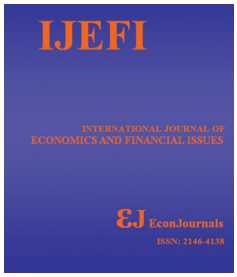

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Impact of Gross Capital Formation, Foreign Direct Investment, and Energy Infrastructure on Economic Growth in Selected Southern African Development Community Countries

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ABSTRACT

This study examines the impact of gross capital formation, foreign direct investment (FDI), and energy infrastructure on economic growth in eight selected Southern African Development Community (SADC) countries from 1994 to 2023. Recognising the crucial role of investment and infrastructure in sustainable development, the study provides an integrated empirical analysis of these growth drivers within a region where economic performance remains uneven. Using a quantitative panel data approach, the analysis applies econometric techniques that address cross-sectional dependence and heterogeneity, including the Feasible Generalised Least Squares (FGLS) and Cross-Sectional Autoregressive Distributed Lag (CS-ARDL) models. Data were obtained from the World Bank's World Development Indicators, covering GDP per capita, gross capital formation, FDI inflows, and electricity access as a proxy for energy infrastructure. The results show that gross capital formation significantly and positively influences growth in both the short and long run, while FDI has a weak and statistically insignificant effect, possibly due to institutional and absorptive capacity constraints. Energy infrastructure exhibits mixed effects, with inefficiencies limiting its contribution. The study recommends strengthening domestic investment mechanisms, improving governance to enhance FDI effectiveness, and upgrading energy infrastructure to support sustained and inclusive growth across the SADC region.

Keywords: Economic Growth, Gross Capital Formation, Foreign Direct Investment, Energy Infrastructure
JEL Classifications: E22 F21 O47 Q40

1. INTRODUCTION

In the quest for sustainable economic growth, developing and emerging economies continue to prioritize investment in productive assets such as capital stock, foreign direct investment (FDI), and energy infrastructure. These elements are widely recognised for their ability to expand productive capacity, support technological advancement, and enable structural transformation. According to the World Bank (2023), gross capital formation accounted for approximately 26.5% of global GDP in 2022, signifying its relevance in driving investment and output growth. Similarly, foreign direct investment remains a key source of external finance, with global FDI inflows reaching USD 1.37 trillion in 2023 (UNCTAD, 2024). The importance of energy infrastructure cannot be overstated, as it directly supports industrial production, facilitates business activity, and enhances the living conditions of populations. The International Energy Agency (IEA, 2023a) highlights that reliable and inclusive energy access forms the foundation for sustainable economic growth, particularly in emerging markets. As Nwachukwu and Odhiambo (2019) note, the synergy between energy development and capital accumulation contributes significantly to enhancing productivity and competitiveness in developing regions.

Sub-Saharan Africa, however, continues to underperform in these key growth indicators. In 2023, the region recorded an average gross capital formation rate of only 20.1% of GDP, far below regions like East Asia and the Pacific (World Bank, 2023). FDI

inflows into Africa declined by 5% in 2023, with Southern Africa receiving a relatively low share despite its resource endowments (UNCTAD, 2024). The SADC region reflects a mixed picture across member states. For example, while countries such as Mauritius, South Africa, and Namibia enjoy over 90% electricity access, others like Madagascar and Tanzania remain below 40% (IEA, 2023b). In terms of economic performance, countries like Seychelles and Botswana recorded growth above 4% in 2022, whereas Zimbabwe and Madagascar saw rates below 2% (IMF, 2023). These inconsistencies underscore the importance of evaluating how capital formation, FDI, and energy infrastructure interact to influence growth within the region. Although previous studies (Olayungbo and Quadri, 2022; Moyo and Bonga, 2021) have investigated these factors in different contexts, few have examined their combined effects across the eight selected SADC countries South Africa, Zimbabwe, Botswana, Mauritius, Madagascar, Seychelles, Namibia, and Tanzania over a long-term horizon using panel data. This study, therefore, seeks to contribute by empirically analysing the extent to which these variables have impacted economic growth from 1994 to 2023.

2. LITERATURE REVIEW

The investigation into the drivers of economic growth in developing regions such as the Southern African Development Community (SADC) is grounded in foundational economic theories. The Solow-Swan neoclassical growth model (Solow, 1956) posits that economic growth is primarily driven by capital accumulation, labour, and technological progress. Gross capital formation fits within this framework as a vital contributor by increasing the physical capital stock. Endogenous growth theory, advanced by Romer (1990), builds on this by emphasizing the role of internal factors such as human capital, innovation, and infrastructure investments as sustainable sources of growth. Foreign direct investment (FDI) and energy infrastructure, for instance, are recognized as vehicles for technology transfer and efficiency gains within this paradigm. Further extensions by Barro and Sala-i-Martin (2004) highlight the importance of public infrastructure and institutional quality, particularly in low- and middle-income countries.

These theoretical models have been critically assessed and adapted to the African context by various scholars. Nnadozie and Njuguna (2020) argue that the persistent infrastructure gap in Sub-Saharan Africa severely limits the productive impact of capital accumulation, implying that the assumptions of the Solow model may not hold uniformly across such settings. Asiedu (2019a; 2019b) highlights the heterogeneous effects of FDI across African countries, where absorptive capacity and institutional effectiveness serve as key moderators. Critiques of these models emphasize their assumption of homogeneity and the underestimation of socio-political institutions' roles. For example, while the Solow model assumes diminishing returns to capital, this may not apply in economies with large infrastructure deficits. Similarly, the endogenous growth framework's assumption that investments are inherently productive is challenged by empirical evidence revealing inefficiencies and corruption in low-income regions (Bonga et al., 2021).

Empirical literature has extensively examined the relationship between gross capital formation, FDI, energy infrastructure, and economic growth across developing countries, employing diverse econometric methods and varying time periods. Sunde (2021) conducted a panel data analysis covering 2000–2018 for SADC countries, using fixed effects and random effects models, and found a significant positive impact of gross capital formation on GDP growth, underscoring capital accumulation's continued relevance. In contrast, Oladipo and Olayemi (2022) applied Dynamic Panel Generalized Method of Moments (GMM) techniques on Sub-Saharan African data from 1995 to 2019 and showed that while FDI inflows positively influence growth, the effect is conditional on infrastructure quality and macroeconomic stability. This contrasts with Sunde's broader capital focus by explicitly factoring in institutional and infrastructural moderators. Focusing on energy infrastructure, Acheampong et al. (2021) used panel vector autoregression (PVAR) for West and Southern African countries between 1990 and 2017, revealing that energy access and reliability have significant positive effects on economic productivity. However, Moyo and Bonga (2020), employing panel cointegration and error correction models on SADC data from 2005 to 2018, reported insignificant growth effects of energy infrastructure investments due to poor project execution and maintenance deficiencies, presenting a contrasting viewpoint that highlights implementation challenges. Further, Ramaphosa and Molefe (2023) analysed Zimbabwe and Madagascar using autoregressive distributed lag (ARDL) models from 2000 to 2020, finding negligible growth impact from FDI, which they attributed to weak regulatory frameworks and inadequate investor protection. This contrasts with Oladipo and Olayemi's broader Sub-Saharan results, illustrating country-specific regulatory constraints.

On the causality between these variables and economic growth, scholars have applied cointegration and causality testing methodologies with nuanced findings. Using panel cointegration techniques, Ngoma and Ismail (2023) established a long-run causal relationship from gross capital formation to economic growth in Southern African economies during 1995–2021. Tshuma and Dube (2022), employing Granger causality tests on Zimbabwe and South Africa (1998-2019), found bidirectional causality between FDI and GDP in some contexts, but unidirectional causality from FDI to growth in others, contingent on institutional readiness and market openness. Regarding energy infrastructure, the International Energy Agency (IEA, 2023b) utilised time series Granger causality tests in Tanzania and Namibia from 2000 to 2022, identifying that electricity access and generation capacity Granger-cause economic growth, supporting theories of capital deepening and productivity enhancement.

Despite the depth of this literature, several gaps remain. Many studies focus on individual variables in isolation or within limited geographic scopes, often lacking integration of gross capital formation, FDI, and energy infrastructure in a single empirical framework. Additionally, comparative analyses across SADC countries over extended periods are scarce, with much research emphasizing broader Sub-Saharan Africa or individual countries. There is also variation in methodological approaches, time

frames, and contextual factors, which complicates cross-study comparisons. Importantly, few studies explicitly address how these variables interact dynamically over the long term within the SADC region, considering institutional and infrastructural heterogeneity. This study seeks to fill these gaps by conducting a comprehensive panel data analysis of the combined effects of gross capital formation, FDI, and energy infrastructure on economic growth in the SADC region, spanning three decades (1994-2023). Employing advanced econometric techniques that account for cross-sectional dependence and heterogeneity, this research aims to provide a region-specific, integrated perspective that improves upon previous fragmented approaches.

3. METHODOLOGY

3.1. Research Design

This study adopts a quantitative panel data research design to investigate the impact of gross capital formation, foreign direct investment, and energy infrastructure on economic growth in eight selected SADC countries between 1994 and 2023. The panel approach enables the study to capture both time-series and cross-sectional variations across countries, thereby improving the reliability of estimations. This design is appropriate as it allows for examining both long-run and short-run dynamics while accounting for country-specific characteristics and structural heterogeneity (Baltagi, 2005).

3.2. Sampling Method

A purposive sampling technique was applied to select the eight SADC countries included in the study: South Africa, Zimbabwe, Botswana, Mauritius, Madagascar, Seychelles, Namibia, and Tanzania. These countries were selected based on the availability and completeness of annual data for the variables of interest from 1994 to 2023. The diversity in economic structures and levels of infrastructure development among these countries enhances the robustness of the panel analysis and provides valuable comparative insights.

3.3. Research Instrument

Since this study is based entirely on secondary data, no traditional research instruments such as surveys or interviews were used. Instead, all data were sourced from the World Bank's World Development Indicators (WDI), a credible and freely accessible international database. The WDI provides consistent and standardized country-level macroeconomic indicators, making it suitable for cross-country econometric analysis.

3.4. Data Collection

The data for all variables were freely collected from the World Bank database covering the period 1994-2023. The variables used in the analysis include:

- Gross Domestic Product (GDP) per capita (constant 2015 US$), representing economic growth (dependent variable);
- Gross Capital Formation (% of GDP), indicating domestic investment;
- Foreign Direct Investment, net inflows (% of GDP);
- Access to electricity (% of population), serving as a proxy for energy infrastructure.

All data were collected in their level form, consistent with the actual values reported in the WDI. No variable was transformed into logarithmic form.

3.5. Data Analysis

The data analysis began with descriptive statistics to provide a summary of the mean, standard deviation, minimum, and maximum values of each variable across the countries and years. This was followed by a correlation matrix to assess the strength and direction of the linear relationships among variables. To address the possibility of contemporaneous correlation among countries, the Pesaran (2004) Cross-Sectional Dependence (CSD) Test was conducted. The Pesaran and Yamagata (2008) slope heterogeneity test was also applied to evaluate whether slope coefficients differ significantly across countries.

To test the stationarity properties of the variables, the study employed both first-generation and second-generation panel unit root tests. The Im e al. (IPS, 2003) test served as the first-generation test, assuming cross-sectional independence, while the Pesaran (2007) Cross-Sectionally Augmented IPS (CIPS) test was used to account for cross-sectional dependence. These tests ensured the correct specification of integration orders prior to proceeding with cointegration testing.

To examine the long-run relationship among variables, the Westerlund (2007) Error Correction Model (ECM) panel cointegration test was applied. This test is robust to cross-sectional dependence and structural heterogeneity, making it suitable for macro-panel data. Based on the cointegration results, the study employed the Cross-Sectionally Augmented Autoregressive Distributed Lag (CS-ARDL) model proposed by Chudik and Pesaran (2015) to estimate both short-run and long-run effects. The CS-ARDL method accounts for cross-sectional dependence and heterogeneous dynamics, making it appropriate for macroeconomic panels.

3.6. Model Specification

The functional form of the baseline regression model estimated in the study is specified as follows:

$$EG_{it}=f(DI_{it},GCF_{it},ENGY_{it}) \quad (1)$$

The corresponding econometric model, presented in level form, is expressed as:

$$EG_{it}=\beta_0+\beta_1 FDI_{it}+\beta_2 GCF_{it}+\beta_3 ENGY_{it}+\varepsilon_{it} \quad (2)$$

In the specified model, EG_{it} represents economic growth, which is measured by GDP per capita for country i at time t. The variable FDI_{it} denotes foreign direct investment net inflows as a percentage of GDP, while GCF_{it} captures gross capital formation, also expressed as a percentage of GDP, for country i at time t. Energy infrastructure is represented by $ENGY_{it}$ which is proxied by access to electricity (% of population) for the same country and time. The constant term in the model is denoted by β_0, and the coefficients β_1, β_2, and β_3 measure the marginal effects of foreign direct investment, gross capital formation, and energy infrastructure, respectively, on economic growth. Lastly, ε_{it} represents the error term, which

captures the variation in economic growth not explained by the model's explanatory variables.

4. RESULTS AND DISCUSSION

This section presents and analyses the empirical results of the study, focusing on the interpretation of data using the estimation techniques detailed in Section 3. The aim is to investigate the dynamic relationship between gross capital formation, foreign direct investment, and energy infrastructure on economic growth in selected Southern African Development Community (SADC) countries. Utilising a range of robust panel econometric methods including descriptive statistics, correlation analysis, cross-sectional dependence tests, homogeneity/heterogeneity assessments, both first- and second-generation panel unit root tests, the Westerlund ECM cointegration test, the Feasible Generalised Least Squares (FGLS) method, and the CS-ARDL model this section provides meaningful insights into the interactions among these variables from 1994 to 2023, highlighting their policy implications for the region's economic development.

4.1. Descriptive Statistic

This subsection provides a statistical summary of the main variables used in the analysis as shown in Table 1. It helps to understand the distribution, central tendencies, and variability of the data across the selected SADC countries over the study period.

The descriptive statistics provide an overview of the key variables in the study. Economic growth (EG) has an average value of 3.36, indicating that on average, the selected SADC countries experienced positive economic growth. However, the standard deviation of 5.01 suggests considerable variation across the countries, with economic contractions observed in some cases, as shown by the minimum value of −17.67, while the maximum value of 21.45 highlights periods of significant growth. Foreign direct investment (FDI) has an average of 3.56, but the large range from −1.70 to 56.28 reflects major differences in FDI inflows across the countries. Some countries experienced negative FDI, possibly due to disinvestment or net outflows, while others had significantly high inflows. Gross capital formation (GCF) averages 22.23, with values ranging between 1.52 and 42.91, indicating substantial differences in investment levels across the countries. Energy infrastructure (ENGY) shows a mean of 55.25 with a high standard deviation of 31.91, suggesting that energy accessibility and infrastructure vary significantly among SADC nations.

4.2. Correlation Matrix

The correlation matrix in Table 2 shows how economic growth, foreign direct investment, gross capital formation, and energy infrastructure are linearly related across the SADC countries.

Table 1: Summary of descriptive statistics

Variable	Obs	Mean	Std Dev	Min	Max
EG	240	3.363264	5.013396	−17.66895	21.45206
FDI	240	3.561984	5.119625	−1.701545	56.28827
GCF	240	22.23427	8.430575	1.525177	42.90622
ENGY	240	55.24897	31.91235	3.30064	100

Source: Authors' computations using Stata

The correlation analysis reveals that economic growth (EG), and foreign direct investment (FDI) have a weak positive correlation of 0.0796, implying that FDI inflows alone may not significantly drive growth a finding consistent with Asiedu's (2019a; 2019b) argument that the impact of FDI in African countries is moderated by absorptive capacity and institutional quality. Gross capital formation (GCF) displays a more meaningful positive correlation with EG at 0.2464, aligning with the Solow-Swan model's emphasis on capital accumulation as a key growth determinant (Solow, 1956). The correlation between GCF and FDI, at 0.3354, suggests that foreign investment may contribute to domestic capital formation, supporting the endogenous growth theory's assertion that FDI facilitates investment and technological spillovers (Romer, 1990). However, energy infrastructure (ENGY) shows a weak negative correlation with EG (−0.0248), possibly reflecting the inefficiencies or lagged effects of infrastructure investment on growth in the SADC context, as noted by Bonga et al. (2021). These findings underscore the importance of institutional and contextual factors in mediating the growth impact of investment and infrastructure, as emphasized in the adapted critiques of both neoclassical and endogenous growth theories for Sub-Saharan Africa.

4.3. Cross-sectional Dependence Test Results

Table 3 below shows the results of the cross-sectional dependence test, which evaluates whether economic activities and structural developments in one SADC country are statistically linked to those in others an important consideration for ensuring accurate model specification in panel data analysis.

The results confirm the presence of significant cross-sectional dependence for all variables, as indicated by P-values of 0.000, leading to the rejection of the null hypothesis of cross-sectional independence. Economic growth (EG) shows a CD-test value of 9.326 and a mean correlation (ρ) of 0.32, suggesting moderate co-movement in growth patterns across countries. FDI and GCF also exhibit statistically significant dependence with CD-test values of 4.5 and 3.753, and mean correlations of 0.16 and 0.13, respectively implying that capital inflows and investment trends in one country are somewhat influenced by regional dynamics. Energy infrastructure (ENGY) records the highest dependence, with a CD-test statistic of 23.523 and a mean ρ of 0.81, highlighting strong

Table 2: Correlation analysis results

Variable	EG	FDI	GCF	ENGY
EG	1.0000			
FDI	0.0796	1.0000		
GCF	0.2464	0.3354	1.0000	
ENGY	−0.0248	0.1902	0.1048	1.0000

Source: Authors' computations using Stata

Table 3: Cross sectional dependence test results

Variable	CD-test	P-value	Average joint T	Mean ρ	Mean abs(ρ)
EG	9.326	0.000	30.00	0.32	0.35
FDI	4.5	0.000	30.00	0.16	0.21
GCF	3.753	0.000	30.00	0.13	0.25
ENGY	23.523	0.000	30.00	0.81	0.81

H_0: Cross sectional independence, Source: Authors' computations using Stata

cross-country similarities in energy development patterns. These findings suggest the presence of regional spillover effects and support endogenous growth theory's emphasis on interconnected development drivers, underscoring the need to use second-generation panel techniques that account for such dependencies.

4.4. Heterogeneity Test Results

The homogeneity/heterogeneity test results, as shown in Table 4, assess whether the impact of economic growth, FDI, GCF, and energy infrastructure varies across the SADC countries.

The homogeneity test results confirm that economic relationships vary across countries. The Delta_tilde value of 2.123 and Delta_tilde_adj of 2.326 both return significant P-values 0.034 and 0.020, respectively, indicating heterogeneity in the dataset. This suggests that the effects of FDI, gross capital formation, and energy infrastructure on economic growth are not uniform across the SADC countries. Differences in institutional quality, economic policies, and structural factors likely contribute to this heterogeneity, necessitating the use of econometric techniques that account for country-specific variations.

4.5. Stationarity Test Results

The stationarity of variables was tested using both first- and second-generation panel unit root tests, with the latter included due to the cross-sectional dependence found in Table 5.

The results show that economic growth (EG) is stationary at level across all tests e.g., IPS w/o trend = −7.1511***, CIPS w/o trend = −4.135***, while foreign direct investment (FDI) is mostly stationary at level but sometimes requires differencing e.g., IPS w/o trend = −2.9950***, CIPS w/o trend = −3.203***. Gross capital formation (GCF) displays mixed stationarity, being stationary at level in IPS w/o trend −1.8207** but requiring differencing in IPS with trend −8.7539***. Energy infrastructure (ENGY) is non-stationary at level IPS w/o trend = 2.1336 but stationary after first differencing IPS w trend = −11.4331***. Importantly, none of the variables are integrated of order two (I(2)), confirming the data is suitable for cointegration analysis. This aligns with theoretical expectations that macroeconomic variables often exhibit different integration orders, and the inclusion of second-generation tests accounts for cross-sectional dependence to ensure reliable results (Pesaran, 2007; Baltagi, 2008).

Table 4: Homogeneity/heterogeneity test results

$EG_{it}=\beta_0+\beta_1 FDI_{it}+\beta_2 GCF_{it}+\beta_3 ENGY_{it}+\varepsilon_{it}$	Statistic	P-value
Delta_tilde	2.123	0.034
Delta_tilde_adj	2.326	0.020

Source: Authors' estimations using Stata

4.6. Cointegration Test Results

This subsection presents the panel cointegration results based on the second-generation Westerlund test, as displayed in Table 6.

The Westerlund error correction model (ECM) cointegration test confirms the existence of a long-run relationship between the variables. The Gt statistic of −5.098 and Pt statistic of −13.060 both return P-values of 0.000, leading to the rejection of the null hypothesis of no cointegration. This indicates that economic growth, FDI, gross capital formation, and energy infrastructure move together in the long run. However, the Ga statistic of −16.279 (P = 0.396) and Pa statistic of −15.540 (P = 0.105) are not significant but they become significant on Robust P-value, suggesting that the strength of this long-run relationship may vary depending on the estimation approach. The presence of cointegration suggests that changes in FDI, capital formation, and energy infrastructure will have lasting effects on economic growth rather than short-term fluctuations.

4.7. Feasible Generalized Least Squares (FGLS) Techniques

This section presents the FGLS results in Table 7, which serve as the base models because they specifically address cross-sectional dependence (CSD) in the data.

The Feasible Generalized Least Squares (FGLS) results, which account for cross-sectional dependence across the panel, reveal varying impacts of the independent variables on economic growth (EG). Foreign direct investment (FDI) consistently shows weak and statistically insignificant coefficients across all model specifications, with values ranging from as low as 0.0007 in model 7 to 0.0645 in model 5, all accompanied by low z-statistics of 0.0845 in model 1 and 0.0354 in model 3. This suggests that while FDI may contribute marginally to economic activity, its direct impact on economic growth in the selected countries is limited when cross-sectional heterogeneity is considered. The lack of significance across models indicates that other factors may mediate the influence of FDI, such as the absorptive capacity of host countries or sectoral allocation of foreign investments.

In contrast, gross capital formation (GCF) consistently exerts a significant and positive influence on economic growth across all

Table 5: First- and second-generation panel unit root tests results

Variables/	1st	Generation	2nd	Generation
Unit root tests	IPS w/o trend	IPS w trend	CIPS w/o trend	CIPS w trend
EG	−7.1511*** *I* (0)	−5.9943*** *I* (0)	−4.135*** *I* (0)	−4.286*** *I* (0)
	−14.2110*** *I* (1)	−12.7267*** *I* (1)	−6.162*** *I* (1)	−6.350*** *I* (1)
FDI	−2.9950*** *I* (0)	−1.2485 *I* (0)	−3.203*** *I* (0)	−3.365*** *I* (0)
	−9.8060*** *I* (1)	−8.2037*** *I* (1)	−5.713*** *I* (1)	−5.848*** *I* (1)
GCF	−1.8207** *I* (0)	−0.3632 *I* (0)	−2.510** *I* (0)	−2.975** *I* (0)
	−8.7539*** *I* (1)	−7.0591*** *I* (1)	−5.460*** *I* (1)	−5.437*** *I* (1)
ENGY	2.1336 *I* (0)	−0.2097 *I* (0)	−2.363** *I* (0)	−3.369*** *I* (0)
	−11.4331*** *I* (1)	−11.3440*** *I* (1)	−5.888*** *I* (1)	−6.222*** *I* (1)

Source: Authors' computations using Stata, ***P<0.01, **P<0.05 and *P<0.1

Table 6: Westerlund (2007) ECM panel cointegration test results

Statistic	Value	Z-value	P-value	Robust P value
Gt	−5.098	−7.775	0.000	0.000
Ga	−16.279	−0.265	0.396	0.000
Pt	−13.060	−6.474	0.000	0.000
Pa	−15.540	−1.253	0.105	0.000

H_o: No cointegration. Source: Authors' computations using Stata

models. The coefficient remains robust, ranging from 0.0915 in model 6 to 0.149 in model 1, with strong statistical significance z-statistics of 7.518 in model 7 and 4.337 in model 4. These results emphasize the critical role of domestic investment in driving economic expansion. On the other hand, energy infrastructure (ENGY) exhibits a mixed and generally negative effect. For instance, in model 4, the coefficient is −0.0208 with a z-statistic of -3.134, indicating a statistically significant adverse impact on growth. Similar negative and significant results appear in models 5 and 7, suggesting that despite increased energy infrastructure, inefficiencies or mismatches between supply and demand may be limiting its contribution to economic performance. This pattern implies a need for policy focus on not just expanding energy infrastructure but also improving its efficiency and accessibility.

4.8. Cross-sectional Autoregressive Distributed Lag (CS-ARDL) Model Results

This section presents the results of the Cross-Sectional Autoregressive Distributed Lag (CS-ARDL) model used to examine the short-run and long-run relationships between economic growth (EG) and its key determinants foreign direct investment (FDI), gross capital formation (GCF), and energy infrastructure (ENGY) across eight selected countries over time. The CS-ARDL model 10 accounts for cross-sectional dependence and heterogeneity, making it appropriate for analysing panel data with different dynamics across countries (Table 8).

In the short run focusing on model 10, the error correction term (ECT) is statistically significant and negative at the 1% level −0.987, indicating a strong and stable convergence toward long-run equilibrium following a shock. This implies that deviations from long-run equilibrium are corrected by nearly 99% in each period. Among the explanatory variables, gross capital formation (GCF) is positively and significantly associated with economic growth 0.198 coefficient, suggesting that increased domestic investment contributes positively to output in the short term. However, FDI and energy infrastructure (ENGY) show positive but statistically insignificant effects in the short run, indicating their immediate impact on economic growth is limited or inconsistent across countries.

In the long run, GCF remains statistically significant at the 1% level coefficient of 0.196, reinforcing its vital role in sustaining economic growth over time. Although both FDI and ENGY have positive coefficients 0.896 and 0.617, respectively, their effects are statistically insignificant, which may reflect structural or absorptive capacity limitations within the sample countries. The model explains a substantial portion of the variation in economic growth, as indicated by the R-squared values overall R^2 = 0.65, mean

Table 7: Feasible generalized least squares (FGLS) technique

Models	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Error structure across the panels		Independent and Identically distributed (IID)			Heteroscedastic but uncorrelated			Heteroscedastic and correlated	
Form of Auto	No Auto	AR (1)	Panel specific AR (1)	No Auto	AR (1)	Panel-specific AR (1)	No Auto	AR (1)	Panel-specific AR (1)
Variables	EG	EG	EG	EG	EG	EG	EG	EG	EG
FDI	0.00556	0.00706	0.00227	0.0499	0.0645	0.0455	0.000699	0.00340	0.00356
	(0.0845)	(0.102)	(0.0354)	(0.812)	(0.999)	(0.725)	(0.0168)	(0.0772)	(0.0851)
GCF	0.149***	0.137***	0.0983**	0.112***	0.106***	0.0915***	0.141***	0.131***	0.106***
	(3.765)	(3.088)	(2.166)	(4.337)	(3.791)	(2.642)	(7.518)	(6.267)	(4.099)
ENGY	−0.00818	−0.00725	−0.00104	−0.0208***	−0.0220***	−0.00756	−0.0119***	−0.0126**	−0.00296
	(−0.817)	(−0.619)	(−0.0973)	(−3.134)	(−2.927)	(−0.898)	(−2.739)	(−2.439)	(−0.578)
Constant	0.491	0.687	1.110 (0.981)	2.116***	2.309***	1.587*	1.167**	1.432**	0.793 (1.137)
	(0.488)	(0.594)		(2.797)	(2.771)	(1.704)	(2.083)	(2.262)	
Obs	240	240	240	240	240	240	240	240	240
No of countries	8	8	8	8	8	8	8	8	8
Chi-square (Wald test)	16.23	10.71	5.197	39.68	32.06	10.35	98.70	66.57	20.25

Source: Authors' computations using Stata. Z-statistics in parentheses, ***P<0.01, ** P<0.05 and *P<0.1

Table 8: CS-ARDL model results

Model (10)	CS-ARDL
Variables	**Output**
EG	
Short run estimates	
L.EG	0.012 (0.14)
FDI	0.970 (1.22)
GCF	0.198*** (2.64)
ENGY	0.549 (1.52)
ECT	−0.987*** (−10.49)
Long run estimates	
Lr_ENGY	0.617 (1.44)
Lr_FDI	0.896 (1.35)
Lr_GCF	0.196*** (3.15)
Observations	232
No of countries	8
R-squared	0.65
R-squared (MG)	0.54

Source: Authors' computations. Z-statistics in parentheses, ***P<0.01, ** P<0.05 and *P<0.1

group $R^2 = 0.54$. These results highlight the importance of domestic investment over external inflows and energy infrastructure in driving long-term growth in the studied regions.

5. CONCLUSION AND RECOMMENDATIONS

This study empirically examined the impact of gross capital formation, foreign direct investment (FDI), and energy infrastructure on economic growth in eight selected Southern African Development Community (SADC) countries from 1994 to 2023. Employing advanced panel econometric techniques that account for cross-sectional dependence and heterogeneity including the Feasible Generalized Least Squares (FGLS) and Cross-Sectional Autoregressive Distributed Lag (CS-ARDL) models the analysis revealed several key findings. Gross capital formation consistently emerged as a significant and robust driver of economic growth both in the short and long run. This finding aligns with the Solow-Swan neoclassical growth model (Solow, 1956) and endogenous growth theory (Romer, 1990), which emphasize the critical role of domestic investment in expanding productive capacity and fostering technological progress. The positive and significant coefficients for gross capital formation underscore the importance of strengthening domestic investment to sustain economic expansion in the SADC region.

Foreign direct investment exhibited a positive but generally weak and statistically insignificant effect on economic growth. This suggests that while FDI inflows may contribute marginally to economic activity, their direct growth enhancing impact is limited by factors such as institutional quality, absorptive capacity, and sectoral allocation of investments, consistent with the findings of Asiedu (2019a; 2019b) and Oladipo and Olayemi (2022). Therefore, policies aimed at improving governance, regulatory frameworks, and investment climate are essential to maximize the benefits of FDI. Energy infrastructure showed mixed and often negative effects on economic growth, indicating potential inefficiencies, supply-demand mismatches, or maintenance challenges within the region's energy sector. This result resonates with the observations of Bonga et al. (2021) regarding implementation deficiencies. It highlights the need for not only expanding energy infrastructure but also enhancing its reliability, accessibility, and operational efficiency to support sustainable growth.

Based on these findings, several policy recommendations emerge. Governments should prioritize creating a conducive environment for domestic capital formation through improved financial markets, incentives for private sector investment, and infrastructure development. Strengthening institutions, regulatory frameworks, and investor protections will help attract and effectively utilize FDI, amplifying its growth impact. Investments in energy should focus on upgrading existing infrastructure, ensuring maintenance, and expanding access to underserved areas to improve productivity and living standards. Given the significant cross-sectional dependence observed across countries, regional integration and policy coordination within SADC can foster spillover benefits and shared growth dynamics. By addressing these areas, SADC countries can better leverage capital formation, FDI, and energy infrastructure to achieve sustainable economic growth.

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