



The Nexus between R&D, Innovation and Economic Growth Revisit: The Case of South Africa and Saudi Arabia

Yusuf Opeyemi Akinwale^a, Jhalukpreya Babs Surujlal^b, ^aCollege of Business Administration, Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia, ^bNorth West University, South Africa, Email: ^ayoakinwale@iau.edu.sa

It is evident in many countries that having abundant natural resources does not guarantee an increased economic growth. In order to diversify the economy, each one of South Africa and Saudi Arabia has developed Vision 2030 as related to their country. The aim of this paper is to study the role and impact of research and development (R&D) and innovation towards economic growth. Using ARDL and ECM for the period 2001-2018, the study finds that R&D and innovation have a long run association with economic growth in both countries, and a long run causality from R&D and innovation to economic growth is also established. Meanwhile in the short run, it is only R&D which has significant impact on economic growth in both countries. The study suggests that the policy makers should continue to advocate for more spending on research and innovative efforts as well as creating a strong collaboration among the stakeholders of national innovation systems as this would boost indigenous innovation capabilities which lead to economic growth.

Key words: *research and development; innovation, economic growth; Saudi Arabia; South Africa; ARDL*

1. Introduction

The global trend has indicated the shift from natural resources to knowledge and innovative economy. Many countries which have enormous natural resources are no longer performing better than other countries which do not have these natural resources. The extent of R&D conducted to generate innovation which hitherto drives economic growth is now the bases for economic development. Unlike the past economic growth theories which focused on mainly



labour and capital as the factors which drive growth of a country, the recent theories have placed great emphasis on the roles that R&D and technology innovation are playing in economic growth, which explain the recent growth in the economy, which was unclear in the past (Akinwale, 2020a). R&D expenditure has become a significant indicator to build indigenous capacity so as to be able to gain comparative advantage in the international market which fosters economic growth (Akinwale et al., 2018a). More so, technology innovation in the form of developing innovative methods to produce goods, learning process and services which improve efficiency and creating new products and market that meet global challenges, improve the standard of living of people and attain sustainable economic development (Akinwale and Kyari, 2020, Ma et al., 2019; Mabrouki, 2018; Hasan and Tucci, 2010). Meanwhile, a growing economy characterised with high income and wealth could also drive the extent of research funding and support as well as technology innovation in a country.

The corona virus (Covid-19) pandemic which resulted into more than eleven million infected people globally as at early-July of 2020 has further shown the significance of research in the health sector. Like the health sector, research and development in all other sectors of a nation is also important to sustain the growth of such sectors. Due to a long period of lockdown, many businesses laid-off their employees, some went bankrupt and many others are struggling to survive. The survival of many businesses relied so much on their internal capabilities they already built through innovation. Technological innovations allow firms to be able to cope during the period of economic turbulence (Akinwale, 2020b). This further corroborates the significant of R&D and innovation in the economy.

Despite the clear assertions of the importance of R&D and innovation in a country, most of the studies in this area are either between economic growth and R&D or between economic growth and innovation. There is a limited amount of empirical research that showed the triangular relationships among economic growth R&D and innovation in general. More so, the few studies which showed the relationship among the three variables are concentrated on the advanced economies with more emphasis on the panel data. Due to the dearth of related studies in developing countries, especially on resource rich countries, this paper focuses on investigating the nexus between R&D, innovation and economic growth in Saudi Arabia and South Africa. While Saudi Arabia is blessed with crude oil in abundance on one hand, South Africa is blessed with abundance of gold, platinum, diamond and other valuable metals on the other hand. The result of this study is expected to reveal the linkage among these three variables, which would provide suggestions that would benefit the economic planners in a country.

The remaining parts of the paper are arranged as follows. Section 2 presents the overview of innovation and R&D as well as empirical literature in the two countries, methodology and discussion of results are presented in sections 3 and 4, while the conclusion is captured by section 5.

2. Literature Review

This section gives brief information on the status of R&D and innovation in South Africa and Saudi Arabia as well as the relevant empirical studies of the variables.

2.1 Status of Innovation and R&D in South Africa and Saudi Arabia

The strength of the economy is laid on the efficacy of human capabilities which relies on research and technology innovation. The expenditures for total R&D related to total expenditures “on creative work undertaken to increase knowledge and the use of knowledge for new applications” (OECD, 2020). It cuts across basic, applied and development research (World Bank, 2019). It consists of R&D conducted by both government and private establishments within the country, which comprises R&D financed from overseas, but ignores locally funded R&D that are carried out overseas.

The Saudi Arabia’s R&D (as a % of GDP) was approximately 0.01 between 2000 to 2009 but experienced a drastic upsurge to 0.884% in 2010 and stood at 0.8% in 2013 (World Bank, 2020). It is also observed that this figure was approximately 0.8% in 2018 based on the report obtained from Arab News in 2019 and Global competitiveness report (World Economic Forum, 2019; Ghalayini, 2019). Few of the Saudi’s Vision 2030 goals include becoming top 10 countries in the Global Competitiveness Index by 2030, increasing from its rank of 39th in 2018, and also to have at least 5 universities ranked in the topmost 200 universities. These goals are clearly related to the R&D and innovation commitment of the country. In order to boost the R&D ecosystem among key participants, approximately \$1.6 billion was being apportioned through 2019 in boosting R&D at universities. Several organizations and programs have been set up in Saudi Arabia which comprises of the King Abdulaziz City for Science and Technology in Riyadh, tertiary institutions which provide endowment funds, big state corporations (like Aramco, Sabic and Taqnia) which collaborate with universities and research centres, as well as other independent research and development centres that serve specific industries (Ministry of Education, 2018). According to the Global Competitive Index 4.0 report (World Economic Forum, 2019) which measures the level of national productivity through a set of institutions, policies and factors, Saudi Arabia improved from 39th position in 2018 to 36th globally in 2019 among 141 sampled countries with the score of 70% as shown in Table 1. On the basis of general R&D, Saudi Arabia was ranked 41st country with the score of 40.1%, ranked 43rd country in terms of investment in R&D which is 0.8% of GDP with a score of 27.2%, and ranked 40th in terms of scientific paper publications and citations with the score of 83.2%. The innovation capability in terms of how the companies share ideas, how universities and companies collaborate and the ability to turn ideas into goods and services was also assessed by the GCI report. In 2019, Saudi Arabia was ranked 36th with the score of 50.6% in innovation capability which improved compared with that of 2018. The GCI report (World Economic Forum, 2019) also assessed business dynamism which is an evaluation of the private sector’s capacity to create and use new technologies. Saudi Arabia was ranked 109th in business

dynamism which is relatively low compared to other competitive indicators. Saudi Arabia was ranked 7th in terms of growth of innovative companies in the country with the score 69.2%.

Table 1: Status of R&D and innovation capability of South Africa and Saudi

Arabia in 2019 (positions globally and their percentage scores)

Index	Saudi Arabia	South Africa
General Global Competitiveness Index 4.0	36 th (70.0%)	60 th (62.4%)
General Research and Development	41 st (40.1%)	44 th (38.4%)
R&D Expenditure (as a % of GDP) both at 0.8%	43 rd (27.2%)	45 th (26.6%)
Scientific Publications and Citations	40 th (83.2%)	33 rd (88.5%)
Innovation Capability	36 th (50.6%)	46 th (45.2%)
Business Dynamism	109 th (53.1%)	60 th (61.9%)
Growth of Innovative Companies	7 th (69.2%)	44 th (56.0%)

Source: Authors' computations from World Economic Forum Report 2019

On the other hand, South Africa's R&D was 0.72% of GDP in 2001 and increased up to 0.9% in 2006, and it dropped to 0.73% in 2013 and started rising again up to 0.82% in 2016 (OECD, 2020; World Bank, 2020). This figure hovers around 0.8% as at 2019 GCI report. According to South African Vision 2030 (also known as National Development Plan 2030), among the goals include eliminating poverty, decreasing inequality, developing the economy by approximately 5.4 percent, and reducing the unemployment rate to 6 percent (National Planning Commission, 2015). Education, training, research and innovation have been recognized as being significant to the achievement of these goals through capacity building. While the government continued to be the main source of funding in South Africa, the business sector retained the country's main performer of R&D in 2018 at 41 percent, though it declined from 56 percent in 2007. Meanwhile, the contribution of the higher education sector has improved from 20 to 37 percent over the same period (Centre for Science, Technology and Innovation Indicators, 2019). As regards the composition of R&D in the business sector, it has been noticed that the growth in business expenditure on R&D (BERD) is credited to the services industries, whereas there is a decrease in manufacturing and mining-related R&D. Meanwhile, the R&D spending is prevalent in financial intermediation, and the real estate and business services sector providing approximately 49% of BERD in 2018 (Centre for Science, Technology and Innovation Indicators, 2019). According to the Global Competitive Index 4.0 report of 2019 as shown in Table 1 above, South Africa improved from 67th position in 2018 to 60th globally in 2019 among 141 sampled countries with the score of 62.4%. Though South Africa and Saudi Arabia both improved from the previous years in terms of global competitiveness, Saudi Arabia is ranked higher than South Africa. Based on the general R&D, South Africa was ranked 44th globally with the score of 38.4%, ranked the 45th country in terms of R&D which is 0.8% of the GDP with the score of 26.6%, and ranked 33rd in terms of scientific paper publications and citations with the score of 88.5%. This shows that South Africa and Saudi Arabia are generally close in terms of R&D by spending the same proportion

of their GDP on R&D, though while South Africa performed better in scientific publications, Saudi Arabia was 3 steps above South Africa in the overall R&D indicator. The innovation capability index revealed that South Africa was ranked 46th with the score of 45.2% which was 10 steps behind that of Saudi Arabia. Considering the business dynamism pillar, South Africa was ranked 60th with the score of 61.9% which was 49 steps ahead of Saudi Arabia. However, South Africa was ranked 44th with the score of 56% in the growth of innovative companies in the country, but this was 37 steps behind than that of Saudi Arabia.

Generally, the two resource rich countries have some similarities in terms of their R&D and innovation index, though few differences could also be noticed in certain indicators. The two countries are working towards economic diversification and to boost their economies by 2030. The governments of the two countries, through adequate policies, should provide additional support for R&D and innovation by creating supportive ambience for the adoption and adaptation of existing technologies as well developing new technologies which are suitable for their local economy (Ukwuoma et al., 2018; Akinwale et al., 2018b; Adelowo et al., 2017)

2.2 Empirical review on R&D, Innovation and Economic Growth

This research is situated within the framework of endogenous growth theory where R&D and innovation are considered as important factors which drive innovation. Investment in R&D drives technological progress and afterwards fosters economic growth and development (Romer, 1990; Lucas, 1988). Guloglu and Tekin (2012) examined the connection among economic growth, R&D and innovation in 13 high income OECD countries using the yearly data for the period 1991-2007. The study tested for pairwise and multivariate causal relations by the VAR model. The results of the bivariate causality test indicated that R&D spending leads to innovation, and then technological innovations cause economic growth as stated by endogenous growth theory. More so, causal direction from economic growth to innovation is also established suggesting that the output growth rate fast-tracks the rate of technological innovation. In addition, the outcomes of the multivariate causality tests specify that economic growth and innovation jointly (Granger) cause R&D, and simultaneously output and R&D jointly cause technology innovation. Armeanu et al. (2018), using regression analysis, also found that total expenditure on R&D triggered economic development of the EU countries. Weresa (2018) conducted a review on R&D, innovation and the competitiveness of the Polish economy. The study found that inadequate R&D spending which affects advanced research and innovation, impedes the growth of Polish enterprises to promote the export of technologically advanced goods and services. Although the study showed a new trend of Poland moving away from regular purchase of machinery towards knowledge and software technology but there is still a gap to be filled between Poland and the average EU R&D as innovation performance needed to foster competitiveness and economic growth. Meanwhile, Akinwale et al. (2012) revealed that R&D spending and innovation are too weak to engender economic growth in Nigeria over the period 1977-2007. The outcome of the study is not

unconnected with weak institutional structure of the system, low collaboration between the universities/research institutions and the industry, and weak industrial clusters.

Kutlaca et al. (2020) explored the association between R&D and GDP in Serbia between the period 1995 and 2015. The result of the correlation showed a strong interdependence between R&D and GDP. Also, the results indicated that unidirectional causality was established from GDP to R&D spending without a feedback effect in Serbia. This suggests that as economic activities expanded in the country, research and development expenditure grew as both the private and public enterprises have more income to invest in research activities. Liu and Xia (2018) studied the linkage between GDP, technology innovation and R&D investment in China over the period 1995-2016. The results of the analysis established a long-term association among the three series. However, R&D investment for short-term profit was established but the conversion efficiency of R&D investment was low. In addition to this, scientific and technological achievement was weak, and its conversion efficiency was also low leading to a slow market integration process. The research generally revealed a weak circular linkage among the three variables, and hence suggested an improved mutual interrelationship among the three series in China.

Tuna et al. (2015) analysed the nexus between R&D spending and economic growth in Turkey between 1990 and 2013. The outcome of the Johansen co-integration test showed that there was no long run association between real R&D spending and economic growth. Furthermore, the result of the Granger causality test indicated no causality between the two series. The paper suggested appropriate apportionment of R&D spending so as to make an impact in the economy. Inekwe (2015) explored the influence of R&D spending on economic growth in 66 upper middle-income and lower middle-income developing nations for the period 2000 to 2009. The general results showed that R&D spending positively impacted economic growth of the developing countries. However, when the data was separated into upper middle-income and lower middle-income developing countries, the results revealed that R&D spending positively and significantly influence economic growth for the former but has an insignificant impact on economic growth for the latter.

Maradana et al. (2019) studied the association between GDP and innovation for the European Economic Area (EEA) countries between 1989 and 2014 using VAR estimation model. The result varied from country to country as it revealed the existence of unidirectional and bi-directional causality between GDP and innovation in the long- and short-run period for different countries. Bakari et al. (2020) in their study conducted in Tunisia using the ARDL approach revealed no significant influence of innovation on economic growth in the short run. The results of the long run analysis further showed that while innovation negatively influenced economic growth on one hand, economic growth positively influenced innovation on the other hand. This implied that there is lack of the tangible expenditure in innovation and R&D which could significantly propel the Tunisian economy from a primitive economy to a modernised

economy which relies on the evolved sector of innovation, technology and knowledge. This result was contrary to the long run bidirectional causality established by Bakari (2019) in the study conducted among 76 developing and developed countries between 1995 and 2016. The results of the studies of Pradhan et al. (2018) using data between 1961 and 2014 for 49 European countries and Pradhan et al. (in press) using data between 2001 and 2016 for the Eurozone countries, have shown the significant positive effect of innovation on economic growth.

Akinwale et al. (2020) observed the effect of innovation and entrepreneurship on economic growth in Saudi Arabia using a regression analysis for the period 2005-2016. The result showed that innovation was not directly significant in influencing economic growth but became significant on economic growth through entrepreneurship. Furthermore, another study (Akinwale, in press) conducted in South Africa relating to technology innovation, economic growth and human capital was able to find bidirectional association between technology innovation and GDP in the long run with the use of Johansen co-integration and VECM for the period 1985-2015. However, only one-way directional relationship from GDP to technology innovation was established in the short run. Fan et al. (2017) investigated the link between economic growth and innovation among 415 firms in Chinese mining industry. The results indicated that the innovation components which include technical employees and assets are positively and significantly influencing economic growth in the industry. Related studies in service sector (Adeyeye et al., 2013), manufacturing sector (Olomu et al., 2016) and oil sector (Akinwale, 2017) in Nigeria found a significant effect of innovation and R&D on performance growth.

The results from the empirical studies differ from country to country which point to the fact that the peculiarities in each country could account for different relationship among R&D, innovation and economic growth. Due to the inconclusiveness of the findings in this type of research, it becomes imperative to revisit the nexus of the three series in South Africa and Saudi Arabia as the outcome could facilitate policy making towards their diversification goal.

3. Data and Methods

The data used in this paper were obtained from the World Bank, OECD and World Economic Forum data base for the period between 2001 and 2018. The variables estimated include economic growth, R&D and technology innovation. Economic growth (RGDP) is measured by real GDP per capita (at constant 2010 USD), research and development (ERD) are measured by R&D expenditure (as a percentage of GDP), and technology innovation (INN) is measured by the summation of number of patents application by both residents and non-residents of a country. The data used are consistent with some of the empirical studies conducted in other countries. However, the proxy for technology innovation goes beyond some of the studies which used patents' applications by residents or non-residents only (Bakari, 2019) as the two

are combined as patent in this paper which is also along the lines of few other studies. This data is constrained by the data available on research and development expenditure.

This article utilised the autoregressive distributed lag (ARDL) to assess the connection between R&D, technology innovation and economic growth. This method is adjudged appropriate when the sample size is not many and also when model consists of combination of variables that are stationary at level I(0) and first difference I(1) (Pesaran et al., 2001). After the natural logarithm is introduced into the model, the linear form of the model is stated as:

$$LRGDP = \alpha_0 + \alpha_1 LERD + \alpha_2 LINN + u_t \quad (\text{Equation 1})$$

From equation (1) above, natural log of economic growth (LRGDP) is the dependent variable while that of expenditure on R&D (LERD) and innovation (LINN) are the independent variables in this model. The ARDL bound test is then conducted to determine the relationship among the variables using equation (2).

$$\Delta LRGDP_t = \alpha_0 + \sum_{j=0}^n Z_j \Delta LRGDP_{t-j} + \sum_{j=0}^n F_j \Delta LERD_{t-j} + \sum_{j=0}^n \lambda_j \Delta LINN_{t-j} + \varphi_1 LRGDP_{t-1} + \varphi_2 LERD_{t-1} + \varphi_3 LINN_{t-1} + u_t \quad (\text{Equation 2})$$

The first difference operator is depicted by Δ and the residual term is denoted by u_t . The coefficients Z_j , F_j and λ_j indicate the short run dynamics of the model whereas φ_1 , φ_2 , and φ_3 test the long-run association otherwise called the bound co-integration test (Pesaran and Shin, 1998). The estimated F-value should be higher than the upper critical value of the F-tabulated for the variables in the model to be co-integrated and hence have a long run association, otherwise no long run association exists among them. The existence of a long run association among the series requires the error correction model (ECM) version in the ARDL model to be tested which would show the ability and the extent to which the relationship would return back to the long run equilibrium if there is any short run disturbance. Also, the significant effect of each independent variable shows its causal effect towards the dependent variable in the short run. The ECM is stated in equation 3.

$$\Delta LRGDP_t = \alpha_0 + \sum_{j=0}^n Z_j \Delta LRGDP_{t-j} + \sum_{j=0}^n F_j \Delta LERD_{t-j} + \sum_{j=0}^n \lambda_j \Delta LINN_{t-j} + \eta ECT_{t-1} + \mu_t \quad (\text{Equation 3})$$

The above equation denoted that economic growth (LRGDP) is dependent on its own lagged values, the lagged values of expenditure on R&D (LERD) and innovation (LINN), the error correction term (ECT) and the residual term (μ). The residual term is expected to be normally distributed and relatively stable over time. The analysis was conducted using Eviews 9 statistical package.

4. Estimation Results

The three series were first subjected to the unit root test to determine whether they are stationary or not and the level of stationary so as to prevent spurious results. The unit root test for each of the series was conducted using Augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1981) and Phillips-Perron (PP) test (Phillips and Perron, 1988) to evaluate the degree of integration of each series. As shown in Table 2, the results indicated that while innovation and economic growth are I(1), expenditure on R&D is I(0) in both South Africa and Saudi Arabia. This presents the presence of both I(0) and I(1) for the series in the two countries, which implied that ARDL seems appropriate for analysing the cointegration of the model. None of the series is I(2), and the dependent variable is I(1) which is a good sign for ARDL model (De Vita et al., 2006).

Table 2: Unit root test

Series	Panel A (Saudi Arabia)				Panel B (South Africa)			
	ADF		PP		ADF		PP	
	Level	First Difference	Level	First Difference	Levels	First Difference	Levels	First Difference
LRGDP	-1.49	-4.73***	-1.46	-4.73***	-2.10	-3.30**	-2.10	-3.30**
LERD	-3.52**	-	-3.23**	-	-2.22	-3.34**	-4.23***	-
LINN	-0.17	-3.51**	-0.19	-3.66**	-2.52	-3.33**	-2.25	-3.28**

(*), (**), (***) denote 10%, 5%, 1% and significant level, respectively

Table 3 presents the estimated ARDL (1,1,1) bounds test for both countries using Schwarz's Bayesian information criterion (SBIC) to choose a suitable lag for the ARDL model with the limited observations. The result for bounds F-test for integration indicates that the three series are co-integrated at 5% level for Saudi Arabia as the calculated F-value (5.31) is above the upper critical value (4.85) at 0.05 significant level. Also, for South Africa, the result of bounds F-test reveals that the null hypothesis for no co-integration is rejected at 5% level, as the calculated F-value (7.59) is above the upper limit (4.85) of the F-table. The results of the two countries signify the existence of a long-run association among the three variables analysed.

Table 3: Bounds test for F-statistic

Country	K	F-statistic	5% Level of Significance	
			Lower Bound	Upper Bound
Saudi Arabia	2	5.31	3.79	4.85
South Africa	2	7.59	3.79	4.85

The results of equation (3) are presented in Table 4. The result for Saudi Arabia shows that the error correction term has the expected negative sign and significant at 1% level, which further corroborates the long run association between the series. This further indicates that R&D and innovation have long run causality towards economic growth. The ECT value of -1.2523 posits

that any disequilibrium in the short run is corrected by 125% in achieving long run equilibrium every year. In addition to this, the analysis of the short run dynamics of Saudi Arabia also reveals that the preceding changes in LRGDP and LERD positively and significantly change the present LRGDP at 1% level with the corresponding coefficients of 0.43 and 0.03 respectively. However, the preceding change in LINN was negative and not significant in influencing LRGDP at 0.10 level of significance. These results suggest that previous changes in economic growth and R&D positively and significantly influence the present economic growth in Saudi Arabia in the short run. On the other hand, regarding South Africa, Table 4 also reveals that the ECT is negative and significant at 5% level confirming the association between the series in the long run. The long run causality from R&D and innovation to economic growth is confirmed for South Africa. The value of the ECT (-1.1785) shows that the speed of adjustment of short run disequilibrium towards a long run equilibrium every year is 118% in South Africa. The short run dynamics also indicate that the past changes in LRGDP and LERD positively and significantly affects the present LRGDP at 1% and 5% level with the corresponding coefficients of 1.12 and 0.01 respectively. Meanwhile, the coefficient value (0.006) of the past changes in LINN has a positive but insignificant influence on LRGDP. Also, these outcomes imply that previous changes in economic growth and R&D have positive and significant influence on the present economic growth in South Africa in the short run.

Table 4: Results of ECM for Saudi Arabia and South Africa

Variables	Coefficient (Saudi Arabia)	Coefficient (South Africa)
Δ LRGDP (-1)	0.4330***	1.1288***
Δ LERD (-1)	0.0327***	0.0121**
Δ LINN (-1)	-0.0063	0.0061
ECT(-1)	-1.2523***	-1.1785***

(*), (**), (***) indicate 10%, 5% and 1% significant level, respectively

The outcomes of ARDL and ECM models for both Saudi Arabia and South Africa are similar in many ways. Firstly, the models of the two countries exhibit the existence of co-integration, and long run association was established. More so, long run causality from R&D and innovation to economic growth was found in the two countries. This confirmed that investment in research and developments as well as engagement in various forms of innovation which are patented have a long run effect on the development of the economy in both Saudi Arabia and South Africa. The outcomes are consistent with that of related studies (Bakari, 2019; Liu and Xia, 2018; Armeanu et al., 2018) and differ from others (Tuna et al., 2015). This implied that diversification from the natural resource endowments towards a knowledge-based economy is promising and significant towards the long run growth of the two economies considered in this paper. The results of short run dynamics also showed that R&D has positive and significant effect in both countries, though the coefficient is slightly higher in Saudi Arabia than South Africa. Meanwhile, innovation is not significant in the short run for the two countries, and this could be as a result of the fact that it usually takes some period of time for innovative activities conducted to have significant impact on economic growth. Similarly, studies such as Bakari et

al. (2020) could not find any significant impact of innovation on economic growth as well. Generally, the coefficient values in the two countries for R&D and innovation are relatively low, which warrant the suggestion of more allocation of funds to R&D and innovation in both public and private institutions by both government and business entities in the two countries.

The results of the diagnostic tests as displayed in Table 5 indicate that the residual of the models of the two countries are normally distributed and free from the presence of autocorrelation and heteroscedasticity.

Table 5: Results of Diagnostic tests

Test	Null hypothesis	Saudi Arabia P-values	South Africa P-values	Decision
ARCH	No conditional heteroscedasticity	0.9476	0.4602	Do not reject H_0
Breusch-Godfrey Serial Correlation LM Test	No serial correlation	0.6975	0.7811	Do not reject H_0
Jarque-Bera (JB)	There is normality	0.3380	0.1514	Do not reject H_0

The stability of the short run and long run coefficients is tested through the cumulative sum (CUSUM) and CUSUM of squares (CUSUMSQ) tests (Brown et al., 1975). Figures 1 and 2 show that that the models are properly specified, which imply that the parameters in the model are stable. These are evident as both CUSUM and CUSUMSQ graphs fall within the critical bounds of 5% significant level in Figure 1 and 2 for Saudi Arabia and South Africa respectively. Hence, there are no structural changes which affect the variables within the period under study signifying the stability of the series for the period 2001-2018.

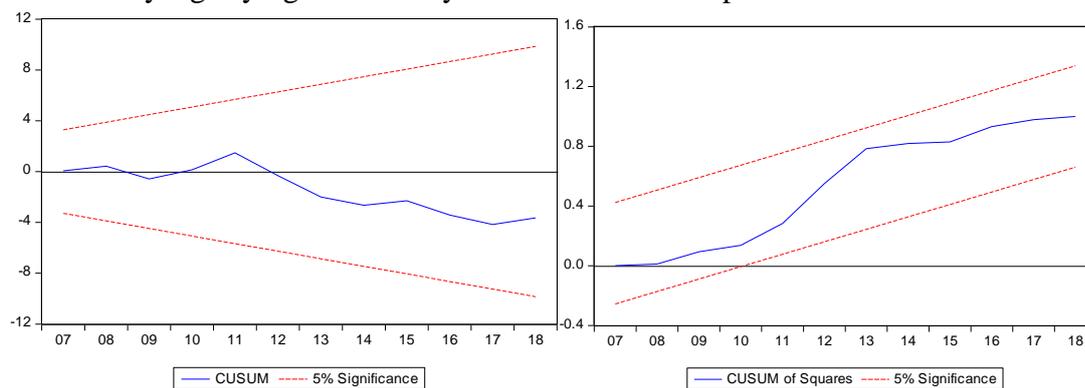


Figure 1: Results of CUSUM and CUSUMSQ tests for Saudi Arabia

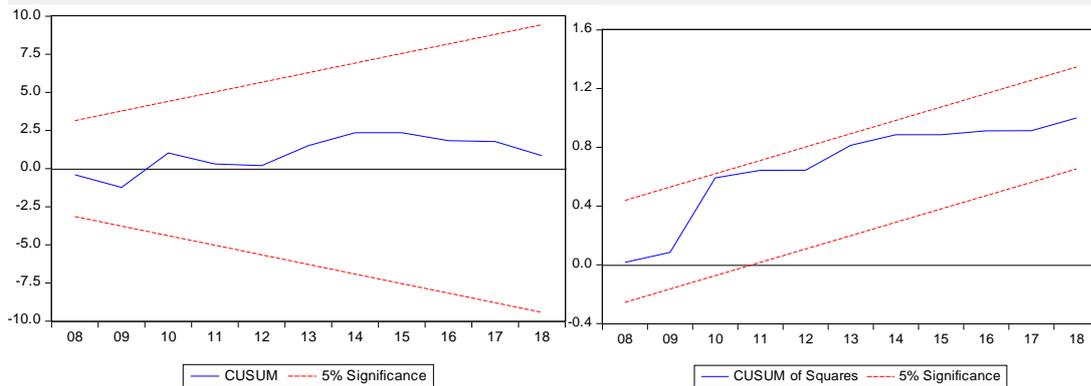


Figure 2: Results of CUSUM and CUSUMSQ tests for South Africa

5. Conclusion

This study examines the effects of R&D and innovation on economic growth in both the short- and long-run period in Saudi Arabia and South Africa. The two countries considered in this study have greater reliance on their natural resources for the government revenue. However, the governments of the two countries are yearning for diversification of the economy which is clearly stated in their Vision 2030. This study utilises ARDL in analysing the data, and the empirical results reveal that there is a long run association between R&D, innovation and economic growth for the two countries. The results further indicate that there is a long run causality from R&D and innovation to economic growth in both countries. The long run economic growth of the two countries is linked with research and innovation, and this calls for the promotion of more public and private funding of research and innovative activities in the two economies. Furthermore, R&D seems to be statistically significant in the two countries in the short run while technology innovation was not significant. This could be as a result of small number of patented innovations which could be attributed to weak innovative efforts, and also could be as a result of the number of lag periods it takes the research and innovative efforts to result into successful innovation outcomes.

The study has some managerial implications for the two economies. Firstly, it is important for the government of both countries to continue to support research in the public institutions through an increased expenditure on research, instilling the research entrepreneurial attitudes in academics so as to come up with innovations which would be able to provide solutions to industrial problems, and also provide an enabling environment for the private enterprises to engage in research and innovative efforts. Secondly, there is a need for the two countries to strengthen their national innovation system by fostering strong collaborations among the higher educational institutions/research institutes, industrial firms, financial institutions and the policy makers. This would lead to building indigenous innovation capability which is strong and dynamic to function under any structural economic turbulence. Such innovation capability



would create a robust system that enables the firms and industries to have a comparative advantage in the global market.

The study is limited to the period where the data of the two countries are available. Also, the data is limited to the number of patents, expenditure on R&D and economic growth, whereas further studies on the two countries could consider other indicators that could be used to capture research and innovation.



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