INFRASTRUCTURE DEVELOPMENT AS A CATALYST FOR ECONOMIC GROWTH IN SOUTH AFRICA

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WP/2024/03

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List of acronyms

ADF	Augmented Dickey-Fuller
ARDL	Autoregression Distributed Lag
ASGISA	Accelerated and Shared Growth Initiative for South Africa
BRICS	Brazil Russia India China South Africa
CONSUMP	Consumption
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GEAR	Growth Employment and Redistribution
GFCF	Gross Fixed Capital Formation
GOVEXP	Government expenditure
IFSA	Infrastructure Fund South Africa
IMF	International Monetary Fund
NDP	National Development Plan
PP	Phillips and Perron
StatsSA	Statistics South Africa
TR	Trade openness
VAR	Vector Autoregressive Model
VECM	Vector Error Correction Model

Abstract

Infrastructure investment amongst other mechanisms provides essential physical structures and systems that support economic activities to achieve economic growth, economic development, and poverty alleviation. South Africa has implemented various policy initiatives and strategies for the development of infrastructure. This study assessed the long-run relationship between infrastructure investment and economic growth in South Africa covering the period between 1994 and 2022. The autoregression distributed lag (ARDL) model is employed in this study as an estimation technique. The study results showed that infrastructure investment has a positive and significant effect on economic growth in South Africa. These results support the implementation of economic policies that support infrastructure development in South Africa.

1. Introduction and background

The South African government's major focus is achieving the socio-economic goals of reducing unemployment, poverty, and inequality (National Development Plan, 2012). In South Africa, unemployment, poverty, and inequality levels remain high and the economic outlook remains constrained by the low growth potential (Asuelime, 2018). South Africa's economy has been growing at less than 2% from 2014 to 2019 (Statistics South Africa, 2022). The low economic growth rates can be attributed to, among others, low foreign and domestic investment, power outages, and deterioration of infrastructure quality (National Treasury, 2019).

The South African government is fully committed to infrastructure investment to grow the country's economy and continues to fund economic and social infrastructure facilities and activities (Cumming *et al*., 2017; Mbeki *et al.,* 2019; National Treasury, 2019). South Africa's infrastructure investment incorporates roads, transportation networks, power stations, communication networks, schools, hospitals, safe water, and sanitation (National Treasury, 2019). Infrastructure investment is regarded as a means of achieving economic growth, economic development, and poverty alleviation in South Africa (Gnade, 2021).

Infrastructure generally refers to physical structures, facilities, and systems such as power supplies, water supplies, roads, buildings, schools, hospitals, and communication networks to provide essential services for public use (Stupak, 2018). The World Bank (2018) divides infrastructure stock into economic infrastructure and social infrastructure. Furthermore, infrastructure includes institutional infrastructure such as banking and civil administration (Torrisi, 2009). In this study infrastructure investment is defined as the allocation of funds toward the development, improvement, and maintenance of essential physical structures and systems that support economic activities (Yapicioglu *et al*., 2017). These include communication networks, transportation networks, water and sanitation systems, energy facilities, and public amenities like hospitals and schools (Stupak, 2018).

South Africa continues to experience underinvestment in infrastructure development and institutional factors have led to a deterioration of the quality of the infrastructure in the country (World Bank, 2018). Furthermore, investment in key economic infrastructure such as the energy and transport sectors has lagged far behind the domestic demand (Mahori, 2022; World Bank, 2018). Infrastructure investment has been on a downward trajectory over the recent few years recording 5% from 2020 to 2022 (Stats SA, 2023).

This study assessed the relationship between infrastructure investment and South African economic growth using the autoregressive distributed lags (ARDL) model of analysis. It is hoped that the findings of this study will contribute knowledge and insights into efforts that seek to increase infrastructure investment to foster economic development and growth in South Africa.

2. Research Goals

The purpose of this study is to investigate the long run relationship between infrastructure investment and economic growth in South Africa from 1994 to 2022.

3. Overview of economic growth and infrastructure investment in South Africa

The South African GDP growth rate registered 1.1% in 2017 and registered a significant decline of -6.3% by 2020 due to low investment growth, shortages of electricity supply, political instability, and the COVID-19 pandemic (Stats SA, 2022; World Bank, 2020). South Africa's GDP growth rate rebounded to 4.7% in 2021 due to the country moving out of the COVID-19 pandemic and the hard lockdown period, increased economic activities, and short-term countercyclical as well as fiscal and monetary policy measures (Stats SA, 2022).

The South African government continues to prioritise and expand infrastructure investment as part of the national growth and development strategy. This is exemplified by strategy documents such as the Growth Employment and Redistribution, Accelerated and Shared Growth Initiatives for South Africa, the National Development Plan, and the Infrastructure Plan 2050 (National Treasury, 2019). However, South Africa continues to have critical infrastructure needs partly because of underinvestment, poor maintenance, and neglect of infrastructure networks which continue to depress economic growth (National Treasury, 2020:15; Makhathini, Mlambo & Mpanza, 2020). The country continues to experience underinvestment and deterioration in the quality of infrastructure due to, among others, misappropriation of funds, and increasing infrastructure bottlenecks (Meyer & Sanusi, 2019; Makhathini, Mlambo & Mpanza, 2020).

4. Literature review

The theoretical underpinnings of the study are based on the endogenous growth theory (Romer 1986, 1990) and the government expenditure in a simple model of endogenous growth (Barro, 1990). The endogenous growth theory assumes that labour, human capital, physical capital as well as technological change are primary sources of economic growth (Romer, 1986). Furthermore, the theory assumes that economic growth tends to be faster in countries that have a relatively large stock of capital (Romer, 1990). In terms of government expenditure in a simple model of endogenous growth, infrastructure investment has a positive effect on economic growth in which final output is a function of both public-sector infrastructure services and private-sector investment (Barro,1990; Perkins, 2006). The theory postulates that public investment encourages new private investment to take advantage of the higher productivity it creates, thus increasing economic growth (Maalim, 2022). Nonetheless, a negative relationship can exist between infrastructure investment and economic growth when public investment crowds out private investment (Fosu, Getachew & Ziesemer, 2016).

Some empirical studies on the relationship between infrastructure investment and economic growth show that infrastructure investment has a positive relationship and impact on economic growth (Kumo, 2012; Palei, 2015; Mbanda & Mabugu, 2016; Sharma & Tenyana, 2019; Zhang *et al.*, 2021; Matsolo, 2021; Du, Zhang & Han, 2022; Cheng & Zhang, 2023). Other studies have established a negative relationship between economic growth and infrastructure investment (Younis, 2014; Vuyeka, 2015; Stungwa & Daw, 2021; Apurv & Uzma, 2020). It can be learned that the main reason for the difference in the results of these studies lies in the different methodologies used, different study periods explored, and country specifics.

5. Data and methodology

Most of the data on the variables were obtained from Statistics South Africa and the South African Reserve Bank. GDP is measured at constant 2015 prices. Infrastructure investment is the sum of gross fixed capital formation (GFCF) of general government infrastructure investment and GFCF infrastructure investment by public corporations which together form aggregate public economic infrastructure investment in the country at constant 2015 prices. Both final consumption expenditures by the general government and households are measured at constant 2015 prices. Trade openness is the sum of exports and imports measured at constant 2015 prices. All the variables are transformed into logarithms. These control variables have an impact on economic growth. The study will cover the period from 1994 to 2022. The rationale behind choosing this study period is to examine the effect of infrastructure investment on economic growth in South Africa since the advent of democracy.

5.1. Methodology

The study uses quantitative research methodology. The Autoregressive Distributed Lags (ARDL) model is selected for the empirical analysis. Unlike Engle-Granger and Johansen, the ARDL approach is suitable for this study as it can be applied with a small number of observations and can be used regardless of the order of integration of the variables, whether they are I (0) or I (1), or a mixture of both (Pesaran and Shin, 1999; Odhiambo, 2013).

The model specification to investigate the relationship between economic growth, infrastructure investment, final government consumption expenditure, final household consumption expenditure, and trade openness is based on a simple multivariate framework where the empirical model is specified as follows:

$$LGDP_t=\beta_0+\beta_1 LGFCF_t+\beta_2 LGOVEXP_t+\beta_3 LCONSUMP_t+\beta_4 LTR_t+\varepsilon_t \quad (5.1)$$

Where:

L represents logarithms, β_o is the intercept, and β_1, β_2, β_3, and β_4, are coefficients to be estimated.

GDP represents the measure of economic growth, GFCF is the indicator for total infrastructure investment from the government sector, public corporations, and private investment enterprise as a percentage of GDP, GOVEXP represents final general government consumption expenditure as a percentage of GDP, CONSUMP is the indicator of the final household consumption expenditure as a percentage of GDP, and

TR is trade openness thus the sum of a country's export and imports, and ε is the error term.

5.1.1. Unit root testing

Unit root tests are conducted before the empirical estimations to determine the order of integration of the variables. The Augmented Dickey-Fuller (1981) test and the Phillips and Perron test (1988) are used in this study.

5.1.2. ARDL bound testing

According to Harris (1995:52), if two series appear to move together over time, it indicates a long-run relationship among the variables. For example, suppose two variables are integrated of order one 1(1) and the residuals obtained from regressing Yt and Xt are 1(0), the two series are co-integrated. This study utilised the ARDL bounds testing approach for the existence of a long-run relationship between variables developed by Pesaran, Shin, and Smith (2003). The test can be used irrespective of whether variables are purely I (1), I (0), or a mixture of variables of different orders of integration. The technique cannot be used in the presence of I (2) variables.

The bound testing approach is based on a VAR model which can be specified as follows:

$$zt = c0 + c1t + \sum \varphi i \Delta zti + \varepsilon t \; p \; i=1 \qquad (5.\ 2)$$

where $c0$ is a vector of intercepts, $c1$ is a vector of trend coefficients and p is the lag length. The vector error correction model (VECM) is specified as follows:

$$\Delta zt = c0 + c1t + \Pi zt-1 + \sum \Gamma i \Delta zt-i + \varepsilon t \; p \; i=1 \qquad (5.3)$$

Where Π and Γ are the long-run and short-run coefficient matrices, respectively. The null hypothesis of no long-run relationship is tested against the alternative hypothesis using the Wald test (F-statistics). Pesaran *et al.* (2003) provided critical values for the F-test. If the F-statistic is greater than the upper critical value, the null hypothesis is rejected. If the F-statistic is less than the lower critical value, the null hypothesis is not rejected irrespective of the order of integration of the variables. If the F-statistic falls between the upper and lower critical values, the results are inconclusive.

The long-run relationship between GDP, total GFCF, government consumption expenditure, household consumption expenditure, and trade openness are specified as an ARDL (p,q,p,q,p,q) dynamic specification which will be used for this relationship as follows:

LGDPt=$\lambda 1i$LGDP$t-1$+$\delta 10i$LGFCFt+$\delta_2 0i$LGOVEXPt+$\delta_3 0i$LCONSUMPt+$\delta_4 0i$LTRt+δ $-1-1i$LGFCF$t--1$+δ_2-1iLGOVEXP$t--1$+δ_3-1iLCONSUMPT$t--1$+δ_4-1iLTR$t--1$+μ i+εt (5.4)

The error correction representation of the ARDL model is specified as follows:

Δ LGDPt= ϕi(LGDP$t-1$- $\theta 0i$- θ $1i$ LGFCF$t-1$+$\theta_2 i$LGOVEXP $t-1$+$\theta_3 i$ LCONSUMP $t-1$+ $\theta_4 i$ TR $t-1$)+ $\delta i01\Delta$ LGFCF+ $\delta i02\Delta$LGOVEXP+$\delta i03\Delta$ LCONSUMP + $\delta i04\Delta$ LTR + μi+$\varepsilon it-1$ (5.5)

Where the Δ is defined as the first difference operator, t is the time trend. It is assumed that the residuals are (ε)normally distributed and white noise.

5.1.3. Diagnostic testing

Diagnostics and stability tests were conducted on the ARDL model to ascertain the goodness of fit of the model. The diagnostic test performed in this study includes the Breusch (1978) – Godfrey (1978) LM test for serial correlation, the Breusch and Pagan (1979) test for heteroscedasticity, as well as the residual normality test for checking the model validity of the estimated coefficients and the stability of the model.

6. Empirical results

The empirical results of the relationship between infrastructure investment and economic growth in South Africa are presented in this section.

6.1. Summary statistics

Table 1 below shows the descriptive statistics of the relationship between infrastructure investment and economic growth from 1994 to 2022.

Table 1 Descriptive statistics

R' million	GDP	Government consumption expenditure	Household consumption expenditure	Infrastructure investment	Trade openness
Mean	3 654 152	691 910	2 287 540	152 523	1 986 935
Median	3 856 572	728 133	2 407 392	180 152	1 385 589
Maximum	4 599 261	900 044	3 066 585	295 024	4 312 584
Minimum	2 389 241	472 455	1 362 465	24 127	202 309
Std. Dev.	772 010	156 457	568 247	100 720	1 139 649
Jarque-Bera	2.976851	3.134598	2.817691	3.437178	1.974497
Probability	0.225728	0.208608	0.244425	0.179319	0.372600
Observations	29	29	29	29	29

Source: Author's construction

As can be seen in Table 1 above, the average value of South Africa's GDP during the period under review was R3.7 trillion, and the mean government consumption expenditure and household consumption expenditure were R691 billion and R2.3 trillion, respectively. The average value of infrastructure investment over the same period under consideration was R152 billion, average trade openness was R1.6 trillion. The minimum GDP in the country of R2.4 trillion was recorded in 2020, whereas the maximum GDP of R4.6 trillion was recorded after the country moved out of the hard lockdown period, increased economic activities, and implemented short-term countercyclical fiscal and monetary policy measures (Stats SA, 2021). The minimum infrastructure investment in the country was observed in 1994 recording R24 billion, whereas the maximum infrastructure investment of R295 billion was seen in 2016. Infrastructure investment has been on a downward trajectory over the recent few years (Stats SA, 2023).

6.2. Unit root test results

The unit root tests are run with a trend term and the unit root results are presented in Table 2 below.

Table 2 Unit root test results intercept and trends

Variables	Level		1st difference	
	ADF test	PP test	ADF test	PP test
LGDP	-0.216	-0.216	-3.480*	-4.730***
LGFCF	-1.173	-0.518	-3.249*	-3.288*
LHCE	-0.794	-0.791	-3.894**	-4.570***
LGCE	-1.008	-1.776	-3.107*	-5.094***
LTR	-2.057	-1.939	-4.019**	-5.972***

Source: Author's construction. Note: (***), (**), and (*) indicate significance at 1%, 5%, and 10%, respectively.

As can be seen Table 2, with a trend term included the ADF and PP tests suggest that all the variables are non-stationary at levels I(0)) and all the variables become stationary at the first difference I (1). The variables in the study are a mixture of I (0) and I (1) and therefore the estimation technique chosen is the ARDL bound cointegration test proposed by Pesaran, et al. (2001).

6.3. Bound testing cointegration results

The application of the ARDL bound test in examining the long-run relationship among the variables entails the estimation of an Unrestricted Error Correction Model (UECM) in first difference form (Khobai, et.al 2016:80). The results of the ARDL bound test are presented in Table 3.

Table 3 Bound test cointegration results

F-statistics	Critical values					
	1%		5%		10%	
	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
3.495	3.29	4.37	2.56	3.49	2.2	3.09

Source: Author's construction drawn from EViews 12 iterations

The ADRL bound results reported in Table 3 reveal that the computed F-statistics are above the upper bound values at a 5% significance level for South Africa. Following these results, the variables are said to be cointegrated, suggesting the rejecting of the null hypothesis that there is no cointegration. The results imply the presence of a long run cointegration relationship among the variables.

Following the finding of the existence of a long-run relationship among the variables, the long-run and short-run dynamics between the variables are estimated. The Akaike information criteria (AIC) is the model selection criteria.

6.4. ARDL long-run and short-run estimates

The long-run and short-run estimates of the relationship between infrastructure investment and economic growth in South Africa are presented in Table 4.

Table 4 Empirical results Dependent variable GDP

Long-run	Coefficient	t-Statistic	Probability
Log Gross fixed capital formation	0.118	2.257	0.035**
Log Household consumption expenditure	0.034	0.078	0.938
Log Government consumption expenditure	0.047	0.269	0.790
Trade openness	0.111	1.447	0.163
Short run			
Log Gross fixed capital formation	0.033	6.468	0.003***
Log Household consumption expenditure	0.625	12.728	0.000***
Log Household consumption expenditure (-1)	-0.615	-5.678	0.000***
Log Government consumption expenditure	0.184	2.525	0.020**
Log Government consumption expenditure (-1)	-0.171	-3.959	0.000***
Trade openness	0.031	2.326	0.030**
ECM	-0.280	-10.596	0.000***

Source: Author's construction based on own computations. Note: (***), (**), and (*) indicate significance levels at 1%, 5% and 10%, respectively.

Gross fixed capital formation (GFCF) has a positive and statistically significant relationship with economic growth both in the long and short run in South Africa. These results are consistent with Mbanda & Mabugu (2016) and Sharma & Tenyana (2019). The results suggest that a 1% increase in infrastructure investment leads to a 0.1% increase in economic growth in the long run. The results imply that infrastructure investment potentially boosts economic growth in South Africa both in the long and short run. Although it is statistically significant both in the short and long run, the impact of infrastructure investment on economic growth is less than 1% during the period reviewed. In this regard, if South Africa continues to invest in new productive infrastructure and maintains the existing infrastructure, this will eventually lead to growth for the economy (Makhatini, Mlambo& Mpaza, 2020).

Household consumption expenditure enhances the South African economic growth scenario. Government consumption expenditure is associated with a higher growth rate in South Africa both in the short and long run. Trade openness has a positive and insignificant relationship with economic growth in South Africa in the long run while a positive and significant relationship with economic growth is reported in the short run.

The Error Correction Model (ECM) coefficient shows that 29% of the disequilibrium in the short run is corrected towards the long run. The error correction term is negative and significant at 1%, providing further evidence of a long-run relationship between the variables.

6.5. Diagnostic tests

The diagnostic tests for normality, heteroscedasticity, serial correlation, and stability were performed to validate the adequacy of the model. Breusch (1978) and Godfrey (1978) LM is selected for serial correlation test. Breusch and Pagan (1979) are chosen for the heteroscedasticity test. Normality is tested using the Jarque-Bera test under the null hypothesis that the residuals are normally distributed (Gujarati and Porter, 2009). The Ramsey test is used for model stability (Ramsey,1969). The diagnostic test results are shown in Table 5 below.

Table 5 Diagnostic test results

Dependent variable: SAGDP								
Country	**Jaque-Bera test**		**Serial Correlation LM test**		**Breusch-Pagan test**		**Ramsey's RESET test**	
	J. Bera	P-value	F-stat	P-value	F-stat	P-value	F-stat	P-value
South Africa	0.799	0.670	1.333	0.288	0.550	0.786	0.000	0.983

Source: Author's computation using SARB, Stats SA data (2023)

The diagnostic test results shown in Table 5 above show no evidence of model misspecification, heteroscedasticity, serial correlation, and instability as the respective null hypotheses are rejected. The results indicate that the ARDL model passed the diagnostic tests, suggesting that the model is adequate and robust for statistical inferences.

7. Conclusion and recommendations

This study investigated the impact of infrastructure investment on economic growth in South Africa using the ARDL model for the period 1994 to 2022. It included final government consumption expenditure, final household consumption expenditure, and trade openness as additional variables to form a multivariate framework. The study found that there is a long-run relationship between infrastructure investment and economic growth in South Africa. Furthermore, the results revealed that infrastructure investment has a positive and significant impact on economic growth both in the long and short run. The results imply that the South African government should ensure that its infrastructure development policies assist with scaling up new infrastructure and maintenance of the existing infrastructure to grow the South African economy.

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APPENDIX A: Data

Year	GDP R' million	Infrastructure investment R' million	Trade openness R' million	Household consumption expenditure R' million	Government consumption expenditure R' million
1994	2 389 241	24 127	202 309	1 362 465	502 660
1995	2 463 307	28 453	245 909	1 443 213	472 456
1996	2 569 229	31 203	296 156	1 507 750	490 434
1997	2 636 029	36 254	329 377	1 556 865	500 911
1998	2 649 210	45 720	372 425	1 583 993	489 788
1999	2 712 791	41 136	391 181	1 611 518	491 916
2000	2 826 728	41 748	486 768	1 678 206	506 322
2001	2 903 049	44 114	573 304	1 736 828	522 132
2002	3 010 473	52 681	727 494	1 791 931	546 001
2003	3 099 254	61 876	681 468	1 842 670	576 869
2004	3 240 412	68 383	754 230	1 957 662	607 082
2005	3 411 410	77 157	871 249	2 077 733	613 633
2006	3 602 579	95 156	1 106 330	2 260 081	636 751
2007	3 795 694	132 820	1 340 527	2 407 392	676 256
2008	3 916 816	180 152	1 723 011	2 436 546	728 133
2009	3 856 572	195 479	1 385 589	2 373 417	740 990
2010	3 973 802	188 020	1 540 216	2 508 374	738 924
2011	4 099 714	217 067	1 817 777	2 610 053	769 098
2012	4 197 952	225 114	1 982 291	2 694 257	805 940
2013	4 302 291	257 468	2 277 657	2 736 048	831 421
2014	4 363 118	266 327	2 459 637	2 755 751	847 435
2015	4 420 793	293 172	2 507 769	2 815 210	839 291
2016	4 450 171	295 024	2 658 747	2 834 426	856 222
2017	4 501 702	278 332	2 718 656	2 883 014	853 842
2018	4 571 783	266 411	2 922 164	2 974 191	863 117
2019	4 583 667	250 454	3 031 874	3 012 316	879 004
2020	4 310 327	222 233	2 822 230	2 827 579	887 166
2021	4 513 044	238 477	3 482 174	2 992 578	891 561
2022	4 599 261	268 628	4 312 584	3 066 585	900 045

Source: SARB (2023), Stats SA (2023)

APPENDIX B: ARDL Bound test, long- run and short-run results

ECM and F- Bound Test

ARDL Error Correction Regression
Dependent Variable: D(LGDP)
Selected Model: ARDL(1, 0, 1, 1, 0)
Case 2: Restricted Constant and No Trend
Date: 12/02/23 Time: 08:32
Sample: 1994 2022
Included observations: 28

ECM Regression
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LGOVEXP)	0.184313	0.032578	5.657566	0.0000
D(LHCEXP)	0.625054	0.031986	19.54127	0.0000
CointEq(-1)*	-0.280106	0.054711	-5.119769	0.0001

R-squared	0.954993	Mean dependent var	0.023390
Adjusted R-squared	0.951392	S.D. dependent var	0.023436
S.E. of regression	0.005167	Akaike info criterion	-7.592103
Sum squared resid	0.000667	Schwarz criterion	-7.449367
Log likelihood	109.2894	Hannan-Quinn criter.	-7.548467
Durbin-Watson stat	2.327659		

* p-value incompatible with t-bounds distribution.

F-Bounds Test Null Hypothesis: No levels relationship

Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	3.494938	10%	2.2	3.09
k	4	5%	2.56	3.49
		2.5%	2.88	3.87
		1%	3.29	4.37

Long run results

ARDL Long Run Form and Bounds Test
Dependent Variable: D(LGDP)
Selected Model: ARDL(1, 0, 1, 1, 0)
Case 2: Restricted Constant and No Trend
Date: 12/02/23 Time: 08:47
Sample: 1994 2022
Included observations: 28

Conditional Error Correction Regression

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.083994	0.747727	4.124491	0.0005
LGDP(-1)*	-0.280106	0.126953	-2.206380	0.0392
LGFCF**	0.033067	0.009961	3.319741	0.0034
LGOVEXP(-1)	0.013261	0.049144	0.269835	0.7901
LHCEXP(-1)	0.009638	0.125939	0.076529	0.9398
LTR**	0.031138	0.013382	2.326843	0.0306
D(LGOVEXP)	0.184313	0.072982	2.525459	0.0201
D(LHCEXP)	0.625054	0.054970	11.37092	0.0000

* p-value incompatible with t-Bounds distribution.
** Variable interpreted as Z = Z(-1) + D(Z).

Levels Equation
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LGFCF	0.118051	0.052283	2.257953	0.0353
LGOVEXP	0.047342	0.175569	0.269650	0.7902
LHCEXP	0.034408	0.436835	0.078768	0.9380
LTR	0.111167	0.076785	1.447762	0.1632
C	11.01008	4.382810	2.512106	0.0207

EC = LGDP - (0.1181*LGFCF + 0.0473*LGOVEXP + 0.0344*LHCEXP + 0.1112*LTR + 11.0101)

F-Bounds Test — Null Hypothesis: No levels relationship

Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic: n=1000	
F-statistic	3.494938	10%	2.2	3.09
K	4	5%	2.56	3.49
		2.5%	2.88	3.87
		1%	3.29	4.37
			Finite Sample: n=35	
Actual Sample Size	28	10%	2.46	3.46
		5%	2.947	4.088
		1%	4.093	5.532
			Finite Sample: n=30	
		10%	2.525	3.56
		5%	3.058	4.223
		1%	4.28	5.84

Short run results

Dependent Variable: LGDP
Method: ARDL
Date: 12/02/23 Time: 08:52
Sample (adjusted): 1995 2022
Included observations: 28 after adjustments
Maximum dependent lags: 1 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (1 lag, automatic): LGFCF LGOVEXP LHCEXP LTR
Fixed regressors: C
Number of models evaluated: 16
Selected Model: ARDL(1, 0, 1, 1, 0)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LGDP(-1)	0.719894	0.126953	5.670558	0.0000
LGFCF	0.033067	0.009961	3.319741	0.0034
LGOVEXP	0.184313	0.072982	2.525459	0.0201
LGOVEXP(-1)	-0.171052	0.043203	-3.959271	0.0008
LHCEXP	0.625054	0.054970	11.37092	0.0000
LHCEXP(-1)	-0.615416	0.108375	-5.678572	0.0000
LTR	0.031138	0.013382	2.326843	0.0306
C	3.083994	0.747727	4.124491	0.0005

R-squared	0.999458	Mean dependent var	15.10250
Adjusted R-squared	0.999268	S.D. dependent var	0.213512
S.E. of regression	0.005777	Akaike info criterion	-7.234961
Sum squared resid	0.000667	Schwarz criterion	-6.854331
Log likelihood	109.2894	Hannan-Quinn criter.	-7.118598
F-statistic	5266.132	Durbin-Watson stat	2.327659
Prob(F-statistic)	0.000000		

*Note: p-values and any subsequent tests do not account for model selection.