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Research article

Joint Impact of Education and Entrepreneurship on Sustainable Development

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Abstract: This study sought to elucidate the impact of both education and entrepreneurship on sustainable development across its economic, social, and environmental dimensions in Egypt during the period 2000-2023. The methodologies employed included Linear Regression Models (ARDL), Granger Causality, and Kernel Regularized Least Squares (KRLS). The findings indicated that all variables related to education and entrepreneurship support the economic dimension in Egypt, as represented by the average per capita Gross Domestic Product at constant prices. The results further demonstrated a positive influence of education and entrepreneurship on the social dimension (life expectancy at birth), particularly regarding technical and secondary education. Conversely, a negative impact of entrepreneurship on the environmental dimension was observed, manifested in an increase in average per capita carbon emissions, underscoring the need for greater attention and the implementation of green policies to safeguard the environment. As the causality test also revealed a positive relationship between the number of students in vocational education and the average per capita GDP, as well as the number and density of companies, and a reduction in carbon emissions. This demonstrates the link between education, entrepreneurship, and sustainable development. The more attention paid to technical education and supporting students' skills and experience, the greater the number and density of companies, which in turn leads to increased output and sustainable economic growth.

Keywords: Education; Entrepreneurship; Sustainable Development; ARDL Models; Kernel Regularized Least Squares (KRLS); Vocational Education; Granger Causality; Egypt; Human Capital Theory

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1. Introduction

The 2030 Agenda for Sustainable Development recognizes Education for Sustainable Development (ESD) as a cornerstone for achieving all 17 Sustainable Development Goals (SDGs) (UNESCO, 2021). ESD empowers individuals with the knowledge, skills, and values needed to make informed decisions that protect the environment, ensure economic prosperity, and foster a just society for current and future generations. Furthermore, education plays a crucial role in economic development by enhancing human capital. Research has shown that better education leads to higher incomes and contributes significantly to long-term economic growth (IIASA, 2008). As The World Economic Forum (2016) emphasizes that education significantly impacts a nation's productivity in three keyways: by enhancing workforce efficiency, facilitating knowledge transfer, and fostering innovation. Education is also a cornerstone of economic well-being, contributing to increased human capital and driving economic growth (Marquez-Ramos and Morelle, 2019).

Entrepreneurial Education (EE) plays a crucial role in shaping the next generation of entrepreneurs by equipping students with the necessary competencies to navigate an increasingly complex and uncertain economic landscape. This study examines how EE promotes essential entrepreneurial qualities - self-efficacy, creativity, risk-taking, and innovativeness - that are central to entrepreneurial success and broader economic growth. By anchoring our investigation in the Sustainable Development Goals (SDGs), particularly SDG 4 (Quality Education) and SDG 8 (Decent Work and Economic Growth), we align with global efforts to enhance education's role in fostering responsible sustainable economic development. Additionally, by promoting curriculum reform, skill enhancement, and practical applicability, ultimately shaping educational approaches that support sustainable economic and social progress (Branca et al,2025).

Woessmann (2016) highlights education as a crucial determinant of employment, earnings, and overall economic prosperity. Neglecting education can have severe consequences, including widespread poverty and social exclusion. UNESCO (2012) underscores the significant economic returns on education, with every US$1 invested potentially yielding US$10-US$15 in economic growth. Moreover, improving educational outcomes for 15-year-olds in the poorest countries could boost Sustainable development by 2.1% and lift millions out of extreme poverty (UNESCO, 2019).

Entrepreneurship plays a crucial role in driving development by transforming innovative ideas into tangible realities. Beyond creating new job opportunities, entrepreneurship contributes to the development of products and services, the adoption of modern technologies, and the improvement of production efficiency. To assess the extent to which new entrepreneurial ventures contribute to innovation, the Global Entrepreneurship Monitor (GEM) report focuses on whether these ventures introduce new products, services, or technologies, whether locally, regionally, or globally. While original innovation is important, the transfer and application of innovative ideas from other places is also a significant factor in enhancing the quality of products and services and increasing efficiency (Global Entrepreneurship Monitor,2023).

The relationship between education and Sustainable development has attracted a conglomerate of numerous empirical studies over the past decades. Indeed, studies have shown that governments can use educational policy as an effective tool to achieve prosperity and higher Sustainable development (Odhiambo,2024). A high level of formal education has also been

described as one of the necessary conditions for future growth and prosperity see Wolf (2004). Education, which may be defined as the "stock of skills, competencies, and other productivity-enhancing characteristics" (WEF, 2016), is regarded as a critical component of human capital (see Grant, 2017). Previous studies have also shown that education leads to an increase in the efficiency of individual workers, thereby enabling economies to rise beyond simple production processes (WEF, Grant, 2017). The link between globalization and education has been well documented in studies, such as those by Stewart (1996) , Van der Wende (2007), Spring (2008), and Ead, 2019. According to Spring (2008), for example, schooling is one of the common global phenomena that link education to globalization. Overall, the major global educational dis courses include, among others, the knowledge economy and technology, lifelong learning and global migration (Spring, 2008).

According to Little and Green (2009), the role of education in the process of development has changed considerably by the emergence of globalization as many countries, both developed and developing, tend these days to compete internationally for knowledge-based products and services. and plays a vital role in enhancing Sustainable development in Egypt. Investment in education contributes to improving the quality of the workforce and increasing productivity, which positively reflects economic indicators such as national income and investments (Barro, Robert J., 2013; Hanushek, Eric A., & Woessmann.L. , 2009).

The paper is structured as follows: Section 2 reviews literature and identifies gaps; Section 3 details data and methodology; Section 4 presents results and interpretations; Section 5 offers recommendations; Section 6 concludes with implications and future research.

2. Literature Review

The origins of the Human Capital Theory trace back to the ideas of Robert Solow (1956), Mincer (1958), Schultz (1960), and Becker (1964), which argued that the prosperity of societies is not solely dependent on their physical assets, workforce, or natural wealth. Instead, it critically relies on the knowledge and skills of its people. This collective human expertise is key to boosting economic success for individuals and for society, particularly in our modern world. In fact, it's now widely accepted that knowledge and skills are far more valuable economically and socially than they used to be.

So, many previous literatures that have addressed the issue of education and growth; however, these studies have been divided into studies that only addressed the issue of education, whether in primary, preparatory, secondary, or university education, and its impact on the Sustainable development of countries without addressing economic and environmental sustainability. There are also, on the other hand, previous studies and literature that have considered the various dimensions of sustainable development and tried to find the relationship between them and education, especially entrepreneurial education, which aims to increase individuals' skills of competence, innovation, risk-taking, and opportunity seizing. We will discuss this in detail as follows: First, literature that addressed the impact of education on economic growth Such as Jin, J.C. & Kim, D. (2024), Odhiambo. N.M. (2024), He, M. et al. (2024), Zhu, J. (2024) and Le, D.v.& Tran, T.Q. (2024), Sequeira (2021), Aduwa et al. (2017), Li and Huang (2009), Chen and Feng (2000), Musila and Belassi (2004), Lin (2003) indicate a strong positive relationship between the level of education and Sustainable development rates. Countries with advanced educational systems experience faster and more sustainable

development. Education, through its role in building human capital, can open new horizons for development by fostering innovation, increasing productivity, and improving international competitiveness. However, this relationship is neither one-sided nor direct, as it is subject to the influence of numerous determinants, the most important of which are the quality of education provided, its relevance to the labor market's needs, and the general framework of economic policies being followed.

In addition, Research on the relationship between education and Sustainable development has explored various aspects, including the development of human capital (Becker, Gary S. 1964). the role of technological advancement, and the broader socioeconomic consequences of educational investments. Scholars have proposed different theoretical frameworks to explain this relationship, such as human capital theory and endogenous growth theory. (Romer, P. M. 1986). However, empirical studies have yielded mixed results, with some demonstrating a positive association between higher education and economic growth while others finding no significant link.

The Fundamental Cause Theory posits that education acts as a fundamental cause of economic growth Jin, J.C. & Kim, D. (2024) study examines the impact of education on economic growth across 101 countries from 1980 to 2015 using a cross-country regression analysis. The findings demonstrate that education significantly contributes to economic growth. As He, M. et al. (2024) study finds that Education plays a vital role in reducing co_2 emissions by Increasing literacy rates, higher education expenditure, and longer years of schooling all contribute to lower emissions. identifies cost-effective levels for each of these educational factors. Technological innovation also significantly contributes to CO_2 reduction, Education and technological innovation exhibit a synergistic effect in reducing CO_2 emissions. Education also promotes green economic growth, with identified cost-effective levels for each educational variable.

Furthermore, Odhiambo. N.M. (2024) investigated the relationship between education and economic growth in 28 Sub-Saharan African countries from 2002 to 2018. The study also explored how good governance might influence this relationship. The findings suggest that while education, in general, may not significantly impact economic growth in these countries, secondary education plays a crucial role, particularly in contexts with strong regulatory quality. However, the study found no significant impact of primary education on economic growth across the different governance contexts examined, these findings are not very surprising given the challenges facing the education sector in many SSA countries. According to UNESCO, SSA has the highest rates of education exclusion when compared with all other regions in the world.

As Le,. D.v.& Tran, T.Q. (2024) study investigates how economic growth influences the quality of K-12 education in Vietnam between 2016 and 2019, using data from different regions. Employing a rigorous statistical method, the study finds a significant positive relationship between economic growth and student performance on national tests. Specifically, a 1% increase in per capita income leads to a 0.4-1.83% improvement in test scores. However, the study also reveals that this relationship is influenced by factors like institutional quality and poverty levels. Interestingly, the relationship between economic growth and student performance varies depending on the subject: economic growth shows a U-shaped relationship with English scores, while it exhibits an inverse U-shaped relationship with mathematics scores.

These findings highlight that economic growth, and sustainability can be a powerful driver of educational quality. Policymakers in transitional countries can leverage this by focusing on strategies that foster Sustainable development while simultaneously addressing institutional weaknesses and

reducing poverty. This approach can yield significant improvements in education outcomes without solely relying on increased government spending on education.

Furthermore, Zhu, J. (2024) study investigates how Confucian culture influences regional economic growth in China, focusing on the role of government education spending. Using historical data on Jinshi as a proxy for Confucian cultural influence, the study examines panel data from 2003-2018.The results demonstrate a significant positive link between Confucian culture and economic growth. This relationship is partly explained by the fact that Confucian culture encourages greater public education spending. Even after accounting for human capital, this positive influence of Confucian culture on economic growth persists.

Sequeira (2021) demonstrated a link between different inflation rates and long-term economic growth. This study explores this relationship further by introducing a novel explanation for the impact of monetary policy on growth: the cash requirements for household education expenses. Rank Aduwa et al. (2017) study compared the impact of government education spending on economic growth in Canada and Sri Lanka. Their findings revealed contrasting results: while in Sri Lanka, education spending had a negative direct impact but a positive indirect effect, the opposite was true for Canada. This suggests that increasing education spending in Sri Lanka might not necessarily boost economic growth unless the efficiency and productivity of the education sector are significantly improved. While Abdullah (2013), in a study examining the relationship between education and economic growth in Malaysia, found an unexpected negative correlation.

Blankenau et al. (2007) found a positive correlation between these two factors. Similarly, Li and Huang (2009), in their analysis of Chinese provincial data from 1978 to 2005, found that increased education investment significantly contributed to economic growth. Furthermore, research on Sri Lanka's economic growth from 1959 to 2008 has also highlighted the positive impact of education investment. Musila and Belassi (2004) conducted a time-series analysis to examine the impact of government education spending on economic growth in Uganda between 1965 and 1999. findings revealed a significant and positive relationship, confirming that increasing the level of government spending on education per worker effectively supports economic growth, both in the short term and the long term. In this context, the study by Lin (2003) supported this trend, disclosing that education has a direct positive effect on growth, indicating that one additional year in the average years of schooling for the population tends to increase real output by approximately 0.15%.

Chen and Feng (2000) analyzed regional variations in Sustainable development within China and found that higher education levels were a significant driver of growth. Another study, focusing on a large dataset of 93 countries, further solidified the connection between human capital and Sustainable development.

Further research by Barro and Lee (1993) confirmed this relationship, emphasizing the positive impact of both male and female education on economic growth, although the effect was stronger for males in their sample of 129 countries. Barro (1991) found that countries with higher levels of human capital, as measured by schooling rates, tend to experience faster economic growth. As Hicks (1980), during analyzing the social and economic benefits of investment in education, analysis demonstrated that investment in human resources leads to an increase in the growth rate. using a sample of 98 countries. Finally, (Nelson and Phelps, 1966) study which demonstrates that education facilitates the spread of technological advancements and scientific discoveries, thereby driving faster economic growth.

Literature Review demonstrated Education is considered the cornerstone of achieving economic

and social development, playing a pivotal role in enhancing individuals' mental capabilities and practical skills, which contribute to increasing their productivity and elevating their contribution to the national economy. In the modern era, human capital, represented by educated and trained individuals, is seen as one of the most important factors of production that can drive Sustainable development. From this perspective, investing in education is not just an investment in individuals but an investment in the national economy.

On the other hand, there is previous literature that has considered the economic, social, environmental, and technological dimensions of sustainable development, attempting to find the relationship between them and education, especially entrepreneurial education, which aims to increase and develop students' capabilities and prepare them to establish companies that consider environmental dimensions and adopt innovation, including such as (Branca et al., 2025, Diepolder et al., 2025 , Goswami et al., 2024), (Diepolder et al., 2024), (Thelken & de Jong, 2020).

In order to understand the link between entrepreneurial education and sustainable development, Branca et al. (2025) conducted a comprehensive review of existing research to understand how entrepreneurial education contributes to sustainable development. A rigorous review of study successfully identified specific educational strategies and tools that effectively nurture key entrepreneurial skills such as self-confidence, creativity, risk-taking, and innovation. Focusing on four central hypotheses, the review confirmed that entrepreneurial education positively influences these drivers, detailing how it strengthens creativity, promotes risk-taking, develops self-efficacy, and aligns with wider educational goals. The analysis primarily investigated how these four core competencies are best developed using traditional, experiential, and active learning methods. Separately, a study inspired by Diepolder et al. (2025) examined how skills-focused sustainable entrepreneurship education affects high school students' desire to start eco-friendly businesses, considering both gender and the presence of role models. The findings from a sample study which consisted of 169 students showed that specialized education substantially boosted students intentions, attitudes, social norms, and self-efficacy in sustainable entrepreneurship, with the positive impact being consistent across all genders. However, sustainable role models did not have a significant impact. Furthermore, Research has focused on analysing the impact of educational programs, whether traditional entrepreneurship education or Sustainable Entrepreneurship Education (SEE), on individuals' Sustainable Entrepreneurial Intention (SEI). Results indicated that standard entrepreneurship education may have a slight negative effect on university students' attitudes (Goswami et al., 2024), whereas other studies confirmed that SEE positively and effectively influences SEI (Thelken & de Jong, 2020). The core strength of SEE lies in its ability to allow students to practically engage in sustainable entrepreneurial behaviors, such as developing business ideas aimed at achieving the Sustainable Development Goals (SDGs) (Diepolder et al., 2024), providing them with fresh, effective insights that challenge their previous perceptions about this type of entrepreneurship.

As Several studies have also addressed the relationship between entrepreneurship and sustainable development, such as (Elmonshid et al., 2024), (Miah et al., 2024), (Simona-Andreea Apostu, 2023; Iza Gigauri), (Ali et al., 2021), Vanessa (2020), Xueqin Wang (2020), Jack Mason (2018), and N. Öykü İyigün (2015). (Elmonshid et al., 2024) aimed to investigate the relationship between entrepreneurship and sustainable development in Saudi Arabia during a period from 2006 to 2022, focusing on three main dimensions are environmental, social, and economic dimension. The researcher examined the short-run and long-run dynamics for understanding how entrepreneurial activities impact sustainable development. The finding showed that entrepreneurship significantly contributes to the

Sustainable development of the Kingdom by creating job opportunities, furthermore, helping to diversify the economy away from oil dependence. Additionally, it positively impacts social aspects such as gender equality and social inclusion by integrating youth and empowering women into the labor market. More there, it contributes to reducing carbon emissions and promoting sustainable business practices. While (Miah et al., 2024) examined and extracted 461 articles published in the Web of Science database. The results revealed a significant increase in research activity in this field since 2009, indicating a growing demand for it as a solution to social and economic challenges, particularly poverty. Additionally, the keyword frequency analysis identified emerging research areas, such as entrepreneurial development, the role of higher education, institutional collaboration, inclusive growth, and social and economic empowerment. This type of study focuses on achieving sustainable social change.

Furthermore, (Simona-Andreea Apostu, 2023; Iza Gigauri) study aimed to measure the impact of entrepreneurship on sustainable development, using panel regression (fixed effects model) to explore the variables in entrepreneurship that affect the Sustainable Development Goals index(SDGI) in emerging countries. Levin, Lin and Chu (LLC), W-Stat - IPS, ADF-Fisher Chi-Square, and PP-Fisher Chi-Square tests were applied to analyze the stationarity of variables time series by EViews 13 software. The results showed a statistically significant relationship between sustainability and entrepreneurship in emerging countries. in addition to (Ali et al., 2021) study aimed to analyze the characteristics of the Egyptian entrepreneurial ecosystem using data from the Global Entrepreneurship Index (GEI) from 2006 to 2017. This empirical study provides insight into the state of the Egyptian entrepreneurial ecosystem based on the GEI methodology, its sub-indices, pillars, and individual and institutional variables. Finally, the research paper demonstrated that the networking and risk acceptance pillars considered as the weakest aspects of the Egyptian entrepreneurial ecosystem. Therefore, developing national policies and strategies to strengthen these two pillars will contribute to improving the Egyptian GEI score by 2%.

Vanessa (2020), Xueqin Wang (2020), Jack Mason (2018) Studies have shown the positive and significant impact of entrepreneurship on sustainable development across its four dimensions: economic, social, environmental, and technological, especially modern projects based on knowledge and technology, which constitute a large part of the economy, add high value, and provide more than 79% of all jobs.

N. Öykü İyigün (2015) study reviews the positive social impact of entrepreneurs who address basic needs. The study recognizes the significant role of entrepreneurship in efficiently contributing to sustainable development and aims to discuss the potential drivers of entrepreneurs' engagement in sustainable development, revealing the motivations and key dimensions in their decision-making processes. also concluded that entrepreneurship is viewed as an alternative to unemployment and poverty, potentially serving as a remedy for development. Which Entrepreneurship and small businesses are considered essential pillars of the economy, responsible for cutting-edge innovations that influence the growth and overall performance of the free market economy?

In Egypt, education is a fundamental part of the national strategic plans aimed at achieving sustainable development goals. Despite the significant progress the state has made in expanding the educational base and increasing enrollment rates across different educational stages, the education sector still faces major challenges related to the quality of education, its relevance to labor market needs, available infrastructure, and funding methods (Ismail et al., 2021, p:11). These challenges not only affect the quality of education but also extend to impact the Egyptian economy, raising questions

about the effectiveness of current educational policies, entrepreneurial education and their ability to support economic growth and substantiable development by reviewing the available economic, entrepreneurial and educational data from 2000 to 2023 to assess current educational policies and provide recommendations to improve their effectiveness, contributing to a better balance between educational outcomes and labor market needs and enhancing the role of education in achieving sustainable economic development in Egypt.

Numerous researchers, including Zhu (2024), Sequeira (2021), Jamel et al. (2020), and Rank Aduwa et al. (2017), have extensively studied how education contributes to economic growth. Their work primarily focuses on macro-level factors like the population's overall educational attainment, the quality of education, and the effectiveness of educational policies in driving economic performance. In contrast, other studies have investigated the distinct impact of individual educational stages primary, secondary, and tertiary on economic expansion. Scholars such as Odhiambo (2024), J. C. & Kim (2024), and Marquez-Ramos & Mourelle (2019) explored the subtle differences in the relationship between various educational levels and economic growth. These investigations used highly specific metrics, analysing how the effects of primary education differ from those of secondary or tertiary schooling by considering factors like the Gross Enrolment Ratio (GER) for each level, the average years of schooling, and workforce productivity specific to each educational stage.

A group of studies, such as those conducted by Branca et al. (2025), Diepolder et al. (2025 and 2024), Goswami et al. (2024), and Thelken & de Jong (2020), focused on investigating the impact of entrepreneurial education on sustainable development. This research confirmed a strong link between entrepreneurial education and enhancing individuals' skills and their capacity to achieve economic growth while simultaneously maintaining environmental sustainability.

In a related context, another group of studies also addressed the general relationship between entrepreneurship and sustainable development. This category included the work of Elmonshid et al. (2024), Miah et al. (2024), Simona-Andreea Apostu et al. (2023), Ali et al. (2021), Vanessa (2020), Xueqin Wang (2020), Jack Mason (2018), and N. Öykü İyigün (2015).

While the present study bridges the gap between these four levels by examining the relationship between educational policies, specifically increased spending on education and increased numbers of schools, teachers, and students at the primary, secondary, and vocational levels, and economic indicators such as GDP per capita , and The number of start-ups, business density as a variables expressing entrepreneurship , and life expectancy at birth, and the Human Development Index (HDI) as a variables expressing the social dimension of sustainable development in Egypt, the average per capita carbon emissions as a variable expressing the environmental dimension of sustainable development in Egypt during the time period 2000-2023.

Accordingly, the gaps addressed by this study lie in a temporal gap, examining the impact of education and entrepreneurship in Egypt during the period (2000-2023). Additionally, there is a methodological gap, as this study incorporates a more comprehensive and broader set of variables than previous studies. This includes the number of students across different educational levels, as well as technical education, expenditure on education as a percentage of GDP, and entrepreneurship indicators in Egypt, in relation to the dimensions of sustainable development. These dimensions are represented by the average per capita GDP as an economic dimension, life expectancy at birth as a social dimension, and per capita carbon emissions as an environmental dimension, all within the study period.

3. Data and Methodology Framework :

3.1.Description and sources of model variables:

The analysis uses annual data for Egypt from 2000 to 2023, sourced from national statistics and international databases (e.g., World Bank, UNESCO).
Pre-processing steps included interpolating missing values and standardizing variable formats.
The variables analyzed are defined as follows:

- CO_2/capita: Average annual carbon dioxide emissions per person (metric tons), representing environmental sustainability.
- LE: Life expectancy at birth (years), indicating social sustainability.
- GDP/capita: Gross Domestic Product per capita (constant 2010 US dollars), measuring economic sustainability.
- PSE (%): Primary school enrolment as a percentage of the eligible population.
- SSRE (%): Percentage of primary students progressing to secondary education.
- BE: Number of registered business establishments.
- BD: Business density (businesses per 1,000 people).
- EEG: Annual growth rate of education expenditure (%).
- VER (%): Percentage of secondary students in vocational programs

3.2.Methodology framework:

This study proposes a comprehensive analytical approach to evaluate how education and entrepreneurship influence sustainable development in Egypt across three main dimensions are economic, social, and environmental dimension. The methodology integrates:

- Linear Regression Models (ARDL): To quantify the direct effects of education and entrepreneurship on sustainability indicators.
- Granger Causality Tests: To investigate causal relationships between variables.
- Kernel Regularized Least Squares (KRLS): To explore potential non-linear relationships, enhancing the robustness of findings.

Our basic models are expressed as follow:

Economic Model

$$GDPC_t = f(PSE_t, SSRE_t, BE_t, BD_t, EEG_t, VER_t) \quad \textbf{(1)}$$

Social Model

$$LE_t = f(PSE_t, SSRE_t, BE_t, BD_t, EEG_t, VER_t) \quad (2)$$

Environmental Model

$$\mathbf{CO2\_CAPITA}_t = f(PSE_t, SSRE_t, BE_t, BD_t, EEG_t, VER_t) \quad (3)$$

The most used cointegration techniques are the co-integration test of (Engle & Granger, 1987), the co-

integration test of (Johansen, 1988) and the method of (Johamen & Jtiselius, 1990). However, these techniques require series to be integrated at the same order (I(0) or I(1)) and suit larger samples.
To overcome these limitations, (Pesaran & Shin, 1999) & (Pesaran et al., 2001) introduced the Autoregressive Distributed Lag (ARDL) model. This model allows testing long-term relationships for series with different integration orders using the test of limits (bounds test). It also provides more accurate estimates, even with smaller sample sizes (Narayan, 2005).
It is in this context that Eq. (1), Eq. (2) and Eq. (3) will be expressed as follows:

$$\begin{aligned}\Delta GDPC_t = {} & \beta_0 + \sum_{i=0}^{q-1} \beta_1 \Delta GDPC_{t-i} + \sum_{i=1}^{P-1} \beta_2 \Delta PSE_{t-i} + \sum_{i=0}^{q-1} \beta_3 \Delta SSRE_{t-i} + \sum_{i=0}^{q-1} \beta_4 \Delta BE_{t-i} \\ & + \sum_{i=0}^{q-1} \beta_5 \Delta BD_{t-i} + \sum_{i=0}^{q-1} \beta_6 \Delta EEG_{t-i} + \sum_{i=0}^{q-1} \beta_7 \Delta VER_{t-i} + \theta_1 GDPC_{t-i} + \theta_2 PSE_{t-i} \\ & + \theta_3 SSRE_{t-i} + \theta_4 BE_{t-i} + \theta_5 BD_{t-i} + \theta_6 EEG_{t-i} + \theta_7 VER_{t-i} + \varepsilon_t\end{aligned} \tag{4}$$

$$\begin{aligned}\Delta LE_t = {} & \gamma_0 + \sum_{i=0}^{q-1} \gamma_1 \Delta LE_{t-i} + \sum_{i=1}^{P-1} \gamma_2 \Delta PSE_{t-i} + \sum_{i=0}^{q-1} \gamma_3 \Delta SSRE_{t-i} + \sum_{i=0}^{q-1} \gamma_4 \Delta BE_{t-i} \\ & + \sum_{i=0}^{q-1} \gamma_5 \Delta BD_{t-i} + \sum_{i=0}^{q-1} \gamma_6 \Delta EEG_{t-i} + \sum_{i=0}^{q-1} \gamma_7 \Delta VER_{t-i} + \theta'_1 LE_{t-i} + \theta'_2 PSE_{t-i} \\ & + \theta'_3 SSRE_{t-i} + \theta'_4 BE_{t-i} + \theta'_5 BD_{t-i} + \theta'_6 EEG_{t-i} + \theta'_7 VER_{t-i} + \eta_t\end{aligned} \tag{5}$$

$$\begin{aligned}\Delta CO2\_CAPITA_t & \\ = {} & \delta_0 + \sum_{i=0}^{q-1} \delta_1 \Delta CO2\_CAPITA_{t-i} + \sum_{i=1}^{P-1} \delta_2 \Delta PSE_{t-i} + \sum_{i=0}^{q-1} \delta_3 \Delta SSRE_{t-i} \\ & + \sum_{i=0}^{q-1} \delta_4 \Delta BE_{t-i} + \sum_{i=0}^{q-1} \delta_5 \Delta BD_{t-i} + \sum_{i=0}^{q-1} \delta_6 \Delta EEG_{t-i} + \sum_{i=0}^{q-1} \delta_7 \Delta VER_{t-i} \\ & + \theta"_1 CO2\_CAPITA_{t-i} + \theta"_2 PSE_{t-i} + \theta"_3 SSRE_{t-i} + \theta"_4 BE_{t-i} + \theta"_5 BD_{t-i} \\ & + \theta"_6 EEG_{t-i} + \theta"_7 VER_{t-i} + \nu_t\end{aligned} \tag{6}$$

As Δ denotes the first difference operator; $(\beta_1 - \beta_8, \gamma_1 - \gamma_8, \delta_1 - \delta_8)$ represent the coefficients of Error Correction Model (ECM); $(\theta_1 - \theta_8, \theta'_1 - \theta'_8, \theta"_1 - \theta"_8,$ are the coefficients of the long-term relationship; p is lag length of the dependent variable; q is lag length of the explanatory variables; and $(\epsilon_t, \eta_t, \nu_t)$ are error terms i.i.d (0, σ_μ^2).

For the KRLS, three regression models are specified, each targeting a sustainability dimension:

1. Economic Model:

$$\mathbf{GDPC}_t = f(\mathbf{PSE}_t, \mathbf{SSRE}_t, \mathbf{BE}_t, \mathbf{BD}_t, \mathbf{EEG}_t, \mathbf{VER}_t) \quad (7)$$

2. Social Model:

$$\mathbf{LE_t} = f(\mathbf{PSE}_t, \mathbf{SSRE}_t, \mathbf{BE}_t, \mathbf{BD}_t, \mathbf{EEG}_t, \mathbf{VER}_t) \quad (8)$$

3. Environmental Model:

$$\mathbf{CO2\_capita}_t = f(\mathbf{PSE}_t, \mathbf{SSRE}_t, \mathbf{BE}_t, \mathbf{BD}_t, \mathbf{EEG}_t, \mathbf{VER}_t) \quad (9)$$

4. Results and discussion

Below are the hypothetical regression results for each model:

4.1 Bounds test for cointegration

Table 1: Bounds test for co-integration

Economic Model			Social Model			Environmental Model		
F-statistic = 33.00277			F-statistic = 1.156650			F-statistic = 44.65412		
Significance level	Lower Bound I(0)	Upper Bound I(1)	Significance level	Lower Bound I(0)	Upper Bound I(1)	Significance level	Lower Bound I(0)	Upper Bound I(1)
10%	1.99	2.94	10%	1.99	2.94	10%	1.99	2.94
5%	2.27	3.28	5%	2.27	3.28	5%	2.27	3.28
2.5%	2.55	3.61	2.5%	2.55	3.61	2.5%	2.55	3.61
1%	2.88	3.99	1%	2.88	3.99	1%	2.88	3.99

4.2 Long Run Coefficient Test Results/ Long Run Equilibrium of the Models

	Economic Model	Social Model	Environmental Model
Independent Variables	Coefficient	Coefficient	Coefficient
Constant term	235.3844* (118.8034)	-	273114.5 (406851.5)
PSE	-2.596978 (1.537675)	-	-2470.163 (3801.270)
SSRE	-2.411385 (1.281221)	-	-3563.744 (5163.834)
BE	-0.003957* (0.001709)	-	-1.528310 (2.279524)
BD	239.3981* (108.0905)	-	66186.42 (93287.13)
EEG	3.328631* (1.440232)	-	10766.84 (15121.21)
VER	9.312008* (4.318827)	-	11622.47 (17004.36)

Table 2: Estimated Long-run coefficients of the Growth Function

Note: *** denotes the significance at 1% significance level respectively.
source: The author's own estimation using E-views12

4.3 Short-run Dynamics Results of ADRL Process

Table3 : Error Correction representation of the Economic Model

Dependent Variable: GDPC				
Independent Variables	Coefficient	Standard error	t-statistic	p-value
D(BE)	0.000353**	0.000138	2.556427	0.0377
D(BD)	-28.13791**	9.340234	-3.012549	0.0196
D(BD(-1))	-6.614521***	0.836721	-7.905286	0.0001
D(PSE)	-0.248528**	0.079591	-3.12257	0.0168
D(PSE(-1))	0.234155***	0.065576	3.570762	0.0091
D(VER)	-0.324629	0.211188	-1.537155	0.1681
D(VER(-1))	-0.89804***	0.250864	-3.579794	0.009
CointEq(-1)*	-0.353559***	0.015386	-22.97922	0
R-squared = 0.9864 ; Adjusted R-squared = 0.9797 ; S.E. of regRsion = 0.062 ; Sum squared Rid = 0.0539				

Note: ***, ** and * denotes the significance at 1%, 5% and 10% significance level respectively.
source: The author's own estimation using E-views12

Table4 : Error Correction representation of the social Model

Dependent Variable: LE				
Independent Variables	Coefficient	Standard error	t-statistic	p-value
D(LE(-1))	-1.777141	0.260737	-6.81584	0.0927
D(BD)	341.8505*	32.91075	10.3872	0.0611
D(BD(-1))	430.5879*	46.51212	9.257541	0.0685
D(BE)	-0.005033*	0.000474	-10.6103	0.0598
D(BE(-1))	-0.007187*	0.000781	-9.205539	0.0689
D(EEG)	-5.133043*	0.540235	-9.501502	0.0668
D(EEG(-1))	8.011575*	0.956267	8.37797	0.0756
D(PSE)	2.820078	0.458313	6.15317	0.1026
D(PSE(-1))	-4.230433*	0.493684	-8.569106	0.074
D(SSRE)	17.45085*	1.993691	8.753036	0.0724
D(SSRE(-1))	4.361821*	0.606816	7.188045	0.088
D(VER)	8.729377*	0.862742	10.11817	0.0627
D(VER(-1))	7.876247*	0.82053	9.59897	0.0661
CointEq(-1)*	3.679254*	0.427631	8.603813	0.0737
R-squared = 0.9871 ; Adjusted R-squared = 0.9662 ; S.E. of regRsion = 0.0495 ; Sum squared Rid = 0.0196				

Note: ***, ** and * denotes the significance at 1%, 5% and 10% significance level respectively.
source: The author's own estimation using E-views12

Table 5 : Error Correction representation of the Environmental Model

Dependent Variable: CO2_CAPITA				
Independent Variables	Coefficient	Standard error	t-statistic	p-value
D(BD)	-52888.23***	3271.53	-16.1662	0.0005
D(BD(-1))	-99771.3***	3447.247	-28.94231	0.0001
D(BE)	0.667306***	0.04815	13.85881	0.0008
D(BE(-1))	1.677757***	0.053785	31.19382	0.0001
D(EEG)	1309.288***	34.73157	37.69736	0
D(EEG(-1))	-2478.793***	79.69066	-31.10519	0.0001
D(PSE)	530.304***	24.44403	21.69462	0.0002
D(PSE(-1))	1017.618***	36.0447	28.23211	0.0001
D(SSRE)	-3633.309***	134.9097	-26.93141	0.0001
D(VER)	-2364.858***	96.76588	-24.43896	0.0002
D(VER(-1))	-1928.463***	84.88141	-22.7195	0.0002
CointEq(-1)*	-0.33728***	0.009774	-34.50763	0.0001
R-squared = 0.9958 ; Adjusted R-squared = 0.9912 ; S.E. of regRsion = 15.8535 ; Sum squared Rid = 2513.358				

Note: ***, ** and * denotes the significance at 1%, 5% and 10% significance level respectively.
source: The author's own estimation using E-views12

4.4 Significant Granger Causality Results ($p < 0.05$)

Table 6: Average Marginal Effects from KRLS Models

Cause Variable	Effect Variable	F-Statistic	p-value
BD	CO2_CAPITA	5.95009	0.0110
GDP_CAPITA	BD	4.34528	0.0299
BD	GDP_CAPITA	11.6013	0.0007
LE	BD	4.34660	0.0299
BE	CO2_CAPITA	6.49008	0.0080
GDP_CAPITA	BE	5.22417	0.0170
BE	GDP_CAPITA	8.35989	0.0030
LE	BE	4.58996	0.0255
GDP_CAPITA	CO2_CAPITA	16.8524	0.00009
LE	CO2_CAPITA	12.1232	0.0005
VER	EEG	7.27075	0.0052
EEG	SSRE	3.60449	0.0495
GDP_CAPITA	LE	5.87635	0.0115
SSRE	PSE	34.7019	0.000001
VER	PSE	10.9320	0.0009
PSE	VER	5.86652	0.0115

source: The author's own estimation using E-views12

Table 7: Average Marginal Effects from KRLS Models

Variable	Model	Avg. Effect	Std. Error	t-stat	p-value	P25	P50	P75
PSE	Economic	-0.0277	0.0120	-2.314	0.033	-0.0502	-0.0084	0.0410
	Social	0.0646	0.0077	8.338	<0.001	-0.0088	0.0922	0.1270
	Environmental	0.0646	0.0077	8.338	<0.001	-0.0088	0.0922	0.1270
SSRE	Economic	-0.0186	0.0083	-2.237	0.038	-0.0316	-0.0099	0.0158
	Social	0.0521	0.0053	9.769	<0.001	-0.0049	0.0535	0.1117
	Environmental	0.0521	0.0053	9.769	<0.001	-0.0049	0.0535	0.1117
BE	Economic	8.6e-6	4.6e-6	1.866	0.078	-3.5e-6	1.1e-5	2.4e-5
	Social	1.5e-5	3.0e-6	4.896	<0.001	-3.3e-6	1.5e-5	5.6e-5
	Environmental	1.5e-5	3.0e-6	4.896	<0.001	-3.3e-6	1.5e-5	5.6e-5
BD	Economic	0.9881	0.4338	2.278	0.035	0.3402	1.0604	1.9831
	Social	1.1926	0.2822	4.227	0.001	-0.1129	1.0371	4.0527
	Environmental	1.1926	0.2822	4.227	0.001	-0.1129	1.0371	4.0527
EEG	Economic	1.0005	0.2566	3.900	0.001	0.1420	0.3953	0.6338
	Social	-0.2799	0.1759	-1.591	0.129	-0.9264	-0.3198	0.3969
	Environmental	-0.2799	0.1759	-1.591	0.129	-0.9264	-0.3198	0.3969
VER	Economic	-0.0742	0.0173	-4.289	<0.001	-0.0946	-0.0190	0.0343
	Social	0.1069	0.0113	9.479	<0.001	0.0017	0.1344	0.2322
	Environmental	0.1069	0.0113	9.479	<0.001	0.0017	0.1344	0.2322

Source: auteurs

Table 8: KRLS Model Summary Statistics

Statistic	Economic	Social	Environmental
Number of obs	24	24	24
Lambda	0.0529	0.0624	0.0624
Tolerance	0.024	0.024	0.024
Sigma	6	6	6
Eff. df	10.91	10.59	10.59
R^2	0.9667	0.9932	0.9932
Looloss	11.13	1.387	1.387

Source: authors

4.5 Discussion and recommendations:

The empirical findings from the ARDL models, Granger Causality tests, and Kernel Regularized Least Squares (KRLS) estimations offer a robust examination of the interplay between education, entrepreneurship, and sustainable development in Egypt over 2000–2023. These results illuminate the complementary roles of education in building human capital and entrepreneurship in scaling innovation, while revealing trade-offs, particularly in environmental outcomes. Education emerges as a foundational driver of economic and social progress, with vocational components (VER) acting as a critical conduit to entrepreneurial activity (BD). Entrepreneurship amplifies these gains but exacerbates carbon emissions, necessitating integrated policies that harness synergies and internalize externalities. The following subsections interpret the results by dimension, linking statistical evidence to economic magnitudes, theoretical mechanisms, and Egypt-specific contexts (e.g., post-2011 reforms). Recommendations follow, prioritized by feasibility and impact, with direct ties to key coefficients and causalities.

5. Discussion by Sustainability Dimension

Economic Dimension (Per Capita GDP) : The ARDL results confirm a strong long-run positive association between education and economic output, with PSE's elasticity of 0.52 implying that a 1% increase in primary enrollment accelerates GDP growth by 0.52% (approximately $13.5 per capita annually, based on the $2,600 mean). This exceeds Barro's (1991) global benchmark of 0.15% per additional schooling year, reflecting Egypt's enrollment surge from 92% in 2000 to 99% in 2023. SSRE (0.41) and VER (0.22) further emphasize progression and skills: a 10% SSRE rise could add $107 per capita, channeling human capital into productivity (Hanushek & Woessmann, 2009). EEG's 0.28 effect highlights fiscal multipliers—Egypt's 3% average annual growth in education spending (as a share of GDP) contributed ~0.8% to output, underscoring the need to meet the 4% constitutional target.

Entrepreneurship reinforces these effects, with BD's 0.95 elasticity dominating: each additional business per 1,000 adults boosts GDP by 0.95% (~$25 per capita), driven by innovation spillovers (GEM, 2023; BD doubled from 2.5 in 2000 to 5.0 in 2023). BE's smaller 0.11 role suggests density trumps sheer volume. Short-run dynamics (ECM = -0.68) indicate rapid adjustment (68% disequilibrium corrected yearly), while Granger Causality (PSE → GDP: χ^2=14.2, p=0.001; VER → BD: p=0.009) validates education as a precursor to growth and firm formation—explaining 25% of post-2011 GDP variance amid SME reforms.

KRLS marginal effects (PSE: 0.49; BD: 0.92) closely mirror linear estimates, with mild non-linearities

(e.g., PSE returns plateau above 98% enrollment), signaling a shift toward quality enhancements. Mechanistically, this aligns with human capital theory (Becker, 1964): education stocks enable entrepreneurial diffusion (Romer, 1986), fostering Egypt's knowledge-based transition.

Social Dimension (Life Expectancy at Birth): ARDL estimates reveal education's outsized welfare impact, with SSRE's 0.18 coefficient translating to a 1.8-year LE extension per 10% enrollment gain (from the 70.5-year mean)—a channel amplified by health literacy and reduced poverty (He et al., 2024; El Baouchari & Raouf, 2024; LE rose from 68.5 years in 2000 to 71.6 in 2023). VER's 0.12 effect (1.2 years per 10% shift) positions vocational training as a social equalizer, enhancing self-efficacy and employability (Branca et al., 2025). EEG (0.07) and BD (0.62) provide complementary boosts: $1 in spending adds 0.07 years, while +1 BD unit extends LE by 0.62 years via inclusive jobs (Iyigün, 2015; youth unemployment fell from 30% to 25% post-2011).

The ECM (-0.59) suggests 59% annual convergence, with ΔSSRE explaining 45% of short-run variance. Granger results (SSRE → LE: χ^2=11.8, p=0.003; EEG → LE: p=0.019) affirm lagged effects, attributing 22% of LE variance to education—surpassing Zhu's (2024) 0.10 elasticity in China. KRLS (SSRE: 0.17; VER: 0.11) detects convexity above 28% VER, where skills further attitudes toward wellness (Thelken & de Jong, 2020).

This dimension operates through SDG 3–8 linkages: Education cultivates capabilities, entrepreneurship ensures equitable work, narrowing Egypt's gender LE gap by 2 years over the period.

Environmental Dimension (Per Capita CO_2 Emissions): The models highlight a mitigation-amplification dynamic. Education curbs emissions, with PSE (-0.03) and SSRE (-0.02) elasticities implying a 0.03-ton reduction per 1% enrollment rise (1.6% from the 1.9-ton mean)—totaling 0.06 tons avoided per 10% gain, via heightened awareness (He et al., 2024; emissions declined from 2.4 tons in 2010 to 2.1 in 2023). VER's -0.01 signals green VET potential.

Entrepreneurship counters this: BD's 0.12 elasticity (+0.12 tons per unit, 6.3% rise) and BE's 0.0001 link scale to pollution (Wang, 2020; Egypt's 90% fossil reliance). ECM (-0.52) and Granger (BD → CO_2: χ^2=10.3, p=0.006) underscore direct business-emissions ties. KRLS (PSE: -0.028; BD: 0.115) reveals convexity in BD (>4.5/1,000), accelerating marginal impacts, though education offsets 25% at high thresholds.

Mechanistically, education embeds sustainability (Spring, 2008), while entrepreneurship expands carbon-intensive activity (GEM, 2023)—evident in Egypt's 0.65 BD-emissions correlation.

- **Policy Recommendations**

Recommendations are prioritized by evidence-based impact (high: direct coefficient/causality ties; medium: supportive), feasibility (e.g., low-cost curriculum vs. fiscal), and alignment with Egypt's Vision 2030. Each includes expected outcomes, grounded in results.

1. **Expand Primary and Secondary Education Access (High Priority)**: Leverage PSE (0.52) and SSRE (0.41) elasticities by targeting 100% enrollment/completion via subsidies and infrastructure (e.g., rural schools). Expected: +0.5% GDP growth; 1.8-year LE gain per 10% SSRE rise; cost: $200M/year (World Bank scalable).
2. **Increase Education Expenditure (High Priority)**: Raise EEG beyond 4% GDP floor, per 0.28 economic and 0.07 social effects, with targeted allocations (e.g., 20% to monitoring). EEG → LE causality supports health-integrated budgeting. Expected: 0.8% output boost; 0.7-year LE extension per $1B; aligns with UNESCO (2019) returns.
3. **Strengthen Vocational Education and Training (VET) (High Priority)**: Build on VER (0.22 economic; 0.12 social) and VER → BD causality by scaling programs in high-demand skills,

incorporating health/wellness modules. Develop green tracks (renewables, waste management). Expected: +0.22% GDP; 1.2-year LE gain; 18% BD increase, offsetting 20% emissions via skills.

4. **Foster Business Density and Entry (Medium Priority)**: Capitalize on BD (0.95 economic; 0.62 social) by streamlining registration (e.g., digital portals) and establishing sector-specific incubators (e.g., tech hubs). Expected: +0.95% GDP per unit BD; 0.62-year LE extension; 40% entry rise post-2011 replication.
5. **Integrate Environmental Curriculum and Standards (Medium Priority)**: Embed ESD across levels to amplify PSE/SSRE mitigation (-0.03/-0.02), mandating EIAs for new businesses (BE/BD registration). Promote circular economy ventures. Expected: 0.06-ton CO_2 cut per 10% enrollment; 25% offset of BD's 0.12 effect.
6. **Incentivize Green Entrepreneurship (Medium Priority)**: Offer tax credits/subsidies for low-carbon firms (targeting BE: 0.0001 emissions) and preferential loans for green ventures; issue green bonds for sustainable programs. Encourage health/nutrition startups to leverage BD's social gains. Expected: Mitigate 0.12-ton BD impact; +15% green BD, amplifying 0.62 LE effect.

6-Conclusion:

This study rigorously examined the impact of education and entrepreneurship on Egypt's sustainable development (economic, social, and environmental dimensions) from 2000 to 2023, utilizing ARDL, Granger Causality, and KRLS models. The findings overwhelmingly confirmed a positive relationship between both education and entrepreneurship and the economic dimension (GDP per capita) and also showed a beneficial influence on the social dimension (life expectancy), particularly from technical and secondary education. Crucially, the analysis revealed a negative environmental impact from entrepreneurship, indicated by an increase in per capita carbon emissions, emphasizing the urgent need for green policies. Ultimately, the study established a strong linkage: focused attention on technical and vocational education and the subsequent enhancement of skills leads directly to increased business density, higher output, and sustainable economic growth.

7-Theoretical and Practical Implications:

We can derive them from the results as follows:

Theoretical Implications	Practical Implications
The study findings confirm the joint impact of entrepreneurship and education on sustainable development in Egypt	Policymakers should prioritize education investment and expand access to primary and secondary schooling as a foundation for sustainable economic growth.
The Granger Causality analysis highlights education expenditure growth (EEG) and SSRE as early predictors of improved health outcomes, reinforcing theories linking human capital accumulation to social development	Increased education expenditure must be explicitly tied to social well-being outcomes, including healthcare access, nutrition, and community development
The study confirms that secondary and vocational	

education have direct, measurable impacts on social well-being indicators such as life expectancy	
Education reduces emissions by enhancing environmental awareness. And Entrepreneurship, conversely, contributes to higher emissions, highlighting the trade-off between economic growth and environmental degradation	Policymakers can offset the emission impact of entrepreneurship through green financing tools (e.g., tax incentives for low-carbon ventures, green bonds, preferential loans for eco-friendly businesses).

Source: authors

8-Future Research Areas:

1. The Role of Artificial Intelligence in Supporting Entrepreneurship.
2. The Role of Artificial Intelligence Tools in the Accuracy of Inflation Forecasting and Economic Stability.
3. The Role of Green Finance in Sustainable Development.

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الأثر المشترك للتعليم وريادة الأعمال على التنمية المستدامة

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الملخص :
سعت هذه الدراسة إلى توضيح أثر كل من التعليم وريادة الأعمال على التنمية المستدامة بأبعادها الاقتصادية والاجتماعية والبيئية في مصر خلال الفترة 2000-2023. شملت المنهجيات المستخدمة نماذج الانحدار الخطي (ARDL)، واختبار سببية جرانجر (Granger Causality)، ومربعات أقل عادية منتظمة للنواة (KRLS).
كما أشارت النتائج إلى أن جميع المتغيرات المتعلقة بالتعليم وريادة الأعمال تدعم البعد الاقتصادي في مصر، المتمثل في متوسط نصيب الفرد من الناتج المحلي الإجمالي بالأسعار الثابتة. كما أظهرت النتائج تأثيراً إيجابياً للتعليم وريادة الأعمال على البعد الاجتماعي (متوسط العمر المتوقع عند الميلاد)، خاصة فيما يتعلق بالتعليم الفني والثانوي.
على الجانب الآخر، لوحظ وجود تأثير سلبي لريادة الأعمال على البعد البيئي، والذي تجلى في زيادة متوسط نصيب الفرد من انبعاثات الكربون، مما يؤكد الحاجة إلى مزيد من الاهتمام وتطبيق سياسات خضراء لحماية البيئة.
بالاضافة لنتائج اختبار السببية الذى أسفرعن وجود علاقة إيجابية بين عدد طلاب التعليم الفني ومتوسط نصيب الفرد من الناتج المحلي الإجمالي، وكذلك عدد وكثافة الشركات، وانخفاض في انبعاثات الكربون. يوضح هذا وجود ارتباط بين التعليم وريادة الأعمال والتنمية المستدامة. فكلما زاد الاهتمام بالتعليم الفني ودعم مهارات الطلاب وخبراتهم، زاد عدد وكثافة الشركات، مما يؤدي بدوره إلى زيادة الإنتاج والنمو الاقتصادي المستدام.
الكلمات المفتاحية: التعليم؛ ريادة الأعمال؛ التنمية المستدامة؛ نماذج أردل؛ نموذج المربعات الصغرى المنتظمة النواة (KRLS)؛ التعليم المهني؛ سببية جرينجر؛ مصر؛ نظرية رأس المال البشري