

PUBLIC MEETS PRIVATE: UNRAVELING THE DYNAMICS OF INFRASTRUCTURE INVESTMENT IN SOUTH AFRICA

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ABSTRACT

Private investment plays a pivotal role in job creation and economic growth. Given its importance, this study scrutinised the dynamics of how public investment, particularly in critical infrastructures, either complements or competes with private investment. The study delved into the intricate relationship between private investment and government-led investment in critical infrastructure in health and electricity generation in South Africa. Quarterly time series data from 2006Q2 to 2023Q2 were used while adopting the autoregressive distributed lag (ARDL) technique. According to the econometric analysis, government spending in health and electricity generation complements private investment. The effects of the investment in the critical infrastructure variables on the ratio of private investment to GDP are quite low, although highly statistically significant. The findings underscore the importance of well-targeted infrastructure investments in driving private-sector development. Overall, this comprehensive analysis contributes to understanding the complex dynamics between public and private investments in the context of critical infrastructure development in South Africa. The findings of this study are essential for policymakers, investors and researchers seeking to enhance the effectiveness of economic policies and foster sustainable economic development in the country.

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1. INTRODUCTION

The economic development of a country hinges significantly on domestic and, more specifically, private investment. Private investment, influenced by a myriad of factors, including infrastructure and infrastructure investment ([Molapo and Damane, 2015](#); [Batu, 2016](#)), plays a pivotal role in job creation and economic growth. It is important to note the difference in these terms within the

broader context of economic development. “Infrastructure” encompasses vital physical structures necessary for a country’s operation, such as transportation, water, power, energy and telecommunication infrastructures. On the other hand, “infrastructure investment” involves the allocation of financial resources for the planning and maintenance of these structures. Such investment is a crucial step towards building a robust economy and is a key determinant of economic performance.

While various entities, including governments, private enterprises and international organisations, contribute to funding infrastructure investments ([Global Infrastructure Hub, 2023](#)), this study focused on government-led infrastructure investment in South Africa. The impact of such investment on economic development is substantial, not only generating jobs during the construction phase but also laying the groundwork for sustained economic growth. Well-planned infrastructure investments can attract additional investments, stimulate economic activity and enhance a country’s overall competitiveness. In addition to different examples of public infrastructure, there are also different types of infrastructure, such as soft infrastructure, hard infrastructure and critical infrastructure. Soft infrastructure includes education, law and order; hard infrastructure includes transport and communication services, while critical infrastructure is regarded as being crucial to the functioning of an economy and includes energy, public health and drinking water.

Therefore, we ask the question, why the focus on private investment? The private sector’s contribution to total gross fixed capital formation in South Africa, as depicted in Figure 1, underscores its pivotal role in the country’s economy. It is thus imperative to scrutinise how public investment in critical infrastructure influences growth in this sector’s investment. This study aimed to investigate the impact of investment in critical infrastructures that would be economically significant determinants of private investments – specifically, total expenditures on health and available electricity – on private investment in South Africa. It is believed that for an economy to benefit from long-term capital flows, conditions such as sufficient infrastructure and human capital, among others, are required ([Bengoa and Sanchez-Robles, 2003](#); [Ahmed et al., 2018](#)). Investment in water and sanitation does not have a clear supporting logical influence on private investments.

Furthermore, South Africa’s labour market is characterised by diverse working hours and varying levels of labour productivity across different sectors and genders, where men typically work an average of four hours longer per week than women, according to the Statistics South Africa Labour Market Dynamic report

(Statistics South Africa, 2022). South Africa’s Basic Conditions of Employment Act provides for a minimum of 30 days of paid sick leave over a three-year cycle. Meanwhile, frequent or extended sick leave can negatively affect labour productivity by reducing the available workforce or by increasing the workload on remaining employees. Investing in healthcare in the long term can help to decrease the number of registered sick days and increase labour productivity. South Africa has therefore embarked on several successful health infrastructure projects, including the recent National Health Insurance Bill that the National Assembly passed in May 2024, which is intended to improve healthcare service delivery and socioeconomic development.

Among the many factors that determine private investment, a major influential variable is public investment, in this case, the investment in infrastructure (Bengoia and Sanchez-Robles, 2003; Adugna, 2013; Hailu and Debele, 2015). In examining the relationship between public and private investments, the complexity of their interaction is acknowledged. Public investment, particularly in infrastructure, can either crowd in or crowd out private investment, depending on the specific dynamics. Crowd-in private investment occurs when public investment positively affects private investment, and crowd-out private investment occurs when public investment adversely affects private investment (Eduardo and Christian, 2011; Nyoni and Bonga, 2017).

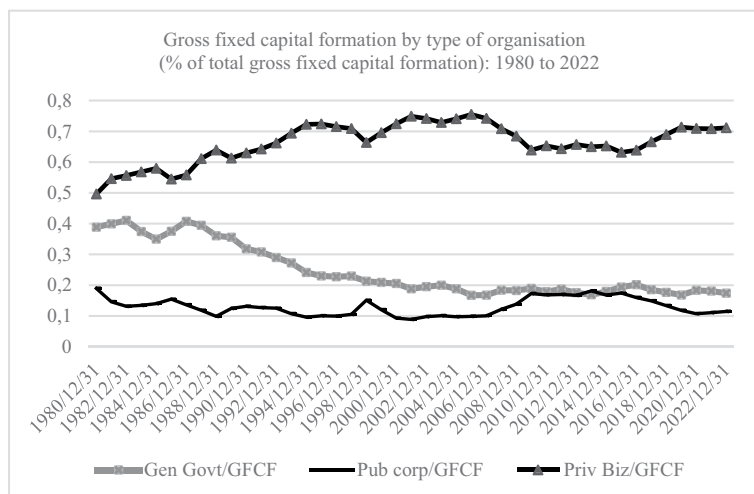


Figure 1: Share of general government, public corporation and private business investments as a percentage of total gross fixed capital formation
Source: Author’s compilation from [SARB Quarterly Bulletin, 2023](#)

Furthermore, the establishment of the Infrastructure South Africa (ISA) programme in May 2022 underscores the country's commitment to accelerate infrastructure investment projects. This initiative aligns with the National Infrastructure Plan 2050 (NIP 2050), emphasising the public sector's role in driving economic development through increased employment (Government Gazette, 2022). Infrastructure plays a crucial role in shaping the investment landscape of South Africa by directly influencing private investment patterns.

However, it is important to highlight South Africa's legal and regulatory barriers to public-private infrastructure investment. The environment for infrastructure investment is governed by multiple overlapping statutes, which lead to many challenges, such as complex and fragmented regulations, cumbersome approvals, procurement bottlenecks and uncertainty in the legal procedures. For instance, the public-private partnership regulations (2004, updated 2017) under the National Treasury provide the framework for procedures, procurement, contracting, monitoring and compliance concerning all projects carried out. These sometimes lead to delays as a result of the multiple layers of approval, lack of harmonisation and procurement requirements, which are inconsistent, thereby frustrating and discouraging private investors.

Furthermore, in many instances, the approval processes are slow, which can take years. There are constraints in the regulations of some sectors, for instance, the delay in the energy sector, whereby the regulatory delays by the National Energy Regulator of South Africa (NERSA) have slowed the Independent Power Producer (IPP) approvals. In general, these legal and regulatory issues lead to increased transaction costs and extension of the project timeframes, among others, thereby dampening the private investment and limiting the effectiveness of the government spending in crowding in private investment.

Figure 2 illustrates the trend in private investment as a percentage of gross domestic product (GDP) from 1980 to 2022. Private investment declined by about 6 per cent during the same period, with the highest increase of over 18 per cent reported in December 1981. There was also an uptick in December 2008, after the onset of the global financial crisis, and just before it ended in June 2009 ([The Wall Street Journal, 2008](#)). Recognising the decline in private investment over certain periods, especially after the global financial crisis of 2008, where it did not increase beyond 16 per cent, prompted an investigation into the factors influencing this movement.

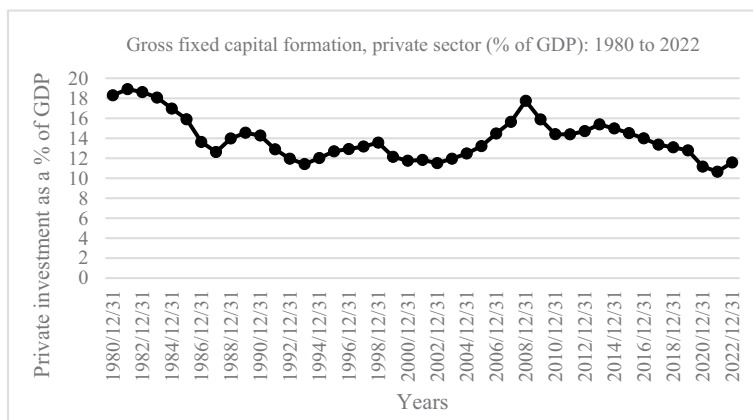


Figure 2: Trend in private investment (as a percentage of gross domestic product)
Source: Author’s compilation from [SARB Quarterly Bulletin, 2023](#)

Some of the factors contributing to the movement in private investment could be attributed to government spending. The study thus identified two major critical infrastructure investments – healthcare and electricity generation – as focal points for analysis. The study aimed to answer the following three questions: 1) Does government investment in each of these critical infrastructures complement or compete with private investment in South Africa? In other words, is government spending crowding in promoting the expansion and development of the private sector, or is it crowding out private investment in South Africa? 2) To what extent do changes in interest rates influence the percentage of private investment to GDP? Lastly, 3) Does the acceleration theory hold for South Africa?

2. LITERATURE REVIEW

Drawing on economic theories related to infrastructure investment and private investment, this section of the paper will first provide a theoretical foundation for understanding the interconnectedness of infrastructure investment and private investment. This will be followed by a review of existing literature highlighting empirical evidence of the link between critical infrastructure investment and private investment.

The availability of infrastructure creates a conducive environment for investment flow. Also, based on existing literature, domestic investment plays a crucial role in a nation’s economic growth by helping to develop the economy through capital formation ([Yousaf and Naila, 2018](#)). According to [Wai and Wong \(1982\)](#), a large component of government investment is concentrated on infrastructure

projects in most developing countries. This is because the creation of special infrastructure facilities by the government for transport, health, electric power, irrigation, etc. will reduce the cost of production or increase the returns to scale, thereby increasing the profitability for private investors.

According to the Keynesian and neoclassical schools of thought, the former assume that there is crowding in of private investment in the economy, while the latter believe that government spending will crowd out private investment. The Keynesians suggest that given an expansionary fiscal policy, whereby the government increases its spending and introduces a tax cut, the country's output level will increase. Thus, Keynesian theorists assert that an expansionary fiscal policy will cause an increase in the private sector through the multiplier effect ([Şen and Kaya, 2014](#); [Omojolaibi, Okenesi & Mesagan, 2016](#)).

Meanwhile, the neoclassical theorists suggest that given an expansionary fiscal policy, the government will borrow to finance its spending. This will lead to an increase in interest rates, thus resulting in less funds available for private-sector consumption and investment, which means that government spending will crowd out private investment ([Sineviciene & Vasiliauskaite, 2012](#)). Contrary to both the neoclassical and the Keynesian approaches, the Ricardian Equivalence hypothesis assumes that there is no relationship between private investment and government spending. The proponents of this theory argue that the revenue from tax funds most of the government spending, and when there is a budget deficit, individuals and the private sector will continue to maintain their levels of consumption and investment behaviours in the economy ([Omitogun, 2018](#)).

Other theoretical foundations include the theories on sustainable finance, public-private partnerships (PPPs) and economic models of public investment, which are discussed briefly. While the PPPs are long-term cooperative arrangements between the public and private sectors in delivering infrastructure or services and offering a mechanism to leverage private capital and expertise in order to achieve public goals, the economic models of public investment include the endogenous growth theory by [Barro \(1990\)](#) among others. [Barro \(1990\)](#) argued that public investment in infrastructure can enhance private sector productivity by improving the marginal efficiency of capital, leading to crowding in private investment.

On the empirical front, [Perkins, Fedderke and Luiz \(2005\)](#) carried out a study in South Africa to observe the long-term trend of the following economic infrastructure, namely railways, roads, ports, air travel, telephone lines and electricity on economic growth, using the [Pesaran, Shin and Smith \(2001\)](#) F-test approach to determine the direction of the association. They found that economic

infrastructure is important for promoting adequate economic growth. The study emphasised the importance of the maintenance and expansion of infrastructure to support economic activity in a growing economy. However, the study by [Maluleke, Odhiambo & Nyasha \(2023\)](#) investigated the linear and non-linear impact of public investment on private investment in South Africa using annual data spanning the period from 1980 to 2018. The study used autoregressive distributed lag (ARDL) and non-linear autoregressive distributed lag (NARDL) techniques. While the public investment was not disaggregated over different infrastructure and non-infrastructure spending, the study used per capita GDP to proxy economic growth. [Maluleke, Odhiambo & Nyasha \(2023\)](#) found that public investment has an asymmetric effect on private investment in South Africa, with negative shocks leading to a decrease and positive shocks resulting in an increase in private investment in both the short and long run.

[Ahmed et al. \(2018\)](#) analysed the critical importance of energy infrastructure for domestic investments in Nigeria, using annual data spanning from 1980 to 2016, and adopting the autoregressive distributed lag (ARDL) technique. The study found that although public investment crowds in private investment, this is statistically insignificant. Thus, there is a positive but insignificant effect of energy infrastructure on domestic investment. The study suggested that the result is due to the non-professional execution of government spending on energy infrastructure through the diversion of funds to private purses. However, another possible reason could be the proxy used for the energy infrastructure, namely the electricity consumption rate, since Nigeria suffers from inadequate electricity supply; hence, there is low consumption of energy. Another study demonstrating the crowding-in effect of public investment on private investment was conducted by [Abdulkarim and Saidatulakmal \(2021\)](#), who examined the effects of fiscal policy on private investment in Nigeria. The study used the ARDL technique and data from 1980 to 2017.

[Yousaf and Naila \(2018\)](#) carried out a study to investigate the effect of the following infrastructure, namely telephone lines and length of roads, along with other control variables, on domestic investment in Pakistan, using annual data from 1975 to 2013 while adopting the ARDL technique. Their results showed that infrastructure has a generally positive and significant effect on domestic investment. Although the telephone lines variable was insignificant in the long run, it remained significant in the short run. Thus, public investment crowds in private investment in Pakistan. Conversely, the study by [Abbas and Ahmed \(2019\)](#) found that public investment crowds out private investment while using the vector error correction model (VECM) technique to analyse the relationship between private domestic investment and public investments in Pakistan, using

data from 1960 to 2015. The same result was obtained by [Mohanty \(2019\)](#), who investigated the impact of fiscal deficit on private-sector investment in India. The study found that fiscal deficit crowds out private investment both in the long run and in the short run. The study adopted the ARDL technique for the analysis and used data from 1970/71 to 2012/13. Meanwhile, the study by [Akber et al. \(2020\)](#) found that public investment crowds in private investment both in the long and short run in India, using the data from 1970 to 2016 and the NARDL technique.

The study by Bakare (2011) used annual data from 1978 to 2008 and the error correction model (ECM) to analyse the determinants of private domestic investment in Nigeria. The study found, among others, political instability and infrastructure, proxied by power supply, as the major determinants. The results show that public investment crowds out private investment, as shown by the negative effect of public investment in infrastructure on private investment. Likewise, [Naa-Idar, Ayentimi & Frimpong \(2012\)](#) found that government investment spending has a crowding-out effect where public investment negatively affects private investment in Ghana; this indicates competition for resources between the public and private sectors. The study by [Mose, Jepchumba & Ouru \(2020\)](#) examined the macroeconomic determinants of private domestic investment behaviours in Kenya, Rwanda and Burundi over the period from 2009 to 2018. They found that public investment crowds out private investment in these countries, as it exhibits negative and significant effects on private investment.

Several studies highlight the importance of economic infrastructure in fostering growth and private investment. However, the gap in the literature, which the current study aimed to fill, pertains to the lack of research examining the effects of critical infrastructure investment on private investment in South Africa.

3. DATA AND METHODOLOGY

3.1 Discussion of data and data sources

This study adopted quarterly data from 2006Q2 to 2023Q2, with over 60 observations. Quarterly data were used because the annual series on the variables of interest were only available from 2007, making 16 observations, which was not enough to estimate. The private sector investment-interest rate nexus has its origin in the classical and financial liberalisation theories ([McKinnon, 1973](#); [Shaw, 1973](#)). The classical theorists argue that interest rates are negatively related to private investment. The hypothesis in classical theory is that the rate of

interest represents the cost of credit for investment. Therefore, private investment is expected to rise in response to falling interest rates, signifying an inverse relationship. The theory of financial liberalisation takes the opposite view by asserting that higher interest rates have a net positive effect on investment through saving – an effect that the proponents refer to as the “conduit effect”. Increases in interest rates are expected to elicit more savings, which ultimately stimulate investment. Thus, a positive relationship is assumed between interest rates and investment. Based on the “accelerator effect”, the change in gross domestic product or output, GDP growth, is one of the major determinants of investment, and it is expected to have a direct relationship with private investment.

The dependent variable is the ratio of private investment to the gross domestic product (GDP), PRV_GDP . The independent variables, which represent the investment in critical infrastructure, are total government expenditure on healthcare as a percentage of total domestic investment, $HEALTH$, and electricity generated and available for distribution, measured in gigawatt hours, $ELECT$, used as the government investment in electricity. Electricity generated and available for distribution is often used as a proxy for investment in energy infrastructure. This is because it reflects the outcomes of capital expenditures in power generation, transmission and distribution. Also, the investment in energy infrastructure normally translates into increased power generation capacity and improved transmission and distribution networks. For instance, previous studies have used this proxy, and South Africa’s Renewable Energy Master Plan initiative links the generation and distribution capacity with explicit infrastructure investments (Khonjelwayo and Nthakheni, 2020; GreenCape, 2021:6, 66).

Although some limitations exist, empirical evidence and case studies strongly support electricity generated and available for distribution as a key indicator of energy sector investment. Some of the limitations are increasing electricity demand due to fuel or coal shortages, or to weather conditions, placing strain on the existing infrastructure. This results in increased generation and distribution independently of infrastructure investment. However, since data on government spending on electricity is lacking, electricity generation and distribution metrics are a good proxy for infrastructure investment because they reflect the direct impact of capital spending on electricity generation capacity and distribution efficiency.

Furthermore, investment in the energy infrastructure in South Africa has a direct impact on electricity generated and available for distribution. The government has increased investment in some key areas, such as the construction of Medupi and Kusile coal-fired power stations intended to increase electricity generated and

distributed. The Renewable Energy Independent Power Producer Procurement Programme is an investment in renewable energy, which has brought private sector investment to increase electricity generation and distribution through solar and wind generation capacity.

The control variables are GDP growth (GDPg), lending rate measured in percentage per annum, INT, and the ratio of total debt-to-GDP, DEBT. To understand the effects of GDP growth (the accelerator principle) on private investments, it is important to present data on the structure of GDP according to the expenditure method, as shown in Figure 3. Consumer spending is the highest, followed by net exports, while capital investment and government spending were quite close in some years, with the latter generally increasing more over the period under consideration. However, government spending increased significantly in 2023. This was due to the increased budget for infrastructure investment to address, especially, the challenges of persistent power cuts and a focus on improving deteriorating infrastructure, funding for the COVID-19 social relief of distress grant, and public sector wage increases, among others (Godongwana, 2023).

The study used the lending rate instead of combining it with the savings rate because of the correlation that exists between them. Higher savings lead to an increase in loanable funds, thereby lowering interest rates and encouraging more private investment. On the other hand, lower savings lead to higher interest rates, since there is a decline in loanable funds and thus less investment. Therefore, there is a direct effect of interest rates on private investment, rather than the indirect effect from savings via interest rates; hence, the choice of interest rate over savings rate.

The total debt-to-GDP ratio is an indicator of external indebtedness, which is also important in the interpretation of public investments through the crowding-in or crowding-out effect. The debt-to-GDP ratio can either cause a reduction or an enhancement in private investment. For instance, increased government borrowing can lead to competition for loans, thereby raising interest rates, and this can adversely affect private firms that depend on external financing, thus leading to a crowding-out effect. Meanwhile, deficit spending during a recession boosts aggregate demand and creates opportunities for the private sector to take advantage of the situation, thus producing a crowding-in effect.

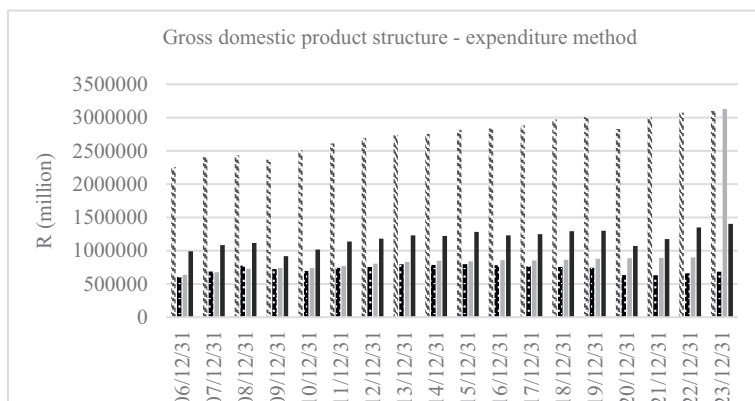


Figure 3: Gross domestic product: expenditure method
Source: Author’s compilation from [SARB Quarterly Bulletin, 2023](#)

The study could not include the effects of political systems because this variable is not available quarterly, and we needed quarterly data to observe the effects on a more frequent basis and to be in line with the variables of interest. Data on total government expenditure on healthcare were sourced from the National Treasury database via Quantec. Data on electricity generated and available for distribution were obtained from Statistics South Africa (StatsSA). The lending rate was sourced from the International Financial Statistics database of the International Monetary Fund, while the ratio of private investment to the gross domestic product, GDP growth and total debt-to-GDP ratio were obtained from the South African Reserve Bank quarterly data bulletin.

However, for a robustness check, the study used a composite business confidence index that reflects the expectations of businesses regarding economic growth and their ability to produce goods and services, as well as cost implications. The variable was sourced from the Rand Merchant Bank/Bureau of Economic Research (RMB/BER) Business Confidence Index (BCI), which indicates *the percentage of businesspeople who are satisfied with prevailing conditions*. An uncertain political environment can lead to the deterioration of business confidence, thus producing negative effects on the economic environment. The instabilities arising from the political scene are associated with uncertainties regarding the functioning of institutions. Hence, the uncertainty related to the political system affects the business environment, which entrepreneurs must consider when deciding, for instance, to start or expand their businesses ([Montes and Nogueira, 2022](#)).

As earlier discussed, the expected relationship between the investments in the two critical infrastructures and private investment can either be positive or

negative, depending on whether public investment crowds in or crowds out private investment, thereby answering the first research question. The interest rate is also expected to affect private investment either positively or negatively, based on the different theories of interest rate-investment nexus, as discussed earlier, thus dealing with the second research question. Lastly, based on the accelerator effect, GDP is expected to have a direct and positive effect on private investment, which relates to the third research question.

3.2 Estimation techniques

The model and the variables defined earlier are as follows:

$$PRV_GDP_t = f (HEALTH_t, ELECT_t, GDP_{gt}, INT_t, DEBT_t) \dots\dots\dots\{1\}$$

ELECT in equation 1 was transformed to logarithms to avoid its being an outlier; the other variables are ratios and growth, so there was no need to log them. Therefore, the log equation model to be estimated is as follows:

$$PRV_GDP_t = \beta_0 + \beta_1HEALTH_t + \beta_2logELECT_t + \beta_3GDP_t + \beta_4INT_t + \beta_5DEBT + \varepsilon_t \dots\{2\}$$

The popular autoregressive distributed lag (ARDL) of the bounds test approach, developed by Pesaran, Shin & Smith (2001), was used to determine the short-run and long-run relationships. Thus, the study first tested all the variables for stationarity, using the Phillips-Perron (PP) test of stationarity. This was done to determine the orders of integration of each variable, since ARDL is sensitive to I(2) variables. The study also estimated the coefficients and effects of the long-run and short-run dynamics of the variables of interest on private investment. The ARDL approach is based on estimating the model using the ordinary least square (OLS) method of a conditional unrestricted error correction model (UECM) for cointegration. One of the many advantages of the bounds testing method of cointegration and the ARDL approach is that it is not compulsory to perform a stationarity test; nevertheless, the variables must not be of order two, I(2). This technique is applicable whether variables are purely I(1) or a combination of I(0) and I(1). However, if they are a combination of I(0) and I(1), the dependent variable must be I(1).

Another advantage of the ARDL technique, besides its statistical properties, is that estimations can be carried out even in the presence of endogeneity of the explanatory variables. The problem of endogeneity is common in growth models because they include the lags of both the dependent and explanatory variables. In addition, the ARDL technique is a powerful tool used to investigate both short-

run and long-run cointegrating relationships among variables (Leshoro and Wabiga 2023; Pesaran, Shin & Smith (2001).

The conditional ARDL private investment model for equation 2 is therefore expressed as follows:

$$\begin{aligned} \Delta PRV_GDP_t = & \gamma_0 + \sum_{i=1}^n \alpha_1 PRV_GDP_{t-i} + \sum_{i=0}^n \gamma_1 HEALTH_{t-i} \\ & + \sum_{i=0}^n \gamma_2 \Delta \log ELECT_{t-i} + \sum_{i=1}^n \gamma_3 \Delta GDP_{g(t-i)} \\ & + \sum_{i=0}^n \gamma_4 INT_{t-i} + \sum_{i=0}^n \gamma_5 DEBT_{t-i} + \beta_0 PRV_GDP_{t-1} \\ & + \beta_1 HEALTH_{t-1} + \beta_2 ELECT_{t-1} + \beta_3 GDP_{t-1} + \beta_4 INT_{t-1} \\ & + \beta_5 DEBT + \varepsilon_t \end{aligned} \dots\dots\dots\{3\}$$

In equation 3, Δ represents the first difference, the short run and long run elasticities are $\alpha_1, \gamma_1, \dots, \gamma_5$ and β_1, \dots, β_5 , respectively, and ε_t is the error term.

The null and alternative hypotheses, which indicate the existence or non-existence of a long-run relationship are as follows:

$$H_0: \beta_0 = \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = 0$$

$$H_1: \beta_0 \neq \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq 0$$

The F-test was used to determine if cointegration existed among the variables. The interpretation of the cointegration test is as follows: If the computed F-statistic lies between the upper bound and the lower bound at a chosen significant level, there is no decision on whether there is cointegration. If the F-statistic exceeds the upper bound, the null hypothesis of “no cointegration” is rejected, and if it lies below the lower bound, the null hypothesis cannot be rejected. Critical values for lower bound or stationary variables, I(0), and the critical values for upper bound or variables integrated of order one, I(1), were developed by Pesaran, Shin & Smith (2001).

If cointegration is found, the short-run and the long-run model of equation 3 will be estimated using the standard OLS. This will allow us to obtain the speed of adjustment of economic growth back to equilibrium, as well as the short-run and long-run coefficients. Thus, the error correction model (ECM) is expressed by re-parameterizing equation 3 as follows:

$$\begin{aligned} \Delta PRV_GDP_t = & \gamma_0 + \sum_{i=1}^n \alpha_1 \Delta PRV_GDP_{t-i} + \sum_{i=0}^n \gamma_1 HEALTH_{t-i} + \sum_{i=0}^n \gamma_2 \Delta \log ELECT_{t-i} \\ & + \sum_{i=1}^n \gamma_3 \Delta GDP_{g(t-i)} + \sum_{i=0}^n \gamma_4 \Delta INT_{t-i} + \sum_{i=0}^n \gamma_5 \Delta DEBT_{t-i} + \delta ECT_{t-1} \end{aligned} \dots\dots\dots\{4\}$$

The coefficient of the error correction term (ECT), δ , measures the short-run speed of adjustment back to the long-run equilibrium. It shows how the private investment deviates from the long-run equilibrium, but gradually returns to its long-run equilibrium path. Therefore, for the economy to adjust to equilibrium, the coefficient of the ECT must be less than one, negative and must be statistically significant (Leshoro, 2020; Chirwa and Odhiambo, 2016). The ECT has a lag of one, which shows the percentage of the speed of adjustment from a shock in the previous period to the present period equilibrium (Mpatane and Eita, 2016).

4. RESULTS

Table 1 provides the descriptive statistics of the variables. Over the period under consideration, all the explanatory variables exhibited higher average, median, maximum and minimum values than did the private investment. On average, government investment in health was higher than its debt-to-GDP ratio, and over 63 000 gigawatt hours of electricity were generated and available for distribution. While the interest rate was about 10 per cent, the economy grew by only 0.4 per cent.

Table 1: Descriptive analysis: 2006Q2 to 2023Q2

	PRV_GDP	HEALTH	ELECT	INT	GDP _g	DEBT
Mean	0.028875	49.49179	63071.49	10.05055	0.436232	43.78986
Median	0.028754	42.32744	63387.00	10.00000	0.480000	42.80000
Maximum	0.035568	116.4253	68605.00	15.50000	13.73000	72.20000
Minimum	0.023581	17.48643	53858.00	7.000000	-16.89000	23.50000
Std. dev.	0.002421	26.65055	2936.445	2.006483	2.755208	15.20463
Skewness	0.201209	0.728144	-0.935108	0.933698	-2.025334	0.443217
Kurtosis	2.980889	2.440454	3.956515	3.821377	31.44979	2.077496
Jarque-Bera	0.466627	6.997365	12.68631	11.96527	2374.171	4.705737
Probability	0.791905	0.030237	0.001759	0.002522	0.000000	0.095096
Sum	1.992370	3414.933	4351933.	693.4881	30.10000	3021.500
Sum sq. dev.	0.000399	48297.11	5.86E+08	273.7663	516.1996	15720.30
Observations	69	69	69	69	69	69

PRV_INV, private investment-to-GDP ratio; HEALTH, total government expenditure on health as a percentage of total domestic investment and ELECT, electricity generated and available for distribution; INT, lending rate; GDP_g, GDP growth; DEBT, the ratio of total debt-to-GDP.

Source: Author’s calculation

Furthermore, kurtosis measures the sharpness (peak) or the tail of a probability distribution, with a value of 3, and the variables, private investment and investments in health and total debt-to-GDP ratio, are close to this peak, while the

kurtosis for the other variables is above this value. This is known as leptokurtic distribution because it has a higher peak (thin bell) and taller (fatter and heavier) tails than a normal distribution.

Table 2 shows the correlation probability of all the variables. The two variables of interest, namely investments in health and electricity generated and available for distribution, are statistically significant at a 1% level of significance, while only electricity generated and available for distribution is positively correlated with private investment. This means that according to the correlation probability results, electricity generated and available for distribution has a positive relationship with private investment. Meanwhile, public investments in health are inversely correlated with private investment.

According to the classical theory and Jorgenson's neoclassical theory of investment, as explained earlier, interest rates are inversely related to private investment, while the conduit effect of financial liberalisation theorists believed that interest rates have a positive effect on private investment. Hence, the correlation probability result supports the financial liberalisation theory with a highly statistically significant result. Although the correlation probability result for the GDP growth supports the acceleration theory, it is not statistically significant.

Table 2: Correlation probability

Variables	PRV_GDP	HEALTH	LOGELECT	INT	GDP _g	DEBT
PRV_GDP	1.000000					
t-Statistic	----					
HEALTH	-0.8127	1.000000				
t-Statistic	-11.4153***	----				
LOGELECT	0.497	-0.6031	1.000000			
t-Statistic	4.6937***	-6.1887	----			
INT	0.7250	-0.6007	0.1855	1.000000		
t-Statistic	8.617***	-6.150696	1.545	----		
GDP _g	0.132	-0.087	0.269	-0.006	1.000000	
t-Statistic	1.086	-0.716	2.289**	-0.047	----	
DEBT	-0.7778	0.9746	-0.6178	-0.6035	-0.0269	1.000000
t-Statistic	-10.130***	35.622***	-6.431***	-6.196***	-0.221	----

PRV_INV, private investment-to-GDP ratio; HEALTH, total government expenditure on health as a percentage of total domestic investment and ELECT, electricity generated and available for distribution; INT, lending rate; GDP_g, GDP growth; DEBT, the ratio of total debt-to-GDP.

** 5%; *** 1%.

Source: Author's calculation

As shown in Table 3, the PP results depict that private investment, investment in health, interest rates and total debt-to-GDP ratio are integrated of order one, I(1). This means that they became stationary after the first difference. Other variables, namely electricity generated and available for distribution and GDP growth, are stationary at levels, integrated of order zero, I(0). Since the results show that the variables have a mix of order of integration – that is, I(0) and I(1) – the ARDL bounds test technique is the most applicable cointegration technique.

Table 3: Stationarity test results: Phillips-Perron

Variable	Levels	First difference	Order of integration
PRV_GDP	-2.843	18.155***	I(1)
HEALTH	-2.557	-9.060***	I(1)
logELECT	-5.139***	NA	I(0)
INT	-1.863	-3.681**	I(1)
GDP	-12.520***	NA	I(0)
DEBT	-2.876	-5.588***	I(1)

***1% -4.098; **5% -3.477

Source: Author’s calculation

Before proceeding to test for cointegration, it is essential to determine the optimal lag and the maximum lag length selected by the Akaike information criterion (AIC) is 4. This is based on the number of regressors included in the private investment model. The optimal ARDL model selected for the equation is ARDL (3, 1, 1, 3, 1, 0). The study observed whether cointegration exists among the variables. The cointegration test results reported in Table 4 are based on ‘Case 2: Restricted Constant and No Trend’ of Pesaran et al. (2001), as chosen by the EViews software used. These results show that the null hypothesis of ‘no cointegration’ is rejected because the F-statistic, 6.541, lies above the upper bound, I(1), at all levels of significance.

Table 4: Cointegration result: ARDL bounds test

Test statistic	Value	Significance (%)	I(0) Bound	I(1) Bound
F-statistic	6.541***	10%	2.08	3
k	5	5%	2.39	3.38
		2.5%	2.7	3.73
		1%	3.06	4.15

Null hypothesis: No long-run relationships exist. *k* is the number of explanatory variables.

*** 1%.

Source: Author’s calculation

Thus, there exists a long-run relationship between the ratio of private investment to GDP and all the explanatory variables. The result shows that we reject the

null hypothesis of no cointegration at all levels of significance, where the F-statistic was 6.541. We therefore proceed to estimate the short-run and long-run coefficients of each of the variables. The results of the long-run relationship are shown in table 5. The results depict that in the long run, one of the two critical infrastructures shows that government investment spending in this area will crowd in private investment and the other will crowd out private investment. While the investments in health show an inverse relationship with private investment, meaning that government investment in health does not complement private investment, it is statistically insignificant. On the other hand, the amount of electricity generated and available for distribution shows a positive relationship with private investment, implying a crowd-in effect, and it is highly statistically significant.

The effects of government investment in health – although statistically insignificant – and in electricity generated and available for distribution are quite small, indicating a weak relationship. The low effect could be due to the corruption in government, where the money allocated towards infrastructure investments does not get to be used for the intended purposes. Thus, the effects are not observed. However, increasing the gigawatt hours of electricity generated and available for distribution by a per cent will increase the share of private investment to the gross domestic product by 0.05 per cent. This finding supports the effects of the ongoing electricity problem, namely loadshedding, in the country and thus shows its importance.

On the other hand, as part of the control variables, the lending rate is consistent with the descriptive analysis result and follows the financial liberalisation theory, whereby interest rates and private investment are positively and highly statistically significant but weakly related, and the former has a net positive effect on the latter through savings. This result contradicts the findings of [Leshoro and Wabiga \(2023\)](#), who found an inverse relationship, although they used the same ARDL technique. This discrepancy could be because [Leshoro and Wabiga \(2023\)](#) used annual data, which provides less frequent changes, while the current study made use of more frequent quarterly variables. Similarly, the GDP growth depicts the accelerator effect in South Africa because not only does it show a positive relationship with private investment, but this relationship is also highly statistically significant over the period considered in the study. Finally, the debt-to-GDP ratio shows a positive relationship with private investment. That is, the increase in government spending during a recession boosts the aggregate demand and crowds in private investment. This is different from the results of [Naa-Idar, Ayentimi & Frimpong \(2012\)](#), where the government investment spending crowds out private investment in Ghana; thus indicating competition for resources between the public and private sectors.

Table 5: ARDL: Long run

Variable	Coefficient	Std. error	T-statistic
HEALTH	-0.0001	0.00005	-0.5868
INT	0.0005**	0.000214	2.1504
GDPg	0.0008**	0.000394	1.9748
logELECT	0.0479**	0.020274	2.3608
DEBT	0.0001	0.000115	0.5678
C	-0.5064**	0.226560	-2.2351

** 5%.

Source: Author’s calculation

The short-run ARDL results provided in Table 6 show that while the investment in the two critical infrastructure variables crowds out private investment in the short run and in the current period, electricity is not statistically significant. Since the effects of infrastructure cannot be immediate in the short run because variables are in the differenced form, the short-run results should not focus on the signs of the parameters in explaining the private investment and critical infrastructure investment nexus.

When variables are differenced, the long-run information is lost and investing in infrastructure in the current period cannot yield an effect on the percentage of investment to gross domestic product. The only sign that should be considered and interpreted in the short run is the error correction term. In this case, the error correction term of -0.419 is reasonably high and satisfies all the conditions that it must be less than one, statistically significant and carry a negative sign. This implies the adjustment back to the long-run equilibrium, where 42% of disequilibrium is corrected quarterly. Thus, if the ratio of private investment to GDP deviates from its long-run equilibrium with the other variables in the preceding quarter, equilibrium will be restored in the following quarters at the rate of 42%.

Table 6: ARDL: Short run

Variable	Coefficient	Std. error	T-statistic
Δ PRV_GDP(-1)	-0.4214***	0.0886	-4.7532
Δ (PRV_GDP(-2)	-0.3215***	0.0787	-4.0838
Δ HEALTH	-0.0006***	2.26E-05	-3.0826
Δ logELECT	-0.0050	0.0035	-1.4531
Δ INT	-0.0002	0.0003	-0.6877
Δ INT(-1)	-0.0005	0.0004	-0.1226
Δ INT(-2)	0.0013***	0.0003	4.1427
Δ (GDPg)	0.0002***	4.04E-05	5.8828
ECM(-1)	-0.419***	0.0586	-7.1533

*** 1%

Source: Author’s calculation

The results from the robustness check model showed that the composite business confidence index is insignificant in the case of South Africa. According to the results (not shown), the variable was automatically dropped from the parsimonious model in the short run, implying that it is economically insignificant in the short run and statistically insignificant in the long run.

Thus, the study answered the three research questions set out above, namely:

1. Does government investment in each of these critical infrastructures complement or compete with the private investment in South Africa? In other words, is government spending crowding in and thus promoting the expansion and development of the private sector, or is it crowding out private investment in South Africa?
 - Public investment in electricity generated and made available for distribution crowds out private investment in the short run, while it crowds in private investment in the long run. It is, however, statistically insignificant in the short run but statistically significant in the long run and in the period under consideration.
 - Although public investment in health crowds out private investment in the short run and in the long run, it is statistically significant in the short run and statistically insignificant in the long run.
2. To what extent do changes in interest rates influence the percentage of private investment to the GDP?
 - They are positively and highly statistically significant, but weakly related in the long run.
 - They are a mixture of statistically significant and insignificant in the short run, while also depicting a mixed relationship with private investment.
3. And lastly, does the acceleration theory hold for South Africa?
 - GDP growth shows a positive relationship with private investment, and it is statistically significant both in the long run and the short run. This shows that the acceleration theory holds for South Africa.

The results further show that the model passed the battery of diagnostic tests of normality, heteroscedasticity and serial correlation, as shown in Table 7, where we failed to reject all the null hypotheses. Lastly, the graph presented in Figure 4 shows that the estimated cointegration relation model is appropriate. This is because the graph reverts to equilibrium, which is zero. Therefore, our results are reliable and well-specified.

Table 7: Diagnostic tests

Test	Null hypothesis	Probability
Normality test: Jarque-Bera	The error term is normally distributed.	1.0498 (0.592)
Serial correlation LM tests: Breusch-Godfrey, F(2,49)	No serial correlation	0.528 (0.593)
Heteroscedasticity test: Breusch-Pagan-Godfrey, F(14,51)	Homoscedasticity	0.8551 (0.609)
Ramsey RESET test: Functional form (1,50)	Stable model	2.2684 (0.138)

Source: Author’s calculation

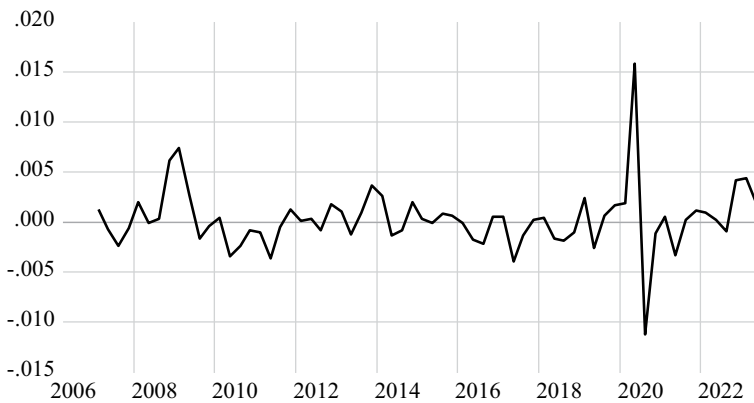


Figure 4: Co-integration graph for private investment model

Source: Author’s calculation

5. CONCLUSIONS

This study contributes to the understanding of the complex relationship between critical infrastructure investment and private investment in South Africa. The study used quarterly data spanning the period from 2006Q2 to 2023Q2 and adopted the auto-regressive distributed lag technique. Based on the econometric analysis, government spending on electricity generated and made available for distribution was found to compete with private investment, but it is statistically insignificant in the short run, whereas it complements private investment in the long run and is highly statistically significant. The same result was found by [Ahmed et al. \(2018\)](#), who analysed the critical importance of energy infrastructure for domestic investments in Nigeria. Their result showed that public investment crowds in private investment, but this is statistically insignificant. Public investment in health competes with private investment in

the long run and the short run; moreover, the effect is statistically significant in the short run and statistically insignificant in the long run. This is different from the study by [Maluleke, Odhiambo & Nyasha \(2023\)](#), who found that aggregate public investment competes with private investment in South Africa in the long run and complements it in the short run.

The effects of the critical infrastructure variables on the ratio of private investment to GDP are very small, indicating a weak relationship, although they are highly statistically significant. This corroborates the findings of [Henkel and McKibbin \(2017\)](#), who argued that the misallocation of infrastructure spending leads to a weak or no crowd-in effect on private investment. It is important to note that the excluded variables, such as political instability or corruption, given the reasons provided above, could affect the results through the weak relationship that the selected variables depict with private investment. Countries with better governance tend to encourage private investment, thus, increasing government spending will crowd in private investment, while weak institutions amplify crowd-out effects on private investment, as found by [Pritchett \(2000\)](#), [Nguyen \(2022\)](#) and [Esfahani and Ramírez \(2003\)](#) for globalised world and developing countries.

The study used a composite business confidence index, which reflects the expectations of businesses regarding economic growth and their ability to produce goods and services, as well as cost implications, as the robustness check. An uncertain political environment can lead to the deterioration of business confidence, thus producing negative effects on the economic environment. However, the results show that the composite business confidence index variable was insignificant in the case of South Africa. The variable was automatically dropped from the parsimonious model in the short run, which implies that it is economically insignificant in the short run and statistically insignificant in the long run.

The study's robust methodology and comprehensive analysis provide valuable insights for policymakers and stakeholders seeking to foster economic growth through strategic infrastructure investments. The findings underscore the importance of well-targeted infrastructure investments in driving private-sector development. The results indicate a need for focused consideration of infrastructure investment to achieve a substantial economic impact on private investment, thereby contributing to economic growth and development. The government should ensure that the funds earmarked for investment in infrastructure are apportioned correctly.

While this study provides a comprehensive analysis, it is not without limitations. Future studies could delve deeper into specific sectors or incorporate additional variables by using the infrastructure index to enhance the understanding of private investment dynamics. The current study examined the investment in infrastructure using electricity generated and distributed instead of loadshedding, because the focus was not on the effect of loadshedding but on infrastructure. However, future studies may investigate the effect of loadshedding on infrastructure. Also, investigating the impact of legal and regulatory frameworks on private investment, which is beyond the scope of this study, is another limitation. Addressing these limitations in future studies will strengthen the knowledgebase for policymakers and researchers interested in fostering sustainable economic development through strategic infrastructure investments.

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Conflict of interests

The authors declare there is no conflict of interest.

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ЈАВНИ И ПРИВАТНИ СЕКТОР НА ДЈЕЛУ: РАЗОТКРИВАЊЕ ДИНАМИКЕ УЛАГАЊА У ИНФРАСТРУКТУРУ У ЈУЖНОАФРИЧКОЈ РЕПУБЛИЦИ

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САЖЕТАК

Приватне инвестиције играју кључну улогу у стварању радних мјеста и економском расту. Имајући у виду њихов значај, ова студија је анализирала динамику односа између јавних инвестиција, посебно у кључну инфраструктуру, и приватних инвестиција – да ли се оне међусобно допуњују или конкуришу једна другој. Истраживање је било усмјерено

на сложени однос између приватних и државних инвестиција у критичну инфраструктуру у области здравства и производње електричне енергије у Јужноафричкој Републици. Користећи кварталне временске серије података у периоду од другог квартала 2006. године до другог квартала 2023. године, примијењена је метода ауторегресивног расподијељеног кашњења (ARDL). Према економетријској анализи, државна потрошња у здравству и производњи електричне енергије допуњује приватне инвестиције. Утицај инвестиција у критичној инфраструктури на однос приватних инвестиција према БДП-у је релативно низак, али статистички веома значајан. Резултати наглашавају важност добро усмјерених инвестиција у инфраструктуру као покретача развоја приватног сектора. У цјелини, ова свеобухватна анализа доприноси бољем разумијевању сложене динамике између јавних и приватних инвестиција у контексту развоја критичне инфраструктуре у Јужноафричкој Републици. Налази ове студије су од суштинског значаја за доносиоце одлука, инвеститоре и истраживаче који настоје да унаприједи економску политику и подстакну одрживи економски развој у земљи.

Кључне ријечи: *АРДЛ, производња електричне енергије, здравство, инфлација, инфраструктура, инвестиције.*