7747
LNPOP does not granger cause LNINFRA	108	3.26480	0.0422
LNINFRA does not granger cause LNPOP		0.16245	0.8503
LNUNEMP does not granger cause LNINFRA	108	2.25771	0.1097
LNINFRA does not granger cause LNUNEMP		2.04162	0.1350
LNPOP does not granger cause LNPGE	108	15.7061	0.0133
LNPGE does not granger cause LNPOP		7.94716	0.0006
LNUNEMP does not granger cause LNPGE	108	4.51014	0.0133
LNPGE does not granger cause LNUNEMP		0.23958	0.2667
LNUNEMP does not granger cause LNPOP	108	3.09361	0.0496
LNPOP does not granger cause LNUNEMP		1.33881	0.2667

Source: Authors' computation: The variables are statistically significant at (*), (**), (***) represent 10%, 5%, 1% respectively

The study further employed granger causality test that was proposed by Granger (1969) to investigate the causal effect between the variables. Based on the previous table, the following conclusions may be drawn about the direction of the short-run causality amongst the variables in the model. LNINFRA does not granger cause LNGDP, independently, at 1%, 5%, and 10% level of significant, meaning that in the short-run, movements in infrastructure services have an insignificant effect on the level Fixed gross domestic product. LNPGE does granger cause LNGDP, bidirectional, at 1% level of significant, meaning that in the short-run, movements in the Provincial government expenditure have a significant effect on the level Gross Domestic Product. LNPOP does granger cause LNGDP, bidirectional, at 1% level of significant, meaning that in the short-run, movements in the population have a significant effect on the level Gross Domestic Product. LNGDP does granger cause LNUNEMP, unidirectional, at 1% level of significant, meaning that in the short-run, movements in the gross domestic product have a significant effect on the level unemployment.

LNPGE does not granger cause LNINFRA, independently, at 1%, 5%, and 10% level of significant, meaning that in the short-run, movements in the Provincial government expenditure have an insignificant effect on the level infrastructure. LNPOP does granger cause LNINFRA, unidirectional, at 5% level of significant, meaning that in the short-run, movements in the Population have a significant effect on the level infrastructure. LNUNEMP does not granger cause LNINFRA, independently, at 1%, 5%, and 10% level of significant, meaning that in the short-run, movements in the unemployment have an insignificant effect on the level infrastructure. LNPOP does granger cause LNPGE, bidirectional, at 1% level of significant, meaning that in the short-run, movements in the population have a significant effect on the level provincial government expenditure. LNUNEMP does granger cause LNPGE, unidirectional, at 1% level of significant, meaning that in the short-run, movements in the unemployment have a significant effect on the level provincial government expenditure. LNUNEMP does granger cause LNPOP, unidirectional, at 5% level of significant, meaning that in the short-run, movements in the unemployment have a significant effect on the level population.

4.6 Normality test

According to Jarque and Bera (1980) normality refers to the property of the time series residual data being normally distributed. The Jarque-Bera is the test statistic that evaluates the normality at the null hypothesis. The p-value is greater than 5% as shown in Table 8 below, therefore we fail to reject null hypothesis and conclude that the residuals are normally distributed.

Table 9: Jarque-Bera

Test	F-statistics	P-value	Conclusion
Normality test	0.0996337	0.952973	Cannot reject nullhypothesis

Source: Authors' computation: The variables are statistically significant at (*), (**), (***) represent 10%, 5%, 1% respectively

1 CONCLUSION

The existing literature gives strong evidence that infrastructure and population growth lead to economic growth. To further enlarge the literature, this study investigates the correlation between infrastructure and population on economic growth in the case of South Africa using Cross-section Seemingly Unrelated regression from 2006 – 2019. The annual panel data from 9 provinces in South Africa was used to archive the objectives of the of the present study. The study used the following variables such as gross domestic product as a dependent variable, provincial government expenditure, population, infrastructure, and unemployment rate.

The results obtained by the study show that there is a negative and significant relationship between infrastructure services and economic growth in the long run. Provincial government expenditure was found to have a positive and significant relationship with economic growth. The population was found to be positively and significant related to economic growth in South Africa in the long run. Furthermore, the study found that unemployment and economic growth have a negative and significant relationship.

In reference to the empirical results of this study, it can therefore be suggested that: Firstly, the study obtained bad results about infrastructure as a driving force towards economic growth. One of the reasons for infrastructure to be a problem in South Africa is that there is a lack of clarity and consistency of national objectives and standards. Lack of transparency makes it difficult for local governments and private sector infrastructure providers to combine their investment with those of the federal government. complementary private sector investment may also be delayed or less effective.

Secondly, lack of coordination in the development of national instruments and inconsistent implementation of national objectives. Inadequate central direction on objectives for economic, social, and environmental resource management makes responding to ad hoc requests to produce national environmental standards problematic. It also creates uncertainty for local governments, sectors, and decision makers, and it may mean that important government infrastructure outcomes in resource management are not met.

Lastly, empirical results suggest that South Africa should continue to have a large population growth as it shows a positive impact on economic growth. However, the study's findings reveal a decline in infrastructure development in South African provinces as the population grows. As a result, fast and often unplanned population increase is frequently coupled with population demands that exceed infrastructure and service capacity, resulting in environmental deterioration. As a result, it is advised that, as the population grows, the South African government, with the help of private sector firms, invest in railways, roads, and other infrastructure projects to sustain and expand infrastructure development.

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