Journal of Infrastructure, Policy and Development 2025, 9(2), 10284.
https://doi.org/10.24294/jipd10284

Article

The nexus of infrastructure spending, public debt and inflation shaping the South African economy

Daniel F. Meyer

College of Business and Economics, University of Johannesburg, Johannesburg 2006, South Africa; dfmeyer@uj.ac.za

CITATION

Meyer DF. (2025). The nexus of infrastructure spending, public debt and inflation shaping the South African economy. Journal of Infrastructure, Policy and Development. 9(2): 10284. https://doi.org/10.24294/jipd10284

ARTICLE INFO

Received: 13 November 2024
Accepted: 28 November 2024
Available online: 11 February 2025

Abstract: This study investigated the influence of infrastructure spending, government debt, and inflation on GDP in South Africa from 1995 to 2023. Motivated by the need for sustainable growth amid fiscal and inflationary pressures, this research addresses gaps in understanding how these factors shape economic performance. The primary objective was to assess these variables' individual and combined effects on GDP and offer policy recommendations. Using an ARDL model, the study explored long- and short-term relationships among the variables. Results indicate that infrastructure spending positively impacts GDP, promoting long-term growth, while government debt hinders GDP in both short and long runs. Moderate inflation supports growth, but excessive inflation poses risks. These findings imply the need for targeted infrastructure investments, strict debt management practices, and inflation control measures to sustain economic stability and growth. Policy recommendations include expanding public investment in productive infrastructure, implementing fiscal rules to prevent unsustainable debt levels, and maintaining inflation within a controlled range. Ultimately, these policies could help South Africa build a resilient, balanced economy that addresses both immediate growth needs and long-term stability.

Keywords: economic growth; government debt; inflation; infrastructure spending; South Africa
JEL Codes: E02; H50

1. Introduction

Gross Domestic Product (GDP) is a crucial measure of economic performance, representing the overall value of goods and services produced within a country (Jean-Paul and Martine, 2018). According to Coyle (2015), GDP is vital to evaluate a nation's economic health and shape fiscal policy, investment, and resource distribution decisions. However, GDP is affected by various macroeconomic elements, with infrastructure investment, government debt, and inflation being especially significant (Antwi et al., 2013; Ramey, 2020). Understanding the interplay among these factors is essential for promoting sustainable growth as countries work to balance economic expansion with fiscal responsibility and stable prices.

Despite its significance, fiscal pressures and inflationary challenges often constrain GDP growth (Ahmed et al., 2021). Developing economies, in particular, struggle to balance growth stimulation through infrastructure investment with the need to control debt levels and keep inflation within acceptable bounds (Stiglitz et al., 2006). These nations often invest in public infrastructure to boost economic activity, increase productivity, and improve quality of life but primarily do not achieve these objectives. However, financing these projects frequently involves taking on public debt, which can result in financial instability if not carefully managed. Moreover,

rising inflation can threaten economic stability, reduce purchasing power, and discourage long-term investment (Girdzijauskas et al., 2022).

The research focuses on South Africa as a proxy for developing countries. Like many such economies, South Africa promotes growth while maintaining fiscal and price stability. Infrastructure investment is crucial for stimulating economic growth by raising productivity and enhancing quality of life (Srinivasu and Rao, 2013). In South Africa, infrastructure spending positively affects GDP by improving essential services, but governance challenges limit its effectiveness (Fedderke and Bogetić, 2009). Financing these projects often requires public debt accumulation, which poses sustainability issues. High debt levels affect GDP growth as future tax obligations and interest payments reduce resources available for productive investment (Holtfrerich et al., 2016). Excessive debt can restrict fiscal flexibility and strain government budgets, while moderate inflation supports growth. High inflation undermines economic stability by eroding purchasing power and discouraging investment, making inflation control essential (Judijanto and Kusnadi, 2024).

Given this South African context, several challenges emerge, such as high debt levels creating future obligations that may deter private investment, a "debt overhang" effect especially concerning for South Africa (Abdullahi, 2016). If not managed, debt accumulation could threaten long-term growth. According to Herrera et al. (2020), the positive impact of infrastructure investment on growth depends on effective governance and efficient project execution, as issues like cost overruns, corruption, and delays can diminish the productivity of infrastructure spending. Managing inflation is also challenging, mainly when economic shocks or fiscal pressures drive prices beyond levels compatible with growth. High inflation can destabilise the economy, complicating fiscal and monetary policies. South Africa thus faces a delicate balance between immediate economic stimulus via increased infrastructure spending and the long-term sustainability of debt. This balance requires careful policy planning and good governance to address both short- and long-term impacts on GDP and inflation (Bassanini and Reviglio, 2011).

This study is motivated by the mixed insights offered by current economic theories and empirical findings, leaving gaps in understanding the balance between productive public investment, debt sustainability, and inflation control. Focusing on this interaction, this research aims to fill a critical gap in macroeconomic analysis. To address the outlined problem, this study seeks to answer the following research question: How do infrastructure spending, government debt, and inflation impact GDP, and what are the relative contributions of each to economic growth?

The relationships between GDP and its potential determinants, such as infrastructure spending, government debt, and inflation, have been extensively studied. However, much of the literature examines these factors in isolation or within the contexts of developed economies. For example, studies often focus on the impact of government debt on economic growth or the relationship between inflation and GDP without integrating infrastructure spending as a parallel variable. Furthermore, while high-income nations have established mechanisms for balancing debt, spending, and inflation, lower-income and developing economies need help in achieving this balance. This gap in existing research creates an opportunity to address how these variables interact in emerging markets, where economic volatility, limited fiscal space,

and inflationary pressures often pose risks to growth. The research seeks to bridge a significant gap by comprehensively analysing the interactions among infrastructure spending, government debt, inflation, and GDP in an emerging economy context. The findings contribute to academic literature and practical economic policy, helping policymakers understand the balance required for sustained economic development.

Therefore, this study aims to empirically estimate the individual and combined effects, including relationships, of infrastructure spending, government debt, and inflation on GDP in the long and short run. This involves measuring the sensitivity of GDP to changes in each independent variable; secondly, determining the direction of causality among these variables; and offering recommendations on optimal levels of public infrastructure spending, debt management strategies, and inflation control measures conducive to sustainable GDP growth.

2. Literature review

The literature review section consists of two components: a theoretical foundation and an analysis of empirical studies.

2.1. Theoretical foundation

The theoretical foundation of this study is based on the Keynesian Economic Theory and the Neo-Classical Economic Theory. The link between government spending (including infrastructure investment) and GDP is a key concept in Keynesian economic theory (Seccareccia, 1995). Keynesian economists argue that government spending, especially on public investments, can create a multiplier economic effect (Cwik and Wieland, 2011). This effect implies that an increase in government spending leads to a rise in aggregate demand, which, in turn, stimulates economic growth. According to Straub (2008), infrastructure investments are particularly impactful as they boost productivity by improving essential services—such as transportation, energy, and communication networks—that businesses and individuals need to function effectively within an improved enabling environment. From this perspective, increased infrastructure spending can enhance GDP by creating a more productive enabling environment.

Conversely, the Neo-classical Economic Theory offers a more restrained perspective. Neo-classical economists recognise that government spending can contribute to economic growth (Raudino and Raudino, 2016). However, they caution that excessive public expenditure, primarily when funded through borrowing, may create inefficiencies and "crowd out" private investment. The crowding-out effect suggests that as government borrowing rises, it competes with the private sector for funds, driving up interest rates and reducing private investment (Awuni, 2021). From the neo-classical viewpoint, the long-term effect of government spending on GDP hinges on how efficiently it is used via good governance and its potential to enhance productivity (Shaddady, 2022).

Regarding specific variables included in the study and the theoretical relationship, government debt and its relationship with GDP have also been debated. The Debt Overhang Theory, developed by Krugman (1988), suggests that high levels of government debt can hamper growth by creating a "debt overhang" effect, wherein

anticipated future taxes required to service the debt discourage private investment. When debt is high, investors may expect future tax increases or inflationary policies to repay the debt, which diminishes investment attractiveness. As a result, the growth potential of an economy becomes constrained (Krugman, 1988).

The relationship between inflation and GDP growth is typically addressed within the framework of the Phillips Curve, which initially suggested an inverse relationship between inflation and unemployment (and, by extension, economic output) (Daniel et al., 2021). However, economists later recognised that this relationship does not hold in the long run. Friedman's (1968) natural rate hypothesis posits that while inflation may temporarily boost output, it cannot do so in the long term as expectations adjust. High inflation can harm growth by eroding purchasing power, increasing uncertainty, and discouraging investment. Studies have also shown that inflationary pressures can create instability, leading to a low growth environment over time, particularly when inflation becomes unpredictable or exceeds a certain threshold or target (Agénor and da Silva, 2013).

2.2. Empirical results

2.2.1. Infrastructure spending and GDP growth

Empirical studies examining the impact of infrastructure spending on GDP generally confirm the positive link posited by Keynesian economics. According to a study by Foster et al. (2022), evidence of public expenditure on infrastructure is limited and allows for a research gap. The research analyses infrastructure spending trends and patterns for more than 70 developing countries from 2010 to 2018. Findings indicate that expenditure on infrastructure has been low and declining. Babatunde (2018) used econometric models to assess government spending on infrastructure in Nigeria from 1980 to 2016. Findings indicate some interesting results. Government spending on hard and soft infrastructure, such as transport infrastructure, communication, education and health infrastructure, significantly affects economic growth positively.

Imran and Niazi (2011) examined infrastructure development in Pakistan, exploring its connection to productivity and economic growth. Their analysis highlighted that, over the past two decades, minimal investment in maintaining and expanding physical infrastructure has contributed to rising unemployment and sluggish economic growth. The findings demonstrate that infrastructure stock significantly boosts productivity and economic growth, with specific components—like electricity generation, agricultural water resources, and telecommunications—showing a powerful and positive effect on economic growth. They recommended an increase in funding, suggesting an allocation of around 1.5% of GDP to address infrastructure capacity issues and stimulate growth.

However, not all research finds a uniformly positive effect. For instance, Romp and de Haan (2007) argue that the impact of infrastructure investment on GDP depends on factors like government efficiency, the type of infrastructure, and the existing infrastructure levels. In situations where government efficiency is low, infrastructure projects may face cost overruns, corruption, and delays, reducing their potential to impact GDP positively.

2.2.2. Government debt and GDP

The link between government debt and GDP growth has been widely examined, with research yielding mixed outcomes. Reinhart and Rogoff (2010) famously argued that when government debt reaches around 90% of GDP, it impedes growth. Drawing on historical data from developed and developing nations, their study suggests that high debt burdens can hinder growth by raising debt servicing costs, reducing funds for productive investment, and increasing financial instability.

Afonso and Jalles (2013) assessed the relationships between government debt, economic growth and productivity in 155 countries. The study results found a negative relationship between growth and debt. According to the OECD, longer debt maturity is associated with greater economic growth, and fiscal consolidation supports this growth. A 10% rise in the debt ratio reduces growth by 0.2% for countries with debt ratios exceeding 90%. Additionally, an endogenous debt ratio threshold of 59% is identified.

In addition, Hassan and Nassar, (2015) analysed the debt and GDP nexus and the impact on unemployment for a range of developing countries. Results showed that GDP was negatively correlated with debt and unemployment. Conversely, debt showed a positive correlation with unemployment. It was concluded that this effect was mainly due to the negative impact of GDP on both debt (deficits) and unemployment.

Semjonova (2017) examined the economic impact of government debt by analysing data from 176 countries. The findings revealed a strong negative correlation between debt and budget deficits and a weak correlation between debt and GDP growth, suggesting that countries primarily use borrowed funds to meet immediate social needs rather than economic investments. The South and East Asia region was the only exception, where higher debt levels were linked to increased GDP growth.

Lastly, Panizza and Presbitero (2013) suggest that the impact of debt on GDP growth varies across countries but depends on factors such as economic structure, fiscal policies, and access to global capital markets. Their findings indicate that while high debt levels may limit GDP growth, moderate debt might have little or no adverse effect. In developing countries, empirical evidence often shows that government debt has a more substantial negative impact on GDP, likely due to limited fiscal flexibility and higher borrowing costs.

2.2.3. Inflation and GDP

Empirical studies on the relationship between inflation and GDP growth indicate that low to moderate inflation is generally compatible with stable economic growth. However, high inflation can negatively affect the economy. For example, Bruno and Easterly (1998) analysed a sample of developing countries and found that high inflation rates are associated with lower GDP growth.

Some studies have focused on the long-term impact of inflation on GDP growth. For example, Fischer (1993) found that inflation has a negative effect on long-term growth by creating distortions in investment and productivity. Studies often report a stabilising effect on GDP in countries with inflation-targeting policies, as these policies help control inflation expectations and reduce volatility. However, for economies with weak inflation control mechanisms, inflation can be a persistent

source of instability, undermining GDP growth over time. Fedderke and Liu (2018) examined several inflation models for South Africa, including the Phillips curve, the New Keynesian Phillips curve, and monetarist and structural models. Key findings indicated a positive link between inflation and nominal wages, while improvements in real labour productivity showed a relatively weak negative relationship with inflation. Additionally, supply-side shocks were consistently associated with inflation. Increases in money supply and government spending demonstrated strong and theoretically consistent links to inflationary pressures.

Mandeya and Ho (2021) explored the effects of inflation on South Africa's economic growth from 1961 to 2019. The study found that inflation adversely affects short- and long-term growth. However, inflation uncertainty was considered a short-term issue with no long-term impact. The authors suggest that policymakers implement policies that maintain price stability to foster growth.

Sekwati and Dagume (2023) studied the impact of unemployment and inflation on South Africa's economic growth from 1994 to 2018. Their findings indicated a long-term relationship among these variables, and the vector error correction model (VECM) confirmed that both inflation and unemployment adversely affect economic growth. The authors recommend that the government enforce effective price regulations for price stability.

2.3. Summary of empirical findings

The literature presents a complex picture of the interactions among GDP, infrastructure spending, government debt, and inflation. Key findings include a positive relationship between infrastructure investment and GDP, especially in developing countries with limited infrastructure. However, the efficiency of public spending and governance factors can moderate this effect. High government debt levels are frequently associated with slower GDP growth, particularly in countries with limited fiscal capacity. However, moderate debt levels may not adversely affect growth if managed prudently. The relationship between inflation and GDP appears to follow a threshold effect, where low to moderate inflation is growth-supportive, while high inflation negatively impacts GDP. Inflation control mechanisms, such as inflation targeting, are crucial for sustaining growth.

3. Methodology

This research followed a quantitative methodology with econometric models using time series data. This study uses an ARDL (Autoregressive Distributed Lag) model to examine the long-term and short-term dynamics between GDP and its key determinants: infrastructure spending, government debt, and inflation. The ARDL model is well-suited for this type of analysis, as it can estimate cointegration relationships among variables even if they are integrated at different orders (I(0) or I(1)) (Nkoro and Uko, 2016). This feature makes ARDL a robust choice when dealing with mixed integration levels, particularly useful with time-series data of limited sample size. Unlike conventional cointegration techniques, ARDL does not require pre-testing for unit roots and applies to variables integrated at different orders, making it ideal for this dataset. Additionally, this model differentiates between short-run and

long-run relationships, providing more detailed insights into the influence of each independent variable on GDP across different time frames.

The data used in this study spans from 1995 to 2023 and includes annual observations of GDP, infrastructure spending, government debt, and inflation. **Table 1** summarises the variables used in this study. Total government debt is designated as the dependent variable.

Table 1. Variables used in the study.

Variable	Type of variable	Variable abbreviation in log format	Unit	Source
GDP	Dependent variable	LGDP	R Millions (at constant prices)	Quantec (2024)
Infrastructure Spending	Independent variable	LINFRASP	R Millions (at constant prices)	National Treasury (2024)
Government Debt	Independent variable	LGOVDEBT	R Millions (at constant prices)	National Treasury (2024)
CPI	Control variable	LCPI	Index	StatsSA (2024)

Source: Own compilation.

All variables are transformed into natural logarithms to stabilise variance and interpret coefficients as elasticities, simplifying the relationship between GDP and its determinants. The ARDL Bounds Testing approach tests for a long-term relationship among the variables. The steps in the Bounds Test involve a hypothesis analysis with the Null Hypothesis representing no long-run relationship (cointegration) exists among the variables. In contrast, the alternative Hypothesis represents a long-run relationship among the variables. The computed F-statistic is compared with critical value bounds. The null hypothesis is rejected if the F-statistic exceeds the upper bound, indicating a long-term relationship.

The estimation procedure includes stationarity testing by conducting the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests to determine the integration order of each variable. Although ARDL can handle mixed orders, ensuring none are I(2) is necessary, as ARDL requires variables to be I(0) or I(1). Secondly, determining the Optimal Lag Selection using the Akaike Information Criterion (AIC), to select optimal lag lengths for the ARDL model. This step is crucial as overfitting or underfitting may distort the estimation of short-term and long-term effects. The next step is the ARDL Bounds Test for cointegration to check for a long-term relationship among the variables. This test is followed by the Error Correction Model (ECM) to confirm the long-run cointegration and to quantify short-term dynamics and the speed of adjustment to long-term equilibrium.

To ensure the robustness of the model, several diagnostic tests are conducted including a Serial Correlation Test (Breusch-Godfrey LM test for autocorrelation in residuals), Heteroscedasticity Test (Breusch-Pagan-Godfrey test to assess whether the variance of errors is constant), Normality Test (Jarque-Bera test to confirm the normal distribution of residuals) and Stability Test (Cumulative Sum of Recursive Residuals) to examine the stability of the model over time.

The ARDL equation can be represented as follows (Equation (1)):

$$\Delta LGDP_t = \partial_0 + \sum_{i=0}^{n} \partial\, 1_i \Delta LINFRASP_{t-i} + \sum_{i=0}^{n} \partial\, 2_i \Delta LGOVDEBT_{t-i} + \sum_{i=0}^{n} \partial\, 3_i \Delta LCPI_{t-i} + a_1 LINFRASP_{t-1} + a_2 LGOVDEBT_{t-1} + a_3 LCPI_{t-1} + \mu_{1t} \quad (1)$$

where the difference operator denoted by Δ indicates how the variable changes over time. ∂_0 represents the intercept term. ∂ and a represents the effects of the explanatory variables on the dependent variable.

$LGDP_t$ denotes the dependent variable: GDP.

$LINFRASP_t$ denotes the first independent variable: Infrastructure spending and

$\alpha_2 LGOVDEBT_t$ denotes the second independent variable: total government debt.

$\alpha_3 LCPI_t$ denotes the control variable: CPI.

μ_{1t} denotes the white noise error term.

Upon confirmation of the cointegration among the variables, the error correction model (ECM) is represented as follows, as suggested by Pesaran et al. (2001):

$$LGDP_t = \partial_0 + \sum_{i=0}^{n} \partial\, 1_i \Delta LINFRASP_{t-i} + \sum_{i=0}^{n} \partial\, 2_i \Delta LGOVDEBT_{t-i} + \sum_{i=0}^{n} \partial\, 3_i \Delta LCPI_{t-i} + \lambda ECT + \mu_{1t} \quad (2)$$

where the difference operator denoted by Δ indicates how the variable changes over time. ∂_0 represents the intercept term. λECT is the error correction term, and μ_{1t} is the white noise error term. The paper seeks to test the following hypothesis:

Hypothesis (H_0): Infrastructure spending, government debt and Inflation do not affect GDP.

4. Results and discussion

4.1. Variable trend analysis

Figure 1 displays the variables from 1995 to 2023. Initially, GDP remained relatively stable from 1995 until 2008, but it was negatively impacted by the global financial crisis between 2008 and 2010. The 2010 Soccer World Cup contributed to the recovery process through to 2019. However, COVID-19 severely affected the South African economy in 2020, leading to a recession. While the economy has shown signs of recovery from 2021 to 2023, it has yet to return to the growth levels seen in 2019. From 2019 to 2023, the economy's average annual growth rate was just 0.22%, falling short of the minimum 3% needed to support inclusive growth.

Infrastructure spending remained relatively low but steady from 1995 to 2007. However, in the lead-up to the 2010 Soccer World Cup, spending surged significantly, peaking in 2009 and 2010 with a spending-to-GDP ratio of 6.8%. This heightened spending level was sustained until 2015, when it declined until 2023. By 2023, infrastructure spending had dropped to only 3.4% of GDP. Large-scale spending is required to support economic growth with the growing infrastructure capacity backlogs.

Total government debt remained consistently low from 1993 until early 2008, but it rose sharply following the global financial crisis. From 2009 onwards, debt escalated quickly, reaching around 75% of GDP by 2023. Between 2019 and 2023, debt grew at an annual rate of 4.2%. This high level of government debt has become

unsustainable, with debt repayments now consuming over 13% of the total government budget.

Consumer price inflation (CPI) remained stable throughout the study period from 1995 to 2023. Inflation rates declined significantly in the early 2000s due to low demand and modest economic growth until 2008. However, inflation rose following the global financial crisis and the 2010 Soccer World Cup, remaining largely within the South African Reserve Bank's target range of 3% to 6% through 2023. From 2015 to 2023, the average annual inflation rate was 5.97%.

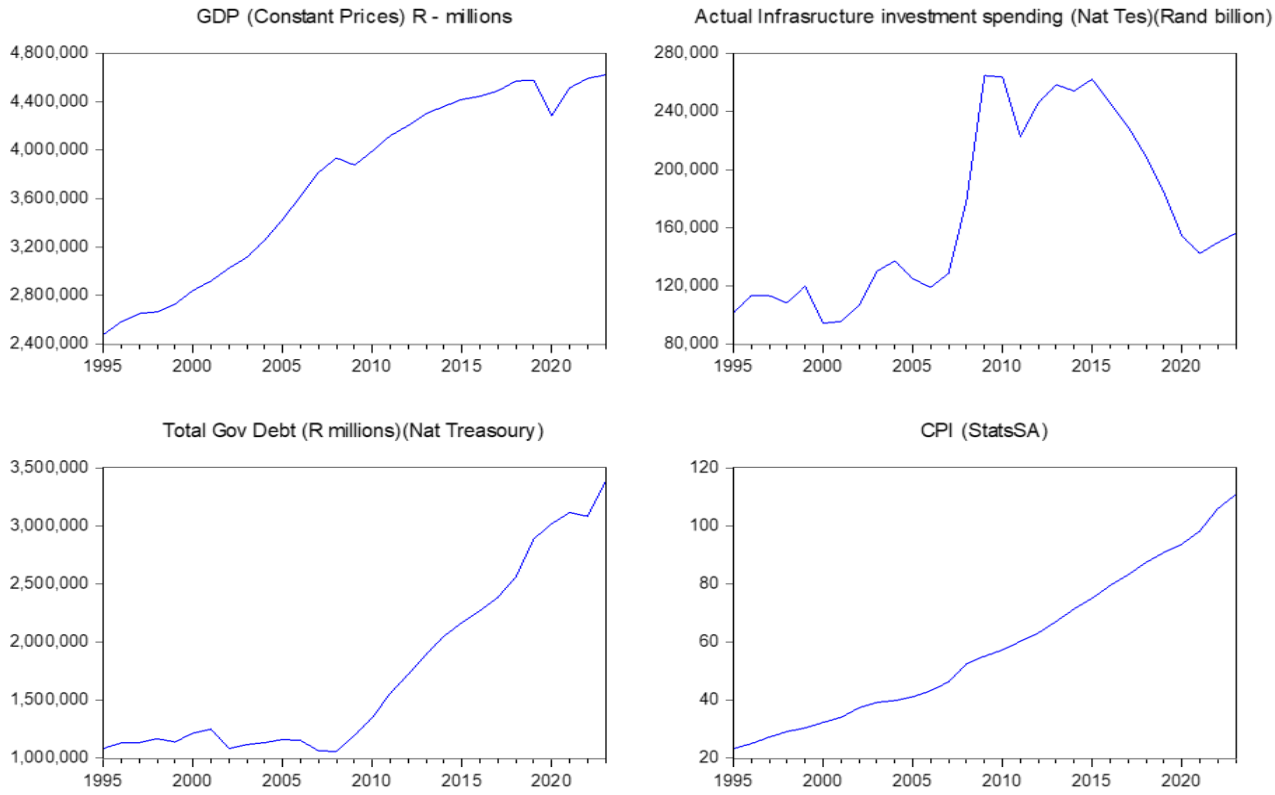

Figure 1. Trend analysis.

Sources: Quantec (2024); National Treasury (2024); StatsSA (2024).

Table 2. Descriptive analysis.

Concept	GDP (R Millions)	Actual Infrastructure Spending (R Billion)	Total Government Debt (R Millions)	Inflation (CPI)
Mean	3739700.	169395.1	1742030.	58.5793
Median	3936882.	149695.2	1248311.	55.1000
Maximum	4624376.	264649.7	3383861.	110.8000
Minimum	2476227.	94253.22	1057540.	23.3000
Std. Dev.	745292.9	61043.91	771405.5	26.3444
Skewness	-0.3823	0.4201	0.8411	0.4232
Kurtosis	1.6048	1.5955	2.2185	1.9550
Jarque-Bera	3.0584	3.2366	4.1574	2.1854
Probability	0.2167	0.1982	0.1250	0.3353

Table 2 summarises the descriptive data for the four variables included in the study. South Africa is an example of a developing economy struggling to balance

growth stimulation through infrastructure investment while maintaining the need to control debt levels and keep inflation within acceptable bounds, as Stiglitz et al. (2006) warned. The country invests in infrastructure with the sim to boost economic activity and increase productivity, but due to poor financial management and corruption, the spending does not translate to growth.

4.2. Stationarity and break-point unit root testing

The Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests were conducted to assess the stationarity of each variable as indicated in **Table 3**. The findings show that all four variables are integrated at order I(1), indicating they become stationary after first differencing. This allows for estimating several econometric models, including the Johansen cointegration or ARDL models. As outlined in the methodology, the ARDL model applies when variables have the same or mixed levels of stationarity. Therefore, the ARDL model could be estimated in this case. The break-point unit root tests revealed no impact from COVID-19 in 2020 on the unit roots of any variables, though all four variables experienced breakpoints during the 2008–2009 global financial crisis.

Table 3. The unit root tests.

Variable (Test type in brackets)	Level I(O)		First Difference I(1)		Test Results
	t-statistic	*p*-value	*t*-statistic	*p*-value	
(PP) LGDP	2.3921	0.1529	−4.3118	0.0023*	I(1)
(ADF) LGDP	2.3921	0.1529	−4.3118	0.0023*	I(1)
(PP) LINFRASP	−1.5381	0.4997	−3.3619	0.0217*	I(1)
(ADF) LINFRASP	−1.3891	0.5716	−3.7721	0.0087*	I(1)
(PP) LGOVDEBT	0.8841	0.9537	−3.2121	0.0303*	I(1)
(ADF) LGOVDEBT	0.6294	0.9879	−3.2121	0.0303*	I(1)
(PP) LCPI	−4.3050	0.0023*	−4.0510	0.0043*	I(1)
(ADF) LCPI	−1.1414	0.5611	−4.1180	0.0037*	I(1)

Note: *denotes a *P*-value at a 5% level of significance. Source: EViews.

4.3. ARDL bounds test for cointegration

Following the unit root tests, the next step in the process was the Bounds test, an extension of ARDL modelling. This test determines whether the data-generating process underlying a time series is a trend or first difference stationary by using *F* and *t*-statistics to evaluate the significance of the lagged levels of the variables (Das, 2017). The Bounds Test determines whether a long-run cointegrating relationship exists among GDP, infrastructure spending, government debt, and inflation. The test reveals that the F-statistic exceeds the upper bound critical value at the 5% significance level, indicating the presence of a long-run cointegrating relationship. The rejection of the null hypothesis confirms that GDP, infrastructure spending, government debt, and inflation are linked in the long run, suggesting that changes in one variable have a lasting impact on the others. **Table 4** presents the critical values and the F-bounds test. The findings rejected the null hypothesis that no long-run relationship exists between GDP and the other independent variables. The computed *F*-statistic (5.975) signified

that it was higher than both the lower I(0) (2.79) and the upper I(1) (3.67) bounds values at the 5% significance level, which confirmed a cointegrated long-run relationship.

Table 4. Results of F-bounds test for cointegration.

Total Debt as the dependent variable			
Significance Level	**Critical Values**		**F-statistic**
	Lower Bound I(0)	**Upper Bound I(1)**	
10%	2.37	3.20	
5%	2.79	3.67	5.9752
2.5%	3.15	4.08	
1%	3.65	4.66	

Source: EViews 12.

4.4. ARDL long-run and short-run coefficients

4.4.1. Long-run coefficients

Table 5 and Equation (3) detail the long-tun results. The long-run coefficients reflect the sustained impact of infrastructure spending, government debt, and inflation on GDP. These coefficients can be interpreted as elasticities, providing insight into how percentage changes in each independent variable affect GDP in the long run:

The long-run equation:

$$LGDP = + 0.1834*LINFRASP – 0.1284*LGOVDEBT + 0.4198*LCPI \quad (3)$$

Infrastructure Spending: The coefficient for infrastructure spending is positive and statistically significant, confirming that increases in infrastructure investment are associated with higher GDP in the long run. A 1% increase in infrastructure spending leads to an estimated 0.18% increase in GDP, emphasising the productive role of public investment in economic growth. This result is similar and confirms previous results by authors such as Babatunde (2018); and Imran and Niazi (2011). Infrastructure spending is important for economic growth because it enhances productivity, reduces production and business costs, and improves access to markets and services, fostering a more efficient and resilient economy. This finding is also supported by the theoretical foundation as developed by Straub (2008), who stated that infrastructure investments are particularly impactful as they boost productivity by improving essential services, eventually leading to economic growth.

Government Debt: The negative coefficient for government debt suggests that high debt levels may hinder long-term GDP growth. This finding supports the debt overhang hypothesis, where excessive debt levels create future fiscal obligations that reduce resources available for productive investment. A 1% increase in government debt is associated with an approximate 0.13% decrease in GDP in the long run. Most previous studies assessed had similar results as indicated in the literature review section, for example, Hassan and Nassar (2015) and Semjonova (2017). Effective government debt management is crucial for economic growth because it helps maintain fiscal stability, reduces borrowing costs, and creates a sustainable investment and economic expansion environment. These findings are by the theoretical

foundation developed by Krugman (1988), who stated that high levels of government debt, as could be found in SA, can hamper growth by creating a "debt overhang" effect, wherein anticipated future taxes required to service the debt discourage private investment. As a result, the growth potential of an economy becomes constrained.

Inflation (CPI): Inflation has a positive long-run coefficient, indicating that moderate inflation may support economic growth by stimulating spending and investment within the sample range. This aligns with the view that controlled inflation can contribute to economic expansion, though excessive inflation would likely have the opposite effect. Results from previous studies confirm that low and stable inflation stimulates growth, but high inflation is negative for growth. Inflation management is vital for economic growth because it preserves purchasing power, reduces uncertainty, and fosters a stable environment for investment and long-term economic planning. These findings align with the findings by Friedman (1968), who stated that while inflation may temporarily boost output, it cannot do so in the long term as expectations adjust. High inflation can harm growth by eroding purchasing power, increasing uncertainty, and discouraging investment.

Table 5. ARDL long run estimates: GDP as the dependent variable, lag (1, 3, 4, 4).

Variable	Coefficient	Std. error	t-statistic	Prob
LINFRASP	+0.1834	0.0275	+6.6627	0.0001*
LGOVDEBT	-0.1284	0.0574	−2.2341	0.0523**
LCPI	+0.4198	0.0585	+7.1649	0.0001*
C	+13.2385	0.8176	+16.1908	0.0001*

Source: EViews 12.
Note: * and ** denotes a *P*-value at a 5% and 10% significance levels respectively.

4.4.2. Short-run coefficients and error correction term

The short-run coefficients in the ARDL model capture the immediate effects of changes in infrastructure spending, government debt, and inflation on GDP (see **Table 6**). The following key findings are mentioned from the analysis: The coefficient for infrastructure spending remains positive and significant, though its impact on GDP is less pronounced than in the long run. This suggests that while infrastructure investments contribute to immediate GDP increases, their full effect is realised over time as projects mature and become operational. Regarding government debt, the short-run effects of government debt on GDP are less significant than the long-run impact, but they are still negative and significant. This indicates that debt accumulation may take time to detract from GDP growth. However, persistent increases in debt could exacerbate fiscal pressures over time, eventually reducing GDP. Lastly, inflation exhibits a clear negative and significant impact in the short run. Lagged inflation values negatively impact GDP, and high inflationary episodes may destabilise, as seen in short-run coefficients where lagged inflation variables display negative signs.

The error correction term (ECT) is negative and statistically significant, with a coefficient value −0.870. The coefficient of −0.870 indicates the speed of adjustment toward equilibrium after a shock. Here, the adjustment rate is approximately 87% per period, meaning about 87% of any disequilibrium is corrected within each period (e.g.,

quarterly or annually). This shows a relatively fast adjustment but not instantaneous—each period brings the system close to equilibrium but does not fully return in one step.

Table 6. ARDL short-run estimates (GDP as a dependent variable).

Variable	Coefficient	Std. error	*t*-statistic	Prob
C	17.0384	4.4562	3.8235	0.0041*
D(LINFRASP(-1))	0.2360	0.0720	3.2738	0.0096*
D(LINFRASP(-2))	0.0731	0.0565	1.2934	0.2281
D(LGOVDEBT(-1))	−0.1652	0.0871	−1.8976	0.0902**
D(LGOVDEBT(-2))	−0.1455	0.1152	−1.2624	0.2385
D(LGOVDEBT(-3))	−0.1616	0.1219	−1.3256	0.2176
D(LCPI(-1))	−0.8660	0.3533	−2.4510	0.0367*
D(LCPI(-2))	−1.2877	0.4780	−2.6938	0.0246*
D(LCPI(-3))	−1.3840	0.4685	−2.9541	0.0161*
CointEq(-1)	−0.8701	0.1409	−6.1753	0.0001*

Note: * and **denotes a *P*-value at a 5% and 10% significance level respectively. Source: EViews 12.

4.5. Diagnostic and stability tests

The diagnostic test was utilised to determine the efficiency and reliability of the model; the ARDL diagnostics test is shown in **Table 7**. The hypothesis can be outlined as follows:

H_0: Errors are normally distributed; therefore, there is no serial correlation and no indication of heteroscedasticity.

H_1: Errors are not normally distributed; therefore, they are serially correlated and are presented with heteroscedasticity.

As indicated in **Table 7**, it is confirmed that the p-values exceeded 0.05 for all variables utilised, meaning the null hypothesis is accepted, indicating that the data were normally distributed, no serial correlations were found, and there was no heteroscedasticity. The Breusch-Godfrey test for serial correlation and the Breusch-Pagan-Godfrey test for heteroscedasticity confirm that the model residuals are free from serial correlation and exhibit constant variance, ensuring the reliability of the ARDL estimates.

Table 7. Diagnostics tests.

Test statistic	*F*-statistics and *p*-value	Decision
Breusch-Godfrey serial correlation LM test	*F* statistic = 0.5071; and *p*-value = 0.0880	Do not reject H_0: No serial correlation
Normality	Jarque-Bera = 0.4390; and *p*-value = 0.8020	Do not reject H_0: Data normally distributed
Heteroscedasticity test	*F* statistic = 0.8321; and *p*-value = 0.2190	Do not reject H_0: No heteroscedasticity

Source: EViews 12.

The CUSUM test is used to assess the stability of the ARDL model over the sample period. **Figure 2** illustrates the plot of the cumulative sum of recursive residuals, a sum test for parameter stability. Both tests show that the residuals remain within the critical bounds, indicating that the model is stable and that the estimated relationships hold consistently over time. In addition, the CUSUM of Squares Test

also indicates that the residuals remain within the critical bounds.

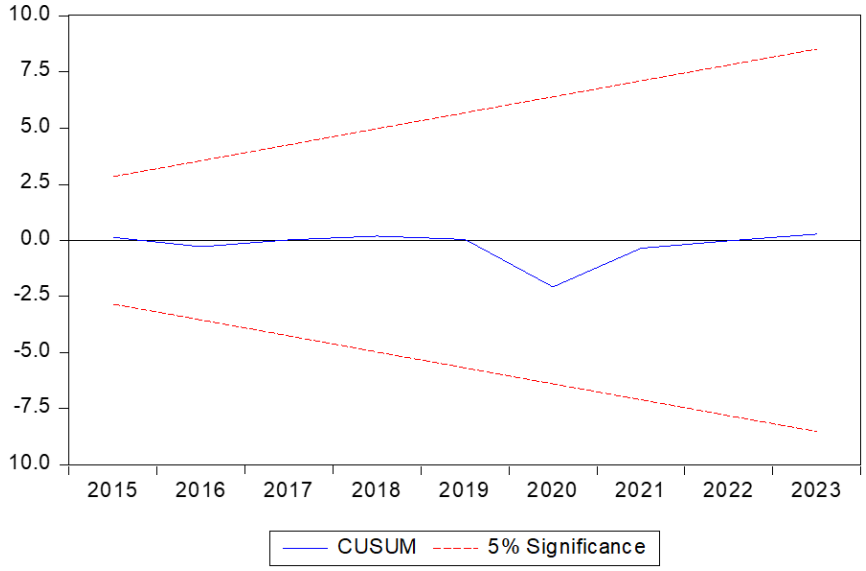

Figure 2. CUSUM test.

4.6. Granger causality analysis

Table 8. Pairwise granger causality test.

Null Hypothesis	Prob	Result
LINFRASP does not Granger cause LGDP LGDP does not Granger cause LINFRASP	0.0427* 0.0897**	Bi-directional
LGOVDEBT does not Granger cause LGDP LGDP does not Granger cause LGOVDEBT	0.0913** 0.0667**	Bi-directional
LCPI does not Granger cause LGDP LGDP does not Granger cause LCPI	0.0516** 0.0315*	Bi-directional
LGOVDEBT does not Granger cause LINFRASP LINFRASP does not Granger cause LGOVDEBT	0.1953 0.0023*	Unidirectional INFRASP → GOVDEBT
LCPI does not Granger cause LINFRASP LINFRASP does not Granger cause LCPI	0.6944 0.0038*	Unidirectional INFRASP → CPI
LCPI does not Granger cause LGOVDEBT LGOVDEBT does not Granger cause LCPI	0.0110* 0.8364	Unidirectional CPI → GOVDEBT

Note: * and **denotes a *P*-value at a 5% and 10% significance level respectively.
Source: EViews 12.

To better understand the direction of influence among the variables, Granger causality tests are conducted as indicated in **Table 8**. Results indicate that infrastructure spending Granger causes changes in GDP, supporting the notion that public investment is a driver of economic growth. But the direction of causality is bi-directional with GDP growth also positively affecting infrastructure spending. Secondly, a Bi-directional Causality exists between Government Debt and GDP. The feedback relationship between government debt and GDP indicates that not only does debt influence GDP, but changes in GDP also affect debt levels, possibly due to changes in government revenue and fiscal capacity. It was also found that a bi-directional relationship exists between GDP and CPI. GDP Granger causes inflation changes, suggesting that increased demand may lead to higher prices as GDP grows,

reflecting demand-pull inflation dynamics.

In terms of causality between the independent variables, infrastructure spending does cause changes in government spending, while infrastructure spending cause changes in CPI.

5. Conclusions

This study examined the connections between GDP, infrastructure spending, government debt, and inflation in South Africa from 1995 to 2023. Results showed that infrastructure spending positively influences GDP, promoting long-term economic growth, whereas government debt has a negative effect on GDP in both the short and long run. Moderate inflation was found to be supportive of growth, though high inflation presents risks. The study successfully met its objectives by analysing these variables' independent and combined effects on GDP using the ARDL model, which offered both short- and long-term insights and contributed to a more comprehensive understanding of South Africa's economic dynamics. The findings underscore the critical role of infrastructure spending in supporting GDP growth and the need for responsible debt management to avoid negative economic impacts.

The insights from the literature review and the results sections have actionable implications. Policymakers should prioritise productive infrastructure investments to drive GDP growth and ensure inflation control mechanisms maintain economic stability. Responsible debt management practices are essential to prevent debt from constraining growth. The study, however, has limitations, particularly regarding external factors like international trade and global economic conditions, which were outside its scope. Future research could investigate these additional variables or delve into sector-specific impacts of infrastructure spending for more nuanced insights. In addition, future studies on this research focus area include more research on the research gap as identified on the neglect of infrastructure spending in developing countries, and also to compare countries in this regard. The policy implications of this study include the following:

Investment in Infrastructure: The positive long-term influence of infrastructure spending on GDP suggests the need for sustained and expanded public investment in infrastructure, especially in developing economies where infrastructure shortages may restrict productivity and growth.

Sustainable Debt Management: The adverse impact of government debt on GDP highlights the importance of sustainable debt practices. Policymakers should carefully monitor debt levels and prioritise debt for productive investments rather than recurrent spending. Implementing fiscal rules to cap debt-to-GDP ratios can also help prevent unsustainable debt.

Controlled Inflation: The finding that moderate inflation supports GDP growth suggests that inflation-targeting policies can benefit economic stability. However, it is essential to avoid high inflation, which could destabilise the economy and reduce purchasing power.

By implementing these policies, South Africa could develop a more resilient and sustainable economy that effectively balances short-term growth needs with long-term fiscal and economic stability.

Conflict of interest: The author declares no conflict of interest.

References

Abdullahi, M. M. (2016). External debt, debt overhang, crowding out effects and capital formation in Nigeria and South Africa [PhD thesis]. Universiti Utara Malaysia.

Afonso, A., & Jalles, J. T. (2013). Growth and productivity: The role of government debt. International Review of Economics & Finance, 25, 384–407. https://doi.org/10.1016/j.iref.2012.07.004

Agénor, P. R., & da Silva, L. A. P. (2013). Inflation targeting and financial stability: a perspective from the developing world. Washington, DC: Inter-American Development Bank.

Ahmed, R., Aizenman, J., & Jinjarak, Y. (2021). Inflation and Exchange Rate Targeting Challenges Under Fiscal Dominance. Journal of Macroeconomics, 67, 103281. https://doi.org/10.1016/j.jmacro.2020.103281

Antwi, S., Zhao, X., & Mills, E. F. E. A. (2013). Impact of Macroeconomic Policies on the Ghana Stock Exchange: A Cointegration Analysis. International Business Research, 6(3). https://doi.org/10.5539/ibr.v6n3p100

Awuni, P. D. (2021). Government Expenditure And Private Investment In Ghana [PhD thesis]. University Of Ghana.

Babatunde, S. A. (2018). Government spending on infrastructure and economic growth in Nigeria. Economic Research-Ekonomska Istraživanja, 31(1), 997–1014. https://doi.org/10.1080/1331677x.2018.1436453

Bassanini, F., & Reviglio, E. (2011). Financial stability, fiscal consolidation and long-term investment after the crisis. OECD Journal: Financial Market Trends, (1), 31–75.

Bruno, M., & Easterly, W. (1998). Inflation crises and long-run growth. Journal of Monetary Economics, 41(1), 3–26.

Coyle, D. (2015). GDP: a brief but affectionate history-revised and expanded edition. Princeton University Press.

Cwik, T., & Wieland, V. (2011). Keynesian government spending multipliers and spillovers in the euro area. Economic Policy, 26(67), 493–549. https://doi.org/10.1111/j.1468-0327.2011.00268.x

Daniel, S. U., Israel, V. C., Chidubem, C. B., et al. (2021). Relationship Between Inflation and Unemployment: Testing Philips Curve Hypotheses and Investigating the Causes of Inflation and Unemployment in Nigeria. Path of Science, 7(9), 1013–1027. https://doi.org/10.22178/pos.74-13

Das, N. (2017). A Time Series Analysis on the Relation between Foreign Direct Investment & Total Factor Productivity Growth of the Indian Organised Manufacturing Sector: 1980-81 to 2010-11. Pacific Business Review International, 9(8), 78–91.

Fedderke, J., & Liu, Y. (2018). Inflation in South Africa: An Assessment of Alternative Inflation Models. South African Journal of Economics, 86(2), 197–230. Portico. https://doi.org/10.1111/saje.12192

Fedderke, J. W., & Bogetić, Ž. (2009). Infrastructure and Growth in South Africa: Direct and Indirect Productivity Impacts of 19 Infrastructure Measures. World Development, 37(9), 1522–1539. https://doi.org/10.1016/j.worlddev.2009.01.008

Fischer, S. (1993). The role of macroeconomic factors in growth. Journal of Monetary Economics, 32(3), 485-512.

Foster, V., Rana, A., & Gorgulu, N. (2022). Understanding Public Spending Trends for Infrastructure in Developing Countries. Policy Research Working Paper. https://doi.org/10.1596/1813-9450-9903

Girdzijauskas, S., Streimikiene, D., Griesiene, I., et al. (2022). New Approach to Inflation Phenomena to Ensure Sustainable Economic Growth. Sustainability, 14(1), 518. https://doi.org/10.3390/su14010518

Hassan, M., & Nassar, R. (2015). Effects of debt and GDP on the unemployment rate: an empirical study. Journal of International Business Disciplines, 10(2).

Herrera, R. F., Sánchez, O., Castañeda, K., et al. (2020). Cost Overrun Causative Factors in Road Infrastructure Projects: A Frequency and Importance Analysis. Applied Sciences, 10(16), 5506. https://doi.org/10.3390/app10165506

Holtfrerich, C. L., Feld, L. P., Heun, W., et al. (2016). Government debt: causes, effects and limits. Berlin-Brandenburg Academy of Sciences and Humanities. Berlin, 76.

Imran, M., & Niazi, J. (2011). Infrastructure and growth. The Pakistan Development Review, 355–364.

Jean-Paul, F., & Martine, D. (2018). Beyond GDP measuring what counts for economic and social performance: measuring what counts for economic and social performance. OECD Publishing.

Judijanto, L., & Kusnadi, I. (2024). The impact of inflation on economic growth: a comprehensive literature study. Journal of Community Dedication, 4(4), 786–796.

Krugman, P. (1988). Financing vs. forgiving a debt overhang. Journal of Development Economics, 29(3), 253–268.

Mandeya, S. M. T., & Ho, S. Y. (2021). Inflation, inflation uncertainty and the economic growth nexus: An impact study of South

Africa. MethodsX, 8, 101501. https://doi.org/10.1016/j.mex.2021.101501

National Treasury. (2024). Infrastructure spending data. Available online: https://www.treasury.gov.za/documents/National%20Budget/2024/review/Annexure%20D.pdf#:~:text=Public%E2%80%90sector%20infrastructure%20spending%20over%20the%202024%20medium%E2%80%90term%20expenditure,projected%20R374.7%20billion%20over%20the%20next%20three%20years (accessed on 23 October 2024).

Nkoro, E., & Uko, A. K. (2016). Autoregressive Distributed Lag (ARDL) cointegration technique: application and interpretation. Journal of Statistical and Econometric Methods, 5(4), 63–91.

Panizza, U., & Presbitero, A. F. (2013). Public debt and economic growth in advanced economies: A survey. Swiss Journal of Economics and Statistics, 149(2), 175–204. https://doi.org/10.1007/bf03399388

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. Journal of Applied Econometrics, 16(3), 289–326. Portico. https://doi.org/10.1002/jae.616

Quantec. (2024). Regional Economic data. Available online: https://www.quantec.co.za/easydata/ (accessed on 20 September 2024).

Ramey, V. (2020). The Macroeconomic Consequences of Infrastructure Investment. National Bureau of Economic Research, 10, w27625. https://doi.org/10.3386/w27625

Raudino, S., & Raudino, S. (2016). The Theory of Economic Development. Development Aid and Sustainable Economic Growth in Africa: The Limits of Western and Chinese Engagements, 43–77.

Reinhart, C. M., & Rogoff, K. S. (2010). Growth in a Time of Debt. American Economic Review, 100(2), 573–578. https://doi.org/10.1257/aer.100.2.573

Romp, W., & de Haan, J. (2007). Public Capital and Economic Growth: A Critical Survey. Perspektiven Der Wirtschaftspolitik, 8(S1), 6–52. https://doi.org/10.1111/j.1468-2516.2007.00242.x

Seccareccia, M. (1995). Keynesianism And Public Investment: A Left-Keynesian Perspective On The Role Of Government Expenditures And Debt. Studies in Political Economy, 46(1), 43–78. https://doi.org/10.1080/19187033.1995.11675366

Sekwati, D., & Dagume, M. A. (2023). Effect of Unemployment and Inflation on Economic Growth in South Africa. International Journal of Economics and Financial Issues, 13(1), 35–45. https://doi.org/10.32479/ijefi.13447

Semjonova, N. (2017). Government Debt and GDP Growth. In Financial Environment and Business Development: Proceedings of the 16th Eurasia Business and Economics Society Conference (pp. 267-283). Springer International Publishing.

Shaddady, A. (2022). Is Government Spending an Important Factor in Economic Growth? Nonlinear Cubic Quantile Nexus from Eastern Europe and Central Asia (EECA). Economies, 10(11), 286.

Srinivasu, B., & Rao, P. S. (2013). Infrastructure development and economic growth: Prospects and perspective. Journal of Business Management and Social Sciences Research, 2(1), 81–91.

Statistics South Africa (StatsSA). (2024). Consumer Price Index. Available online: https://www.statssa.gov.za/publications/P0141/P0141June2024.pdf (accessed on 18 September 2024).

Stiglitz, J., Ocampo, J. A., Spiegel, S., et al. (2006). Stability with growth: macroeconomics, liberalisation and development. OUP Oxford.

Straub, S. (2008). Infrastructure and growth in developing countries. World Bank Publications.