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The Effect of Governance on the Relationship Between Research and Development Expenditure and Economic Growth in South Africa

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Abstract: This study analyzes the effects of governance on the relationship between research and development expenditure and economic growth in South Africa using annual data from 1997 to 2022 using an autoregressive distributed lag (ARDL) model. The calculated F-tests for the two models in the ARDL bounds testing approach to cointegration revealed a long-run relationship between the series. In the model without a mediating factor, an insignificant impact of research and development (R&D) expenditure on economic growth is reported. However, when R&D interacted with governance, a positive and significant impact was observed. This implies that for R&D to have a positive impact on economic growth, there is a need for strong and quality governance to provide a conducive productive environment. Furthermore, given the ambiguous relationship between governance and economic growth, the Granger causality test results showed that governance granger-causes economic growth and not the other way round. The findings presented in this paper are expected to provide some useful insights for policymakers in South Africa and the African continent. The findings demonstrate the important role that governance plays in enhancing the developmental performance of critical macro-economic growth factors. The study potentially generates new dimensions (by including governance as a mediating factor) in the understanding of how the impact of R&D and other macroeconomic parameters on economic growth can be promoted.

Keywords: autoregressive distributed lag (ARDL); economic growth; research and development expenditure; governance; South Africa

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1. Introduction

Africa is faced with numerous sustainable developmental and geopolitical challenges including malnutrition, climate change, food insecurity and poverty (Haile and Wasike 2020). The NORAD (2023) report further iterates that long brewing crises including increasing and unsustainable debt, the accumulated effects of the climate and nature crisis, demographic trends out of step with labour markets, inflation and recession, and the slowdown of the impressive poverty reduction from recent decades are aggravating the challenges already hindering global stability and prosperity. The above-mentioned challenges require harnessing science, technology and innovation (STI) through research and development (R&D) (Fu and Shi 2022; Akhtar et al. 2016). A study by (Adenle et al. 2023) on how STI can accelerate the achievement of sustainable development goals (SDGs) for all suggests that human resource capacity on STI is still low in many developing countries. Their findings suggest that to achieve SDGs it is necessary to strengthen the educational system, increase investment in R&D programs and foster collaboration, among other things. Moreover, R&D investment can potentially position developing countries including Africa to effectively deal with its challenges and also to engage with the Fourth Industrial Revolution (4IR) (Fu and Shi 2022). As indicated by Ildırar et al. (2016), R&D investment is

one of the most important factors that affect a country's competitiveness, economic growth and development through its influence on the technology capabilities, increasing resource base and promoting efficient resource utilization. Investing in R&D also enables economies to come up with technologies and innovations that are critical in providing solutions to the societal challenges that the continent is faced with. Fintech is one such example of an innovation with M-Pesa in Kenya being a game changer in the digital financial services ecosystem. M-Pesa has significantly enhanced output productivity and output growth in Kenya (Wachira and Njuguna 2023) and is now serving as a blueprint for other African countries and globally. This points to the importance of how innovation and R&D can have a transformative and positive impact on an economy. According to Gurib-Fakim and Signé (2022), bridging the skills deficiency gap in STI is key to unlocking Africa's potential and accelerate economic growth and prosperity.

Despite the importance of R&D in realizing solutions to national challenges, most African countries are lagging behind in their contribution to R&D. This occurs despite the call from the Lagos Plan of Action for Economic Development for African countries to spend at least 1% of their GDP on R&D (Iizuka et al. 2015). This chronic underinvestment prevents the continent from transforming its intellectual capital into tangible products, technologies and services that could boost economic growth, livelihoods and well-being (Kariuki et al. 2023).

This paper focuses on South Africa because it is the largest and most industrialized economy in Sub-Saharan Africa and therefore will serve as a good learning experience for other African countries. Although ranked among the top investors in R&D in Africa, statistics from the World Bank indicate that South Africa on average spends a meager 0.71% of their GDP on R&D, lagging behind the global average of 2.1%. Specifically, Figure 1 illustrates South Africa's R&D expenditure as a percentage of GDP as compared to the BRICS (Brazil, Russia, India, China and South Africa) countries and the world. For South Africa, the trend has always been almost constant over the years and decreasing since 2017, whereas the world trend has been rising since 2013. Moreover, in comparison with other BRICS countries, South Africa has the lowest recent statistics on R&D expenditure.

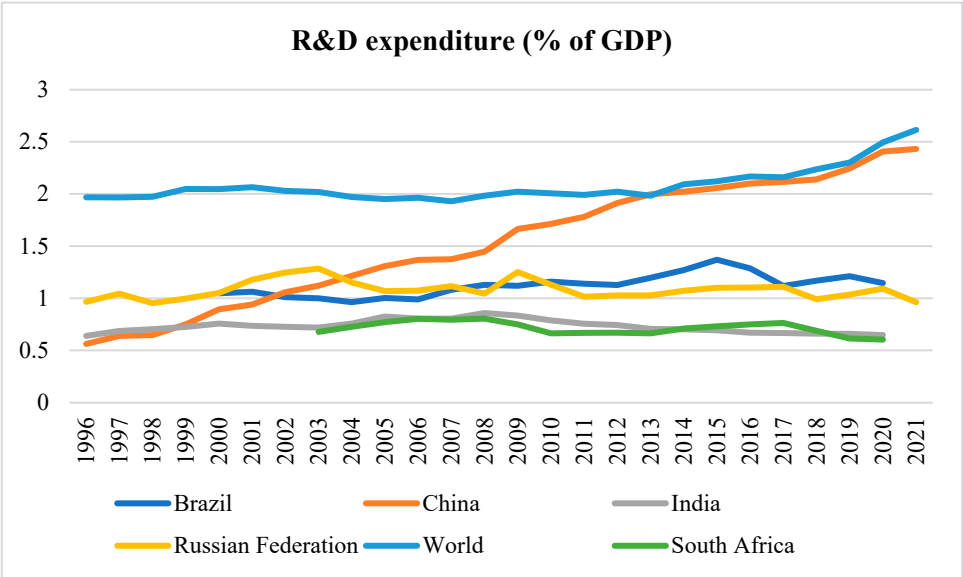

Figure 1. R&D expenditure (% of GDP)—South Africa vs BRICS countries and world. Source: Authors' computation using World Bank's WDI dataset.

Above all, we argue that for any intervention or investment to have a desired impact, the political landscape of the country (or countries) in question has to be favorable. In this paper, the role that governance can play in influencing the relationship between R&D expenditure and economic growth is studied. As indicated by Kaufmann et al. (2010),

public governance has to do with the traditions and institutions by which authority in a country is exercised. This includes (a) the process by which governments are selected, monitored and replaced; (b) the capacity of the government to effectively formulate and implement sound policies; and (c) the respect of citizens and the state for the institutions that govern economic and social interactions among them. Hence, governance is included in the model as a mediating factor. Even though the focus of this study is on public governance, we acknowledge that private governance (board composition; remuneration, and environmental, social and governance (ESG)) as indicated in de Mariz et al. (2024) is related and equally important. In both cases, upholding governance in decision making at all levels translates to better outcomes. As indicated by Meyer (2022), good governance is central to the growth and development of economies. There is strong evidence that governance and institutions play a critical role in accelerating development and in reducing poverty in developing countries (Khan 2006).

One main contribution of this study is that it includes governance as an interaction variable to see how it influences the impact of R&D on economic growth. Even though there are some multi-country panel studies (notably (Olaoye et al. 2021); (Akinwale and Surujlal 2021); Bayraktar et al. (2022); Özek (2020) and Perrot et al. 2012) that have looked at the effect of R&D expenditure on economic growth in South Africa, no study has explored how governance can affect that relationship. Moreover, with its focus on institutions, this study is highly pertinent to the global development agenda as it contributes notably to Sustainable Development Goal (SDG) 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.

The current research seeks to test the following hypotheses in the South African context:

H_1: *Economic growth is not affected by R&D expenditure in South Africa.*

H_2: *Economic growth is affected by R&D expenditure in South Africa.*

H_3: *Governance does not affect the impact that R&D expenditure has on economic growth.*

H_4: *Governance affects the impact that R&D expenditure has on economic growth.*

The rest of the paper is structured as follows. Section 2 provides a review of the literature on R&D and governance, and the theoretical framework upon which the study is anchored. Section 3 presents the methodological approach, outlining the data sources and data analytical techniques adopted for analysis. The results are presented and discussed in Section 4. Lastly, Section 5 presents the conclusions and suggests some recommendations for policy.

2. Literature Review

With the "new and old" challenges that the world is grappling with, research on the impact of R&D on economic growth has become a topic of interest in the area of development economics. Pelinescu (2015) asserts that achieving economic growth that is smart, sustainable and inclusive requires, among other things, a great effort to create a research-intensive economy. This can partly be achieved if the economies can direct funding towards R&D (Sarpong et al. 2023). As indicated by Karhan (2020), the relationship between R&D and economic growth has been widely studied within the economic science ecosystem. Using various methodologies and datasets, the findings on the R&D–growth nexus reported in the literature are quite mixed and therefore cannot be generalized across economies.

For instance, Bayraktar et al. (2022) examined the relationship between R&D expenditures and growth in the period of 2000–2018 in Brazil, Russia, India, China, South Africa, and Turkiye (BRICS-T) and found out that R&D expenditures positively affect the economic growth of those countries. Even though the authors did not include governance, they acknowledge that parameters such as corruption and bad governance will weaken the effectiveness of R&D, and this should be transparent in R&D support policies. Similarly, another study by Özek (2020) that focused on BRICS-T using annual data from 2003–2017

showed that R&D expenditure effectively increases economic growth only in the long run. Akinwale and Surujlal's (2021) case study of South Africa and Saudi Arabia between 2001 and 2018 also showed that R&D significantly impactde economic growth for both countries in the short run. In South Africa, Perrot et al. (2012) analyzed the impact of government R&D on the macro-economy of South Africa. The results indicate that the real economic significance of R&D lies not in spending, but in the outcomes. These outcomes are measured in terms of contribution to innovation as a key determinant of economic and social wellbeing, productivity, and growth and development.

In another study, Ildırar et al. (2016) explored the effect of different types of R&D expenditures on economic growth for the selected OECD countries from 2003 to 2014 using the GMM framework. Their results showed that all of the R&D expenditures had positive and significant effects on economic growth but with varying magnitudes where business enterprise expenditure had a higher impact as compared to government expenditure. Similar research by Falk (2007) using data from 1970 to 2004 concluded that investments in R&D significantly increased GDP per capita.

A further study by Coe et al. (1997) brought an interesting angle into the R&D–economic growth nexus analysis. The authors estimated the spill-over effect of R&D expenditure in developed countries to developing countries. The findings suggest that developing countries that hardly invest in research and development themselves benefit from R&D that is performed in the industrial countries. Their findings suggest that an increase in R&D expenditure in industrial countries positively and substantially influences growth capacities of developing countries through high-tech goods imported from the highly industrialized economies, highlighting the importance of trade. Statistically speaking, on average, a 1% increase in the R&D capital stock in the industrial countries raises output in the developing countries by 0.06% (Coe et al. 1997).

Some studies even went further by disaggregating the source of R&D expenditure to private and public. For instance, Lichtenberg (1993) used data spanning 1964–1989 from 74 countries to examine the relationship between the private and public sector R&D expenditures and economic growth. The results revealed that private sector R&D expenditures positively influenced economic growth while public sector R&D expenditures did not have any effect on economic growth and in some cases significantly and negatively influenced economic growth.

Another study by Gumus and Celikay (2015) utilized data from 52 countries from 1996 to 2010 and employed a dynamic panel data model to assess the impact of R&D expenditure on economic growth. The findings showed that R&D expenditures have a strong and positive effect on GDP in both the short and long run for developed countries. In contrast, for developing countries the effects were strong in the long run but weak in the short run. The study recommended that developing countries should allocate more resources towards R&D activities to speed up growth and economic performance. Samimi and Alerasoul (2009) also estimated the impact of R&D on economic growth of 30 developing countries using data spanning from 2000 to 2006. Their findings showed no significant effect of R&D expenditures on economic growth for all the countries studied. The authors attributed this non-significance to the low R&D expenditure in the developing countries under examination.

The findings presented here are quite mixed (either positive, negative or non-significant) and therefore necessitate the undertaking of the current study to establish how R&D expenditure affects economic growth in the South African context particularly with governance as a mediating factor.

2.1. Does Governance Matter?

The increased acknowledgement on the role that institutions can play in promoting economic growth have brought about research work focusing on the importance of governance as a mediating factor in promoting economic growth and development. As alluded to earlier on, this study focuses in particular on institutions and how they influence economic

growth. Douglass North, an American economist, provided the pioneering work in the field of institutional economics. He argued that institutions, especially well-developed property rights, plays an important role in explaining economic growth. North (1990) hypothesized that when wealth-seeking individuals in society see a chance to make higher profits that are impossible to earn within existing institutional arrangements, they devise ways to make these higher profits possible through institutional changes. This ultimately points to the importance of the quality of governance. The World Bank (1994) defined governance as the manner in which power is exercised in the management of a country's economic and social resources for development. This definition resonates well with the idea within which this study is framed. Governance in Africa plays a significant role in determining the relationship between the leaders and the followers in allocating state resources in order to improve the socio-economic wellbeing of Africans (Momoh 2015). The continent's developmental challenges are largely attributed to governance failures (Dooms and Fayoyin 2021). In South Africa, the issue of governance is of particular importance given its failure to realize substantial economic growth over the past 15 years owing to poor governance, among other factors (Berstein 2023).

It is important to note that both donors and recipients of global development financial resources acknowledge the importance of good governance as one of the critical sources of economic growth and social development in developing countries (Fayissa and Nsiah 2013). Donors are inclined to fund and invest in countries with good governance because the likelihood of the resources being misused is minimal. Countries with relatively good governance tend to grow at a faster rate, while the opposite is true for countries with relatively bad governance (Adeleke 2014; Khan 2006).

Mixed findings on how governance can influence economic growth have been reported in the literature. Adeleke (2014) used governance as an interacting factor when analyzing the FDI–growth nexus in Africa. The results provided clear evidence that governance positively influenced economic growth when interacting with FDI. The author concluded that African governments should put effort into enhancing their governance structures if they desire to attract more FDI and experience increased economic growth. In a similar vein, Mahran (2023) used spatial econometrics to estimate the impact of governance on economic growth in a sample of 116 countries worldwide in 2017. The results of the study showed that governance had a statistically significant positive impact on economic growth.

In contrast, other authors reported a negative relationship between governance and economic growth. Using annual Polity IV Project data from 1970 to 2014 and dynamic panel data-estimation techniques, Owusu-Sekyere and Jonas (2017) investigated the relationship between democracy and economic growth in five Anglophone West African countries. They found a negative relationship between democracy and economic growth when considering the full sample. Their general conclusion was that democracy is not a panacea for economic growth in Anglophone West African countries but must be accompanied by good governance and a healthy investment climate to attract the required levels of capital investment, human capital development that can influence growth, technological progress and a productive labor force. However, country-specific results varied. For instance, Nigeria showed a positive relationship between democracy and economic growth, whereas Liberia and Sierra Leone showed a negative relationship; and the relationship was insignificant for Gambia and Ghana.

2.2. Theoretical Framework

There are a few theoretical perspectives underlying the relationship between R&D expenditure and economic growth. This study is therefore based on the Endogenous Growth Theory and the Solow Growth Model. The Endogenous Growth Theory is built on the idea that improvements in innovation, knowledge, and human capital lead to increased productivity, positively affecting the economic outlook of a nation. It emphasizes the important effects of the factors behind the technological development such as R&D, human capital accumulation, and externalities on long-term growth (Ildırar et al. 2016). It

considers long-run growth as a function of technological progress, and in this case provides a framework in which R&D, through its effect on technology and innovation, can promote sustainable economic growth. As indicated by Inekwe (2015), four basic inputs in the endogenous growth model are physical capital, human capital, labor and technology.

Complimenting the Endogenous Growth Theory, the Solow Growth Model considers the importance of investment, technological advancements, savings and population growth in advancing the economic growth of a country. An increase in technological progress increases the production and the efficiency of the labor force, thereby increasing the country's GDP. Following this discussion, the current study borrows from both theories as an anchor for the proposed model.

The Cobb–Douglas function provides the basis for estimating the two models of economic growth. Hence, estimating the returns to R&D relies on the Cobb–Douglas production function augmented with knowledge capital. Moreover, as indicated by Zouhaier (2012), institutions can influence economic growth through productivity or capital accumulation. We therefore adopt a production function similar to the work of Zouhaier (2012) that incorporates the institutional factors into the growth model. The model can be presented in its simplified form as follows:

$$Y = AL\alpha\ INST£\ C\beta\ [K]\gamma\ [K0]\ \varphi\ e^{u} \quad (1)$$

where Y measures output (gross domestic product), C is ordinary (tangible) capital, K and K0 designates the intangible knowledge and external knowledge capital, respectively, L represents labor force, INST represents quality of governance and A is a constant reflecting the technological starting position of society

3. Data and Methodology

This section outlines the data sources and provides definitions of variables used in the analysis. It discusses the data analytical techniques employed in the study and introduces the autoregressive distributed lag (ARDL) model linking economic growth (GDP) with R&D, governance and other macro-economic variables.

3.1. Data Description

The data for this study were obtained from the World Bank's World Development Indicators (WDIs) and World Governance Indicators (WGIs). The annual data spanning 1997 to 2022 were used for the analysis. Table 1 shows all the variables that were included in the analysis. The dependent variable is economic growth (Gross Domestic Product—GDP). The research and development expenditure (RDexp) is the main variable of interest since we are interested in how it influences economic growth. An interactive term between R&D and governance (RDexp*GOV) was created to account for the impact of their interaction on economic growth. Other macroeconomic variables included in the model include urbanization, level of domestic investment and total labor force. Urbanization serves as a measure of the extent of how much a country is industrialized.

The principal component analysis (PCA) which according to Lopes et al. (2023) is most commonly used to reduce the dimensionality of high-dimensional datasets was used to create the index for the governance indicator. There are six broad dimensions of governance from the Worldwide Governance Indicators (WGIs): Voice and Accountability, Political Stability and Absence of Violence/Terrorism, Government Effectiveness, Regulatory Quality, Rule of Law and Control of Corruption. The score within the index ranges between +2.5 and −2.5, with a score above zero indicating effective governance and a score below zero indicating ineffective governance. However, following a crude analysis, only three dimensions were found to have an impact on GDP in South Africa and were therefore used to create the index: Government Effectiveness, Control of Corruption and Regulatory Quality. The other three dimensions were therefore excluded from creating the composite index since they did not significantly influence economic growth.

Table 1. Data sources and definitions of variables.

Variable (As They Appear in the Model)	Source	Definition
GDP	World Bank	Gross Domestic Product (base 2015)
RDexp	World Bank	Research and development expenditure (as a % of GDP)
GOV	World Bank (WGI)	Governance (as an average of the 6 governance indicators)
RDexp*GOV	Authors' construction	Interaction factor between research and expenditure and governance
INV (Level of domestic investment)	World Bank	Gross Fixed Capital Formation (as a % of GDP)
LFTotal	World Bank	Labor force participation rate, total (% of total population ages 15–64)
URB	World Bank	Urban population growth (annual %)

* Authors' construction = the author made variables interact to create an interaction term.

3.2. Analytical Techniques

The data were analyzed using the time series analysis approach. The STATA software was employed for data handling, management and analysis. We employed an econometric time series model, the Autoregressive Distributed Lag model (ARDL) which was developed by Pesaran and Shin (1999). The model was later modified by Pesaran et al. (2001). The model has some significant benefits over the other related models. Apart from being suitable for shorter time series and different orders of integration, the ARDL bounds test is capable of correcting endogeneity by providing efficient long-run estimates with valid t-statistics.

The first procedure when dealing with time series data is to test the unit root properties of the data. This was done using the Augmented Dickey–Fuller (ADF) (1979) unit root test. The test about the unit root properties of the series is critical to ascertain that the series are reliable and efficient. To establish whether or not there is a long-run relationship among the variables, a bounds test procedure for cointegration by Pesaran et al. (2001) was employed. The test compares the estimates of the F-value and the critical value from the Pesaran et al. (2001) table. The Akaike Information Criteria (AIC) were used to choose a suitable lag length. In the presence of cointegration, an error-correction model (ECM) is then estimated since cointegration is the precondition to estimating an ECM. The error-correction term, ECt-1, can only be included in the existence of cointegration amongst the variables under study. In the absence of a long-run relationship, only the short-run equation is estimated. The ECM should be negative and statistically significant and this shows that there is convergence in the long run. However, if the ECM comes out positive, it means that the model is explosive and there is no convergence in the long run.

The null hypothesis (H_0) suggests that there is no cointegration or a long-run relationship amongst the variables is presented as follows:

$$H_0 : \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = 0 \quad (2)$$

The alternative hypothesis states that a long-run relationship exists among the variables, implying the existence of cointegration, as follows:

$$H_1 : \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq \beta_6 \neq 0 \quad (3)$$

The F statistic is used as the decision criteria. If the calculated Wald F statistic is smaller than the lower bound of the critical values, we cannot reject the H_0 and conclude that there is no long-run relationship. However, if the calculated F statistic is greater that the upper bound of the critical values then we reject the H_0 and conclude that there is a long-run relationship. If the F statistic falls between the upper- and lower-bound critical values, then the result is inconclusive.

Two models are estimated, one without a mediating factor and the other with governance as a mediating factor as a function of a number of macro-economic variables and is specified as follows:

$$\text{GDP} = \text{f (RDexp, GOV, INV, LFTotal, URB)} \tag{4}$$

The ARDL bounds cointegration model to test for cointegration between the variables in accordance with Pesaran et al. (2001) was specified as follows:

$$\begin{aligned} GDP_t = {} & \beta_0 + \omega_1 GDP_{t-1} + \omega_2 RDexp_{t-1} + \omega_3 GOV_{t-1} + \omega_4 INV_{t-1} + \omega_5 URB_{t-1} + \omega_6 FFTotal_{t-1} + \sum_{i=1}^{q} \beta_1 \Delta GDP_{t-i} \\ & + \sum_{i=0}^{q} \beta_2 \Delta RDexp_{t-i} + \sum_{i=0}^{q} \beta_3 \Delta GOV_{t-i} + \sum_{i=0}^{q} \beta_4 \Delta INV_{t-i} + \sum_{i=0}^{q} \beta_5 \Delta URB_{t-i} + \sum_{i=0}^{q} \beta_6 \Delta FLTotal_{t-i} + e_t \end{aligned} \tag{5}$$

The short-run dynamic relationship is estimated using an error correctional model formulated as follows:

$$\begin{aligned} \Delta GDP_t = {} & \beta_0 + \sum_{i=1}^{q} \beta_1 \Delta GDP_{t-i} + \sum_{i=0}^{q} \beta_2 \Delta RDexp_{t-i} + \sum_{i=0}^{q} \beta_3 \Delta GOV_{t-i} + \sum_{i=0}^{q} \beta_4 \Delta INV_{t-i} + \sum_{i=0}^{q} \beta_5 \Delta URB_{t-i} \\ & + \sum_{i=0}^{q} \beta_6 \Delta LFTotal_{t-i} + \delta ecm_{t-1} + e_t \end{aligned} \tag{6}$$

where GDP is the dependent variables, β_0 is the intercept, β_1–β_6 are the short-run elasticities (coefficients of the first-differenced explanatory variables), ecm_{t-1} is the error-correction term lagged for one period, ω_1–ω_6 are the long-run elasticities (coefficients of the explanatory variables), δ is the speed of adjustment, Δ is the first difference operator, q is the optimum lag length and e_t is the white noise.

A series of post-estimation diagnostic tests including normality, serial correlation, heteroscedasticity and stability are performed. Once the main analysis is completed, it is important to perform all these tests to check if there are issues with the model.

4. Empirical Results and Discussion

In this section, the results of the estimation of the ARDL model are presented and discussed in relation to previous empirical results. Post-estimation diagnostic test results are also presented in this section.

4.1. Descriptive Statistics

A summary of the macro-economic variables included in the model are presented in Table 2. These statistics are important because they give a historical background of the variables that are included in the model. The behavior of such macroeconomic variables gives important signals to policymakers, thereby allowing them to anticipate trends, to identify areas of concern and to seize economic opportunities. By looking at the minimum and maximum figures of the series, one can unpack a number of issues regarding the variable in question. The standard deviations of all the variables are generally small. Variables such as RDexp and URB both exhibit smaller standard deviations of 0.06 and 0.30, respectively, thereby indicating that the series are more stable. For GDP, the minimum is −5.96 and the maximum is 5.60 with a standard deviation of 2.41, which is also not high.

Table 3 presents the cross-correlation analysis results between the dependent variable (GDP) and the explanatory variables. The results show that there is a positive correlation between R&D expenditure, total labor force, governance, interaction between governance and R&D and economic growth. This implies that an increase in any of these variables is expected to increase economic growth in South Africa.

A negative correlation is observed between urbanization and economic growth. This inverse relationship implies that an increase in urbanization results in a decrease in economic growth in South Africa. This negative relationship can be attributed to the absence of the enabling factors such as sufficient good infrastructure and employment opportunities.

In a similar vein, Turok and McGranahan (2020) point out that for urbanization to promote economic growth, there has to be conducive infrastructure and institutions.

Table 2. Summary statistics of macro-economic variables.

Variable	Obs	Mean	Std. Dev.	Min	Max
GDP	26	2.29	2.41	−5.96	5.60
INV	26	16.47	2.06	13.18	21.61
RDexp	26	0.70	0.06	0.53	0.81
LFTotal	26	61.83	2.05	57.35	64.90
URB	26	1.97	0.30	1.16	2.87
GOV	26	-4.01×10^{-9}	1.63	−3.19	2.50
RD_GOV	26	0.026	1.16	−2.23	1.84

Source: Author's computation.

Table 3. Cross-correlation matrix of variables.

	GDP	INV	RDexp	GOV	RD_GOV	URB	LFTotal
GDP	1.0000						
INV	0.0372	1.0000					
RDexp	0.3735	0.4299	1.0000				
GOV	0.4374	0.0444	0.2565	1.0000			
RD_GOV	0.4314	0.0462	0.2573	0.9984	1.0000		
URB	−0.1376	0.4109	−0.2225	0.0100	0.0146	1.0000	
LFTotal	0.3005	−0.1946	0.1115	0.5461	0.5353	−0.2015	1.0000

Source: Authors' calculations.

4.2. Unit Root Test

The ARDL works with variables that are either I(0) or I(1) or a mix of the two. However, it does not work with variables that are integrated of order 2, i.e., I(2) or higher since they produce spurious regressions. This necessitates carrying out the unit root test to ascertain that all the variables included in the model satisfy this condition. Table 4 shows the results of the Augmented Dickey–Fuller (ADF) tests. We used the Akaike Information Criteria (AIC) to choose suitable lag length of the series.

Table 4. ADF unit root test on variables.

Variable	Lag Order	*t*-Stat	Critical Value (5%)	Decision
GDP	0	−3.898	0.0021 ***	1(0)
INV	2	−3.336	0.0133 **	1(1)
RDexp	0	−5.474	0.0000 ***	1(1)
LFTotal	0	−5.239	0.0000 ***	1(1)
URB	2	−3.762	0.0033 ***	1(1)
GOV	1	−3.226	0.0185 **	1(1)
RD_GOV	1	−3.023	0.0328 **	1(1)

Source: Authors' calculations. ** The rejection of the null hypothesis at 5%. *** The rejection of the null hypothesis at 1%.

The statistics of the ADF show that the null hypothesis of the existence of a unit root can be rejected for GDP since it is stationary in levels. However, the null hypothesis of the

existence of a unit root cannot be rejected for the rest of the variables since they were not stationary in levels. The ADF test was then applied to the first difference of the variables and they all became stationary. The results show that all the variables are stationary at either level I(0) or first difference I(1) and therefore validate the application of the ARDL model.

4.3. Bounds Testing Approach to Cointegration

Table 5 presents the results of the ARDL bounds test for cointegration for the two models (one model without a mediating factor and another one with a mediating factor—governance). For the first model without a mediating factor, the result of the bounds test shows that the series are cointegrated at the 1% level. The calculated F-value (15.287) is above the upper bound I (1) (4.68) at the 0.01 significance level. This implies that the null hypothesis for no cointegration is rejected at 1% and that there is a long-run linkage between the series.

Table 5. Bounds test for cointegration.

Equation	K	Wald F-Statistic	Lower Bound I0	Upper Bound I1	Decision
Model without mediator	5	15.287	2.26	4.68	Cointegrated
Mediating factor model	4	31.515	3.74	5.06	Cointegrated

Source: Authors' computations using STATA.

Similar results are observed for the mediating factor model. The results obtained from the ARDL bounds test and the estimated F-test indicate the presence of a long-run relationship amongst variables. The decision rule is based on the F-statistics (31.515) above the upper-bound critical value of 5.06, at 1% level of significance; thus, we reject the null hypothesis of no cointegration and conclude that the series have a long-run linkage between them.

4.4. Long-Run Model Equation

The long-run results of the two econometric models (one without a mediating factor and the one with a mediating factor) are displayed in Table 6. Starting with the original model without a mediating factor, the results show that an improvement in the quality of governance has a positive effect on economic growth, at the 1% significance level. The other variables were not statistically significant. In particular, the variable of interest, R&D, presented a negative but insignificant influence on economic growth. This finding is consistent with the results reported by Lichtenberg (1993) who reported that public sector R&D expenditures did not have any effect on economic growth and in some cases significantly and negatively influenced economic growth. Similar results were also reported by Samimi and Alerasoul (2009) who found no significant effect of R&D expenditures on economic growth for all the countries studied.

Now switching to the model with a mediating factor, the results show that three variables (URB, LFTotal and RD_GOV) were significant. A one-unit increase in urbanization (URB) in associated with a 3.5% decline in GDP on average, ceteris paribus, at the 1% significance level. The implication of this result is that an increased level of urbanization negatively impacts economic growth. Urbanization in the growth theory logically, in an environment of good infrastructure, quality institutions, good governance and jobs, is supposed to be a source of labor supply that should ideally propel economic growth. Observing the opposite here means the contrary due to the absence of (some of) the enabling factors as previously mentioned. The observed negative impact could possibly be due to increased pressure on infrastructure and service delivery. As indicated by Saghir and Santoro (2018), the consequences of urbanization can be complex and intertwined with other development policy issues such as climate change and migration.

Table 6. Long-run coefficients for ARDL.

	Model Without Mediating Factor ARDL (1,2,2,2,2,2) Selected Based on AIC		**Model with Mediating Factor ARDL (1,2,2,2,2) Selected Based on AIC**	
Variable	**Coefficient**	***p*-Value**	**Coefficient**	***p*-Value**
INV	0.184	0.507	0.116	0.179
RDexp	−1.244	0.853	-	-
GOV	1.262	0.000 ***	-	-
URB	−3.470	0.112	−2.907	0.007 **
LFTotal	−0.2272	0.200	−0.209	0.079 *
RD_GOV	-	-	1.847	0.000 ***
Model summary	Number of obs = 24 R-squared = 0.9732 Adj R-squared = 0.9119		Number of obs = 24 R-squared = 0.9694 Adj R-squared = 0.9296	

Source: Authors' computations using STATA. Note: *** 1%, ** 5%, * 10%.

Likewise, a unit increase in total labor force (LFTotal) participation is associated with a 0.23% decrease in GDP on average in the long run, ceteris paribus, at the 10% significance level. Contrary to the economic theory and practice, the long-run results show a negative influence of LFTotal on economic growth. Cung and Hung (2020) attribute this negative relationship to the fact that there are other factors at play that can influence the relationship and cause an increase in labor force to result in a gradual reduction in the marginal benefit of economic growth in the long run.

Lastly, a percentage increase in the interaction between R&D and governance (RD_GOV) is associated with a 1.8% increase in GDP in the long run, ceteris paribus, at the 1% significance level. In the model without a mediating factor, a negative and insignificant impact of R&D on economic growth was reported. However, when R&D interacts with governance, a positive and significant impact is observed. This implies that for R&D to have a positive impact on economic growth, there is a need for strong and quality governance to provide the necessary quality institutional environment required to foster growth. This is more important in Africa where strong governance is needed to create an atmosphere that promotes equitable sustainable development. Our results are consistent with the findings of Adeleke (2014) which showed that governance positively influenced economic growth in Africa when interacting with FDI.

4.5. Short-Run Relationship and Error-Correction Model Results

The results of the model without the mediating factor are presented in Table 7. The error-correction term which measures the speed of adjustment has the expected negative sign and significance at the 1% level, which further corroborates the long run relationship between the series. The ECT value of −1.632 suggests that any disequilibrium in the short-run is corrected by 1.63% in achieving a long-run equilibrium every year.

The lagged GDP variable is significant at the 5% significance level, suggesting that the current year's GDP is directly influenced by the previous year's GDP value. The results further show that GDP is positively and significantly influenced by domestic investment (INV) at a level implying that a unit increase in INV will lead to a 0.83% increase in economic growth. The coefficient of lagged INV of −1.45 depicts a negative relationship. INV impacts growth positively contemporaneously (same time period); however, the negative coefficient a year later means as INV is utilized (decreases) growth should improve; hence, they are negatively related.

With regard to governance, the first lag is positively and significantly related to economic growth in the short run, ceteris paribus. The implication of this result is that the better the quality of governance, the higher the economic growth in South Africa. The coefficient of the level of total labor force (LFTotal) is positively and significantly related

to economic growth. A unit increase in LFTotal is associated with a 0.78% increase in economic growth in the short run, ceteris paribus. This finding is consistent with the results of Yakubu et al. (2020) who reported that labor force participation positively and significantly increased economic growth in Nigeria.

Table 7. Short-run coefficients for ARDL (1,2,2,2,2,2) (without mediating factor).

Variable	Coef.	Std. Err.	*t*-Stat	$p > \|t\|$
GDP				
L1.	−0.6322476	0.2100128	−3.01	0.020 **
INV				
--.	0.8258128	0.3652789	2.26	0.058 *
L1.	−1.451771	0.4024229	−3.61	0.009 ***
RDexp				
--.	1.568662	13.40703	0.12	0.910
L1.	4.433912	14.31192	0.31	0.766
GOV				
--.	−0.3165817	0.4178523	−0.76	0.473
L1.	0.9036117	0.3181654	2.84	0.025 **
URB				
--.	−1.983312	1.200281	−1.65	0.142
L1.	−0.9480547	0.90006	1.05	0.327
LFTotal				
--.	0.7810507	0.2276591	3.43	0.011 **
L1.	−0.5147205	0.3229619	−1.59	0.155
ECM_{t-1}	−1.632	0.2100	−7.77	0.000 ***

Source: Authors' computations using STATA 15. Dependent variable is GDP: ARDL (1,2,2,2,2,2) selected based on AIC. Number of obs = 24; F (16, 7) = 9.78; Prob > F = 0.0026; R-squared = 0.9572; Adj. R-squared = 0.8594. Note: *** 1%, ** 5%, * 10%.

Our variable of interest, RDexp depicted a positive but insignificant impact on economic growth. This result is in line with various other studies including Samimi and Alerasoul (2009). In contrast, other authors, for instance, Akinwale and Surujlal (2021) reported a positive and significant impact of RDexp on economic growth in South Africa. This deviation can be attributed to the length of the series that they used in their analysis which only went up to 2018. Our series included the year 2020 when the COVID-19 pandemic was at its peak in an economy with pre-existing economic fragilities. This could potentially explain the reason why RDexp did not have a significant impact on economic growth.

For the model with a mediating factor, the short-run results are presented in Table 8. The error correction term has the expected negative sign and significance at the 1% level, which further corroborates that the series is not explosive and there is a long-run relationship between the series. The ECT value of −1.700 posits that any disequilibrium in the short run is corrected by 1.7% in achieving long-run equilibrium every year.

The lagged GDP variable is significant at the 1% significance level, suggesting that the current year's GDP is directly influenced by the previous year's GDP value. The results also revealed that a unit increase at the level of INV is associated with a positive and significant impact on economic growth in the short run, holding other things constant. However, the same variable has a negative impact on economic growth in the first lag.

Consistent with the long-run results, the interaction factor RD_GOV has a positive and significant impact on economic growth in the short run in the first lag at the 1% significance level. This again confirms the findings of Adeleke (2014) which showed that

governance plays a critical role in promoting economic growth. Similarly, but looking at the direct impact of governance on economic growth, Fayissa and Nsiah (2013) found that the composite index of good governance (GOV) had a positive and significant effect on the GDP per capita growth at the 1% significance level. Mahran (2023) also reported that governance had a statistically significant positive impact on economic growth on the 116 countries studied worldwide.

Table 8. Short-run coefficients for ARDL (1,2,2,2,2) (with mediating factor).

Variable	Coef.	Std. Err.	*t*-Stat	$p > \|t\|$
GDP				
L1.	−0.7004429	0.1459289	4.80	0.001 ***
INV				
--.	0.7140936	0.2789904	2.56	0.028 **
L1.	−1.427905	0.3506351	−4.07	0.002 ***
RD_GOV				
--.	−0.4575387	0.4326166	−1.06	0.315
L1.	1.597955	0.3206345	4.98	0.001 ***
URB				
--.	−1.515001	0.8140218	−1.86	0.092 *
L1.	−1.113902	0.759281	−1.47	0.173
LFTotal				
--.	0.9953144	0.1794655	5.55	0.000 ***
L1.	−0.4818287	0.2187692	−2.20	0.052 **
ECM_{t-1}	−1.700	0.1459289	−11.65	0.000 ***

Source: Authors' computations using STATA 15. Dependent variable is GDP: ARDL (1,2,2,2,2) selected based on AIC. Number of obs = 26; F (13, 10) = 14.97; Prob > F = 0.0001; R-squared = 0.9511; Adj. R-squared = 0.8876. Note: *** 1%, ** 5%, * 10%.

We also found out that URB negatively influences economic growth in the short run. Hence, a unit increase in urbanization causes a decline in economic growth. This could be because the cities have limited labor-absorptive capacity (FAO 2017) and also the pressure on infrastructure and other critical resources. In a similar vein, Cali (2008) reported a negative impact of urbanization on economic growth in the Indian states. However, Arouri et al. (2014) reported an inverted U-shape relationship between the urbanization and per capita GDP in their study on African countries. In another study, Nguyen and Nguyen (2018) also found an inverted U-shaped relationship between urbanization and economic growth. They reported that urbanization positively impacted economic growth until urbanization reached a threshold, thereby impeding economic growth. Turok and McGranahan (2020) argue that the potential of urbanization to promote growth lies in how conducive the infrastructure and institutional settings are. Likewise, total labor force (LFTotal) had a negative and significant impact on economic growth in the first lag, ceteris paribus, but a positive and significant relationship is observed on the level of LFTotal.

4.6. Causality Analysis on the Causal Links Between GDP and Governance

It is generally believed that good governance promotes economic growth (Acemoglu et al. 2001; Meyer 2022). In a similar vein, empirical evidence also exists that shows a positive impact of economic growth on governance (Kaufmann and Kraay 2003). Thus, not only does the quality of governance affect economic growth, but economic growth also affects the quality of governance. Hence, there is a bi-directional causal relationship between the two variables. To ascertain this, we employed the Granger causality test and the results are presented in Table 9.

Table 9. Granger causality Wald tests.

Equation	Excluded	Chi2	df	Prob > chi2
GDP	GOV	23.679	2	0.000
GDP	ALL	23.679	2	0.000
GOV	GDP	0.161	2	0.923
GOV	ALL	0.161	2	0.923

Source: Authors' computations using STATA.

The vector autoregression results show that the second lag of GOV is statistically significant (0.000) in the equation where GDP is the dependent variable. However, in the equation where GOV is the dependent variable, both lags of GDP are not statistically significant. As far as the Granger causality results are concerned, the null hypothesis states that there is no Granger causality. For the equation where GDP is the dependent variable, we can conclude that governance (GOV) Granger causes economic growth. However, in the equation where GOV is the dependent variable, we can conclude that GDP does not Granger cause governance. Hence, there is no bi-directional relationship between GDP and GOV and therefore the growth impact of governance is sufficiently supported in South Africa.

4.7. Diagnostic and Stability Test Results

A series of diagnostic tests were run and the results are presented in Table 10. The Durbin–Watson statistics for both models show that there is no serial correlation for both models and this is supported by the Breusch–Godfrey LM Test for Correlation. The ARCH and white tests for both models show that the models are free from heteroskedasticity. This implies that our estimations are robust to both serial correlation and heteroscedasticity. Regarding the Jarque–Bera test where the null hypothesis states that the residuals are normally distributed, we cannot reject the null hypothesis of normality for both models. Hence, the series in both models are normally distributed.

Table 10. Diagnostic tests results.

Test	Null Hypothesis	Model Without Mediating Factor	Model with Mediating Factor	Decision
Breusch–Godfrey LM Test for Correlation	No serial correlation	0.5753	0.3141	Accept H_0 of no serial correlation
Durbin–Watson	No serial correlation	2.1013	2.2282	Accept H_0 of no serial correlation
ARCH	No conditional heteroskedasticity	0.8836	0.4231	Accept H_0 no ARCH effects
White	No heteroskedasticity	0.4038	0.4038	Accept H_0 of no heteroskedasticity
Jarque–Bera (JB)	Residuals are normally distributed	0.5227	0.5227	Accept H_0 of normality

Source: Authors' computations using STATA.

The two models were tested for stability of the short-run and long-run coefficients through the cumulative sum (CUSUM) and CUSUM of squares (CUSUMSQ) tests. These tests are suggested by Pesaran and Shin (1999) as part of post-estimation tests and the null hypothesis (H_0) suggests that the regression coefficients are stable. The graphical presentation of the stability tests for the two models (model without mediating factor and model with a mediating factor) are shown in Figures 2 and 3. The plots of the CUSUM test

for both models cross the lower limit around 2020. The general conclusion from the two graphs is therefore that the two models are only stable at the 5% significance level.

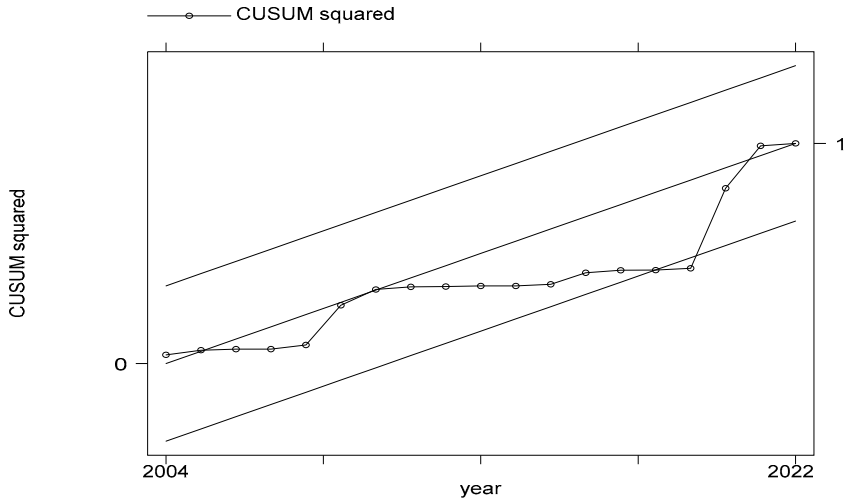

Figure 2. CUSUM squared tests for model without mediating factor. Source: Authors' construction using STATA.

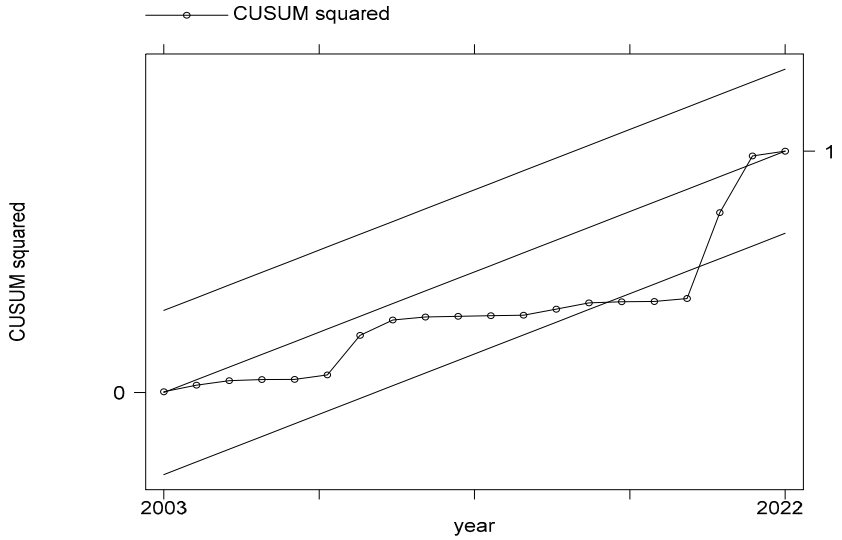

Figure 3. CUSUM squared test for model with mediating factor. Source: Authors' construction using STATA.

5. Conclusions and Policy Implications

The relationship between R&D and economic growth has been intensively studied in various contexts. Even though the findings reported are quite mixed, the general impression is that R&D positively impacts economic growth. However, less attention, if any, has been given to the role that quality of governance can play in influencing the relationship between R&D and economic growth. The study used the ARDL model to assess the impact of R&D expenditure on economic growth in South Africa with governance as a mediating factor. ADF tests were employed to ascertain the order of integration and the results showed a mixed order of integration (I(0) and I(1)), validating the use of the ARDL model. The calculated F-tests for the two models in the ARDL bounds testing approach to cointegration were greater than the critical value from the Pesaran et al. (2001) table, suggesting a long-run relationship between the series. In the model without a mediating factor, a negative and insignificant impact of R&D on economic growth is reported. However, when R&D interacts

with governance, a positive and significant impact is observed. We, therefore, reject H_0 and accept H_1 which states that governance affects the impact that R&D expenditure has on economic growth. The results further revealed that urbanization has a negative impact on economic growth. As indicated by Sukanya and Tantia (2023), urbanization can pose severe challenges with regard to strained infrastructure, inadequate housing, and social exclusion which can all impede growth. Given the ambiguous relationship between governance and economic growth, a Granger causality test was employed to determine the direction of causality between the two variables. The results showed that governance Granger causes economic growth and not the other way round.

Based on these findings, the study recommends that:

- Governments, particularly in developing countries, should make sure to enhance good governance structures so that other critical macro-economic factors such as R&D can yield significant impact on economic growth
- Governments should prioritize investing more towards R&D so that the effects on economic growth can be more pronounced
- Policymakers should also give more attention to non-economic issues such as governance when making policies since it determines how well the other macro-economic factors function to promote economic growth
- Urbanization should be properly managed and controlled so that it does not impede economic growth but rather propels growth

We acknowledge that this study has some limitations regarding the length of the series. It is therefore imperative that more regular data be collected on the important institutional parameters such as governance.

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