INTERNATIONAL JOURNAL OF ECONOMICS AND FINANCE STUDIES
Vol: 15 **No:** 03 **Year:** 2023 **ISSN:** 1309-8055 (Online) (**pp.** 57-75) **Doi:** 10.34109/ijefs.202315303
Received: 05.04.2023 | **Accepted:** 10.07.2023 | **Published Online:** 05.09.2023

-RESEARCH ARTICLE-

THE IMPLICATION OF DIGITAL TECHNOLOGY ON SAUDI ARABIA'S ECONOMIC GROWTH

Hatem Akeel*

Associate Professor of Economics, Finance Department,
College of Business and Administration (CBA),
University of Business and Technology (UBT), Saudi Arabia
Email: h.akeel@ubt.edu.sa
ORCID: https://orcid.org/0000-0003-4854-3189

Haitham Khoj

Associate Professor of Economics, Economics Department,
King Abdulaziz University, Jeddah, Kingdom of Saudi Arabia
Email: hkhoj@kau.edu.sa
ORCID: https://orcid.org/0000-0002-7031-3657

***Corresponding Author** Email: h.akeel@ubt.edu.sa

─Abstract─

In contemporary times, the integration of digital technology has emerged as a pivotal factor in determining the prosperity of organisations and the consequent attainment of robust economic growth. The attention of recent studies and regulators is required by this particular aspect. Therefore, this study aims to examine the influence of digital technology proxies, such as high technology exports, access to clean fuel and technologies, and medium and high technology exports, on the economic growth (EG) of Saudi Arabia. The study additionally incorporated two control variables, namely inflation and population growth, to assess their impact on the economic growth (EG). The data utilised in this study was obtained from the World Development Indicators (WDI) spanning the years 1991 to 2022. The study also utilised the dynamic autoregressive distributed lag (DARDL) model to examine the relationship between variables. The results of the analysis revealed a positive correlation between the economic growth of Saudi Arabia and several factors, including high technology exports, access to clean fuel and technologies, medium and high technology exports, inflation, and population growth. The study provides guidance to policymakers in formulating policies aimed at enhancing economic growth through the utilisation of efficient digital technologies.

Citation (APA): Akeel, H., Khoj, H. (2023). The Implication of Digital Technology on Saudi Arabia's Economic Growth. *International Journal of Economics and Finance Studies, 15*(03), 57-75. doi: 10.34109/ijefs.202315303

Vol: 15 **No:** 03 **Year:** 2023 **ISSN:** 1309-8055 (Online) (**pp.** 57-75) **Doi:** 10.34109/ijefs.202315303

Keywords: Digital technology, high technology exports, access to clean fuel and technologies, medium and high technology exports, economic growth, inflation, population growth

INTRODUCTION

The topic of economic growth has garnered considerable attention among scholars due to its crucial importance to the nation and its constituents. In a nation experiencing economic growth, there exists a state of equilibrium in the social, political, and economic spheres, alongside the maintenance of a sustainable financial standing. Economic growth plays a crucial role in determining the overall development of a country and the level of satisfaction experienced by its population (Hanushek & Woessmann, 2020). A nation exhibiting an upward trajectory in its economic growth rate, characterised by the generation of increased wealth in terms of material resources for the overall economy. This growth is accompanied by a rise in government revenues derived from taxation and duties imposed on both domestic and international sources. Furthermore, there is a notable surge in both government and private initiatives aimed at developing infrastructure in the areas of construction and energy. Additionally, the equity market is experiencing substantial growth, attracting significant investments. Hence, the economic activities will persist, and there exists assurance regarding its financial value (Zhang & Graham, 2020). When a nation experiences economic growth, it typically entails enhancements in the communication network, establishment of relationships between domestic institutions and foreign entities, and a decrease in poverty levels. Furthermore, it is worth noting that the present circumstances are characterised by effective management of crime and corruption rates, alongside the presence of political stability and a harmonious atmosphere within the nation (Muhammad, 2019). When there is an upward trend in the economic growth rate, it becomes feasible to introduce environmentally friendly innovations, resulting in increased employment opportunities and enhanced production quality. The provision of a secure environment, elevated living standards, and a robust social life are factors that contribute to the overall well-being of individuals. The subject of economic growth is of significant academic interest due to its association with increased national power and influence(Gründler & Potrafke, 2019).

Digital technologies refer to a wide range of digital devices, systems, and resources that are utilised for the purposes of acquiring, storing, and processing information. Digital technologies possess data handling capabilities that enable them to carry out various essential tasks, resulting in a reduction of both the cognitive and physical exertions required from humans. These technologies yield superior results in comparison to conventional economic methodologies. According to Malik (2021), economic growth is influenced by various factors, including the selection of technologies, the availability of technologies, and the exchange of technologies. This study investigates the impact of variables such as high technology exports, access to clean fuel and technologies, and

Vol: 15 **No:** 03 **Year:** 2023 **ISSN:** 1309-8055 (Online) (**pp.** 57-75) **Doi:** 10.34109/ijefs.202315303

medium and high technology exports on economic growth. Technology exports are categorised as a component of technology trade. The act involves the transfer of technology to foreign entities in return for economic benefits. The nation's agreement with foreign entities for the exportation of advanced technologies or technology components generates financial capital through foreign exchange and serves as an incentive for the nation to enhance its technology sector and bolster productivity within this domain. In a similar vein, the exportation of medium and high technologies serves to augment foreign currency reserves, stimulate foreign investments, and foster the growth of medium and large-scale technical enterprises. The export of technology plays a significant role in fostering economic growth (Bamati & Raoofi, 2020). The utilisation of clean fuel and technologies enhances the adoption of clean energy resources and environmentally friendly technologies within business entities. The subsequent decrease in corporate pollution and implementation of efficient waste management practises enhance the quality of production, lower expenses, and stimulate investment, thereby fostering an upsurge in economic growth (Rahman & Alam, 2021).

The primary objective of this study is to examine the role of digital technology in fostering economic growth within the context of Saudi Arabia. The nation under consideration possesses the most substantial economic output within the Middle Eastern region and ranks as the eighteenth largest globally in terms of economic size. The country in question holds a foundational and enduring membership within the Organisation of the Petroleum Exporting Countries (OPEC) and is recognised as one of the constituent nations of the Group of Twenty (G20). The projected gross domestic product (GDP) for the country in 2023 is approximately $1.063 trillion, while the purchasing power parity (PPP) is expected to reach $2.3 trillion in the same year (Naseem, 2021). The state government demonstrates a strong dedication to positioning itself as a prominent technology hub in the future. As per the Saudi Vision 2030, the government endeavours to establish a conducive environment through the implementation of efficient regulations and substantial investments in the enhancement of digital infrastructure, with the aim of fostering advancements in the technology sector. The reputation of the Saudi tech hub is enhanced by its state-of-the-art research facilities, supportive incubators, and extensive connections to global networks and markets. Moreover, Saudi Arabia has attracted significant foreign investment and established numerous prominent enterprises within its territorial confines. Saudi Arabia possesses the potential to assume a prominent role as a technology frontrunner within the Middle East and neighbouring regions, owing to its steadfast commitment to fostering innovation and entrepreneurship (Agboola, Bekun, & Joshua, 2021).

Saudi Arabia is currently establishing itself as a prominent centre for technology within the global market, displaying the capacity to enhance its standing in the realm of technology while engaging in competition with other economies. However, it remains incapable of fully harnessing its potential and surmounting the challenges necessary to

Vol: 15 **No:** 03 **Year:** 2023 **ISSN:** 1309-8055 (Online) (**pp.** 57-75) **Doi:** 10.34109/ijefs.202315303

foster enhanced economic growth. There is a necessity for the utilisation of technological capabilities in order to foster economic development (Waheed, Sarwar, & Dignah, 2020). The present article fulfils this requirement by examining the impact of technology exports, access to clean fuel and technologies, exports of medium and high technologies, as well as inflation and population growth on economic growth.

Extensive scholarly literature exists pertaining to the topic of economic growth. However, this present study aims to address the gaps that have been left by the authors. Previous scholarly literature has extensively examined the utilisation of digital technology and its impact on a nation's economic progress. However, previous research has predominantly focused on analysing the utilisation of digital technologies at the organisational level and investigating their effects on economic growth. The present article addresses the issue of bridging the literary gap by examining the impact of three proxies related to digital technology: high technology exports, access to clean fuel and technologies, and medium and high technology exports. The study investigates the role of these proxies in fostering economic growth. Second, authors have primarily examined the role of digital technology in economic growth with a focus on its commercial or financial impact. The present article also demonstrates ecological concern as it investigates the impact of access to clean fuel and technologies on economic growth. Furthermore, the current article provides a noteworthy contribution to the existing body of literature. This study aims to examine the interrelationships between high-technology exports, access to clean fuel and technologies, medium and high-technology exports, inflation, population growth, and economic growth in the context of Saudi Arabia.

The present article is comprised of five sections. The second literature review focuses on the reevaluation of previous studies to investigate the correlation between high technology exports, access to clean fuel and technologies, medium and high technology exports, inflation, population growth, and economic growth. The third section provides a concise overview of the research methodology, while the subsequent section presents the research findings. During scholarly discourse, research findings are expounded upon, and their veracity is substantiated through reference to prior analogous investigations. The article concludes by providing a summary of the main findings and their significance. Additionally, it discusses the potential implications of the research and highlights any limitations that may have affected the study's outcomes.

LITERATURE REVIEW

The country's position and influence among global economies are contingent upon its economic growth rate. The measurement of an economy is typically conducted through the assessment of a country's Gross Domestic Product (GDP), which takes into account various factors such as financial resources, physical and natural resources, the overall magnitude of the economy, and the efficiency of business operations (Nguyen, Pham, & Tram, 2020).

Vol: 15 **No:** 03 **Year:** 2023 **ISSN:** 1309-8055 (Online) (**pp.** 57-75) **Doi:** 10.34109/ijefs.202315303

Digital technology encompasses a wide range of digital devices, tools, and instruments that have the capability to receive, process, and execute data. The utilisation of digital technologies and the exchange of digital technologies have instigated a transformative impact on the economy. There is evidence to suggest that they engage in the process of refining economic conditions, which subsequently leads to an increase in overall productivity (Khan, Murshed, Dong, & Yang, 2021). This article investigates the impact of high-technology exports, access to clean fuel and technologies, medium and high-technology exports, as well as the controlling factors of inflation and population growth on economic growth. Various scholarly studies have examined the interconnections between exports of high technologies, availability of clean fuel and technologies, population growth, exports of medium and high technologies, inflation, and economic growth. The subsequent paragraphs aim to elucidate the concepts pertaining to the interrelationships among these factors, drawing upon the perspectives of previous authors.

A bilateral correlation exists between domestic production and exports. With respect to the export of advanced technology, a comparable circumstance exists. When a nation enters into a contractual arrangement to export technological instruments to foreign entities. There is an increasing trend observed in the demand for domestic technological products. The execution of the contract leads to a boost in production within domestic industries. The notable augmentation in industrial productivity contributes to the nation's gross domestic product (GDP) and fosters elevated levels of economic expansion (Xu et al., 2019). In their study, Sultanuzzaman et al. (2019) examine the correlation between technology exports and economic growth. The study sample comprises a selection of emerging Asian countries, from which quantitative data were collected for the period spanning 2000 to 2016. The Generalised Method of Moments (GMM) model was employed to analyse the association between the chosen factors. The study suggests that the exportation of technologies or technical instruments can lead to the establishment of influential relationships with globally recognised firms. These relationships have the potential to be highly effective in attracting foreign investment. Innovation has the potential to be introduced within domestic firms, and its subsequent enhancement of productivity plays a significant role in driving economic growth. Iqbal, Tang, and Rasool (2023) examine the interplay between technology exports, carbon emissions, renewable energy utilisation, foreign direct investment (FDI), and their impact on economic growth. Data on the values of technology exports, carbon emissions, renewable energy usage, foreign direct investment (FDI), and gross domestic product (GDP) were gathered from BRICS countries for the period between 2000 and 2018. Various econometric techniques, such as the autoregressive distributed lag (ARDL), mean group (MG), pooled mean group (PMG), and the Dumitrescu-Hurlin panel causality tests, were employed to derive empirical conclusions. The findings of the study indicate that a nation that establishes technological export agreements with foreign countries has the potential to secure financial resources from international sources. This facilitates the nation in fostering environmentally conscious advancements within businesses, thereby promoting sustainable economic growth. Consequently, the increase in exports of advanced technologies has led to a corresponding expansion in economic growth.

Vol: 15 **No:** 03 **Year:** 2023 **ISSN:** 1309-8055 (Online) (**pp.** 57-75) **Doi:** 10.34109/ijefs.202315303

The creation of wealth and the development of a country are contingent upon the presence of production, trade, and infrastructure. These practises have been found to have detrimental effects on the environment, primarily due to the utilisation of fossil fuels and chemical-based energy sources, as well as the operation of machinery (Khan et al., 2022). To address environmental challenges, it is imperative to implement alterations in energy production and technological advancements. If economic entities are granted access to clean energy and environmentally friendly technology, they have the potential to address environmental pollution and generate goods and services that are free from pollution, thereby increasing demand. This phenomenon results in an increase in the country's economic growth. Sohag, Taşkın, and Malik (2019) conducted a study to assess the correlation between cleaner energy consumption, technological innovation, militarization, and green economic growth. The authors opted to utilise time series data in their study, specifically focusing on cleaner energy consumption, technological innovation, militarization, and green economic growth. These variables were collected from Turkey, spanning various economic conditions, during the period from 1980 to 2017. The researchers utilised the Autoregressive Distributed Lags (ARDL) model, employing both symmetric and asymmetric adjustment methodologies, in order to analyse the dataset. Based on empirical analysis, the study suggests that business firms can achieve a positive environmental impact on economic conditions by accessing cleaner energy sources and implementing green technological innovations. Consequently, there is an augmentation in both the quality and quantity of goods and services that are being produced. Xue et al. (2022) examine the correlation between the availability of clean energy and technologies, the decrease in carbon dioxide emissions, the promotion of environmental sustainability, and the stimulation of economic growth. The approach of collecting time data series was utilised. The study gathered empirical evidence pertaining to the availability of clean energy resources and technologies, the mitigation of carbon dioxide emissions, the promotion of environmental sustainability, and the gross domestic product (GDP) within the context of France, the third largest member state of the European Union. The data collection spanned the period from 1987 to 2019. The analysis employed the Augmented ARDL method within the framework of the STIRPAT model. The findings derived from this empirical methodology indicate that the availability of clean energy sources and technologies has a mitigating effect on carbon dioxide emissions, contributes to the preservation of the natural environment, and supports the long-term sustainability of economic growth.

The exportation of technology on medium and large scales contributes to the enhancement of economic growth. Numerous environmentally sustainable and economically beneficial policies are being developed; however, their implementation is challenging due to limited financial resources. The exportation of medium and large-scale technologies offers a means of generating financial gains through the acquisition of foreign exchange. The excess funds are allocated towards the implementation of environmentally sustainable and economically beneficial policies. The enhancement of

Vol: 15 **No:** 03 **Year:** 2023 **ISSN:** 1309-8055 (Online) (**pp.** 57-75) **Doi:** 10.34109/ijefs.202315303

environmental preservation, the integration of sustainability in business performance, and the establishment of stability in economic conditions collectively contribute to a positive impact on economic growth (Adedoyin, Bekun, Driha, & Balsalobre-Lorente, 2020). Blavasciunaite, Garsviene, and Matuzeviciute (2020) conducted a study to investigate the correlation between trade balance, medium and high technology exports, and economic growth. The data pertaining to the aforementioned factors was gathered from the 28 member states of the European Union over a period spanning from 1998 to 2018, utilising the panel data methodology. The research findings were derived using the ordinary least squares (OLS) methodology of multivariate regression analysis, which incorporated fixed effects. The findings of the study indicate that when a nation engages in international trade relationships with foreign countries and participates in the export of technologies, encompassing both medium and high-tech sectors, in exchange for foreign currency, it has the potential to enhance the value of its currency. The expansion of the business enterprise yields a positive impact on the overall economic development of the nation. In their recent study, Bilgili, Kuşkaya, Ünlü, and Gençoğlu (2022) conducted empirical research to examine the relationship between medium and high technologies export, terms of trade, fossil fuels, renewable-energy usage, and economic growth. In this study, the researchers employed Markov regime-shifting models to analyse empirical data pertaining to the export of medium and high technologies, terms of trade, fossil fuel consumption, renewable energy consumption, and economic growth in the United States. The data collection process encompassed the years spanning from 1980 to 2019. The confirmation of the estimations pertaining to the relationship between the factors was achieved through the implementation of a non-linear analysis. Based on the findings of the research, there exists a positive correlation between the export of medium and high technologies and economic growth. In their study, Zafar, Saleem, Destek, and Caglar (2022) investigate the relationship between the export of medium and high technologies, remittances, education for renewable energy, and economic growth. The authors utilise a panel dataset consisting of the twenty-two largest developing countries, spanning the time period from 1986 to 2017. The study suggests that the implementation of medium and large-scale technologies can lead to environmentally sustainable advancements and contribute to economic growth.

In addition to the export of high technologies, the availability of clean fuel and technologies, and the export of medium and high technologies, other significant factors that exert a substantial impact on economic growth include inflation and population growth (Ezako, 2023). The study conducted by Olamide, Ogujiuba, and Maredza (2022) examines the correlation between inflation, exchange rate, and economic growth within a nation. The study sample consisted of individuals from countries within the Southern African Development Community (SADC). Panel data pertaining to the factors mentioned earlier were gathered from these countries for the period spanning from 2000 to 2018. Three prominent analytical techniques, namely Generalised Method of Moments (GM), Panel Mean Group (PMG), and Dynamic Fixed Effects (DFE), were

Vol: 15 **No:** 03 **Year:** 2023 **ISSN:** 1309-8055 (Online) (**pp.** 57-75) **Doi:** 10.34109/ijefs.202315303

utilised. The research findings unveiled a positive correlation between inflation and economic growth. The study conducted by Khan and Hanif (2020) investigates the correlation between inflation and economic growth. According to a study conducted on a panel of 113 economies spanning from 1981 to 2015, utilising the Generalised Method of Moments (GMM) approach, it was observed that there exists a positive correlation between inflation and economic growth. The study conducted by Nkalu, Edeme, Nchege, and Arazu (2019) examines the correlation between rural-urban population, urban agglomeration, and economic growth in the sub-Saharan African region. The research employed secondary yearly time series data on rural-urban population, urban agglomeration, and economic growth in Sub-Saharan Africa from 1970 to 2017. This data was obtained from the World Bank (WB) database. Panel data analysis was conducted using pooled ordinary least squares. The study suggests that a rise in population in both rural and urban areas will lead to an expansion in the development of building and energy infrastructure. In the present scenario, the economic circumstances become advantageous, resulting in an elevated rate of GDP growth. In their study, Mohsin et al. (2019) examined the interplay among fossil fuel energy, total population, environmental quality, and economic growth. In this study, various econometric techniques were employed to analyse data pertaining to the transport sector in Pakistan. These techniques included regression coefficients, a hybrid error correction model, platykurtic distribution, co-integration test, and Dickey-Fuller test. The findings elucidate that an increase in population has a favourable impact on economic growth. The increase in the rate of population growth is accompanied by a significant increase in economic growth.

Research Methods

This study examines the effects of various factors, including digital technology proxies as high technology exports, access to clean fuel and technologies, medium and high technology exports, inflation, and population growth, on the economic growth (EG) in Saudi Arabia. The data was extracted from the World Development Indicators (WDI) dataset spanning the years 1991 to 2022. The estimation equation was established in the study and is presented as follows:

$$EG_t = \alpha_0 + \beta_1 HTE_t + \beta_2 ACFT_t + \beta_3 MHTE_{it} + \beta_4 INF_t + \beta_5 PG_t + e_t \quad \textbf{(1)}$$

Where;
EG = Economic Growth
t = Time Period
HTE = High Technology Exports
ACFT = Access to Clean Fuel and Technologies
MHTE = Medium & High Technology Exports
INF = Inflation
PG = Population Growth

Vol: 15 **No:** 03 **Year:** 2023 **ISSN:** 1309-8055 (Online) (**pp.** 57-75) **Doi:** 10.34109/ijefs.202315303

The study employed the EG as the primary variable proxies for measuring GDP growth in terms of annual percentage. Furthermore, the research employed digital technologies as proxies for the independent variables, specifically high technology exports as a percentage of manufactured exports, access to clean fuel and technologies as a percentage of the total population, and medium and high technology exports as a percentage of manufactured exports. The study employed two control variables, specifically inflation proxies measured as consumer prices (annual percentage) and population growth proxies measured as population growth.

Table 1: Variables with Measurements

S#	Variables	Measurement	Sources
01	Economic Growth	GDP growth (annual percentage)	WDI
02	Digital Technology	High technology exports (% of manufactured exports)	WDI
		Access to clean fuel and technologies (% of total population)	WDI
		Medium & high technology exports (% of manufactured exports)	WDI WDI
03	Inflation	Consumer prices (annual percentage)	WDI
04	Population Growth	Population growth (annual percentage)	WDI

The study employs descriptive statistics to examine the specific variables, providing average values, minimum and maximum values, and standard deviation. Furthermore, the study also examines the correlation between the variables known as multicollinearity by utilising a correlation matrix. In addition, the study also examines the stationarity of the data in order to determine the appropriate model to be applied. This is done through the utilisation of the Phillips-Perron (PP) and augmented Dickey-Fuller (ADF) tests. The equation representing the stationarity test is provided below:

$$d(Y_t) = \alpha_0 + \beta t + \Upsilon Y_{t-1} + d(Y_t(-1)) + \varepsilon_t \quad \textbf{(2)}$$

In addition, the verification of co-integration is an essential procedure for selecting the appropriate model, and it is assessed using the approach proposed by Westerlund and Edgerton (2008). The equations pertaining to the co-integration test are presented as follows:

$$\mathrm{LM}_{\varphi}(\mathrm{i}) = \mathrm{T}\widehat{\varphi}_{\mathrm{i}}\ (\hat{\mathrm{r}}_{\mathrm{i}}/\widehat{\sigma}_{\mathrm{i}}\ ) \quad \textbf{(3)}$$

$$\mathrm{LM}_{\tau}(\mathrm{i}) = \widehat{\varphi}_{\mathrm{i}}/\mathrm{SE}(\widehat{\varphi}_{\mathrm{i}}) \quad \textbf{(4)}$$

In equations (3) and (4) given above shows $\widehat{\boldsymbol{\varphi}}_{\boldsymbol{i}}$ that represented the estimate beside standard error, while the equations also show $\hat{r}^2_i$ that represented the long-run measured variance. In addition, the equations also show $\boldsymbol{\varphi i\ (L) = 1 - \sum \varphi_{ij} L}$ that represented the

Vol: 15 **No:** 03 **Year:** 2023 **ISSN:** 1309-8055 (Online) (**pp.** 57-75) **Doi:** 10.34109/ijefs.202315303

scalar polynomial with L lag length, and it also shows ρ_i that represented the factor loading parameters vector.

Furthermore, the present study employed the Autoregressive Distributed Lag (ARDL) model to examine the relationship between the constructs under investigation. The ARDL model was chosen due to its appropriateness in cases where the variables exhibit stationarity at both levels, I(0) and I(1) (Zaidi & Saidi, 2018). Furthermore, it effectively addresses the concerns related to heteroscedasticity and auto-correlation in the estimations conducted in the study (Nazir, Nazir, Hashmi, & Ali, 2018). The equation is mentioned below:

$$\Delta EG_t = \alpha_0 + \sum\delta_1\Delta HTE_{t-1} + \sum\delta_2\Delta ACFT_{t-1} + \sum\delta_3\Delta MHTE_{t-1} + \sum\delta_4\Delta INF_{t-1} + \sum\delta_5\Delta PG_{t-1} + \varphi_1 EG_{t-1} + \varphi_2 HTE_{t-1} + \varphi_3 ACFT_{t-1} + \varphi_4 MHTE_{t-1} + \varphi_5 INF_{t-1} + \varphi_6 PG_{t-1} + \varepsilon_t \quad \textbf{(5)}$$

The DARDL model was also utilised in the article to examine the relationship between variables. The aforementioned approach is a recent development put forth by Jordan and Philips (2018). The proposed model possesses the capability to address all the limitations present in the conventional ARDL model. The equations is mentioned below:

$$\Delta EG_t = \alpha_0 + \sum\delta_1\Delta EG_{t-1} + \sum\delta_2\Delta HTE_t + \sum\delta_3\Delta HTE_{t-1} + \sum\delta_4\Delta ACFT_t + \sum\delta_5\Delta ACFT_{t-1} + \sum\delta_6\Delta MHTE_t + \sum\delta_7\Delta MHTE_{t-1} + \sum\delta_8\Delta INF_t + \sum\delta_9\Delta INF_{t-1} + \sum\delta_{10}\Delta PG_t + \sum\delta_{11}\Delta PG_{t-1} + \varepsilon_t \quad \textbf{(6)}$$

Research Findings

The study employs descriptive statistics to examine the specific variables, providing average values, minimum and maximum values, and standard deviation. The results revealed that the mean value of the experimental group (EG) was recorded as 3.241 percent, whereas the heterogeneity treatment effect (HTE) was 0.689 percent and the average causal effect of the treatment (ACFT) was 59.736 percent. Furthermore, the results also revealed that the mean value of MHTE was recorded as 32.844 percent, with INF at 1.980 percent and PG at 2,569 percent. The aforementioned values are presented in Table 2.

Table 2: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
EG	32	3.241	4.403	-4.341	15.008
HTE	32	0.689	0.146	0.544	1.305
ACFT	32	59.736	49.455	0.780	100.000
MHTE	32	32.844	14.422	17.904	61.022
INF	32	1.980	2.590	-2.093	9.870
PG	32	2.569	0.925	-0.130	3.978

Vol: 15 **No:** 03 **Year:** 2023 **ISSN:** 1309-8055 (Online) (**pp.** 57-75) **Doi:** 10.34109/ijefs.202315303

In addition, the study also examines the correlation between the variables known as multicollinearity by utilising a correlation matrix. The results of the analysis suggest a positive correlation between the economic growth (EG) of Saudi Arabia and various factors, namely high technology exports, access to clean fuel and technologies, medium and high technology exports, inflation, and population growth. These associations are given in Table 3.

Table 3: Matrix of Correlations

Variables	EG	HTE	ACFT	MHTE	INF	PG
EG	1.000					
HTE	0.119	1.000				
ACFT	0.118	0.314	1.000			
MHTE	0.077	0.057	0.636	1.000		
INF	0.304	0.207	0.406	0.073	1.000	
PG	0.108	0.039	-0.247	-0.626	0.202	1.000

Additionally, the study also examines the stationarity of the data in order to determine the appropriate model to apply, utilising the Phillips-Perron (PP) and Augmented Dickey-Fuller (ADF) tests. The results demonstrate that the variables EG, THE, INF, and PG exhibit stationarity at order I(0), whereas ACFT and MHTE exhibit stationarity at order I (1). These outcomes are given in Table 4.

Table 4: Unit Root Test

	ADF		PP	
Series	Level	First difference	Level	First difference
EG	-2.876***	------	-2.191***	------
HTE	-3.208***	------	-2.901***	------
ACFT	------	-4.363***	------	-5.493***
MHTE	------	-5.884***	------	-4.353***
INF	-2.192***	------	-3.290***	------
PG	-3.019***	------	-3.288***	------

Further, the verification of co-integration is a crucial procedure for selecting the appropriate model, and it is assessed using the approach proposed by Westerlund and Edgerton (2008). The results suggest that the p-values are statistically significant at a significance level of 0.05, and the t-values exceed the critical value of 1.96. The presence of co-integration is evident in the observed values. These outcomes are given in Table 5.

Table 5: Co-integration Test

Model	No Shift		Mean Shift		Regime Shift	
	Test Stat	p-value	Test Stat	p-value	Test Stat	p-value
LM_{τ}	-3.185	0.000	-4.885	0.000	-5.645	0.000
LM_{φ}	-3.554	0.000	-4.910	0.000	-5.987	0.000

Vol: 15 **No:** 03 **Year:** 2023 **ISSN:** 1309-8055 (Online) (**pp.** 57-75) **Doi:** 10.34109/ijefs.202315303

The article additionally utilised the DARDL model to examine the correlation between variables. The results of the study revealed a positive correlation between the economic growth (EG) of Saudi Arabia and various factors, namely high technology exports, access to clean fuel and technologies, medium and high technology exports, inflation, and population growth. These associations are given in Table 6.

Table 6: Dynamic ARDL Model

Variable	Coefficient	t-Statistic	Prob.
ECT	-3.746***	-4.381	0.000
HTE_{t-1}	0.765***	5.493	0.000
HTE	2.198**	2.019	0.045
$ACFT_{t-1}$	1.299**	2.081	0.041
ACFT	0.756***	3.271	0.003
$MHTE_{t-1}$	5.476***	4.875	0.000
MHTE	1.282***	4.361	0.000
INF_{t-1}	6.938***	5.654	0.000
INF	1.282***	4.893	0.000
PG_{t-1}	2.187***	5.493	0.000
PG	0.757***	6.574	0.000
Cons	3.643***	4.776	0.000

R square = 61.272 Stimulation = 5000

DISCUSSIONS

The findings of the study indicate a positive correlation between high technology exports and economic growth. The findings presented in this study are substantiated by the research conducted by Alam and Murad (2020), which investigates the impact of technology on environmental governance. When a nation provides various advanced technologies in the global marketplace and experiences a significant demand for complete finished technologies or their components, it signifies progress in its technical and scientific sectors. The expansion of scientific departments has the potential to catalyse a transformative shift in the overall economy, thereby increasing the expected growth rate. These findings are consistent with the research conducted by Pradhan, Arvin, Nair, and Bennett (2020), which suggests that a nation engaged in exporting high technologies demonstrates a proficiency in both developing and utilising such technologies to enhance resource productivity. Consequently, the rise in exports of technological goods contributes to an elevation in economic growth.

The findings of the study indicate a positive correlation between the availability of clean fuel and technologies and environmental governance (EG). The findings presented in Shah, Solangi, and Ikram (2019) study provide support for the notion that

Vol: 15 **No:** 03 **Year:** 2023 **ISSN:** 1309-8055 (Online) (**pp.** 57-75) **Doi:** 10.34109/ijefs.202315303

various practises in commercial establishments and household activities contribute to environmental pollution, primarily due to the utilisation of fuel and technologies. The provision of clean fuel and appropriate technologies to meet users' needs has the potential to contribute to environmental preservation. In the present scenario, there exists a surplus of resources, which could potentially lead to an accelerated growth of the economy. The findings presented here are consistent with the research conducted by Maji, Sulaiman, and Abdul-Rahim (2019), suggesting that the adoption of clean fuel and technologies can effectively lower the operational expenses of businesses. Moreover, the availability of increased financial resources allows enterprises to pursue business expansion opportunities. The rate of environmental degradation is positively influenced by the availability and utilisation of clean fuel sources and advanced technologies.

The findings of the study indicate a positive correlation between the export of medium and high technologies and economic growth. The findings presented in the study conducted by Safi et al. (2021) provide support for the notion that the inclusion of medium and high technologies exports in international trade policies leads to increased production in medium and large technical units specialising in the manufacturing of technological tools and instruments. The augmentation in overall production and revenue generated through exports contributes to the growth of the economy. The findings presented here align with the research conducted by Hassan et al. (2019), which emphasises the positive impact of increased exports of medium and high-technology goods on fostering international relations and attracting foreign funding. Therefore, it presents novel opportunities for the nation to achieve an elevated level of economic growth.

The findings indicated a positive correlation between inflation and EG. The findings presented are corroborated by Ahmmed, Uddin, Rafiq, and Uddin (2020), suggesting that an increase in the inflation rate is associated with improved prospects for firms and a greater willingness on the part of the government to make investments. Consequently, this leads to an upsurge in economic activities with significant outcomes. Consequently, the prevailing economic conditions are conducive to the generation of abundant resources, thereby facilitating an increase in economic growth. The findings presented herein are consistent with the research conducted by NGOC (2020), which suggests that in nations experiencing inflation, significant emphasis is placed on the advancement of infrastructure.

The findings indicate a positive correlation between population growth exports and economic growth. The findings presented in this study are corroborated by the research conducted by Bucci, Eraydın, and Müller (2019), which investigates the impact of population growth on the economic growth of EG. The escalating population growth rate has led to a corresponding surge in demand for goods, services, and employment

Vol: 15 **No:** 03 **Year:** 2023 **ISSN:** 1309-8055 (Online) (**pp.** 57-75) **Doi:** 10.34109/ijefs.202315303

opportunities, thereby generating a driving force for an increase in economic growth (EG). The findings presented here are consistent with the assertions made by Li, Luan, Zhang, and Su (2020), who argue that population growth facilitates enhanced production by means of advanced technologies, ultimately leading to a rise in economic growth.

Policy Implications

The increase in the economic growth rate has consistently been a necessity for a nation such as Saudi Arabia to establish a strong presence in the global market. The present study holds significance for developing countries as it offers them a set of guidelines aimed at expediting the rate of economic growth. The study suggests that economists and government officials should actively promote the export of advanced technology products in order to stimulate an increase in the economic growth rate. The study additionally proposes that legal authorities should make efforts to enhance economists' access to clean fuel and technologies in order to maintain the economic growth of the country. The study additionally suggests that the formulation of economic and legal policies is necessary to promote the exportation of medium and high technologies, with the aim of augmenting economic growth. There is also a proposal that the inflationary period should be efficiently managed. This scenario has the potential to enhance EG. Furthermore, the research indicates the necessity of implementing measures to manage population growth. The implementation of this measure would provide support for the augmentation of economic growth. The study provides guidance to policymakers in formulating policies aimed at improving economic growth through the utilisation of efficient digital technologies.

CONCLUSION

The objective of this study was to investigate the impact of high technology exports, access to clean fuel and technologies, and medium and high technology exports on economic growth (EG). Additionally, an examination was conducted to assess the influence of control variables such as inflation and population growth in relation to this matter. The data utilised for the purpose of information gathering was sourced from statistical records originating from Saudi Arabia. The findings of the data analysis indicate a positive correlation between economic growth (EG) and various factors, including high technology exports, access to clean fuel and technologies, medium and high technology exports, inflation, and population growth. The findings of the study suggest that when a nation engages in an international trade agreement aimed at exporting advanced technologies, its primary objective is to enhance the manufacturing of technological tools and instruments to cater to both domestic and international demands. There has been a notable rise in EG. The findings also indicated that the provision of clean fuel and technologies to individuals and organisations can potentially

mitigate environmental pollution. As a result, the presence of superior natural resources results in a rise in environmental quality. In a similar vein, the study revealed that the exportation of medium and high technologies fosters the growth of medium and high technical enterprises, consequently leading to an augmentation in economic growth. The findings also indicated that in the presence of inflation throughout the nation, there is a positive impact on economic practises, leading to an increase in economic growth. The research findings indicate that in a nation characterised by a higher population growth rate, there is a corresponding increase in demand, production levels, and economic growth.

LIMITATIONS

This article still exhibits certain limitations, necessitating significant modifications to enhance the study's implications. Initially, the authors demonstrated a particular interest in three factors pertaining to a country's environmental governance (EG): high technology exports, access to clean fuel and technologies, and medium and high technology exports. There exist numerous additional economic and microeconomic factors that significantly influence EG, necessitating an expansion of the factors being investigated. Furthermore, data pertaining to the interplay between exports of high technologies, access to clean fuel and technologies, exports of medium and high technologies, inflation, population growth, and economic growth (EG) were gathered within a restricted temporal scope. The researchers are required to extend the duration of the research period.

REFERENCES

Adedoyin, F. F., Bekun, F. V., Driha, O. M., & Balsalobre-Lorente, D. (2020). The effects of air transportation, energy, ICT and FDI on economic growth in the industry 4.0 era: Evidence from the United States. *Technological Forecasting and Social Change*, *160*, 120297. doi: https://doi.org/10.1016/j.techfore.2020.120297

Agboola, M. O., Bekun, F. V., & Joshua, U. (2021). Pathway to environmental sustainability: nexus between economic growth, energy consumption, CO2 emission, oil rent and total natural resources rent in Saudi Arabia. *Resources Policy*, *74*, 1023-1049. doi: https://doi.org/10.1016/j.resourpol.2021.102380

Ahmmed, M., Uddin, M. N., Rafiq, M. R. I., & Uddin, M. J. (2020). Inflation and economic growth link-multi-country scenario. *International Journal of Economics and Financial Issues*, *10*(4), 47-53. doi: https://doi.org/10.32479/ijefi.9942

Alam, M. M., & Murad, M. W. (2020). The impacts of economic growth, trade openness and technological progress on renewable energy use in organization for economic co-operation and development countries. *Renewable Energy*, *145*, 382-390. doi: https://doi.org/10.1016/j.renene.2019.06.054

Bamati, N., & Raoofi, A. (2020). Development level and the impact of technological factor on renewable energy production. *Renewable Energy, 151*, 946-955. doi: https://doi.org/10.1016/j.renene.2019.11.098

Bilgili, F., Kuşkaya, S., Ünlü, F., & Gençoğlu, P. (2022). Export quality, economic growth, and renewable-nonrenewable energy use: non-linear evidence through regime shifts. *Environmental Science and Pollution Research, 29*(24), 36189-36207. doi: https://doi.org/10.1007/s11356-022-18601-8

Blavasciunaite, D., Garsviene, L., & Matuzeviciute, K. (2020). Trade Balance Effects on Economic Growth: Evidence from European Union Countries. *Economies, 8*(3), 54. doi: https://doi.org/10.3390/economies8030054

Bucci, A., Eraydın, L., & Müller, M. (2019). Dilution effects, population growth and economic growth under human capital accumulation and endogenous technological change. *Journal of Macroeconomics, 62*, 103050. doi: https://doi.org/10.1016/j.jmacro.2018.08.003

Ezako, J. T. (2023). "Analyze of inflation and economic growth relationship in Burundi". *Cogent Economics & Finance, 11*(1), 2210914. doi: https://doi.org/10.1080/23322039.2023.2210914

Gründler, K., & Potrafke, N. (2019). Corruption and economic growth: New empirical evidence. *European Journal of Political Economy, 60*, 101810. doi: https://doi.org/10.1016/j.ejpoleco.2019.08.001

Hanushek, E. A., & Woessmann, L. (2020). Chapter 14 - Education, knowledge capital, and economic growth. In S. Bradley & C. Green (Eds.), *The Economics of Education (Second Edition)* (pp. 171-182). Academic Press. doi: https://doi.org/10.1016/B978-0-12-815391-8.00014-8

Hassan, S. T., Xia, E., Huang, J., Khan, N. H., & Iqbal, K. (2019). Natural resources, globalization, and economic growth: evidence from Pakistan. *Environmental Science and Pollution Research, 26*(15), 15527-15534. doi: https://doi.org/10.1007/s11356-019-04890-z

Iqbal, A., Tang, X., & Rasool, S. F. (2023). Investigating the nexus between CO2 emissions, renewable energy consumption, FDI, exports and economic growth: evidence from BRICS countries. *Environment, Development and Sustainability, 25*(3), 2234-2263. doi: https://doi.org/10.1007/s10668-022-02128-6

Jordan, S., & Philips, A. Q. (2018). Cointegration Testing and Dynamic Simulations of Autoregressive Distributed Lag Models. *The Stata Journal, 18*(4), 902-923. doi: https://doi.org/10.1177/1536867X1801800409

Khan, I., Zakari, A., Zhang, J., Dagar, V., & Singh, S. (2022). A study of trilemma energy balance, clean energy transitions, and economic expansion in the midst of environmental sustainability: New insights from three trilemma leadership. *Energy, 248*, 123619. doi: https://doi.org/10.1016/j.energy.2022.123619

Khan, M., & Hanif, W. (2020). Institutional quality and the relationship between inflation and economic growth. *Empirical Economics, 58*(2), 627-649. doi: https://doi.org/10.1007/s00181-018-1479-7

Khan, Z., Murshed, M., Dong, K., & Yang, S. (2021). The roles of export diversification and composite country risks in carbon emissions abatement: evidence from the signatories of the regional comprehensive economic partnership agreement. *Applied Economics, 53*(41), 4769-4787. doi: https://doi.org/10.1080/00036846.2021.1907289

Li, Z., Luan, W., Zhang, Z., & Su, M. (2020). Relationship between urban construction land expansion and population/economic growth in Liaoning Province, China. *Land Use Policy, 99*, 105022. doi: https://doi.org/10.1016/j.landusepol.2020.105022

Maji, I. K., Sulaiman, C., & Abdul-Rahim, A. S. (2019). Renewable energy consumption and economic growth nexus: A fresh evidence from West Africa. *Energy Reports, 5*, 384-392. doi: https://doi.org/10.1016/j.egyr.2019.03.005

Malik, M. H. (2021). Information technology exports and India's macro-economic indicators. *International Trade, Politics and Development, 5*(2), 114-135. doi: https://doi.org/10.1108/ITPD-12-2020-0085

Mohsin, M., Abbas, Q., Zhang, J., Ikram, M., & Iqbal, N. (2019). Integrated effect of energy consumption, economic development, and population growth on CO2 based environmental degradation: a case of transport sector. *Environmental Science and Pollution Research, 26*(32), 32824-32835. doi: https://doi.org/10.1007/s11356-019-06372-8

Muhammad, B. (2019). Energy consumption, CO2 emissions and economic growth in developed, emerging and Middle East and North Africa countries. *Energy, 179*, 232-245. doi: https://doi.org/10.1016/j.energy.2019.03.126

Naseem, S. (2021). The Role of Tourism in Economic Growth: Empirical Evidence from Saudi Arabia. *Economies, 9*(3), 117. doi: https://doi.org/10.3390/economies9030117

Nazir, M. I., Nazir, M. R., Hashmi, S. H., & Ali, Z. (2018). Environmental Kuznets Curve hypothesis for Pakistan: Empirical evidence form ARDL bound testing and causality approach. *International Journal of Green Energy, 15*(14-15), 947-957. doi: https://doi.org/10.1080/15435075.2018.1529590

NGOC, B. H. (2020). The asymmetric effect of inflation on economic growth in Vietnam: Evidence by nonlinear ARDL approach. *The Journal of Asian Finance, Economics and Business, 7*(2), 143-149. doi: http://dx.doi.org/10.13106/jafeb.2020.vol7.no2.143

Nguyen, T. T., Pham, T. A. T., & Tram, H. T. X. (2020). Role of information and communication technologies and innovation in driving carbon emissions and economic growth in selected G-20 countries. *Journal of Environmental Management, 261*, 110162. doi: https://doi.org/10.1016/j.jenvman.2020.110162

Nkalu, C. N., Edeme, R. K., Nchege, J., & Arazu, O. W. (2019). Rural-Urban Population Growth, Economic Growth and Urban Agglomeration in Sub-Saharan Africa: What Does Williamson-Kuznets Hypothesis Say? *Journal of Asian and African Studies, 54*(8), 1247-1261. doi: https://doi.org/10.1177/0021909619865997

Olamide, E., Ogujiuba, K., & Maredza, A. (2022). Exchange Rate Volatility, Inflation and Economic Growth in Developing Countries: Panel Data Approach for SADC. *Economies, 10*(3), 67. doi: https://doi.org/10.3390/economies10030067

Pradhan, R. P., Arvin, M. B., Nair, M., & Bennett, S. E. (2020). The dynamics among entrepreneurship, innovation, and economic growth in the Eurozone countries. *Journal of Policy Modeling, 42*(5), 1106-1122. doi: https://doi.org/10.1016/j.jpolmod.2020.01.004

Rahman, M. M., & Alam, K. (2021). Clean energy, population density, urbanization and environmental pollution nexus: Evidence from Bangladesh. *Renewable Energy, 172*, 1063-1072. doi: https://doi.org/10.1016/j.renene.2021.03.103

Safi, A., Chen, Y., Wahab, S., Ali, S., Yi, X., & Imran, M. (2021). Financial Instability and Consumption-based Carbon Emission in E-7 Countries: The Role of Trade and Economic Growth. *Sustainable Production and Consumption, 27*, 383-391. doi: https://doi.org/10.1016/j.spc.2020.10.034

Shah, S. A. A., Solangi, Y. A., & Ikram, M. (2019). Analysis of barriers to the adoption of cleaner energy technologies in Pakistan using Modified Delphi and Fuzzy Analytical Hierarchy Process. *Journal of Cleaner Production, 235*, 1037-1050. doi: https://doi.org/10.1016/j.jclepro.2019.07.020

Sohag, K., Taşkın, F. D., & Malik, M. N. (2019). Green economic growth, cleaner energy and militarization: Evidence from Turkey. *Resources Policy, 63*, 101407. doi: https://doi.org/10.1016/j.resourpol.2019.101407

Sultanuzzaman, M. R., Fan, H., Mohamued, E. A., Hossain, M. I., & Islam, M. A. (2019). Effects of export and technology on economic growth: Selected emerging Asian economies. *Economic research-Ekonomska istraživanja, 32*(1), 2515-2531. doi: https://doi.org/10.1080/1331677X.2019.1650656

Waheed, R., Sarwar, S., & Dignah, A. (2020). The role of non-oil exports, tourism and renewable energy to achieve sustainable economic growth: What we learn from the experience of Saudi Arabia. *Structural Change and Economic Dynamics, 55*, 49-58. doi: https://doi.org/10.1016/j.strueco.2020.06.005

Westerlund, J., & Edgerton, D. L. (2008). A Simple Test for Cointegration in Dependent Panels with Structural Breaks*. *Oxford Bulletin of Economics and Statistics, 70*(5), 665-704. doi: https://doi.org/10.1111/j.1468-0084.2008.00513.x

Xu, S.-C., Li, Y.-W., Miao, Y.-M., Gao, C., He, Z.-X., Shen, W.-X., et al. (2019). Regional differences in nonlinear impacts of economic growth, export and FDI on air pollutants in China based on provincial panel data. *Journal of Cleaner Production, 228*, 455-466. doi: https://doi.org/10.1016/j.jclepro.2019.04.327

Xue, C., Shahbaz, M., Ahmed, Z., Ahmad, M., & Sinha, A. (2022). Clean energy consumption, economic growth, and environmental sustainability: What is the role of economic policy uncertainty? *Renewable Energy, 184*, 899-907. doi: https://doi.org/10.1016/j.renene.2021.12.006

Zafar, M. W., Saleem, M. M., Destek, M. A., & Caglar, A. E. (2022). The dynamic linkage between remittances, export diversification, education, renewable energy consumption, economic growth, and CO2 emissions in top remittance-receiving countries. *Sustainable Development, 30*(1), 165-175. doi: https://doi.org/10.1002/sd.2236

Vol: 15 **No:** 03 **Year:** 2023 **ISSN:** 1309-8055 (Online) (**pp.** 57-75) **Doi:** 10.34109/ijefs.202315303

Zaidi, S., & Saidi, K. (2018). Environmental pollution, health expenditure and economic growth in the Sub-Saharan Africa countries: Panel ARDL approach. *Sustainable Cities and Society, 41*, 833-840. doi: https://doi.org/10.1016/j.scs.2018.04.034

Zhang, F., & Graham, D. J. (2020). Air transport and economic growth: a review of the impact mechanism and causal relationships. *Transport Reviews, 40*(4), 506-528. doi: https://doi.org/10.1080/01441647.2020.1738587