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# Nexus between Natural Resources, Technology Innovation, Green Energy and Financial Performance in the Saudi Arabia: Evidence from asymmetric causality test

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**Abstract**

After the global financial crisis, the volatilities in oil prices have caused a severe negative impact on the Saudi Arabia's earning hence government initiated the policies to decrease its oil dependence and recognized the substantial role of the financial sector. In this regard, the goal of the study is to recognize the potential role of natural resources, green energy, and technological innovations in influencing the performance of the financial sector in the Saudi economy. For recognizing the asymmetric empirical relationship among the studied variables on the data from 1990 to 2018, nonlinear ARDL was applied. The results confirm that positive shocks of natural resources and technology innovation increase the financial performance in Saudi Arabia whereas the positive and negative fluctuation in green energy have a positive and significant impact on financial performance. Based on the findings, proper allocation for the natural resources for improving financial performance is recommended whereas more attention is needed to improve technology innovation. Lastly, this study helps in providing better understanding of the determinants of Saudi Arabia's financial performance with an application of NARDL that further helps in capturing the asymmetric empirical relationship among the studied variables.

**Key words:** Natural resources, technology innovation, green energy, financial performance, Saudi Arabia.

## 1. Introduction

In order to compete in the present globalized world, the economic prosperity of the country plays a crucial part, leading to bringing social welfare into society. The growth of a country is stimulated by the advancements in financial sectors in the form of stable financial markets, progress in financial institutions and improved level of investments. It is argued that economic development cannot be anticipated without the progress of the financial sector and hence is crucial in advancing growth by improving the efficiency and quality of financial institutions through enabling innovation in the distribution of financial services (Mishkin, 2009).The progress of the financial sector supports technical advancements that decline the cost of information and borrowing, along with introducing reforms in institutional quality. In this regard, the role of technological innovation is crucial in leading financial growth. Through innovation, the financial sector is likely to benefit from cost reduction, resource allocation and efficient evaluation of administrative and financial projects (Hsu, Tian, & Xu, 2014).It further resulted in enhancing the

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capability of mobilizing savings & investments and thus stimulates growth, especially in emerging economies (Sadorsky, 2010).

The benefits of an efficient financial sector lie in supporting investments decisions of the organizations Bhattacharyya and Hodler (2014), permitting economies to perform effective management of resources (Shahbaz, Naeem, Ahad, & Tahir, 2018) and motivating technological advancements to boost growth (Hsu et al., 2014).On the other hand, many studies established that the growth of the financial sector carries a negative environmental impact by enhancing energy dependence in both developing (Sadorsky, 2010) and developed economies (Sadorsky, 2011), whereas rise in financial sector performance augments energy demand in the resource-dependent economy of Saudi Arabia Baloch, Meng, Zhang, and Xu (2018) thus leading to establishing a positive link between financial development and energy utilization (Sadorsky, 2010).This follows that the positives of financial sector expansion in the form of resource allocation and technology spillover flourish growth but also carries a negative impact on the environment by enhancing energy intensity in the financial structure leading to threatens the country's prospect of sustainable development (Nasreen, Anwar, & Ozturk, 2017).

In the current environmental era, the significance of environmental sustainability is among the top priorities of several economies. Considering the inevitable role of energy utilization in the country's growth, the role of green energy offers a solution to meet the economic need of the energy in a country by exerting minimal pressure on the environment. The link between the financial sector and green energy is also strengthened by witnessing the upsurge in the investments of green energy projects that can avail energy efficiency along with offering due protection to the environment. In a similar context, Shahbaz, Jam, Bibi, and Loganathan (2016) also stated that the eco-friendly financial sector is encouraged by offering subsidies to innovative technologies and R&D plans of green energy that can sustain the country's energy needs without dismantling environmental condition.

Thus, it implies that the benefits of financial advancements are ascribed from the smooth distribution of resources and investments that can carry positive spillovers into numerous industrial and service sectors of the country, as well as on environment through channeling energy needs in renewable sources of energy. Many studies claimed that resources play a crucial role in the country's development, especially in developing economies. The traditional view of resource curse assumed natural resources to be detrimental to the country's economy by asserting that the resource-abundant economies experience a slower rate of growth. In a similar context, Hoshmand, Hosseini, and Rajabzadeh Moghani (2013) elaborated that financial advancement is identified to persist feeble growth in several emerging oil economies implying that the process by which resource dependence hinders economic growth also hampers the growth of the financial sector. However, more recently, Shahbaz, Bhattacharya, and Mahalik (2018) established that natural resource abundance influenced positively to financial sector progress through improved economic and financial institutions.

Thus, the presence of ambiguity in the financial sector-natural resource link amplified its significance for re-evaluation in different time-series investigations. From the aspect of natural resources, Saudi Arabia is blessed with abundant resources, especially metal and minerals including, oil, gold, silver, natural gas, iron core, phosphate, tungsten, copper, zinc, sulphur etc. The country is included among the top twenty economies of the World (Albassam, 2015). The economy of Saudi Arabia is exclusive for being extensively resource-dependent and earns 75 percent of the revenues from natural resources (KSA, 2017). Also, Saudi Arabia is believed to be the Energy Superpower for being the largest exporter of oil in the World while owing second-largest petroleum and fifth-largest natural gas reserves with a total worth of 33.2 trillion dollars (Anthony, 2019). Hence, the role of natural resources in molding Saudi Arabia's financial structure is pertinent as they underlie the potential to upset financial development which can carry a negative impact on the country's overall growth. On the other hand, Albassam (2015) asserted that the availability of natural resources is eminent for Arabia's growth as many foreign investors are attracted to the Kingdom for encompassing sufficient natural resources.

Over the last decade, the volatilities in oil prices have caused a severe negative impact on the country earning as ninety percent of the country's revenues are derived from oil exports. As a solution, the government initiated the policies to decrease its oil dependence (International Monetary Fund, 2017) and recognized the substantial role of the financial sector, through the expansion of financial institutions and markets, in improving the country's progress (Xu, Baloch, Meng, Zhang, & Mahmood, 2018). Given the augmented emphasis on the country's financial structure, the current study is motivated to analyze the determinants of Saudi Arabia's financial performance. Moreover, the goal of the study is to recognize the potential role of natural resources, green energy and technological innovations in influencing the performance of the financial sector in the Saudi economy. Since adopting advanced econometrics for performing empirical investigations has always been emphasized (Sharif, Afshan, & Qureshi, 2019), therefore present study contributes in the existing literature by capturing the asymmetric empirical relationships among the studied variables by the help of Non-linear ARDL. The novel findings from this technique further helps the potential decision makers in understanding the role of natural resource, green energy and technological innovation in triggering the positive and negative shocks in the Kingdom's financial sector.

The rest of the examination is structured as below. Section-two would present the review of existing literature regarding natural resources, green energy, technological innovation, and financial development nexus. Moreover, section-three will discuss the adopted methodology of the study, followed by section-four that will report empirical findings and their explanation. Finally, section-five of the study would conclude the investigation by offering a discussion of the derived findings with future policies and recommendations seventeen sampled economies from the period of 1995 to 2005. The result reported the significant positive impact of the studied variables on stock market development. Precisely, the results established that natural resources, measured from oil rents significantly derived financial development, especially in economies that contain abundant natural resources.

**2. Literature review**

Given the contentious role of financial development in leading country's growth, many studies analyzed the numerous economic (Kandil, Shahbaz, & Nasreen, 2015), political (M. A. Khan, Kong, Xiang, & Zhang, 2019) and social (Katircioglu, Katircioğlu & Altinay, 2018) determinates of financial sector performance. Owing to the critical impact of natural resources, technology innovation, and green energy in leading financial development, the prevailing literature has presented mixed findings (Hoshmand et al., 2013); Shahbaz et al. 2018a) resulting in causing inconsistencies in the precise link among the variables. From the evidence of the existing literature, it is witnessed that the link between natural resources and financial development is unclear to reach a consensus over the presence of resource curse or resource blessing relationships among the variables. For instance, Billmeier and Massa (2007) studied the factors that contributed to the development of the financial sector in the economies of Central Asia and the Middle East. For this, the authors studied the impact of remittance, natural resources and institutional quality in influencing financial development measured from stock market capitalization in

On the other hand, in a panel examination, Gylfason and Zoega (2006) investigated the link between natural resources and financial development on the sample of eighty-five mixed economies from the period of 1965 to 1998. The results of the study, unlike Billmeier and Massa (2007), found the significant negative link among the variables suggesting that a rise in resource abundance dismantled the financial structure measured from saving and investment levels in the sampled economies. Moreover, For the Chinese economy, Yuxiang and Chen (2011) analyzed the relationship between natural resources and financial sector performance by utilizing the provincial panel data of the country from the period of 1996 to 2006. The empirical results of the study found that natural resource is significant to influence the growth of the financial sector. Precisely, the study confirmed the presence of resource curse for financial development in China by recognizing the slower financial sector performance of Chinese provinces that are resource-rich, than the limited resource provinces.

More recently, Shahbaz, Naeem, et al. (2018) examined the link o natural resources in determining financial development in the United States on data of 1960 to 2016 by utilizing the method of linear ARDL bound testing approach, the study reported that natural resources in significant to influence the financial development of the United States measured from domestic credit to the private sector. Specifically, the outcomes found that a rise in natural resource abundance per capita further enhanced financial progress in the United States, both in the long-run and short-run. Alternatively, Kurronen (2015) also investigated the impact of natural resources on the progress of the financial sector. For this, the author has gathered the data of 128 economies from the time-span of 1995 to 2009. Moreover, the study measured the development of the financial sector from the performance of the banking sector in the selected economies. The results of the study, contrasting to Shahbaz, Naeem, et al. (2018), found the presence of a resource curse in countries' financial development. Specifically, the resulted witnessed that financial sector performance is low in economies that are resource-dependent.

In another panel investigation, Hoshmand et al. (2013) examined the link between natural resources measured from oil rents and financial sector performance proxied by private credit by deposits in banks and financial institutions. In order to perform an empirical examination, the data of seventeen-panel economies are analyzed during the period of 2002 to 2010. The findings of the study established the significant impact of natural resources on financial sector performance stating that the rise in natural resource rents of oil declined the performance of the financial sector in the sampled economies. Interestingly, Bhattacharyya and Hodler (2014) also examined the nexus of natural resources and financial development in a panel of 133 economies from the period of 1970 to 2005. The results of the empirical findings reported that the association of natural resources with financial performance depends on the quality of institution highlighting that the economies where the institutional quality is adequate, the abundance of natural resources carried a positive effect on financial development. On the other hand, when Faisal, Sulaiman, and Tursoy (2019) analyzed the association between resources and financial sector performance, the study found the insignificant impact of natural resources in influencing financial advancements in the panel of developing nations from 1990 to 2016.

Emphasizing the role of technological innovation in driving financial development, Sassi and Goaied (2013) studied the connection between financial development, innovation, and growth in the economies of the MENA region. For this, the authors studied the impact of innovation, measured from Information and communication technology diffusion on the financial development of seventeen MENA nations from the period of 1960 to 2009. The result reported the significant impact of the studied variables on the country's development. Precisely, the results established that technological innovation derived financial development that resulted in enhancing countries' economic growth. On the other hand, in a panel examination, Hsu et al. (2014) investigated the impact of financial development on technological innovation. For this, the authors have analyzed the sample of thirty-two mixed economies from the period of 1976 to 2006. The results of the study found the significant link among the variables suggesting that a rise in financial development, reflected from the credit market, discouraged the improvements of technological innovation in the sampled economies.

Pradhan, Arvin, Hall, and Nair (2016) also analyzed the relationship between technology innovation and financial sector performance by utilizing the panel data of eighteen European economies from the period of 1961 to 2013. The empirical results of the study, unlike Hsu et al. (2014), found that the expansion of the financial sector improved the level of technological innovation in Europe. More recently, Comin and Nanda (2019) examined the link between technology innovation and financial development in a panel of seventeen economies. In doing so, the authors gathered the data from the time-span of 1870 to 2000. The outcomes of the study found that the rise in financial progress further enhanced the diffusion of technologies in the sampled economies.

Koç and Koç (2017) also investigated the impact of technological innovation, measured from Research and development expenditures, on the progress of the financial sector. For this, the author has gathered the data of G-8 economies from the time-span of 1998 to 2013. Moreover, the study measured the development of the financial sector from the level of foreign investment in the selected economies. The results of the study, contrasting to Hsu et al. (2014) found the significant positive effect of technological innovation on countries' financial development. In another investigation, M. K. Khan, He, Akram, Zulfiqar, and Usman (2018) examined the role of technology innovation in the financial structure of China. For this, the authors examined two core financial sectors of the country namely, capital market and banking. The findings of the study established the significant role of technology innovation activities in both financial sectors. However, the study found that technology innovation has more dominance in the financial sector based on capital markets as compared to the banking sector.

While emphasizing the role of green energy in influencing financial development, Kahia, Kadria, and Aïssa (2016) studied the economies of the MENA region. For this, the authors collected the data of twenty-four MENA nations from the period of 1980 to 2012. The result of the investigation reported the insignificant impact of renewable energy in influencing the financial sector performance of the studied economies. The study stated that the energy mix in the analyzed sample had not reached an adequate level of renewable consumption; therefore, it is unlikely to protect the environmental quality of the region. In Saudi Arabia, Mahalik, Babu, Loganathan, and Shahbaz (2017) investigated the association between energy utilization and financial development from the period of 1971 to 2011. The study found that financial sector growth, measured from domestic credit to financial sector carried a significant positive impact on green energy consumption in the economy.

Similarly, in a time-series examination, Burakov and Freidin (2017) also investigated the link between green energy and financial development in Russia. For this, the authors have gathered the data from the period of 1990 to 2014. The results of the study, similar to Kahia et al. (2016),found the insignificant role of green energy consumption in driving financial sector performance in Russia. Moreover, For the Chinese economy, Ji and Zhang (2019) analyzed the impact of financial sector growth on renewable energy utilization using the time-series data of the country from the period of 1992 to 2013. The empirical results of the study found that the financial sector is significant in influencing the usage of green energy. Precisely, the study found that the development of the financial sector has contributed to increasing green energy growth by 42.2 percent in China. Similar results were reported by Kim and Park (2016) while analyzing green energy-financial development link in a panel of thirty economies from the time span of 2000 to 2013.

## 3. Methodology

To examine the connection among natural resources, technology innovation, and green energy with the financial performance in the context of the Saudi Arabia, practically, time-series data from the era 1990 to 2018 has been gathered from the database of World Bank for the above-mentioned variables. The natural resources are measured as natural resources rent (% of GDP), green energy is proxied by renewable energy utilization (% of primary energy), for technology innovation, the present research uses Principal Component Analysis (PCA) to make an index using three different proxies of technology innovation which are number of internet users, number of mobile phone subscriber and number of fixed broadband users. finally, financial performance is measured by domestic credit by the financial sector (% of GDP). Moreover, financial performance, natural resources, technology innovation and green energy are termed as FP, NAR, INV, GEN respectively. Therefore, the following equation has been proposed:

$$\ln \mathrm{FD_t} = \mathrm{f}\,(\ln \mathrm{NAR_t}, \ln \mathrm{INV_t},\ \ln \mathrm{GEN_t}) \quad (1)$$

The equation 1 is represented in linear form as follows:

$$\ln \mathrm{FP_t} = \beta_0 + \beta_1 \ln \mathrm{NAR_t} + \beta_2\ \ln \mathrm{INV_t} + \beta_3\ \ln \mathrm{GEN_t} + \ \mu_t \quad (2)$$

As per Fareed, Meo, Zulfiqar, Shahzad, and Wang (2018) in econometrics, the stationary features of the factors for the long term relationship might be investigated by various methodologies which are Granger Causality, ECM and ARDL methods etc. Because of these approaches, the asymmetric behavior of the connection among the selected factors can be detected. Though the linear regression approach can individually describe the linear association among the factors and flop to explain the non-linear associations (if any). Hence, Shin, Yu, and Greenwood-Nimmo (2014) developed the ARDL model of Pesaran, Shin, and Smith (2001) to enlighten the asymmetric features of the association among the factors. With the support of these methods, a scholar can gauge the instabilities focused on short term and structural breaks both. Later, the asymmetric behavior of the association among the FP, NAR, INV and GEN is therefore explored. Furthermore, to account the asymmetric association, the long run founded equation is presented below:

$$\mathrm{FP_t} = \ \alpha_0 + \alpha_1 \mathrm{NAR_t^+} + \alpha_2 \mathrm{NAR_t^-} + \alpha_3 \mathrm{INV_t^+} + \alpha_4 \mathrm{INV_t^-} + \alpha_5 \mathrm{GEN_t^+} + \alpha_6 \mathrm{GEN_t^-} + \varepsilon_t \quad (3)$$

EQ-3, financial performance is represented by FP; however, the co-integrating vector that requires to be calculated consequently is characterized by $\alpha = (\alpha_0, \alpha_1, \alpha_3, \alpha_4, \alpha_5, \alpha_6)$. On the one hand, the fractional summation of the negative and positive fluctuations in FP by NAR, INV and GEN is denoted by $NAR_t^+$, $NAR_t^-$, $INV_t^+$, $INV_t^-$, $GEN_t^+$, $GEN_t^-$, as stated below:

$$\mathrm{NAR}_t^+ = \sum_{t=1}^{t} \Delta\mathrm{NAR}_t^+ = \sum_{t=1}^{t} \max(\Delta\mathrm{NAR}_i 0). \qquad (4)$$

$$\mathrm{NAR}^- = \sum_{t=1}^{t} \Delta\mathrm{NAR}_t^- = \sum_{t=1}^{t} \min(\Delta\mathrm{NAR}_i, 0). \qquad (5)$$

$$\mathrm{INV}_t^+ = \sum_{t=1}^{t} \Delta\mathrm{INV}_t^+ = \sum_{t=1}^{t} \max(\Delta\mathrm{INV}_i, 0). \qquad (6)$$

$$\mathrm{INV}_t^- = \sum_{t=1}^{t} \Delta\mathrm{INV}_t^- = \sum_{t=1}^{t} \min(\Delta\mathrm{INV}_i, 0). \qquad (7)$$

$$\mathrm{GEN}_t^+ = \sum_{t=1}^{t} \Delta\mathrm{GEN}_t^+ = \sum_{t=1}^{t} \max(\Delta\mathrm{GEN}_i, 0). \qquad (8)$$

$$\mathrm{GEN}^- = \sum_{t=1}^{t} \Delta\mathrm{GEN}_t^- = \sum_{t=1}^{t} \min(\Delta\mathrm{GEN}_i, 0). \qquad (9)$$

Focusing EQ-2, as anticipated by Shin et al. (2014), the prolonged asymmetric ARDL framework is explained as follows:

$$\begin{aligned}\Delta\mathrm{FP}_t = {} & \beta_0 + \beta_1\mathrm{FP}_{t-1} + \beta_2\mathrm{NAR}_{t-1}^+ + \beta_3\mathrm{NAR}_{t-1}^- + \beta_4\mathrm{INV}_{t-1}^+ + \beta_5\mathrm{INV}_{t-1}^- + \beta_6\mathrm{GEN}_{t-1}^+ + \beta_7\mathrm{GEN}_{t-1}^- \\ & + \sum_{i=1}^{m} \delta_{1i}\Delta\mathrm{FP}_{t-1} + \sum_{i=0}^{n} \delta_{2i}\Delta\mathrm{NAR}_{t-i}^+ + \sum_{i=0}^{p} \delta_{3i}\Delta\mathrm{NAR}_{t-i}^- + \sum_{i=0}^{q} \delta_{4i}\Delta\mathrm{INV}_{t-i}^+ + \sum_{i=0}^{r} \delta_{5i}\Delta\mathrm{INV}_{t-i}^- \\ & + \sum_{i=0}^{s} \delta_{6i}\Delta\mathrm{GEN}_{t-i}^+ + \sum_{i=0}^{t} \delta_{7i}\Delta\mathrm{GEN}_{t-i}^- \\ & + u_i \end{aligned} \qquad (10)$$

Discussing EQ10, the lags order is represented by m, n, p, q, r, s, and t. Furthermore, the negative and positive shock impact on financial performance by natural resources, technology innovation and green energy is denoted by $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7$. Lastly, the short-run negative and positive effect on financial performance by natural resources, technology innovation, and green energy utilization are denoted by $\sum_{i=0}^{n} \delta_{2i}, \sum_{i=0}^{p} \delta_{3i}, \sum_{i=0}^{q} \delta_{4i}, \sum_{i=0}^{r} \delta_{5i}, \sum_{i=0}^{s} \delta_{6i}, \sum_{i=0}^{t} \delta_{7i}$

To utilizes the asymmetric ARDL model, Fareed et al. (2018) have explained the subsequent phases: Initially, the stationarity features requires to be investigated of all the selected factors. This can be tested by utilizing two traditional methods, which are augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests. Though the assessment of stationarity features is not essential while utilizing ARDL and henceforth, the ARDL could be consequently used either the behavior of stationarity is supposed at 1(0), 1(1), or the amalgamation of 1(1) and (0). But it has been detected by Ibrahim (2015) that ARDL could not be progressed further at the level of 1(2); therefore, the estimation of the stationarity features of the factors was assessed to remove the likelihood of a group of ambiguous outcomes by the framework. Moreover, the EQ-10 was gauged by utilizing the OLS technique. In addition, focused on the thoughts by, the overall to a detailed method and SIC is also tracked. Thirdly, the occurrence of co-integration was estimated by utilizing the bounds test. Subsequently, the validation of the presence of co-integration, the asymmetric ARDL model is used. Likewise, the derivation of 1% modification was considered focused on asymmetric cumulative dynamic multiplier effects in $NAR_{t-1}^+$, $NAR_{t-1}^-$, $INV_{t-1}^+$, $INV_{t-1}^-$, $GEN_{t-1}^+$, $GEN_{t-1}^-$ consequently, as displayed as follows:

$$s_h^+(\mathrm{NAR}) = \sum_{j=0}^{h} \frac{\partial \mathrm{FP}_{t+i}}{\partial \mathrm{NAR}_{t-1}^+} \qquad (11)$$

$$s_h^-(NAR) = \sum_{j=0}^{h} \frac{\partial FP_{t+i}}{\partial NAR_{t-1}^-} \quad (12)$$

$$s_h^+(INV) = \sum_{j=0}^{h} \frac{\partial FP_{t+i}}{\partial INV_{t-1}^+} \quad (13)$$

$$s_h^-(INV) = \sum_{j=0}^{h} \frac{\partial FP_{t+i}}{\partial INV_{t-1}^-} \quad (14)$$

$$s_h^+(GEN) = \sum_{j=0}^{h} \frac{\partial FP_{t+i}}{\partial GEN_{t-1}^+} \quad (15)$$

$$s_h^-(GEN) = \sum_{j=0}^{h} \frac{\partial FP_{t+i}}{\partial GEN_{t-1}^-} \quad (16)$$

Focusing on the above-mentioned stages, the asymmetric ARDL background is utilized in the current research. In addition, the individual causality of one factor over the other factor is inspected by the asymmetric causality test, which is anticipated by Hatemi-j (2012).This test is an amalgamation of two aspects. Initially, asymmetric cointegration, which was introduced by Granger and Yoon (2002) and next, bootstrap distribution in lag augmented causality, which was introduced by Hacker and Hatemi-J (2006). Hence, the factors examined in the current research are explained as the following:

$$FP_t = FP_{t-1} + \varepsilon_{1t} = FP_0 + \sum_{i}^{t} \varepsilon 1i \quad (17)$$

$$NAR_t = NAR_{t-1} + \varepsilon_{2t} = NAR_0 + \sum_{i}^{t} \varepsilon 2i \quad (18)$$

$$INV_t = INV_{t-1} + \varepsilon_{3t} = INV_0 + \sum_{i}^{t} \varepsilon 3i \quad (19)$$

$$GEN_t = GEN_{t-1} + \varepsilon_{4t} = GEN_0 + \sum_{i}^{t} \varepsilon 4i \quad (20)$$

In the EQ17-20, the initial coefficients are explained by FP0, NAR0, INV0, and GEN0. Furthermore, the positive and negative shocks can be signified as $\varepsilon_{1i}^+ = \max(\varepsilon_{1i}, 0)$, $\varepsilon_{2i}^+ = \max(\varepsilon_{2i}, 0)$, $\varepsilon_{3i}^+ = \max(\varepsilon_{3i}, 0)$, $\varepsilon_{4i}^+ = \max(\varepsilon_{4i}, 0)$, $\varepsilon_{1i}^- = \min(\varepsilon_{1i}, 0)$, $\varepsilon_{2i}^- = \min(\varepsilon_{2i}, 0)$, $\varepsilon_{3i}^- = \min(\varepsilon_{3i}, 0)$, $\varepsilon_{4i}^- = \min(\varepsilon_{4i}, 0)$, correspondingly. In simple words, $\varepsilon 1i$ explains the sum of the shocks counting both positive and negative in $\varepsilon 1i$, $\varepsilon 2i$ signifies the sum of the shocks counting both positive and negative in $\varepsilon 2i$ , $\varepsilon 3i$ explains the sum of the shocks counting both positive and negative in $\varepsilon 3i$, and $\varepsilon 4i$ explains the sum of the shocks counting both positive and negative in $\varepsilon 4i$ respectively. Then, focused on these, the equalities can be signified as follows:

$$FP_t^+ = \sum_{i=1}^{t} \varepsilon_{1i}^+, FP_t^- = \sum_{i=1}^{t} \varepsilon_{1i}^- ;\ NAR_t^+ = \sum_{i=1}^{t} \varepsilon_{2i}^+, NAR_t^- = \sum_{i=1}^{t} \varepsilon_{2i}^- ; INV_t^+ = \sum_{i=1}^{t} \varepsilon_{3i}^+, INV_t^- = \sum_{i=1}^{t} \varepsilon_{3i}^- ; GEN_t^+ = \sum_{i=1}^{t} \varepsilon_{4i}^+, GEN_t^- = \sum_{i=1}^{t} \varepsilon_{4i}^- \quad (21)$$

Moreover, for describing the association among the positive shocks of financial performance, natural resources, technology innovation, and green energy, assuming that $y_t^+ = (FP_t^+, NAR_t^+, INV_t^+, GEN_t^+)$ whereas lagged Vector Autoregressive Model (VARp) was used to inspect the causal relationship among the series, as mentioned below:

$$y_t^+ = v_t + A_1 y_{t-1}^+ + \cdots + A_p y_{t-p}^+ + \cdots + A_{p+d} y_{t-p-d}^+ + \varepsilon_t^+ \quad (22)$$

Whereas the optimal lag length is identified by the help of Hatemi-J Criterion (HJC). Moreover, the construction of a model of VARp+d is discussed as follows:

$$K = DZ + \delta \quad (23)$$

Where;

$$K = (y_1^+, \dots, y_T^+)\ (n \times T)\ matrix \quad (24)$$

$$D = \left(v, A_1, \dots, A_p, \dots, A_{p+d}\right)\left(n \times \left(1 + n(p+d)\right)\right)\ matrix \quad (25)$$

$$Z = \begin{bmatrix} 1 \\ y_t^+ \\ y_{t-1}^+ \\ \dots \\ y_{t-p+1}^+ \end{bmatrix} \left(\left(1 + n(p+d)\right) \times 1\right) matrix\ for\ t = 1, \dots, T \quad (26)$$

$$Z = (Z_0, \dots, Z_{T-1})\left(\left(1 + n(p+d)\right) \times T\right) matrix \quad (27)$$

$$\delta = (\varepsilon_1^+, \dots, \varepsilon_T^+)(n \times T)\ matrix \quad (28)$$

The null hypothesis, which shows the absence of Granger Causality, can be examined and tested by the help of modified WALD statistics (MW), which are shown as follows:

$$MW = (X\theta)'[X(Z'Z)^{-1} \otimes V_U)X']^{-1}(X\theta) \sim \chi_P^2 \quad (29)$$

In EQ-29, Kronecker multiplier is represented by ⊗, indicator function having restrictions is represented by $X = ap \times n(1 + n(p+d))$, whereas vec shows the stacking operator of a column.

**RESULTS AND DISCUSSION**

From the start, the recent research applied the main descriptive estimations for all the four variables used in this recent investigation. The revelations of main descriptive estimations appear in Table-1. It provides mean estimation, minimum, maximum, standard deviation also the estimation of the Jarque-Bera test which confirms that whether our variables are linear or nonlinear in nature. The findings certify that the mean of all the variables is positive. The mean value of NAR is 0.0046, with the lowest value of -0.0015 and the highest estimation of 0.0073. Additionally, the mean estimation of INV is 0.0029 with the lowest figure of -0.0539 and the highest figure of 0.0268. Moreover, the mean estimation of GEN is 0.0094 with the lowest figure of -0.1375 and the highest figure of 0.0832. Along with this, the FP has a mean coefficient of 0.0031, with the lowest estimation of -0.0644 and the maximum estimation of 0.0381. Moreover, the standard deviation for NAR, INV, GEN, and FP is 0.0060, 0.0195 and 1.073. Also, recent research applied the Jarque-Bera test to emphasize the normality features of the factors. The findings of the JB test confirm the rejection of the invalid hypothesis at a 1% level of noteworthiness, which suggests that each factor is non-linear in behavior. The outcomes of further declare that there suggests that nonlinearity in each of the factors (Shahbaz, Naeem, et al., 2018); Shahzad et al. 2017).

*Table 1*. **Results of Disruptive Statistics**

| Variables | NAR | INV | GEN | FP |
|---|---|---|---|---|
| Mean | 0.0046 | 0.0029 | 0.0094 | 0.0031 |
| Minimum | -0.0015 | -0.0539 | -0.1375 | -0.0644 |
| Maximum | 0.0073 | 0.0268 | 0.0832 | 0.0381 |
| Std. Dev. | 0.0060 | 0.0195 | 0.0215 | 0.0055 |
| Skewness | -2.4836 | -1.5835 | -1.7836 | -0.382 |
| Kurtosis | 8.8256 | 5.3726 | 6.4833 | 7.3823 |
| Jarque-Bera | 28.4915 | 13.4837 | 30.7963 | 21.6942 |
| Probability | 0.0000 | 0.000 | 0.000 | 0.000 |

Source: Authors Estimation

There is one basic obligation of utilizing the ARDL bound testing technique that the total of the grouping of factors ought to be stationary at I(0) or I(1), notwithstanding, not I(2). As appeared by Ouattara (2004), the outcomes of ARDL would be unacceptable if there are an I(2) variables that are picked up in the framework. Hence, it is vital to pick the stationarity of the dataset.

*Table 2*. **Results of Unit root test**

| Variables | ADF Unit root test | | | | PP unit root test | | | |
|---|---|---|---|---|---|---|---|---|
| | I(0) | | I(1) | | I(0) | | I(1) | |
| | C | C&T | C | C&T | C | C&T | C | C&T |
| **NAR** | 1.438 | 1.375 | -5.382*** | -5.227*** | 1.394 | 1.218 | -5.881*** | -5.216*** |
| **INV** | -0.265 | -0.272 | -5.836*** | -5.336*** | -0.217 | -0.270 | -5.124*** | -5.092*** |
| **GEN** | -0.674 | -0.691 | -7.372*** | -6.963*** | -0.572 | -0.559 | -6.893*** | -6.997*** |
| **FP** | 0.277 | 0.295 | -5.775*** | -5.873*** | 0.327 | 0.392 | -5.174*** | -5.209*** |

Note: NAR represents the natural resources rents, and INV describes the index of technology innovation; GEN explains the utilization of green energy and FP represents the performance of the financial sector. Moreover, ***, ** & * represents level of significance at 1%, 5% and 10% respectively.

Source: Author Estimation

Moreover, the present examination used two routine unit root tests (for example, ADF and PP), and the results of the ADF and PP unit root are shown in Table 2. The outcomes showed that NAR, INV, GEN and FP are demonstrating non-stationary performance at a level and thereafter changed over into stationary at the differential series. Moreover, the present examination comparably utilized structural break unit root test, for example, Zivot and Andrews (2002) which reflects disturbances as clarified by Perron (1990).Thinking about the problem of the break in the time series, utilizing Zivot and Andrews (1992), the investigation additionally observed that all of the components are stationary at I(1), not I(2), as showed in Table 3. Along these lines, it is verified that the recent examination is utilized the ARDL methodology as an entire set of variables are not I(2).

*Table 3*. **Zivot-Andrews Structural Break Trended Unit Root Test**

| Table 3: Zivot-Andrews Structural Break Trended Unit Root Test | | | | |
|---|---|---|---|---|
| Variable | At Level | | At 1st Difference | |
| | T-Statistics | Time Break | T-Statistics | Time Break |
| **NAR** | 1.094 (1) | 2008 | -5.982 (1)*** | 2015 |
| **INV** | -0.472 (1) | 2014 | -7.425 (1)*** | 1992 |
| **GEN** | -0.983 (1) | 2014 | -7.812 (1)*** | 2006 |
| **FP** | 0.472 (1) | 1998 | -5.889 (1)*** | 2001 |

Note: Lag order shown in parenthesis.
*** Represents significance at 1% level.

Source: Author Estimations

Moreover, Shahbaz, Balsalobre-Lorente, and Sinha (2019) expressed that long-haul affiliations concentrated on the best lag, and Stock and Watson (2012) additionally affirmed that utilizing a superfluous number of lags or using fewer lags could lose greatest significant proof of the structure or may reason biased evaluation. Along these lines, considering the position of perfect lags, the recent investigation study 1 lag as flawless in the view of Schwarz Info Criteria (SIC). The discoveries of bound testing and nonlinear assurance have appeared in Table 4. The assessment of the F-test is more than the tabulated values that confirm a nonlinear long-run association between NAR, INV, GEN and FP in Saudi Arabia. In that capacity, the recent examination can push ahead to assess nonlinear ARDL coefficients.

*Table 4.* **Results of Bond test cointegration in the asymmetric specification**

| Model | F-Statistics | Upper Bond | Lower Bond |
|---|---|---|---|
| ln FP / (ln NAR_POS, ln NAR_NEG, ln INV_POS, ln INV_NEG, ln GEN_POS, ln GEN_NEG) | 57.438 | | |
| **Critical Values** | | | |
| **10%** | | 4.463 | 1.735 |
| **5%** | | 5.433 | 2.231 |
| **1%** | | 6.873 | 2.802 |

Note: The combine null of no long-run relationship is p=o+ = o-=0. Moreover, the critical values are depending on Narayan (2005), the sample period.

Source: Author Estimations

The findings of bond testing cointegration confirm a nonlinear long run connection between NAR, INV, GEN, and FP in Saudi Arabia, the recent investigation will continue towards long-run coefficients of our independent factors. The findings of long-run coefficients are displayed in Table-5. The discoveries of NARDL affirmed that all factors altogether noteworthy on the performance of the financial sector in Saudi Arabia. The outcomes further recommended that there is a chance of an asymmetric association between NAR, INV, GEN and FP in Saudi Arabia. The discoveries likewise showed that on account of the negative shocks of NAR, the FP decreased by 37.2%; however, due to positive shocks of NAR, the performance of the financial sector increased by 28.3%. The sign of the two shocks is diverse which affirms a nonlinear connection between NAR and FP in Saudi Arabia. On the other hand, the negative shocks in INV decline the FP by 19.6%; whereas, the positive shocks in INV increase the financial performance by 29.5%. Again, the sign of the two shocks are different which affirms a nonlinear connection between NAR and FP in Saudi Arabia. At last, the outcomes showed that green energy utilization and financial performance have a nonlinear relationship as the negative shocks in GEN increase the FP by 34.3%; notwithstanding, the positive shocks increased the FP by 13.8%. For this situation, the signs of the two shocks are similar; however, the magnitude and size of both shocks are significantly different which affirms that the connection between green energy and financial performance is nonlinear in nature. This implies when the economy shifts towards green power source or environmentally friendly energy vitality, so it will diminish the degree of greenhouse gas emissions and other toxic gases as well.

*Table 5.* **Results of Long-run asymmetric using NARDL Approach**

| Variables | Coeff. | t-stats | Prob. |
|---|---|---|---|
| ln NAR_NEG | -0.372 | -4.094 | 0.000 |
| ln NAR_POS | 0.283 | 4.592 | 0.000 |
| ln INV_NEG | -0.196 | -5.093 | 0.000 |
| ln INV_POS | 0.295 | 3.887 | 0.000 |
| ln GEN_NEG | 0.343 | 5.968 | 0.000 |
| ln GEN_POS | 0.138 | 7.583 | 0.000 |

Note: Dependent Variable: Financial Performance

Source: Author Estimations

In the accompanying stage, the findings of the diagnostic test of the NARDL strategy are represented in table 6. Here, the worth estimation of LM and Breusch-Pagan-Godfrey are more noticeable than 0.100, which avow that the framework is unconventional from serial correlation and heteroscedasticity issues. Besides, the recent examination uncovered the p-value of the Ramsay RESET tests, which is moreover more than 0.100, recommending that the recent model is sensibly specified. Finally, the recent investigation explained the VIF value which is 4.632 recommending that there is no issue of multicollinearity in our model.

*Table 6.* **Results of Diagnostic Tests**

| Diagnostic Test | Problem | P-value | Status |
|---|---|---|---|
| LM test | Serial Correlation | 0.472 | No serial correlation |
| Breusch-Pagan-Godfrey | Heteroscedasticity | 0.391 | No heteroscedasticity |
| Ramsey RESET test | Model specification | 0.228 | Model is correct |
| VIF | Multicollinearity | 4.632 | No multicollinearity |

Source: Author Estimation

In the last phase, the recent research applied the asymmetric Granger causality, which is introduced by Hatemi-j (2012).The present study used asymmetric causality to investigate the causal connection between the positive and negative shocks of NAR, INV, GEN, and FP in the Saudi Arabian economy.

*Table 7.* **Results of Asymmetric Granger Causality**

| Null hypothesis | Wald Test | Bstrap 1% | Bstrap 5% | Bstrap 10% |
|---|---|---|---|---|
| $NAR^{-}$ does not Granger cause $FP^{-}$ | 16.606 | 56.567 | 42.259 | 27.367 |
| $NAR^{-}$ does not Granger cause $FP^{+}$ | 40.630*** | 31.182 | 24.308 | 17.917 |
| $NAR^{+}$ does not Granger cause $FP^{-}$ | 10.567 | 39.499 | 30.557 | 19.783 |
| $NAR^{+}$ does not Granger cause $FP^{+}$ | 32.695 | 90.365 | 71.623 | 62.110 |
| $FP^{-}$ does not Granger cause $NAR^{-}$ | 18.688* | 28.274 | 22.198 | 16.883 |
| $FP^{-}$ does not Granger cause $NAR^{+}$ | 54.117*** | 53.237 | 43.971 | 34.895 |
| $FP^{+}$ does not Granger cause $NAR^{-}$ | 2.946 | 35.897 | 27.536 | 21.620 |
| $FP^{+}$ does not Granger cause $NAR^{-}$ | 17.859 | 34.996 | 28.686 | 22.374 |
| $INV^{-}$ does not Granger cause $FP^{-}$ | 68.930*** | 57.283 | 41.981 | 31.509 |
| $INV^{-}$ does not Granger cause $FP^{+}$ | 92.779*** | 71.255 | 37.111 | 27.131 |
| $INV^{+}$ does not Granger cause $FP^{-}$ | 253.278*** | 86.690 | 66.198 | 58.378 |
| $INV^{+}$ does not Granger cause $FP^{+}$ | 70.078*** | 62.122 | 49.799 | 38.948 |
| $FP^{-}$ does not Granger cause $INV^{-}$ | 84.842*** | 69.086 | 44.114 | 35.262 |
| $FP^{-}$ does not Granger cause $INV^{+}$ | 90.795*** | 54.322 | 34.895 | 28.825 |
| $FP^{+}$ does not Granger cause $INV^{-}$ | 50.938*** | 27.506 | 16.846 | 5.455 |
| $FP^{+}$ does not Granger cause $INV^{+}$ | 207.461*** | 71.986 | 53.822 | 36.895 |
| $GEN^{-}$ does not Granger cause $FP^{-}$ | 109.750*** | 38.629 | 30.694 | 22.789 |
| $GEN^{-}$ does not Granger cause $FP^{+}$ | 96.364*** | 64.417 | 56.480 | 48.779 |
| $GEN^{+}$ does not Granger cause $FP^{-}$ | 49.815*** | 35.611 | 22.739 | 18.177 |
| $GEN^{+}$ does not Granger cause $FP^{+}$ | 180.701*** | 28.000 | 17.986 | 14.858 |
| $FP^{-}$ does not Granger cause $GEN^{-}$ | 12.860** | 14.178 | 8.683 | 2.811 |
| $FP^{-}$ does not Granger cause $GEN^{+}$ | 32.896** | 37.107 | 27.742 | 19.018 |
| $FP^{+}$ does not Granger cause $GEN^{-}$ | 72.371*** | 19.912 | 15.822 | 11.747 |
| $FP^{+}$ does not Granger cause $GEN^{-}$ | 38.648*** | 33.205 | 29.113 | 25.143 |

Note: *, ** and *** indicate statistical significance at 10, 5 and 1% level respectively. Critical values are obtained from 10000 bootstrap replications.
Source: Author Estimations

The outcomes are appeared in Table-7. The findings proposed a unidirectional causal relationship from negative shocks of NAR and positive shocks of FP. Also, the results additionally proposed a unidirectional causal relationship from negative shocks of FP to positive shocks of NAR. Furthermore, the causal relationship among INV and FP are significant. A bidirectional causal relationship was found between positive and negative shocks of the technology innovation to positive and negative shocks of FP and positive and negative shocks of FP to positive and negative shocks of INV in the Saudi Arabian economy. Additionally, the findings of green energy and financial performance are exceptionally fascinating. The examination found a bidirectional causal association among positive and negative fluctuations of GEN to FP and from the positive and negative fluctuation of FP to green energy utilization in Saudi Arabia. In summary, the findings of asymmetric causality confirm a unidirectional causal connection between NAR and FP, where causality is running from NAR to FP. On the other hand, the findings further confirmed a bidirectional causal connection between INV and FP and GEN and FP, where causality is running from innovation to financial performance and green energy to financial performance and vice versa.

**4. Conclusions and Implications**

After the global financial crisis, the volatilities in oil prices have caused a severe negative impact on the country earning as ninety percent of the country's revenues are derived from oil exports. As a solution, the government initiated the policies to decrease its oil dependence and recognized the substantial role of the financial sector, through the expansion of financial institutions and markets, in improving the country's progress. Given the augmented emphasis on the country's financial structure, the current study is motivated to analyze the determinants of Saudi Arabia's financial performance. Thus, the objective of the current study is to analyze the empirical significance of the factors that contribute to the financial sector development of Saudi Arabia. In this regard, the goal of the study is to recognize the potential role of natural resources, green energy and technological innovations in influencing the performance of the financial sector in the Saudi economy. Therefore, the current study has selected the method of Non-linear ARDL to recognize the asymmetric empirical relationship among the variables of interest using a time series data from 1990 to 2018.

The findings of NARDL confirmed that all variables have a significant and asymmetric impact on financial performance in Saudi Arabia. Moreover, the results confirm that positive shocks of natural resources and technology innovation increase the financial performance in Saudi Arabia however, the positive and negative fluctuation in green energy have a positive and significant impact on financial performance. On the other hand, the asymmetric causality confirmed a unidirectional causal connection from natural resources to financial performance however, a bidirectional causal connection is found from technology innovation and green energy to financial performance and vice versa.

The findings of the current study recommend that the government of Saudi Arabia and policymakers need a proper allocation for the natural resources in order to improve financial performance. Moreover, the government should pay more attention to improve technology innovation strategies which will also help to improve the generation of green energy that ultimately boost the financial performance of Saudi Arabia. The present study applied time series econometric however, panel study and a comparison of two different Arab countries can provide a better understanding of the relationship of a studied variable in the Arab region. Moreover, some advanced econometric like quantile based ARDL or quantile based NARDL can also be applied to provide fresh insights on the nexus between natural resources, green energy and technology innovation with financial performance.

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