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Globalization, Agriculture and Entrepreneurship in Saudi Arabia: Implications for Economic Growth and Sustainable Development

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ABSTRACT

The evolving discourse on globalization has increased academic and heightened scholarly interest in its effects on economic growth, agricultural transformation, and sustainable development in both developed and developing nations. This study examines the causal relationships between entrepreneurship development, agricultural performance, economic growth, and sustainability in Saudi Arabia over the period 2000–2020. Recognizing the agriculture’s strategic role played in food security, rural employment creation, and environmental balance, the study situates it within the globalization–entrepreneurship nexus to assess development pathways aligned with Saudi Arabia’s Vision 2030. Applying Granger causality within a VAR framework, augmented by impulse response analysis and variance decomposition, the study reveals that entrepreneurship development is a significant driver of economic growth and exerts a positive influence on agricultural value-added and sustainability outcomes. Globalization is shown to boost agricultural efficiency through technological transfer, border market access, and increased investment, thereby supporting long-term sustainable growth. Based on these findings, policymakers should pursue targeted strategies that cultivate sustainable entrepreneurship and promote innovation driven practices in agriculture. The study underscores the interconnected roles of globalization, education, agriculture, and entrepreneur-

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ship as key drivers of economic diversification and sustainable development within the Saudi context. By fostering an entrepreneurial ecosystem and promoting knowledge spillovers, the findings point to a path where economic resilience and environmental stewardship reinforce one another, aligning prosperity with sustainable agricultural transformation and broader societal well-being.

Keywords: Globalization; Agriculture; Entrepreneurship Development; Economic Growth; Sustainability; Saudi Arabia

1. Introduction

The intersection of globalization, agriculture, and entrepreneurship has become a central focus in understanding the pathways to sustainable economic growth, particularly in emerging economies Nnyanzi et al., (2019)^[1]. In Saudi Arabia, recent decades have witnessed profound structural transformations driven by the dual forces of economic diversification and global integration Abid and Gafsi (2025)^[2]. While globalization has facilitated increased access to international markets, technology, and capital, it has also posed new challenges for traditional sectors, notably agriculture, which remains critical for food security and rural livelihoods. Concurrently, entrepreneurship has emerged as a strategic driver, enabling the creation of innovative business models, fostering competitiveness, and enhancing the absorptive capacity of local economies. Despite the increasing interest in these processes, empirical research examining the synergistic effects of globalisation, agricultural development, and entrepreneurship on economic growth and sustainability within the Saudi context is still scarce. This study seeks to address this gap by analysing the causal relationships among these variables from 2000 to 2020, thereby identifying policy measures that can enhance sustainable growth, foster environmental stewardship, and leverage the potential of entrepreneurial activity in the agricultural sector. Through an integrated analytical framework, this research contributes to the ongoing discourse on how developing economies can strategically align globalization and entrepreneurship with sustainable agricultural development to achieve long-term economic resilience.

Sustainable development, popularized by the Brundtland Report (1987)^[3], refers to meeting present needs without compromising the ability of future gener-

ations to meet theirs. It rests on three interrelated pillars “environmental, economic, and social” and serves as both a policy framework and a strategic approach to ensure long-term growth while preserving natural resources. Far from being a transient concept, sustainable development has gained significant academic and policy relevance, reflecting deep-rooted concerns that emerged during the economic slowdown of the 1970s. According to Cimpeanu and Ruse (2021)^[4], its evolution unfolded through three major stages, marking its transformation into a central paradigm in contemporary research and governance. A growing body of neo-Schumpeterian and evolutionary research has examined the notion of “globalization in the age of digitization,” focusing on how economies adapt to deep technological transformations (Hamdouch and Moulart, 2006)^[5]. The roots of globalization can be traced to the Industrial Revolution, where technological progress and industrial expansion fueled global competition and the pursuit of natural resources, particularly in developing regions. This process laid the foundation for increased trade openness and economic interdependence across nations. According to Mallinson (2021)^[6], the concepts of “globalization” and “information explosion” emerged almost concurrently, promoted by multinational corporations as innovative and beneficial phenomena driving modern development. The Rio+20 Declaration (2012) further recognized globalization as a catalyst for sustained, inclusive, and sustainable growth, enhancing employment, income, and welfare worldwide. In recent decades, developing economies have implemented proactive strategies to strengthen their integration into global markets. As highlighted by the International Monetary Fund (2011), their share of global trade expanded from roughly one-quarter in the 1970s to one-third in the early 2010s, underscoring their rising influence in

the global economic system (Awad and Mallek, 2023)^[7].

Technological development has a tremendous impact on economic, social, institutional, and political life. Technology increases productivity, allowing organisations and individuals to work more successfully. Technological advancement and invention make it possible to create wealth. However, these advantages are dependent on the effective spread of technology and the society's ability to embrace and implement innovations (Nieto & Quevedo, 2005)^[8]. These two characteristics are critical for analysing and studying the influence of globalisation on socioeconomic development in the age of the digital revolution.

Sustainable entrepreneurship plays a pivotal role in addressing Saudi Arabia's current economic and environmental challenges by fostering innovation, reducing dependence on fossil fuels, and supporting the national transition toward a diversified and resilient economy under Vision 2030. It enables businesses to balance profitability with social and environmental responsibility, transforming them into active contributors to sustainable development and the realization of global goals. Within this framework, enterprises not only drive economic growth but also promote value creation, employment, and societal well-being, operating within established regulatory systems to ensure long-term prosperity and ecological balance.

Our paper offers a significant theoretical contribution to the existing body of research, particularly in the context of emerging economies. Previous studies have often focused on the impact of globalization on economic growth in developed nations, with limited exploration of its interaction with entrepreneurship in the context of a rapidly transforming economy like Saudi Arabia. By employing the VECM model, this study advances the understanding of long-term equilibrium relationships between globalization, entrepreneurship, and economic growth in Saudi Arabia. The use of impulse response functions further elucidates how shocks in one variable, such as a policy change in globalization, can impact economic growth and entrepreneurship over time. Additionally, causality analysis within this framework provides empirical evidence on the directionality of these relationships, offering insights that

can inform both policy and theoretical debates. This approach not only bridges gaps in the literature but also highlights the unique dynamics at play in Saudi Arabia's pursuit of sustainable development, aligning with its Vision 2030 goals. Saudi Arabia's agricultural sector faces challenges from reliance on traditional practices and limited diversification, which constrain its contribution to economic growth and sustainable development. Under *Vision 2030*, the Kingdom seeks to enhance the roles of globalization and entrepreneurship in transforming agriculture, promoting innovation, and supporting sustainable growth. However, empirical evidence on the interactions among globalization, agricultural development, entrepreneurial activity, and their impact on economic growth and sustainability in Saudi Arabia remains scarce. This study addresses this gap by providing a context-specific analysis to inform policies that strengthen agriculture's contribution to economic expansion and sustainable development.

After the introduction, the article presents a literature review that explores existing research on agriculture, globalization, entrepreneurship, economic growth, and sustainable development. The subsequent section defines and operationalizes the study's key variables, followed by an analysis of their correlations to assess interdependencies. The econometric models are then presented and justified, with a stationarity analysis ensuring data suitability. Causality tests identify directional relationships among globalization, entrepreneurship, and growth, while impulse response functions and variance decomposition analyses explore dynamic effects and the contribution of each variable. The study concludes with a summary of findings and policy implications for Saudi Arabia's sustainable economic development.

2. Literature Review

2.1. Globalization, Agriculture, and Sustainability

Globalization has changed farming systems in a big way by increasing trade, spreading technology, and moving money around. As goods, services, and knowledge cross borders, farmers and agribusinesses get new

chances to sell their goods and make them, but they also have to deal with problems like competition and damage to the environment. Research by Sultana et al. (2019)^[9] and You and Lv (2018)^[10] shows that Globalization has many effects on the environment. For example, while developed countries may benefit from cleaner technologies and lower CO₂ emissions, developing countries may see emissions rise at first because of industrial growth. But in the long run, technology transfer and efficiency gains help lessen these effects.

Agriculture is still a key part of food security and rural livelihoods. To stay that way, it needs to find a balance between productivity and taking care of the environment. Studies by Gurbuz et al. (2021)^[11] and Scharfy et al. (2017)^[12] underscore that energy intensity, modernisation, and the adoption of clean technologies, such as photovoltaic power and precision irrigation, are essential for sustainable agricultural development. Ajam et al. (2023)^[13] discovered that Globalization and agricultural value-added decrease agricultural CO₂ emissions via technology diffusion and robust environmental institutions, demonstrating the “developed-country advantage” prevalent in advanced economies. Receptoğlu et al. (2025)^[14] say that policymakers might be better off getting rid of pollution than using more resources to make farming more productive. This method lets you move resources that are used to grow crops to other areas. Globalization has a dynamic effect on agriculture. In the short term, it increases emissions in less developed areas, but over time, it makes agriculture more sustainable through new ideas and policies that work together. Consequently, we can postulate hypothesis 1:

H1. *Globalization positively impacts sustainable agricultural development via technological diffusion and efficiency enhancements.*

2.2. Entrepreneurship and Economic Growth

Entrepreneurship is acknowledged as a crucial driver of economic growth. Entrepreneurial activity, as articulated in the frameworks of Schumpeter (1934)^[15] and Acs et al. (2016)^[16], is a catalyst for innovation, productivity, and job creation. It promotes com-

petition, encourages knowledge spillovers, and facilitates structural transformation (Audretsch & Thurik, 2001^[17]; Naudé, 2013^[18]). Empirical studies by Carree and Thurik^[19] (2008) and Bosma et al. (2018)^[20] demonstrate that entrepreneurship has a positive impact on economic performance, particularly in contexts with robust institutional quality. Ugboaja and Onu (2021)^[21] employed a survey research design to investigate the entrepreneurial competencies required to empower women involved in cocoyam production in Abia and Imo States, Nigeria. The research focused on identifying the entrepreneurship skills employed in women’s empowerment in cocoyam production and assessing extension strategies to enhance this process. The findings highlighted the need to improve cocoyam production by providing access to critical entrepreneurial competencies, particularly agronomic knowledge and business management skills, to foster sustainable empowerment and productivity among women farmers.

Entrepreneurship in Saudi Arabia serves as a fundamental component of Vision 2030, which seeks to diversify the economy and foster innovation across sectors such as agriculture, renewable energy, and technology. Research by Stoica et al. (2020)^[22] and Peprah & Adekoya (2020)^[23] indicates that entrepreneurial ecosystems enhance economic growth through increased productivity and financial inclusion. However, the relationship is still insufficiently examined in developing economies, especially in the context of the Gulf Cooperation Council (GCC).

Entrepreneurship contributes to economic growth via innovation and competitiveness; however, the extent of its impact is contingent upon the quality of institutions, access to financing, and the support of policies. This analysis leads to the formulation of Hypothesis 2:

H2. *Entrepreneurship contributes to economic growth by fostering innovation and increasing productivity in emerging economies.*

2.3. Globalizations, Entrepreneurship, and Sustainable Development

Recent studies examine the interplay between globalization and entrepreneurship as dual influences on

sustainable development. Globalization creates chances for entrepreneurs by moving technology, expanding markets, and bringing in foreign direct investment (Coulibaly et al., 2018)^[24]. Ajide et al. (2021)^[25] say that Globalization makes it easier for people to start businesses and helps everyone grow by making it easier to get money and do business in other countries. Nonetheless, Prieger et al. (2016)^[26] warn that excessive or unregulated entrepreneurship in fragile institutional contexts may lead to inefficiencies.

In developing economies such as Saudi Arabia, Globalization enhances entrepreneurial endeavours that facilitate job creation, knowledge dissemination, and sustainability objectives (Amoa-Gyarteng & Dhliwayo, 2024)^[27]. Education and human capital are very important (Arshed et al., 2024)^[28] because a skilled workforce can take advantage of opportunities that come with Globalization. Liñán et al. (2020)^[29] further assert that digitalization and internationalisation have revolutionised entrepreneurial paradigms, particularly within small and medium-sized enterprises (SMEs).

When backed by strong institutions, human capital development, and policies that encourage innovation, the combination of Globalization and entrepreneurship makes sustainability better. But without government oversight, Globalization could make inequality and market concentration worse. Based on these arguments, we postulate Hypothesis 3:

H3. *Globalization helps the relationship between entrepreneurship and long-term economic growth by making it easier for new ideas to spread and for markets to connect around the world.*

2.4. Entrepreneurship and Agricultural Transformation

Entrepreneurship has emerged as a vital catalyst for innovation, productivity, and employment generation (Acs et al., 2016)^[16]. Entrepreneurial projects in the farming business make things run more smoothly, help technology move forward, and encourage products that add value (Pan et al., 2024)^[30]. Academics say that rural entrepreneurship helps structural change by bringing small-scale farmers into modern supply chains and

encouraging activities that lead to new ideas (Naudé, 2013)^[18]. Suman et al. (2025)^[31] do a thorough cost-benefit analysis of the effects of AI-driven smart irrigation systems on the economy and the environment. This study gives strong evidence that smart irrigation systems with AI worked better than regular ones. They saved 50% more water, 45% more energy, and 20% more crops. Aditi, Suginam, and Cen (2025)^[32] use structural equation modelling to look into how the green economy transformation affects the link between individual farmer innovations and long-term food security outcomes. This is a new area of research in agricultural innovation. Their research gives us new real-world proof of how micro-level innovations improve macro-level food security in developing countries. The results show that a long-term plan for food security needs to include both improving the skills of individual farmers and supporting the growth of the green economy as a whole. The study makes it clear that policy changes that only focus on encouraging innovation don't work well unless they are combined with big changes in markets, institutions, and infrastructure. This is important information for making evidence-based policies for sustainable agricultural development in developing economies. Thann et al. (2025)^[33] say that technical innovation (TI) is very important for improving farming in the ASEAN area. Their study shows that technological innovation has a big effect on the rise of agricultural research and development (R&D) intensity and worker productivity. The results show that digitalization is a moderating variable that makes the positive effects of technical innovation on agricultural output even stronger. This shows how important it is to include digital transformation strategies in agricultural innovation frameworks if we want to make long-term improvements in productivity. He, S. (2025)^[34] explains how digital financial innovation can help agriculture become more sustainable by making technology better and more useful. He also stresses the need for supportive agricultural policies.

In Saudi Arabia, entrepreneurship serves two purposes: it helps the economy become more diverse and it helps agriculture grow in a way that is good for the environment. Saudi Arabia is facing growing food security issues because its population is growing quickly, there

isn't enough land for farming, and there isn't enough water (Ahmed, Al-Khayri and Elbushra (2024)^[35]. The Kingdom is at the forefront of agritech innovations through the Public Investment Fund (PIF) to improve food systems that are both sustainable and strong, in line with Vision 2030. The Public Investment Fund (PIF) makes strategic investments in other countries, such as Brazil, India, and Australia, through The Saudi Agricultural and Livestock Investment Company (SALIC). It also makes smart local investments to protect important goods and make the supply chain less vulnerable. The Covid-19 pandemic made it clear how important it is to have a variety of reliable food sources, which led to a more proactive value-chain strategy. New projects like NEOM's Topian help make agriculture and aquaculture more climate-resistant, which helps protect the country's food supply (PIF, 2025)^[36]. Policies that support Vision 2030, such as the Agricultural Development Fund and the National Entrepreneurship Plan, have encouraged young people to get involved and private businesses to invest in agriculture. Neffati and Jbir (2024)^[37] and Neffati (2025)^[38] have focused their research on how the Saudi economy will grow under Vision 2030, with a focus on major diversification, Global-

ization, and the key role of digitalization. This change has a good effect on the long-term growth of the global economy in many areas. According to Alfehaid, Omri, and Altwaijri^[39] (2024), ICT diffusion has two roles: it can make environmental problems worse and it can also help solve them, depending on how widely it spreads and how it interacts with business activities that affect the quality of the environment in Saudi Arabia. They say that entrepreneurial activities have both direct and indirect effects when it comes to environmental risks and uncertainties. There aren't many studies that look at the link between entrepreneurship and agricultural performance in GCC economies, which shows how important it is to have real-world data. We can suppose Hypothesis 4:

H4. *In Saudi Arabia, encouraging entrepreneurship greatly increases the productivity of agriculture and the value of goods.*

According to the literature assessment, the dynamic link between Globalization, Entrepreneurship, and Agricultural Transformation, Economic Growth, and Sustainability may be represented in a framework model as a follow (**Figure 1**).

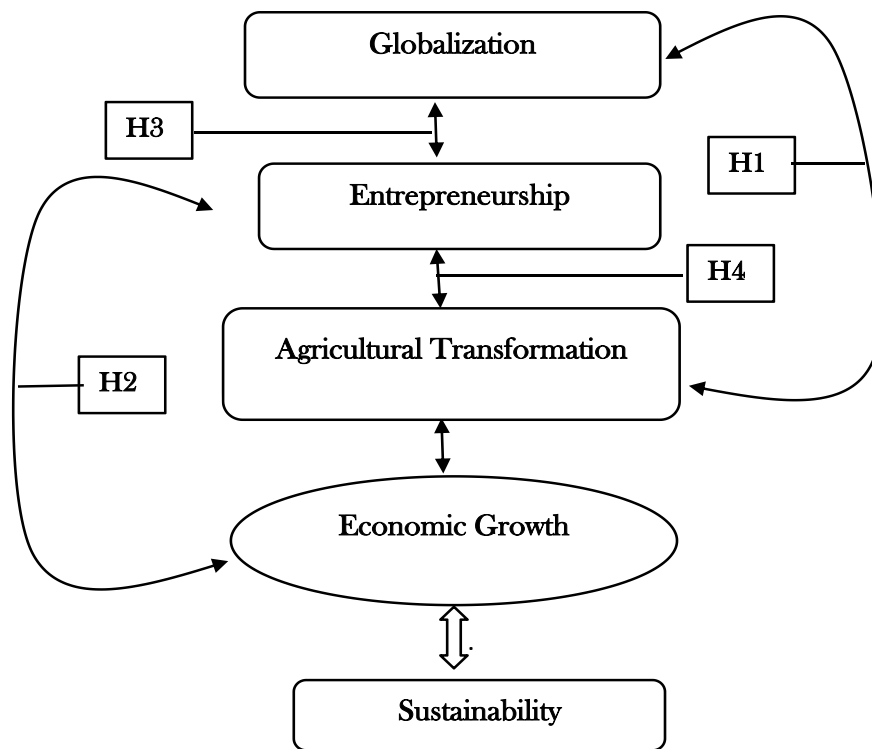


Figure 1. Theoretical framework.

Sources: authors elaboration.

Figure 1 shows how globalization, entrepreneurship, agricultural change, and sustainability are all connected to economic growth. Globalization affects entrepreneurship (H1) and changes in agriculture (H3), which then lead to economic growth through new ideas and better productivity. Agricultural transformation also plays a role in the link between entrepreneurship and economic growth (H2), showing how important the sector is for long-term growth. Lastly, it is shown that economic growth and sustainability help each other, which means that long-term success depends on a balance between economic and environmental progress (H4).

A significant body of literature review examines the individual impacts of Globalization, entrepreneurship, and agriculture on economic growth and sustainability; however, empirical studies that combine these factors, particularly within the Saudi Arabian context, are limited. Previous studies predominantly concentrate on advanced or African economies, neglecting the distinctive influence of Vision 2030 reforms, regulatory frameworks, and institutional modernisation on the globalization–entrepreneurship–sustainability nexus in Saudi Arabia. This study empirically investigates the synergistic effects of Globalization and entrepreneurship on sustainable economic growth and agricultural transfor-

mation within the context of Saudi Arabia’s evolving development agenda.

This framework provides a structured theoretical and analytical basis for examining how these constructs interact to drive economic growth and sustainability.

3. Data Description and Empirical Study

3.1. Introducing Variables

In this part of the study, we use annual data for all variables during the period 2000–2020 for the case of Saudi Arabia. **Table 1** summarizes the descriptive statistics associated with all the variables, namely the economic globalization index (GLOB), adjusted net savings (ANS) which is considered as an indicator for measuring sustainability, economic growth measured by gross domestic product (GDP), new businesses (ENT) which is measured by the density rate of new businesses compared to the population and which measures the development of entrepreneurship in Saudi Arabia, greenhouse gas emissions (GEE), the level of education (EDUC), and agriculture, forestry, and fishing value added (AGRFF) measured in constant 2015 US dollars as presented in **Table 1**.

Table 1. Definition and Measurement of Variables.

Variable	Symbol	Definition	Measurement/Unit	Source
Agriculture, Forestry, and Fishing Value Added	AGRFF	Value added by agriculture, forestry, and fishing to the total GDP, reflecting the contribution of the primary sector.	Constant 2015 US dollars	World Bank (World Development Indicators)
Economic Globalization Index	GLOB	Degree of economic integration of Saudi Arabia with the rest of the world through trade, investment, and financial flows.	Index (0–100 scale)	KOF Swiss Economic Institute (https://kof.ethz.ch)
Adjusted Net Savings	ANS	True rate of savings after accounting for human capital investment, natural resource depletion, and environmental damages; sustainability indicator.	% of Gross National Income (GNI)	World Bank (World Development Indicators)
Economic Growth	GDP	Level of economic output and performance over time.	Constant 2015 US dollars	World Bank (World Development Indicators)
Entrepreneurship Development	ENT	Density rate of new business registrations relative to working-age population; measures entrepreneurial activity.	Number of new businesses per 1,000 people (15–64 years)	World Bank (World Development Indicators)

Table 1. Cont.

Variable	Symbol	Definition	Measurement/Unit	Source
Greenhouse Gas Emissions	GEE	Total emissions of greenhouse gases from various sectors; proxy for environmental pressure.	Metric tons of CO ₂ equivalent	World Bank (World Development Indicators)
Education Level	EDUC	Progress and investment in human capital through education.	Gross enrollment ratio (% of population)	World Bank (World Development Indicators)

Source: authors elaboration.

Indeed, Adjusted Net Savings (ANS) is considered a leading indicator for measuring sustainability, proposed and estimated by the World Bank (Hamilton and Clemens 1999)^[40]. Two definitions of weak sustainability are commonly associated with the use of comprehensive savings indicators like the ANS. One assumes that development at a given time is sustainable if current consumption can be sustained indefinitely (Pezzey, 2004)^[41], while the other assumes that development is sustainable if welfare does not decline (Arrow et al., 2012)^[42]. In both cases, if aggregate savings are negative, development is not sustainable. However, having positive overall savings does not guarantee that consumption will not decline (Asheim, 1994^[43]; Pezzey,

2004^[41]), and in this sense the indicator is of sustainability. Economic growth measured by GDP refers to the sum of the gross value added of all resident producers in the economy, plus taxes on products and minus subsidies not included in the value of products.

Table 2 shows that GLOB averages 65.214; lnGDP ranges from 25.939 to 27.464; lnEDUC from 23.316 to 24.776; lnNENT, lnGEE, and ANS have means of 8.687, 13.196, and 20.973, respectively. AGRFF is stable, with a mean of 23.456, standard deviation of 0.2105, slight positive skewness (0.3164), low kurtosis (1.5457), and near-normal distribution (Jarque–Bera = 0.3327), indicating consistent sector output over the period.

Table 2. Descriptive Statistics.

	GLOB	ANS	LNGDP	LNGGE	LNNENT	LNEDUC	AGRFF
Mean	65.213	20.973	26.867	13.195	8.6866	24.233	23.456
Median	64.150	20.275	26.992	13.244	8.6590	24.372	23.423
Maximum	73.060	31.565	27.464	13.506	9.7623	24.776	23.781
Minimum	59.060	8.5235	25.938	12.750	7.7782	23.316	23.207
Std. Dev.	3.7133	7.3054	0.5394	0.2737	0.6533	0.5300	0.2105
Skewness	0.6235	0.0045	-0.6184	-0.3083	0.0611	-0.6616	0.3164
Kurtosis	2.5965	1.6427	1.9079	1.6020	1.5995	1.9357	1.5457
Jarque-Bera	1.5034	1.6120	2.3819	2.0428	1.7291	2.5232	2.2010
Probability	0.4715	0.4466	0.3039	0.3601	0.4212	0.2832	0.3327
Sum	1369.5	440.43	564.21	277.11	182.42	508.89	492.577
Sum Sq. Dev.	275.77	1067.3	5.8185	1.4988	8.5371	5.6193	0.8867
Observations	21	21	21	21	21	21	21

Source: authors estimation.

The descriptive statistics provide insights into the central tendency, dispersion, and distribution characteristics of the variables under study described in Table 1. Where we notice that, GLOB has the highest mean (65.21), while ANS has the lowest (20.97), indicating the average values around which these variables center. The median values are close to the mean for most variables, e.g., GLOB (64.15) and ANS (20.28), suggesting symmetrical distributions. The highest variability is observed in ANS (7.31), while the lowest is in LNGGE (0.27), indicat-

ing that ANS fluctuates more than other variables. In fact, GLOB (0.62) is positively skewed, implying a longer right tail, while LNGDP (-0.62) is negatively skewed, suggesting a longer left tail. All variables have kurtosis values less than 3, such as GLOB (2.60) and ANS (1.64), indicating flatter distributions compared to the normal distribution. The Jarque–Bera test shows that all variables have *p*-values greater than 0.05, with GLOB at 0.47 and LNEDUC at 0.28. These *p*-values suggest that the null hypothesis of normality cannot be rejected, implying that

the data distributions are not significantly different from normal.

Given the normality and general stability (low standard deviations), it is crucial to check for stationarity using the ADF test and confirm cointegration with Johansen’s test before applying the VECM for causality. The descriptive statistics, with relatively close mean and median values and non-significant skewness, support the conditions required for these pre-tests. This detailed analysis confirms the appropriateness of proceeding with stationarity and cointegration tests, setting a solid foundation for VAR or VECM-based causality analysis.

3.2. Correlation between Variables

The correlation matrix is primarily used to detect potential multicollinearity among the variables rather than to establish causal relationships. It provides preliminary insights into the direction and strength of associations between the key study variables: Economic Globalisation (GLOB), Adjusted Net Savings (ANS), Economic Growth (lnGDP), Number of New Businesses (lnENT), Greenhouse Gas Emissions (lnGGE), Level of Education (lnEDUC), and Agricultural, Forestry, and Fisheries Value Added (AGRFF). As shown in **Table 3**, lnGDP

and lnENT exhibit a strong positive correlation (0.9302), reflecting the close link between economic expansion and entrepreneurial activity. A weaker positive correlation (0.1832) is observed between ANS and lnENT, suggesting a limited contribution of sustainable savings to business creation. Education is also strongly positively associated with entrepreneurship growth, highlighting the role of human capital. AGRFF shows positive correlations with all other variables, with the strongest relationships observed with the number of new enterprises (0.976), greenhouse gas emissions (0.947), GDP (0.877), and education (0.863), indicating the sector’s importance for promoting entrepreneurship, economic growth, and human capital development while exerting environmental pressures. Moderate positive correlations with ANS (0.295) and GLOB (0.494) suggest that agricultural growth is linked to sustainable wealth accumulation and international integration. Given the relatively high intercorrelations, standard estimation techniques such as OLS would be inappropriate due to potential multicollinearity and simultaneity issues. Therefore, a Vector Autoregression (VAR) framework is employed to appropriately capture the dynamic interrelationships among these variables and support reliable econometric analysis.

Table 3. Correlation Test.

	AGRFF	ANS	GLOB	LNEDUC	LNGDP	LNGGE	LNNENT
AGRFF	1.000000	-	-	-	-	-	-
ANS	0.294740	1.000000	-	-	-	-	-
GLOB	0.493960	0.636997	1.000000	-	-	-	-
LNEDUC	0.863112	0.162226	-0.162258	1.000000	-	-	-
LNGDP	0.876927	0.144280	-0.176998	0.999353	1.000000	-	-
LNGGE	0.947234	-0.083643	-0.332669	0.964123	0.967756	1.000000	-
LNNENT	0.976167	-0.183210	-0.375870	0.921535	0.930190	0.973203	1.000000

Source: authors estimation.

3.3. Model Presentation

In this study, we employ a Vector Autoregressive (VAR) framework to examine the dynamic relationships among key economic, environmental, and sectoral indicators in Saudi Arabia. The analysis incorporates adjusted net savings (ANS) as a measure of sustainable wealth accumulation, GDP growth as a proxy for economic performance, the number of newly established

businesses to capture entrepreneurship development, greenhouse gas (GHG) emissions, the level of education (EDUC), and agriculture, forestry, and fishing value added (AGRFF) to represent the contribution of the primary sector. The VAR(P) model allows us to assess how shocks in one variable propagate through the system and influence the others over time, providing a comprehensive understanding of the interplay between sustainability, economic growth, entrepreneurship, the agricultural

sector, and environmental outcomes. The model is formally expressed as follows:

$$Y_t = c \sum_{i=1}^p \varphi_i Y_{t-i} + \mu_t$$

The mathematical expressions of the general VAR(P) model are as follows:

$$Y_t = A_1 Y_{t-1} + \dots + A_p Y_{t-p} + Bx_t + \mu_t$$

The VAR model is a technique used to estimate the system of equations that was proposed by Sims (1980)^[44], as a solution to the one-dimensionality problem of the uni-variate time series approach.

The using of VAR (Vector Autoregressive) and VECM (Vector Error Correction Model) estimation techniques is crucial for analyzing the complex relationships

between economic variables. Somoye (2013)^[45] emphasizes how these models enable the investigation of both short-term fluctuations and long-term equilibrium connections. Ben Mbarek et al. (2014)^[46] illustrate the effectiveness of VECM in capturing cointegrated relationships while accounting for short-term adjustments. More recent studies by Boca Saravia and Rodríguez (2022)^[47] and Dutta and Saha (2023)^[48] reinforce the significance of these models in unraveling the dynamic interactions of economic factors across various contexts.

In a Vector Autoregression (VAR) model, each variable is expressed as a linear function of its own lagged values and the lagged values of all other variables in the system. Given the variables ANS, AGRFF, GLOB, LNEDUC, LNGDP, LNGGE, and LNNENT, the VAR model can be structured as follows:

$$\begin{bmatrix} ANS_t \\ GLOB_t \\ LNEDUC_t \\ LNGDP_t \\ LNGGE_t \\ LNNENT_t \\ AGRFF_t \end{bmatrix} = \begin{bmatrix} c_1 \\ c_2 \\ c_3 \\ c_4 \\ c_5 \\ c_6 \\ c_7 \end{bmatrix} + \begin{bmatrix} \alpha_{11,i} \alpha_{12,i} \alpha_{13,i} \alpha_{14,i} \alpha_{15,i} \alpha_{16,i} \alpha_{17,i} \\ \alpha_{21,i} \alpha_{22,i} \alpha_{23,i} \alpha_{24,i} \alpha_{25,i} \alpha_{26,i} \alpha_{27,i} \\ \alpha_{31,i} \alpha_{32,i} \alpha_{33,i} \alpha_{34,i} \alpha_{35,i} \alpha_{36,i} \alpha_{37,i} \\ \alpha_{41,i} \alpha_{42,i} \alpha_{43,i} \alpha_{44,i} \alpha_{45,i} \alpha_{46,i} \alpha_{47,i} \\ \alpha_{51,i} \alpha_{52,i} \alpha_{53,i} \alpha_{54,i} \alpha_{55,i} \alpha_{56,i} \alpha_{57,i} \\ \alpha_{61,i} \alpha_{62,i} \alpha_{63,i} \alpha_{64,i} \alpha_{65,i} \alpha_{66,i} \alpha_{67,i} \\ \alpha_{71,i} \alpha_{71,i} \alpha_{71,i} \alpha_{71,i} \alpha_{71,i} \alpha_{71,i} \alpha_{71,i} \end{bmatrix} \begin{bmatrix} ANS_{t-i} \\ GLOB_{t-i} \\ LNEDUC_{t-i} \\ LNGDP_{t-i} \\ LNGGE_{t-i} \\ LNNENT_{t-i} \\ AGRFF_{t-i} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \\ \varepsilon_{3,t} \\ \varepsilon_{4,t} \\ \varepsilon_{5,t} \\ \varepsilon_{6,t} \\ \varepsilon_{7,t} \end{bmatrix}$$

For example, for the first variable, adjusted net savings (ANS) it is written as:

$$ANS_t = c_1 + \sum_{i=1}^p \alpha_{11,i} ANS_{t-i} + \sum_{i=1}^p \alpha_{12,i} GLOB_{t-i} + \sum_{i=1}^p \alpha_{13,i} LNEDUC_{t-i} + \sum_{i=1}^p \alpha_{14,i} LNGDP_{t-i} + \sum_{i=1}^p \alpha_{15,i} LNGGE_{t-i} + \sum_{i=1}^p \alpha_{16,i} LNNENT_{t-i} + \sum_{i=1}^p \alpha_{16,i} AGRFF_{t-i} + \varepsilon_{1,t}$$

Explanation: Each equation represents one of the six variables as a function of its own past values (lags) and the past values of all the other variables in the system.

- c_1, c_2, \dots, c_6 are constants (intercepts)
- $\alpha_{jk,i}, \alpha_{JK,i}$ are the coefficients for the lagged variables where i and j correspond to the dependent and independent variables, respectively, and k represents the lag order.
- p is the lag length, which is determined by criteria

such as the Akaike Information Criterion (AIC) or the Schwarz Bayesian Criterion (SBC).

- $\varepsilon_{1,t}, \dots, \varepsilon_{6,t}$ are the error terms (or innovations).

This structure allows for the modeling of the dynamic relationships between the variables over time.

To further examine the dynamic interactions among the study variables, we employ the Impulse Response Function (IRF) analysis, which traces the response of each variable to a one-time shock in another variable over time, providing insights into the magnitude, direction, and persistence of these effects.

The Impulse Response of *GLOB* to a Shock in *ANS* described by equation how a one-time shock in *ANS* affects *GLOB* over future periods:

$$IRF_{ANS \leftarrow GLOB}(h) = \sum_{i=0}^h \varphi_{ANS,GLOB,i} \cdot u_{GLOB}$$

- $IRF_{ANS \leftarrow GLOB}(h)$ is the response of ANS at horizon h to a one-unit-shock in *GLOB*.

- $\varphi_{ANS,GLOB,i}$ are the impulse response coefficients, derived from the estimated VAR model.
- u_{GLOB} is the initial shock to *GLOB*.

This equation describes how a one-time shock in ANS affects GLOB over future periods:

$$IRF_{GLOB \leftarrow ANS}(h) = \sum_{i=0}^h \varphi_{GLOB,ANS,i} \cdot u_{ANS}$$

- $IRF_{GLOB \leftarrow ANS}(h)$ is the response of GLOB at horizon h to a one-unit-shock in ANS.
- $\varphi_{GLOB,ANS,i}$ are the impulse response coefficients, derived from the estimated VAR model.
- u_{ANS} is the initial shock to ANS.

To complement the VAR and Impulse Response analysis, we perform Variance Decomposition, which quantifies the proportion of the forecast error variance of each variable that can be attributed to shocks in itself and in the other variables, thereby highlighting the relative importance and contribution of each factor over time.

While the impulse response function traces the effects of a shock on an endogenous variable on other variables of the VAR, the variance decomposition (VDC) breaks down the variation of variables and helps trace the size of the interaction of the variables by quantifying the contribution of each innovation variance to the total error. In order to analyze the shock, utilizing the Choleski decomposition, one has to select a sequence of shocks. The method of variance decomposition has been applied in some studies. Moreover, Diebold and Yilmaz (2012)^[49] applied the generalised VAR model given by Pesaran and Shin (1998)^[50]; he built command-invariant variance decompositions. Now let us assume the generalised variance decompositions of the variance associated with forecast errors as follows:

$$\theta_{ij}^g(H) = \frac{\sigma_{ij}^{-1} \sum_{h=0}^{H-1} (e_i' A_h \sum e_j^2)}{\sum_{h=0}^{H-1} (e_i' A_h \sum A_h' e_i)}$$

Where Σ is the variance matrix for the error vector ε , σ_{ij} is the standard deviation of the error term for j^{th} equation and e_i is the selection vector, with one as the i^{th} element and zeros otherwise.

3.4. Stationarity Analysis

To examine the stationarity of the variables, we assess the presence of the “unit root” for each variable within the timeframe of 1990–2020. There are many unit root tests that have been suggested and used in the literature, such as the Dickey-Fuller test (DF), the Augmented Dickey-Fuller test (ADF), the Phillips-Perron test (PP), Maddala and Wu (1999)^[51], Breitung (2000)^[52], and Im, Pesaran and Shin (2003)^[53]. Recently, Hlouskova and Wagner (2006)^[54] conducted a comprehensive Monte Carlo simulation, revealing that Breitung’s (2000)^[52] unit root test exhibited the most significant and minimal size distortion compared to other unit root panel tests, including the LLC tests by Levin, Lin, and Chu (2002)^[55] and the IPS tests by Im, Pesaran, and Shin (2003)^[53]. In fact, IPS and LLC can determine the order of integration and find out where the time series variable becomes stationary. The LLC and IPS procedures are based on the classical Augmented Dickey-Fuller (ADF) test. The LLC technique looks at how different the intercepts are between the members of the group, whereas the IPS method looks at how different the intercepts and slope coefficients are. The ADF individual mean statistic was used to apply both tests to the section units.

We use two tests, Dickey-Fuller (ADF) and Phillips-Perron (PP), to see if the variables are stationary. The results are reported in **Table 3**. Dickey and Fuller (1979)^[56] observed (ADF), while Phillips and Perron (1988)^[57] observed (PP). These two tests are standard, which means that the unit root is not rejected. This result could be seen as suspicious if the sample includes economic and financial events that could induce changes in the regime at the court of time. The Student Statistics (ST) values for the level and first-difference variables are shown in **Table 3** below. The unit root test shows that all series are integrated to order one (I(1)), meaning they are all stationary in first difference. **Table 3** displays the results of the unit root tests. After these findings, we may use the VAR model, which addresses the short-term relationship among the variables examined in this part of the study (Sims, 1980)^[44].

Using the ADF test on the lnGDP series as an example, we formulate the test equation as follows, including

the constant term, trend, and intercept terms:

$$\Delta \ln GDP_t = \alpha + \beta_t + \Delta \ln GDP_t + \sum_{i=1}^k \beta_i \ln GDP_{t-i} + \varepsilon_t$$

where α , β and δ are coefficients; ε is a residual term; and k is the lag length, which transforms the residual term into a stochastic variable. The null hypothesis H_0 is $\delta = 0$; that is, there is at least one-unit root, causing the series to be non-stationary. The test is carried out with three formulations: $(\alpha \neq 0, \beta \neq 0)$, $(\alpha = 0, \beta \neq 0)$ and $(\alpha = 0, \beta = 0)$. As long as one of the three models rejects the null hypothesis, the series are considered stationary. However, when the results of the three models do not

reject the null hypothesis, the series are considered non-stationary at the level.

Table 4 indicates the potential existence of a long-term equilibrium relationship among adjusted net savings (ANS), economic growth measured by GDP, the number of new businesses as a measure of entrepreneurship development in Saudi Arabia, greenhouse gas (GHG) emissions, the level of education (EDUC), and agriculture, forestry, and fishing value added (AGRFF). Since all the variables are stationary in first differences, we proceed to analyze and comment on the existence of one or more long-term relationships among these variables in the Saudi economy.

Table 4. Unit Root Test.

Variables	Level		1st Difference	
	(i)	(ii)	(i)	(ii)
	<i>ADF Test</i>			
ANS	6.6054	-2.4722	-4.8994*	-3.1015**
GLOB	-0.4164	-1.4293	-5.0355*	-4.8837*
LNEDUC	1.7361	-0.3057	-3.6741*	-4.4371*
LNGDP	3.3394	-0.9017	-4.2765*	-6.3616*
LNGGE	1.9066	-2.1329	-2.7599*	-3.7120**
LNNENT	5.9817	-1.4635	-4.2940*	-9.1414*
	<i>PP test</i>			
ANS	5.4116	-2.4722	-4.8994*	3.8845**
GLOB	-0.3101	-1.4294	-5.0355*	-4.8837*
LNEDUC	3.7236	0.7322	-3.6739*	-4.5601*
LNGDP	5.9717	-1.4535	-4.2844*	-9.1384*
LNGGE	1.9066	-2.1703	-2.6948*	-2.9165*
LNNENT	1.7361	-0.3057	-3.6741*	-4.4371*

Note: (i) Without constant, (ii): with a constant. *and **: asterisks denote p -value less than 1% and 5%. Critical levels in the model. (i) -2.60 (1%) and (ii) -1.95 (5%).

Source: authors estimation.

3.5. Causality between Variables

The Granger causality test is focused on analysing the connections and direction of causal relationships between variables, whereas correlation tests are unable to ascertain the direction of causality. In time series analysis, the ideas of Granger causality (GC) and Granger non-causality (GNC), which were established by Wiener (1956) and Granger (1969), are essential (see, for instance, Geweke surveys (1984)^[58], Hamilton and Clemens (1999)^[40] or Bressler & Seth (2011)^[59]). Granger causality test has, in fact, been used extensively to investigate the causal relationship between variables. Engle and Granger (1987)^[60] demonstrated that when

the variables are co-integrated, the causality test based on a vector autoregressive (VAR) model in first differences will be misspecified. All of the variables in this study are integrated of order 1, or I(1). Following the specification and estimation of the VAR model, the Causality/Block Exogeneity Wald Tests are used to ascertain the causal relationships between the variables ANS, GLOB, LNEDUC, LNGDP, LNGGE, and LNNENT from 2000 to 2020.

The Granger test equation can be written as follows:

$$Y_t = \gamma + \sum_{i=1}^m \alpha_i Y_{t-1} + \sum_{j=1}^m \beta_j X_{t-j} + \varepsilon_t$$

$$X_t = \gamma + \sum_{i=1}^m \alpha_i Y_{t-1} + \sum_{j=1}^m \beta_j X_{t-j} + \varepsilon_t$$

The first model tests whether past values of GLOB can predict ANS.

$$ANS_t = \gamma_1 + \sum_{i=1}^m \alpha_i ANS_{t-1} + \sum_{j=1}^m \beta_j GLOB_{t-j} + \varepsilon_t$$

- t is the time period (2000–2020).
- m is the number of lags.
- γ_1 is the constant term.
- α_i are the coefficients of the lagged ANS terms.
- β_j are the coefficients of the lagged GLOB terms.
- ε_t is the error term.

The null hypothesis means $\beta_1 = \beta_2 = \dots = \beta_m = 0$.

To determine whether historical values of one variable aid in the prediction of another, the Granger causality test entails estimating two distinct equations. **Table 5** shows that, at the 1% significant level, there are bidirectional relationships between globalisation and economic growth. At the 1% significant level, a

bidirectional relationship between the growth of entrepreneurship and globalisation was discovered. There are unidirectional connections between ANS and globalisation. At the 1% level of significance, **Table 5** further demonstrates that there is unidirectional causality between LnNENT and economic growth. This finding is supported by Schumpeter’s theory, which conceptually established entrepreneurial behaviour as a crucial component of economic development. Schumpeter (1934)^[15] also brought up the concept of social capability. By consistently upsetting an equilibrium economic system, entrepreneurial activity triggers the process of creative destruction (Schumpeter, 1934)^[15]. Economic rent is made possible by these disruptions. According to Schumpeter’s theory, economic growth will therefore rise in tandem with the number of entrepreneurs. Thus, entrepreneurship and economic growth can be connected (Schumpeter, 1934)^[15].

Table 5. Granger Causality Test.

	AGRFF	GLOB	Excluded Variables: Block Exogeneity					All
			LnGDP	ANS	LNNENT	LNEDUC	LNGGES	
AGRFF	-	3.6035** (0.0577)	0.1961 (0.6578)	1.6597 (0.1976)	4.4436** (0.0350)	0.1844 (0.6676)	3.4121** (0.0647)	27.15* (0.0001)
GLOB	0.4607 (0.4973)	-	9.4038* (0.0091)	0.2591 (0.8785)	13.185* (0.0016)	22.786* (0.0000)	4.210 (0.1223)	40.78* (0.0000)
LnGDP	0.9824 (0.3216)	7.5013** (0.0241)	-	8.6282** (0.0134)	18.793* (0.0001)	2.0693 (0.3553)	17.715* (0.0001)	38.433* (0.0000)
ANS	4.6406** (0.0312)	7.3061 (0.0259)	4.2386 (0.1201)	-	15.091* (0.0005)	1.4872 (0.4754)	15.785* (0.0004)	31.950* (0.0001)
LNNENT	14.547* (0.0001)	5.465*** (0.0601)	0.3970 (0.8199)	0.2038 (0.9031)	-	5.665*** (0.0588)	1.5384 (0.4634)	15.443*** (0.0511)
LNEDUC	1.0655 (0.3019)	28.79* (0.0000)	2.0201 (0.3642)	5.4388*** (0.0659)	12.786* (0.0017)	-	0.2591 (0.8785)	23.125* (0.0032)
LNGGES	0.7602 (0.3833)	0.5693 (0.7553)	4.2033 (0.1223)	10.981* (0.0041)	7.4775** (0.0238)	0.2597 (0.8782)	-	50.440* (0.0000)

Notes: *, ** and *** indicate that the parameter estimates are significant at the 1%, 5% and 10% levels respectively. Source: authors estimation.

There was also a one-way causal link from ANE to economic growth that was statistically significant at the 5% level. **Table 5** illustrates a bidirectional causal relationship between education and entrepreneurship development in Saudi Arabia. These findings underscore the essential role of education and innovation in the development of entrepreneurs and their progression towards success. Entrepreneurship is widely regarded as a vital component of economic development that can be fostered and enhanced through education. Saudi Arabia should also try to take advantage of economies of scale

by encouraging both domestic and foreign direct investment, as well as the growth of infrastructure and education.

The Granger causality test results indicate that the short-run interactions between agricultural factor growth (AGRFF) and the other variables are largely characterized by unidirectional causal relationships. Globalization (GLOB) is found to Granger-cause AGRFF at the 5% significance level ($p = 0.0577$), suggesting that past variations in globalization significantly help predict changes in agricultural factor growth, while the reverse

effect from AGRFF to GLOB is not statistically significant. This unidirectional link implies that external openness, trade integration, and global market interactions play a determining role in shaping the agricultural sector, whereas the evolution of the agricultural sector itself does not exert a notable influence on the degree of globalization in the short run.

A similar pattern emerges with ANS, which exerts a significant predictive influence on AGRFF ($p = 0.0312$), whereas AGRFF does not Granger-cause ANS. This result points to another unidirectional link in which changes in ANS precede and help explain agricultural factor growth. The relationship with LNENT is stronger, as LNENT significantly influences AGRFF at the 1% level ($p = 0.0001$), indicating that past developments in entrepreneurship or enterprise activity are key drivers of agricultural performance. Although AGRFF also Granger-causes LNENT at the 5% level ($p = 0.0350$), the influence is comparatively weaker, highlighting that the primary direction of causality runs from enterprise development to the agricultural sector. In fact, Dalvi et al. (2025)^[61] further support this by proposing a framework for cultivating sustainable entrepreneurship in agriculture, emphasizing that entrepreneurial initiative within the agricultural sector can contribute to the realization of SDGs. Their analysis suggests that such initiatives are instrumental in addressing challenges like food security, environmental conservation, and economic development, thereby reinforcing the observed directional relationships in our study.

Additionally, LNGGES is found to Granger-cause AGRFF at the 10% significance level ($p = 0.0647$), showing that governance effectiveness or related policy actions contribute to predicting changes in agricultural factor growth, while no reverse effect is observed. In contrast, no significant short-run causal relationships are identified between AGRFF and either GDP growth ($p = 0.3216$) or education ($p = 0.3019$), suggesting that in the short term, neither macroeconomic growth nor educational attainment directly drives agricultural factor growth, and agricultural development does not, in turn, predict changes in these variables. Overall, these findings emphasize the critical role of globalization, entrepreneurial activity, governance, and ANS-related fac-

tors as short-run predictors of agricultural sector performance, while the effects of GDP growth and education appear to be less immediate and potentially more relevant in the long run.

Table 5 also indicates a unidirectional causal relationship from NENT to ANS at the 1% significance level, a finding consistent with Galindo-Martín et al. (2021)^[62], who highlight the role of entrepreneurship in promoting sustainable outcomes. Given that entrepreneurial activity can contribute to higher greenhouse gas emissions, it is imperative for business owners to adopt greener production practices. Increasingly, young graduates are drawn to sustainable business ventures, reflecting a growing commitment among entrepreneurs to environmental stewardship. The green business sector thus offers an opportunity to generate economic value while simultaneously supporting environmental protection. These results suggest that entrepreneurial activity in Saudi Arabia is not solely an economic phenomenon but also encompasses social and environmental dimensions, aligning business objectives with broader sustainability goals.

This suggests that entrepreneurial activity contributes to sustainable wealth accumulation, while also highlighting the need for businesses to adopt greener production methods to mitigate environmental impacts. The rise of environmentally conscious entrepreneurs and the growth of the green business sector provide dual benefits: generating economic value and advancing environmental protection. Overall, these results illustrate that fostering entrepreneurship in Saudi Arabia not only drives agricultural growth but also promotes sustainable economic development, human capital formation, and environmental stewardship.

Social and sustainable entrepreneurship today represents a new mode of entrepreneurship based on motivation and social innovation but conditioned by the economic viability of the project.

Social entrepreneurs wish to develop their business to make profits to be reinvested in the business to be able to create jobs and continue the initial social objective. We have tried to explain the essential role that social entrepreneurship can play and to analyze the innovative way of conceiving social innovation at the heart of so-

cial enterprise. Social enterprises, which go beyond accepting social enterprise responsibility, can become an important element, a driver of social development. Analysis of the concepts of social enterprise responsibility and social innovation have lost light on how CSR is integrated into companies. The strategy itself can be considered as social innovation. Social enterprise innovation and social entrepreneurship attempt to solve the social problem while maintaining economic sustainability. Most of the literature differs among them based on the priority of social life from economic viewpoints.

The results suggest that in the short run, agricultural development in the studied context is primarily driven by external and institutional factors rather than domestic macroeconomic or educational improvements. Globalization, entrepreneurial activity, governance quality, and ANS-related factors significantly influence agricultural performance, highlighting the importance of international integration, business dynamism, and effective institutions in boosting the sector. In contrast, GDP growth and education do not show immediate causal effects, implying that their impact on agriculture is likely more gradual and long-term, reinforcing the idea that structural and market-oriented drivers are more deci-

sive for short-term agricultural growth.

These results have important policy implications and indicate that there is still a need for further studies. Therefore, impulse response function and variance decomposition analysis will be used in the next phase.

Table 6 presents the results of the Lag-Length Criteria based on the Wald Tests within the VAR framework for the period 2000–2020. The Wald statistics and their corresponding *p*-values indicate that the null hypothesis of lag exclusion is strongly rejected for all variables at the 1% significance level. Specifically, the high Wald chi-square values across all endogenous variables AGRFF, GLOB, LNEDUC, LNGDP, LNGGE, LNNENT, and ANS confirm that the inclusion of the first lag is statistically significant in explaining the dynamics of the system. The joint test further reinforces this conclusion, as the overall chi-square statistic (7281.536) is highly significant (*p* = 0.0000), suggesting that the first lag captures essential intertemporal relationships among the variables. Therefore, these results justify the retention of one lag in the VAR or subsequent VECM specification, ensuring a well-specified dynamic structure that adequately reflects the short-run interactions within the model.

Table 6. Lag-length Criteria by Wald Tests.

	AGRFF	GLOB	LNEDUC	LNGDP	LNGGE	LNNENT	ANS	Joint
Lag 1	3711.399	35.69436	584.7973	599.3889	2688.654	1892.720	67.96984	7281.536
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
df	7	7	7	7	7	7	7	49

Notes: Sample: 2000–2020.
Source: authors estimation.

4. Impulse Response Function Result

After the Granger causality test, the internal relationship between adjusted net savings (*ANS*), economic growth measured by *GDP*, the number of new businesses which measures the development of entrepreneurship in Saudi Arabia, gas emissions at greenhouse effect and the level of education (*EDUC*) for the Saudian economy. However, the test does not consider the dynamic effects of these variables (Koop et al. 1996)^[63]. Through the impulse response figure, the current and future state of each variable’s effect on the remaining variables can

be seen. Impulse response analysis is a crucial component of econometric investigations employing autoregressive vector models. Their primary aim is to elucidate the progression of the model’s variables in reaction to a perturbation in one or more variables. This attribute enables the identification of a singular shock inside a predominantly chaotic system of equations, rendering them highly effective instruments for assessing economic strategies. A multitude of researchers have examined the impulse response function (IRF). A multitude of researchers have examined and applied the impulse response function (IRF) to analyze the dynamic relationships among economic variables in different contexts, in-

cluding forecasting, monetary policy, and sustainability-growth linkages (Koop et al., 1996^[63]; Pesaran & Shin, 1998^[50]; Belloumi & Alshehry, 2015^[64] among others). The impulse reaction can be understood as the effect of a variable following a shock in innovation. Numerous studies in economics and finance have extensively examined the impulsive response. In applied econometrics, the computation of the impulse response function (IRF) has been extensively utilised, as evidenced by the following publications: Leigh and Rossi (2002)^[65] employed the impulse response function to examine the effects of exchange rate fluctuations on the overall price level.

If $IRF_{ANS \leftarrow GLOB}(h)$ is positive and significant for several periods, there is a positive shock in GLOB increases ANS over periods.

The findings illustrated in **Figure 2** indicate a short-term negative impact of $\ln NENT$ on $\ln GDP$, which subsequently shifts to a positive effect in the long term. A significant finding illustrates the beneficial impact of $NENT$ on the ANS over an extended period. The development of entrepreneurship is observed to play a crucial role in sustainable development in Saudi Arabia. This finding aligns with the conclusions drawn by Ningrum et al, (2025)^[66], who advocate for entrepreneurship as a viable approach to addressing environmental challenges while fostering sustainable economic growth. The authors assert that entrepreneurship serves as a significant catalyst for change in the pursuit of sustainable processes and products. In fact, engaging in entrepreneurial activities can address various environmental and social challenges in Saudi Arabia because new businesses often introduce innovative solutions, promote sustainable resource use, and create employment opportunities. By developing green technologies, eco-friendly products, and socially responsible business models, entrepreneurs contribute to reducing environmental pressures, supporting community well-being, and advancing sustainable development goals. In the Saudi context, this aligns with Vision 2030's emphasis on economic diversification, environmental protection, and social development, highlighting entrepreneurship as a key driver of both economic and societal transformation. According to Ningrum et al, (2025)^[66], numerous leading academics support the notion that engaging in entrepreneurial activities can address various environ-

mental and social challenges. In fact, the positive long-term impact of GDP on the development of entrepreneurship in Saudi Arabia indicates that sustained economic growth creates a favorable environment for new business formation. Higher GDP levels are typically associated with increased household income, improved access to finance, and greater market demand, all of which lower entry barriers for entrepreneurs. In the Saudi context, this relationship reflects the role of economic expansion under Vision 2030 in fostering a more dynamic private sector, encouraging innovation, and diversifying the economy beyond oil dependence. Essentially, as the economy grows, it provides the necessary resources, infrastructure, and incentives that enable entrepreneurial activities to flourish, thereby reinforcing a virtuous cycle of growth and enterprise development.

Figure 2 illustrates the impulse response functions (IRFs) of Adjusted Net Savings (ANS), Globalization ($GLOB$), Economic Growth ($\ln GDP$), and Entrepreneurship ($\ln ENT$) as a main variables, to one standard deviation shocks in each variable over 10 periods. ANS shows a declining trend after its own shock but responds positively to globalization and economic growth, highlighting their role in enhancing sustainable savings, while shocks to $\ln ENT$ has weaker effects. $GLOB$ exhibits persistent self-reinforcing dynamics and responds positively to shocks in ANS and $\ln GDP$, emphasizing sustainability and economic growth as globalization drivers. Economic growth is significantly boosted by shocks in ANS , $GLOB$, and education, reflecting the interconnected roles of sustainability, globalization, and human capital in growth. Entrepreneurship is strongly influenced by ANS , $GLOB$, and $\ln GDP$, demonstrating the importance of sustainability and economic prosperity in fostering business creation. Education responds positively to shocks in ANS , $GLOB$, and $\ln GDP$, reinforcing the link between sustainability, globalization, and human capital development. Finally, $\ln GGE$ increases with shocks to $GLOB$ and $\ln GDP$, signaling environmental challenges associated with globalization and growth, while showing weaker responses to ANS and education shocks. These findings underscore the interdependencies between sustainability, globalization, education, and entrepreneurship, alongside the need to balance economic growth with environmental responsibility.

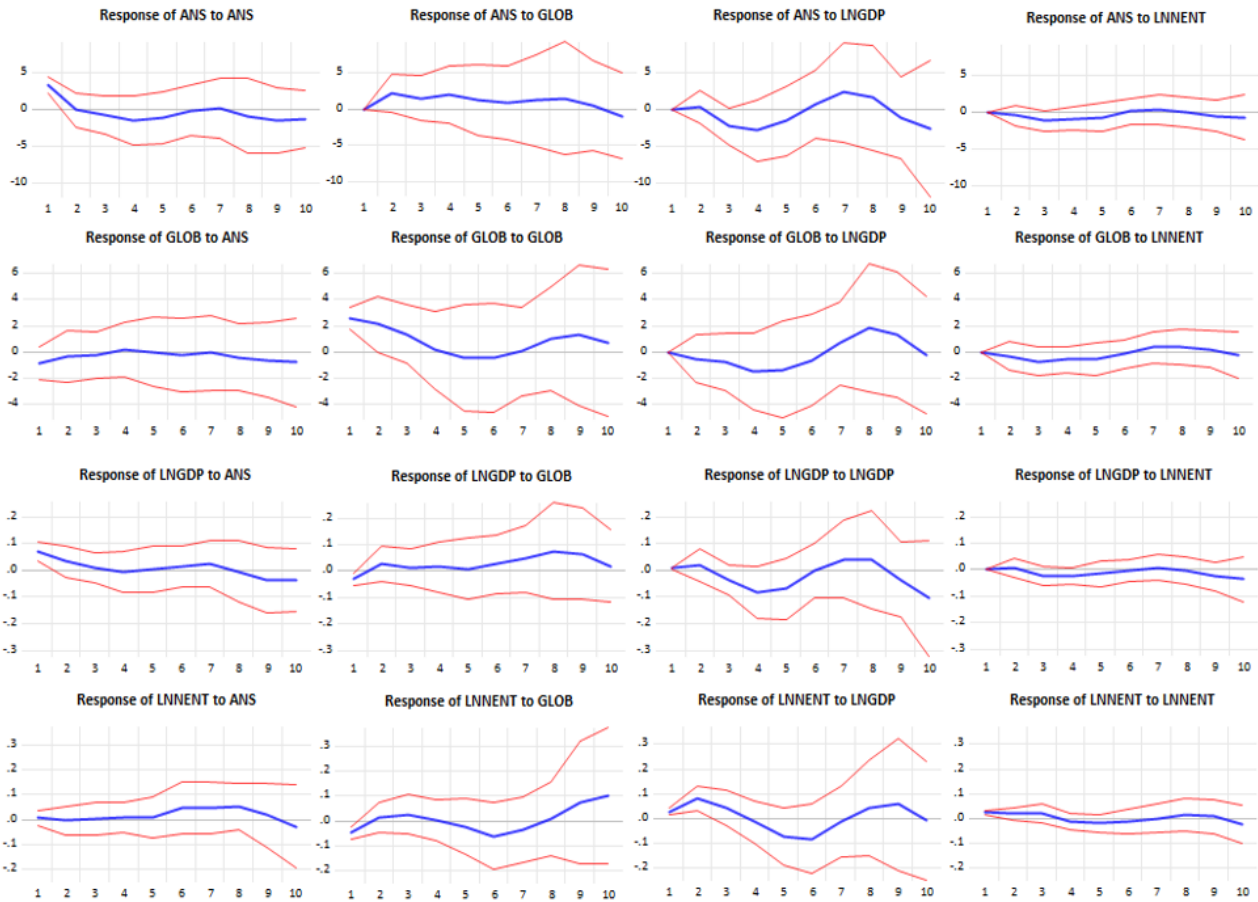


Figure 2. Response to Cholesky One S.D. (d.f. adjusted) Innovations+/- 2S.E.

Source: Authors building from data source.

5. Variance Decomposition Test

We may employ the variance decomposition as a technique in our study. According to Sims (1980)^[44], the technique enables us to see to what degree the variables interact amongst themselves by estimating the proportion of influence of each of the innovations on the variance of the aggregate error. The method of variance decomposition has been employed by other studies, including Soytaş and Sari (2007)^[67], and Sallam and Neffati (2023)^[68]. The technique will allow us to decompose the forecast variance of each variable in our model.

Table 7 shows the results of the variable decomposition analysis. As seen in this table, the variance decomposition analysis verifies the Granger causality test results. After five periods, variation in GLOB accounts for approximately 24.279% of future ANS variation; this

significant effect of globalization on sustainable development for Saudi Arabia is estimated to be 25.210% after five periods and approximately 26.492% after ten periods, reflecting the pioneering role of entrepreneurship in the Saudi economy in the short and long term. More than 30% of the error variance in GDP prediction is explained by the error variance of entrepreneurship and globalizations over ten intervals; this conclusion is due to education's inadequate contribution to economic development. The findings also show that entrepreneurial development is properly justified in the short and long run, and that economic expansion contributes to the long-term development of NENT. In essence, the 5.5% variation in the GDP forecast error is explained by the variation in the LNNENT forecast error in the tenth quarter.

Table 7. Results of variance decomposition.

Variance Decomposition of ANS:							
Period	S.E.	ANS	GLOB	LNEDUC	LNGDP	LNGGE	LNNENT
1	3.3601	100.00	0.0000	0.0000	0.0000	0.0000	0.0000
2	4.2666	62.059	24.279	11.691	0.7794	0.0690	1.1211
3	5.2639	42.691	24.096	7.7284	18.800	0.8454	5.8372
4	6.6398	32.156	23.918	6.4019	30.087	2.0516	5.3837
5	7.0624	30.714	25.209	5.7029	31.368	2.3960	5.6088
6	7.1715	29.803	25.035	5.9573	31.347	2.3712	5.4850
7	7.6566	26.193	24.249	5.3724	36.702	2.3179	5.1635
8	8.0072	25.134	25.465	4.9533	37.494	2.2311	4.7213
9	8.2441	26.647	24.372	4.7171	37.224	2.1820	4.8561
10	8.8288	25.289	26.49220	4.1526	40.970	2.3076	4.7871

Variance Decomposition of GLOB:							
Period	S.E.	ANS	GLOB	LNEDUC	LNGDP	LNGGE	LNNENT
1	2.7590	9.901494	90.09851	0.000000	0.000000	0.000000	0.000000
2	3.5645	6.631901	90.29344	0.021369	2.138208	0.264470	0.650611
3	3.9921	5.568058	83.47836	1.585007	5.115480	0.492564	3.760535
4	4.3193	4.950688	71.48442	1.577113	16.15120	0.794505	5.042076
5	4.6121	4.342111	63.71767	2.145226	22.56121	1.458795	5.774987
6	4.6866	4.453240	62.53609	2.340835	23.49712	1.468408	5.704311
7	4.7501	4.345246	60.89007	2.331398	24.84495	1.485777	6.102559
8	5.2434	4.153827	53.97782	2.130936	32.47455	1.577759	5.685111
9	5.6107	4.788908	52.54772	2.152146	33.75800	1.648380	5.104847
10	5.7261	6.530671	52.06516	2.117015	32.57323	1.601475	5.112450

Variance Decomposition of LNGDP:							
Period	S.E.	ANS	GLOB	LNEDUC	LNGDP	LNGGE	LNNENT
1	0.089516	61.22238	12.44320	25.62917	0.705246	0.000000	0.000000
2	0.105473	54.33307	15.18294	25.80389	3.977689	0.202797	0.499621
3	0.116592	45.02541	13.84259	21.40729	13.05017	2.063604	4.610937
4	0.149151	27.75954	9.522852	14.05999	39.92437	3.300085	5.433159
5	0.167435	22.16177	7.876860	11.67647	48.37125	4.682661	5.230986
6	0.170200	22.07710	9.872378	11.42246	46.83822	4.692764	5.097079
7	0.183340	20.97546	14.75848	9.914712	45.62347	4.093185	4.634697
8	0.201937	17.33140	25.90472	8.174716	41.34977	3.377310	3.862090
9	0.220164	17.12995	30.74751	6.916888	37.37442	3.213646	4.617595
10	0.251123	15.32395	24.24995	5.475663	45.68858	3.710997	5.550853

Variance Decomposition of LNNENT:							
Period	S.E.	ANS	GLOB	LNEDUC	LNGDP	LNGGE	LNNENT
1	0.061742	1.023163	60.18016	0.058765	22.44000	0.252650	16.04526
2	0.112396	0.391492	19.78701	11.17632	60.71073	0.163811	7.770638
3	0.125310	0.463646	20.46708	9.007860	60.16429	0.463513	9.433616
4	0.128040	0.823643	19.60848	9.474750	58.77777	1.613034	9.702330
5	0.150704	0.794017	16.37780	6.839363	65.07062	2.210333	8.707864
6	0.189221	6.275003	20.72801	4.837901	59.69168	2.623517	5.843888
7	0.198552	11.13987	22.04990	4.442856	54.51528	2.538820	5.313275
8	0.210728	15.77397	19.76650	3.975404	52.68537	2.374493	5.424263
9	0.231361	13.66932	26.30657	3.329142	50.09681	1.983990	4.614175
10	0.254986	12.48431	37.21727	2.749275	41.33789	1.777197	4.434068

Source: authors estimation.

The variance decomposition results in **Table 6** (lnENT), in shaping Saudi Arabia's economy under Vision 2030. Economic growth (lnGDP) and globalization (GLOB), adjusted net savings (ANS), economic growth (lnGDP), and entrepreneurship development (lnENT) emerge as central pillars across all variables, with lnGDP becoming the primary driver of vari-

ance in ANS (40.97%), education (41.75%), and entrepreneurship (41.34%) by period 10, while GLOB plays a dominant role in influencing government expenditure (34.87%) and entrepreneurship (37.22%). ANS significantly influences GDP and education in early periods, reflecting its foundational role in sustainable growth, though its impact diminishes over time as globalization and GDP take precedence. Entrepreneurship (lnENT) is a key catalyst for economic diversification with the control variable education (lnEDUC), driven by globalization and economic growth, also influenced by sustainable investments (ANS) and entrepreneurship benefiting from human capital development. The results also underscore the environmental trade-offs of growth and globalization, as (lnGDP) and GLOB explain 32.08% and 34.87%, respectively, of the variance in greenhouse gas emissions by period 10, emphasizing the need for sustainability-focused policies. These findings suggest that fostering globalization, supporting entrepreneurship, investing in education, and promoting environmental sustainability are crucial for achieving Vision 2030's goals of economic diversification, growth, and sustainability.

6. Discussion of Findings across Hypotheses

The empirical evidence robustly corroborates that the interactions among globalisation, entrepreneurship, economic growth, and agricultural development in Saudi Arabia adhere to the established patterns delineated in the existing literature. First, the results demonstrate that globalisation has a substantial impact on agricultural performance and sustainability outcomes, corroborating previous research that emphasises the role of international integration in fostering technological diffusion and efficiency improvements within the agricultural sector (Sultana et al., 2019^[9]; You & Lv, 2018^[10]; Ajam et al., 2023^[13]). This unidirectional effect from globalisation to agricultural value-added substantiates **H1**, suggesting that global openness fosters sustainable agricultural development in accordance with theoretical predictions. Second, the findings indicate that entrepreneurship Granger-causes economic growth, align-

ing with Schumpeter's (1934)^[15] "creative destruction" hypothesis and empirical evidence that entrepreneurial activity fosters innovation, productivity, and structural transformation (Acs et al., 2016^[16]; Carree & Thurik, 2008^[19]; Stoica et al., 2020^[22]). The affirmative long-term impact of entrepreneurial activity on GDP substantiates **H2**, affirming that entrepreneurship enhances economic growth in Saudi Arabia.

Third, the observed bidirectional causality between globalisation and entrepreneurship corresponds with previous studies indicating that international integration promotes technology transfer, financing, and market expansion, while entrepreneurial dynamism enhances global competitiveness (Ajide et al., 2021^[25]; Coulibaly et al., 2018^[24]; Liñán et al., 2020^[29]). This reciprocal enhancement substantiates **H3**, illustrating that globalisation enhances the beneficial impact of entrepreneurship on sustained economic growth. Finally, the strong causal link between entrepreneurship and agricultural value-added, as well as the positive impulse response and variance decomposition results, back up studies that stress the importance of entrepreneurial efforts in modernising farming systems, boosting productivity, and encouraging green innovation (Naudé, 2013^[18]; Pan et al., 2024^[30]; Suman et al., 2025^[31]; Aditi et al., 2025^[32]; Thann et al., 2025^[33]). These results support **H4**, showing that entrepreneurship is a major factor in changing agriculture and making the sector more sustainable in Saudi Arabia.

These results collectively bolster the assertion that globalisation, entrepreneurship, and agricultural transformation are interdependent catalysts of sustainable development. They are in line with Vision 2030's goal of using global integration, innovation, and modernisation of institutions to encourage economic diversification, technological advancement, and long-term environmental stewardship in Saudi Arabia (Abid & Gafsi, 2025^[2]; Ahmed et al., 2024^[35]; Alfehaid et al., 2024^[39]). The empirical evidence substantiates all four hypotheses, reinforces the theoretical propositions delineated in the literature review, and affirms that the proposed framework effectively encapsulates the dynamics propelling sustainable economic and agricultural development within the Saudi context.

7. Conclusion

This study underscores the pivotal role of entrepreneurship, globalization, and sustainability in shaping economic and agricultural development in Saudi Arabia. The findings reveal that entrepreneurship functions as a key driver of economic growth, emphasizing the importance of fostering opportunity-driven ventures and innovative business activities. Agricultural performance is closely linked to global integration, institutional quality, and sustainable practices, indicating that the sector's long-term development depends on effective governance, adoption of modern technologies, and alignment with global economic trends. Human capital emerges as a significant enabler of entrepreneurial activity, highlighting the need for continued investment in education, skills development, and knowledge-intensive sectors.

Sustainable practices and responsible entrepreneurship are shown to complement economic expansion, suggesting that policies promoting green business models and environmentally conscious production can simultaneously support economic diversification and environmental protection. Furthermore, the integration of globalization benefits into agricultural and industrial strategies reinforces the potential for enhanced competitiveness, efficiency, and food security. Overall, the evidence highlights that coordinated efforts across policy, institutional, and entrepreneurial dimensions are essential for achieving long-term, inclusive, and resilient growth. By aligning entrepreneurial initiatives with sustainability and global engagement, Saudi Arabia can foster a dynamic economic environment capable of supporting both structural transformation and the objectives of Vision 2030.

Overall, our findings confirm a positive relationship between entrepreneurship development and economic growth, showing that high levels of entrepreneurial capital are linked to higher rates of growth. This underscores the importance of redefining strategies to encourage entrepreneurship as a key driver of economic expansion. At the same time, the evidence on agriculture emphasizes the necessity of designing agricultural and environmental policies that integrate globalization benefits and

strengthen institutional frameworks to secure both sustainable growth and food security. In terms of long-term development, entrepreneurial strategies driven by opportunity recognition and institutional support appear essential, while necessity-driven entrepreneurship may only solve short-term challenges without contributing to structural transformation.

7.1. Findings Implications

The findings of this study highlight the importance of sustainable entrepreneurship as a mechanism to address market inefficiencies and promote long-term economic, social, and environmental objectives in Saudi Arabia. Specifically, entrepreneurial initiatives can translate the opportunities created by globalization and economic growth into environmentally responsible business practices, such as adopting green technologies, energy-efficient production methods, and sustainable supply chains. Policymakers and business support institutions should facilitate this by providing targeted incentives, including tax benefits, low-interest financing, and grants for environmentally innovative startups.

Moreover, capacity-building programs should focus on educating entrepreneurs about resource-efficient production, circular economy practices, and compliance with environmental standards to ensure that business expansion does not exacerbate ecological degradation. The agricultural sector, in particular, can benefit from entrepreneurial ventures that integrate modern irrigation techniques, precision agriculture, and renewable energy solutions to enhance productivity while safeguarding natural resources. By embedding sustainability into business models, entrepreneurs can correct existing market failures, reduce greenhouse gas emissions, and improve social welfare, contributing directly to Saudi Arabia's Vision 2030 goals of economic diversification and environmental sustainability.

In essence, sustainable entrepreneurship should be promoted not only as a driver of economic growth but as a practical tool to operationalize policies that balance profitability with planetary boundaries, ensuring long-term resilience for both businesses and society.

7.2. Future Research and Limitations

While this study offers valuable insights, several areas remain unexplored and warrant further investigation. First, although the research identifies significant causal relationships between globalization, entrepreneurship, and sustainable development, it does not fully dissect the underlying mechanisms driving these interactions, particularly within the Saudi Arabian context. Future studies should incorporate micro-level data on entrepreneurial activities, firm performance, and sector-specific globalization effects to offer a more detailed perspective on these linkages.

Second, the study does not explicitly examine the influence of digital transformation and technological advancements on entrepreneurship in an increasingly globalized economy. Given Saudi Arabia's Vision 2030, which prioritizes digitalization and knowledge-based industries, future research should assess how digital globalization impacts entrepreneurial development and sustainability outcomes.

Third, while the findings emphasize the role of sustainable entrepreneurship, further exploration is needed regarding policy frameworks and institutional mechanisms that can strengthen entrepreneurial resilience against external shocks, such as economic downturns and environmental challenges. Examining the role of green financing, regulatory support, and public-private partnerships in fostering sustainable entrepreneurship would be particularly beneficial for shaping long-term policy strategies.

From a policy perspective, these results suggest that agriculture in Saudi Arabia and other developing economies can greatly benefit from the opportunities offered by globalization, such as access to advanced technologies, global markets, and international best practices in sustainable farming. Encouraging new forms of entrepreneurship in agriculture; especially those based on innovation, digitalization, and green practices, can transform the sector into a more competitive and resilient driver of growth. For developed countries, investing in agricultural entrepreneurship and transferring know-how to emerging economies could foster global food security, reduce environmental pressures, and promote sustainable development worldwide. Therefore,

policies should prioritize attracting private and foreign investment in agriculture, supporting agri-tech startups, and creating stronger institutional frameworks that enable farmers and entrepreneurs to take advantage of globalization while ensuring environmental sustainability and long-term economic growth.

Finally, conducting comparative analyses between Saudi Arabia and other developing economies could provide deeper insights into the effectiveness of globalization-driven entrepreneurial policies. Future research should focus on cross-country comparisons to identify best practices and adapt policy recommendations accordingly, thereby enhancing the understanding of how globalization promotes sustainable entrepreneurship across diverse economic and institutional landscapes.

While the study provides valuable insights, it is limited by its focus on annual data from 2000 to 2020 and reliance on aggregate national-level indicators, which may mask regional variations and sector-specific dynamics. Future research could extend the analysis using firm-level or regional data to capture microeconomic heterogeneity, explore sector-specific sustainability initiatives, and assess the impact of emerging digital technologies on entrepreneurship and agricultural productivity. Additionally, incorporating other dimensions of sustainability, such as social inclusion and biodiversity, could provide a more comprehensive understanding of the drivers of sustainable development in Saudi Arabia.

Author Contributions

Conceptualization, M.N. and M.B.M.; methodology, M.N. and F.A.A.; software and validation M.B.M. and M.N.; investigation, M.B.M. and M.N.; writing—original draft preparation, M.B.M., F.A.A. and M.N.; writing, review and editing, M.N. B.A.B. and F.A.A.; visualization, F.A.A.; supervision, B.A.B.; project administration, M.N, B.A.B. and F.A.A.; funding acquisition, M.N. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request, subject to approval by relevant institutional or ethical committees.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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