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The Impact of Business Incubators in Arab Universities in Supporting Sustainable Entrepreneurship in the Era of Artificial Intelligence

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Abstract

Findings: The research reveals several key findings, the most significant being that university business incubators have a significant and positive impact on sustainable entrepreneurship. Additionally, it identifies a mediating role for artificial intelligence in enhancing sustainable entrepreneurship within the context of the sampled Arab universities.

Research Limitations/Implications: The study underscores the crucial role of university business incubators in assisting university students in securing employment by enhancing their skills and steering their research towards addressing the needs of the labor market. This, in turn, results in pioneering and strategic projects that leverage artificial intelligence, aligning with labor market demands and ensuring long-term sustainability. Key limitations identified in the study include the shortage of administrative personnel and expertise, insufficient allocated budgets, the lack of an adequate information technology infrastructure, and potential information security risks associated with the use of modern technologies.

Originality/Value: This study provides an integrative approach to the general trends observed in previous research. Its distinctive contribution lies in exploring the relationship between three critical variables—university business incubators, artificial intelligence, and sustainable entrepreneurship—by measuring them within the context of Arab universities. Through an exploratory approach, the study reveals a gap in both Arab and international literature, as no previous model has addressed the interplay between these variables, making this study unique.

Keywords: *University Business Incubators; Sustainable Entrepreneurship; Artificial Intelligence; Arab Universities.*

1. Introduction

The global trends and challenges of sustainable development and digital transformation in the 21st century have redefined the roles of higher education institutions in driving societal solutions. Universities are now required to operate as economic, social, environmental, and technological entities, utilizing innovation and entrepreneurship tools to meet global demands. This requires a focus on artificial intelligence (AI) and a commitment to working according to its evolving indicators. Within this context, sustainable entrepreneurship projects have emerged as a critical pathway to economic efficiency, and university business incubators are increasingly recognized as significant platforms for creating job opportunities for students. Several factors have contributed to the growing interest in sustainable entrepreneurship, particularly in Arab countries. These include the economic stagnation, rising unemployment rates, and volatile global markets that have been experienced in recent years, conditions that have not been observed since the Second World War (Saad, 2023). The concept of sustainable entrepreneurship refers to the

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establishment, ownership, and management of non-traditional, sustainable economic ventures aimed at achieving both financial success and personal fulfillment. Key characteristics of sustainable entrepreneurship include leadership, innovation, risk-taking, initiative, opportunity recognition, securing appropriate funding, introducing new products to the market, resource allocation, project management, and job creation (Ling & Venesaat, 2015). As a result, the role of higher education organizations in fostering innovators, inventors, and entrepreneurs has become indispensable in today's world. This necessitates an expanded role for higher education in nurturing innovative projects and transforming them into tangible products. Achieving this goal requires preparing innovative minds, supporting innovation and entrepreneurship, increasing invention rates, embracing the ideas of innovators and inventors, and addressing their lack of confidence in their inventive abilities and diminishing motivation. In response, many Arab universities have initiated programs and projects aimed at investing in the minds of youth and their creative ideas. These initiatives include the establishment of creativity and entrepreneurship centers, the organization of exhibitions, conferences, and training courses, and the integration of innovation and entrepreneurship as key focal points in these events. Such initiatives are essential for spreading entrepreneurial thinking among students, leveraging the wealth of knowledge available within the academic environment (Bisar, 2022). The current research is grounded in the fundamental belief that universities are the driving forces for societal advancement and the shaping of its future. This role is realized through the adoption of higher education policies and mechanisms that foster the development of university business incubators, with the aim of enhancing sustainable entrepreneurship through the integration of artificial intelligence. By transitioning from mere knowledge production to the initiation of knowledge-based projects, and from isolated efforts to their integration, universities can effectively contribute to a more sustainable and innovative future.

2. Research Methodology

2.1 Research Problem

Business incubators at Arab universities play a crucial role in fostering sustainable entrepreneurship, particularly within the context of artificial intelligence. These incubators provide various services and programs that assist entrepreneurs in transforming their ideas into successful ventures. However, several challenges continue to affect the effectiveness of business incubators in supporting sustainable entrepreneurship within Arab universities (Al-Otaibi, 2023). Among the key challenges are issues related to financing, infrastructure, and human capabilities. Business incubators require sufficient funding, robust infrastructure, and qualified human resources to offer the services and programs necessary for supporting entrepreneurs. Unfortunately, the financial resources allocated to these incubators remain inadequate, and many incubators lack the essential infrastructure, especially with the rapid advancement of digital transformation and artificial intelligence technologies. Furthermore, human resource development efforts are often insufficient, leading to a gap in achieving the intended goals of these incubators (Al-Sharif, 2022). As a result, there is a clear need for an expanded and more inclusive role of business incubators across Arab universities, particularly considering the organizational and financial independence of several institutions (Bisar, 2022). In light of the above, the research problem is framed around the central question: What is the role of business incubators at Arab universities in supporting sustainable entrepreneurship in the context of artificial intelligence? This main question is further explored through the following sub-questions:

i. What are the theoretical and intellectual foundations of the research variables (university business incubators, sustainable entrepreneurship, artificial intelligence) in the context of Arab universities?
ii. What is the current state of business incubators in Arab universities regarding their support for sustainable entrepreneurship in the age of artificial intelligence?
iii. What are the main obstacles hindering the effective implementation of business incubators in Arab universities in promoting sustainable entrepreneurship within the realm of artificial intelligence?
iv. What mechanisms and policies can be proposed to enhance the role of business incubators in Arab universities in supporting sustainable entrepreneurship in the context of artificial intelligence?

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2.2 Research Objectives

The objectives of this research are defined through the following key aspects:

i. To explore the theoretical and intellectual foundations of the research variables (university business incubators, sustainable entrepreneurship, and artificial intelligence) within the context of Arab universities.
ii. To assess the efforts of business incubators in Arab universities in supporting sustainable entrepreneurship, focusing on initiatives related to creativity, innovation, and entrepreneurship in the era of artificial intelligence.
iii. To analyze the current state of business incubators in Arab universities and their role in promoting sustainable entrepreneurship in light of artificial intelligence.
iv. To identify the challenges and obstacles faced by business incubators in Arab universities in effectively supporting sustainable entrepreneurship in the context of artificial intelligence.
v. To propose strategies and policies that can enhance the effectiveness and role of business incubators in Arab universities in fostering sustainable entrepreneurship through the integration of artificial intelligence.

2.3 Research Importance

This research gains its significance from the following key points:

i. Providing a comprehensive knowledge base through scientific sources on the role of business incubators at Arab universities in supporting sustainable entrepreneurship within the context of artificial intelligence, backed by both quantitative and qualitative data.
ii. Linking the research to vital administrative and economic variables, incorporating recent developments such as artificial intelligence, and analyzing their impact on sustainable entrepreneurship.
iii. Aligning with global trends by promoting entrepreneurial projects through business incubators, which contribute to expanding the innovation, invention, and entrepreneurship base, driving economic growth, and addressing the challenge of unemployment.
iv. Highlighting the efforts of Arab universities in supporting innovators, inventors, and entrepreneurs, who are a key community segment capable of contributing to societal transformation and providing solutions to various sustainable development challenges in Arab countries.
v. Aiming to benefit decision-makers and administrative leaders by providing insights to formulate developmental plans, programs, and economic and knowledge-based legislation that will support the transition of the Arab economy towards a knowledge-based economy and entrepreneurship.

2.4 Research Model

This model provides a visual representation of the research concept, illustrating the nature of the relationships and directional influences among its key variables. It has been developed based on a comprehensive review of the relevant scientific literature pertaining to the research variables. To gain a clearer and more detailed understanding of the model, it can be viewed as consisting of three interrelated components, as depicted in Figure (1).

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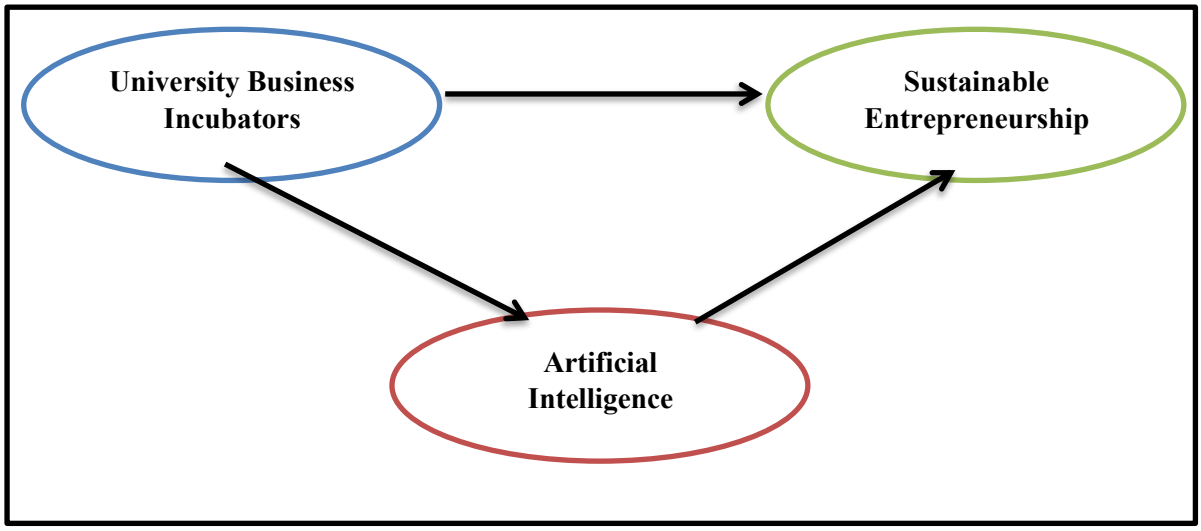

Figure (1): A conceptual model for research

2.5 Research Hypotheses

The research hypotheses have been formulated and developed based on management theories and previous scholarly efforts related to the research topic. These hypotheses aim to clarify and explain the nature of the relationship, as well as the intellectual and logical connections between the research variables, as outlined below:

i. The first hypothesis: "There is a significant impact of university business incubators in supporting sustainable entrepreneurship".
ii. The second hypothesis: "There is a significant impact of university business incubators on artificial intelligence".
iii. The third hypothesis: "There is a significant impact of artificial intelligence in supporting sustainable entrepreneurship".
iv. The fourth hypothesis: "There is a significant impact of university business incubators in supporting sustainable entrepreneurship in the context of artificial intelligence".

2.6 Research Population and Sample

To meet the practical framework requirements of the research and achieve its objectives, it was necessary to select an appropriate population for the research variables and test its hypotheses. After conducting thorough research, experimentation, and consulting experts, and considering the researchers' observation of the pressing need to apply this study in the field of higher education and scientific research, the Arab universities sector was identified as the most suitable population for this research. For the purposes of this study, five Arab universities were selected: (University of Baghdad, The University of Jordan, Cairo University, University of Sfax, and King Abdulaziz University). These universities were chosen due to their significant role in supporting and developing the higher education and scientific research sector, meeting the needs of the labor market and society, and keeping pace with scientific and technological advancements. Additionally, these institutions have established scientific partnerships, collaborations, and international agreements with leading global universities. The cooperation of the individuals involved in providing information and facilitating the research process was also a critical factor in the selection. An electronic questionnaire was designed using KoboToolbox, and it was distributed electronically to a purposive sample consisting of senior and middle management leaders, as well as faculty members at these universities. The final sample for the study consisted of (138) individuals.

2.7 The Theoretical Grounds of Research Variables

Several theories have addressed the relationship between university business incubators and sustainable entrepreneurship in the context of artificial intelligence to answer the research questions. Among the most prominent of these theories are:

i. **Cognitive Theory:** Cognitive theory is one of the most prominent theories related to scientific research and learning, focusing on three main factors: biological maturity, interaction, and the natural environment. This theory views the mind as the primary and sole source of knowledge. It is defined as the theory concerned with mental processes, treatments, and continuous interventions in the process of scientific research (thinking), aimed at organizing and integrating knowledge within the learning environment. Cognitive theory posits that cognitive learning, based on thinking, results from the researcher's serious attempt to understand their surrounding environment by using available cognitive tools (Qatami, 2013). The theory is closely associated with the mind, which stores and acquires knowledge through thinking. The researcher analyzes, discusses, inquires, and applies these processes.

ii. **Situational Theory:** Emerging in the 1970s through its pioneers such as Fred Edward Fiedler, the Situational Theory introduced a new approach to management thinking, based on the principle that no single management theory fits all times, places, and situations. Management theories must be applied according to the specific environment in order to be successful. According to the theorists, environmental and technological variables, social values, and desired outcomes play a crucial role in selecting and applying this or that theory. The concept of an "optimal way to work" does not exist; rather, there is the "appropriate method for each work environment." Skilled management identifies the influencing factors in a given context, allowing for the selection of the appropriate approach to improve organizational performance. It seeks to harness employees' skills and competencies to enhance overall productivity (Al-Ani, 2024).

iii. **Social Exchange Theory:** Proposed by sociologist George C. Homans in 1985, Social Exchange Theory is widely applied in organizational behavior and entrepreneurship. Originating from multiple scientific and social disciplines, including management, sociology, and psychology, the theory suggests that individuals who receive resources or benefits from others are more inclined to reciprocate (Jang, 2018). According to this theory, university business incubators enhance universities' commitment to entrepreneurship by guiding students' research toward the labor market and facilitating job opportunities after graduation. Additionally, they contribute to the creation of new projects that meet the evolving market demands, thus promoting sustainable development. In return, business incubators and universities benefit from equity in the projects established, gaining resources for the services they provide to students.

iv. **Stakeholder Theory:** Stakeholder theory assumes that the owners of organizations are not the only group with an interest in its success; rather, the organization is an integrated entity consisting of a group of stakeholders, both internal and external, who are either direct or indirect participants. These stakeholders are interconnected by a shared interest: benefiting from the activities, outcomes, and goals of the organization. They both influence and are influenced by the organization's success or failure (Hamed & Fisal, 2023). Proponents of this theory emphasize the importance of stakeholders, advocating that organizations should create value for all those who influence and are influenced by the achievement of organizational objectives. The theory envisions every organization as a network of interconnected relationships internal and external united by common interests, with the aim of achieving shared goals (Thomas & Lamm, 2012).

3. Literature Review

3.1 University Business Incubators

3.1.1 Concept of University Business Incubators

The concept of university business incubators has attracted significant attention from researchers and economists. Despite its relatively recent emergence, it has sparked discussions and debates, leading to varying

perspectives among individuals and organizations involved in science, technology, artificial intelligence, entrepreneurship, and sustainable development. This has resulted in the absence of a comprehensive and unified definition of business incubators. However, there are several definitions that align with the general concept relevant to the current research, including: University business incubators are centers established by universities that house a team of experts, mentors, and investors who provide services such as guidance, networking, office space, administrative support, and access to knowledge and experience. These services are designed to assist university entrepreneurs in developing their businesses and meeting the needs required to establish their own projects (Hoffman & Kelley, 2012). Additionally, university business incubators are defined as units managed by the university to optimize the intellectual and technical resources available within the institution. These incubators support both economic activity and the academic community, specifically focusing on student entrepreneurs (Siemieniuk, 2015). Another definition describes university business incubators as an integrated set of services, facilities, and mechanisms that offer support, guidance, and consultation to entrepreneurs aiming to establish organizations or small projects over a specified period. The goal is to reduce the initial costs, which are often the most challenging for entrepreneurs and small business owners. These incubators are seen as partnership projects among stakeholders, providing the necessary support to new companies by generating and refining creative ideas from university students and transforming them into viable job opportunities that meet the needs of the labor market. They focus on the generation, preservation, dissemination, and conversion of knowledge into broader social and economic benefits (Alsaad, 2021). University business incubators are integrated service centers affiliated with universities, offering programs, activities, and services that guide students toward entrepreneurship, innovation, and creativity. They assist students in developing their ideas and transforming them into successful entrepreneurial ventures, providing support and consulting on how to manage, grow, and sustain these projects, ensuring their continuation and success (Zuhair, 2021).

3.1.2 Objectives of University Business Incubators

University business incubators play a crucial role in helping universities transition into the knowledge and artificial intelligence era. These incubators are developmental and economic centers established within universities to support and nurture creative, innovative students, and researchers with project ideas. Their objectives can be defined as follows (Al-Ani, 2024):

i. To assist university graduates with innovative ideas in establishing their own organizations and entrepreneurial ventures.
ii. To help researchers transition from the laboratory phase of their research to practical applications, leading to commercial production.
iii. To promote creative ideas by encouraging incubators to align with the local business environment and ensure that the services and products developed are effectively brought to market.
iv. To support entrepreneurs, innovators, and researchers in transforming their ideas into pioneering projects that benefit the local community by providing services, support, and scientific guidance.
v. To enable university researchers and economists to utilize the outcomes of their research conducted within incubators and scientific research centers to advance education and contribute to economic development in society.
vi. To foster connections between educational institutions and the economic, industrial, and commercial sectors, facilitating collaboration and mutual growth.
vii. To contribute to the transfer of technology from advanced countries, enhancing its utilization and application to support scientific development and the establishment of successful projects.

3.1.3 The most important Arab experiences in the field of university business incubators

i. **The Jordanian Experience:** The first business incubator in Jordan was established in 1988 under the name "Jordan Technology Group". It was a profit-oriented technological incubator focused on supporting technological entrepreneurial projects by providing technical, consulting, financial, and marketing services. Over its operational period, it contributed to the creation of 13 entrepreneurial

projects that generated between 880 and 900 job opportunities. Unfortunately, the incubator ceased operations in 2001 due to limited financial capacity (Qataf, 2016). The second incubation initiative in Jordan began in 1996, with the establishment of a business incubator by the Jordan Women Business Forum (Al-Ain & Talbouni, 2005). Currently, Jordan is home to eight business incubators, most of which operate within academic and university organizations.

ii. **The Egyptian Experience:** Egypt's experience in business incubation is one of the earliest in the Arab world, following Jordan. The country managed to establish a number of incubators across various governorates as part of its national program launched through the Egyptian Association for Small Project Incubators in 1995, with support and funding from the Social Development Fund. A strategic plan aimed at creating 21 business incubators was developed, of which only seven are currently operational, supporting projects across multiple fields. Several other incubators are still under construction (Jad Allah, 2018).

iii. **The Tunisian Experience:** Tunisia began its business incubation journey in 1999 following an agreement between the Ministry of Industry and Mines and the Ministry of Higher Education and Scientific Research. This was part of the government's desire to support young people wishing to start their own entrepreneurial projects and to assist startups in integrating into the labor market. Several incubators were established, including El Ghazala Technology and Communications Park in 1999, Nabeul Technology, Sfax Creative Incubator in 2001, Gabes Technology Development Incubator in 2002, Gafsa Future Technology Incubator, Sousse Technological Innovation Incubator in 2003, and Kairouan Technological Innovation Incubator in 2004. These incubators expanded to cover all governorates in Tunisia (Zmit, 2015).

iv. **The Saudi Experience:** The official emergence of incubators in Saudi Arabia dates back to 2002, with the establishment of the first entrepreneurship center, which included the first fully operational business incubator based on the concept of business incubation. In 2008, King Abdulaziz University for Science and Technology launched the Bader Technology Business Incubator, focused on supporting entrepreneurship in the field of information and communication technology. In 2009, the Saudi Business Incubators Network was founded as a guiding entity to help, encourage, and provide best practices for business incubator programs. This unified national network works to develop and support the business incubation industry, facilitating the exchange of experiences and information between Saudi business incubators, decision-makers, beneficiaries, and stakeholders (Yusuf & Abis, 2015). By the end of 2014, the number of incubators had reached 20, operating in various fields according to the Saudi Incubators Network estimates (Sulaiman & Abdul Qadir, 2020).

v. **The Iraqi Experience:** Despite the importance of business incubators in supporting entrepreneurship and driving economic growth, Iraq's experience in this field is relatively new and requires further research for successful implementation. The Iraqi Ministry of Higher Education and Scientific Research established a Higher Education Incubator Division in 2015, which was linked to the Director General of the Research and Development Department. This division became an official department in 2019, with branches and units established in Iraqi universities. The department's vision is to drive Iraq's economy by supporting creative and talented entrepreneurs, promoting the culture of private enterprise, and fostering a generation capable of self-reliance (Al-Obaidi et al., 2020).

3.2 Sustainable Entrepreneurship

3.2.1 Concept of Sustainable Entrepreneurship

The literature on entrepreneurship has not yet fully captured or explained the logic behind creating current value for the economy, society, and the environment, while simultaneously contributing to the well-being of future generations at both conceptual and empirical levels. While traditional economic definitions of entrepreneurship acknowledge the impact of entrepreneurial activity, sustainable entrepreneurship introduces a new logic. It focuses

on generating current value for the economy, society, and the environment, while also energizing future generations and creating opportunities that pursue multiple outcomes simultaneously—namely, economic, social, and environmental sustainability to ensure the generation of wealth in the future (Pablo Munoz, 2013). In this context, sustainable entrepreneurship connects sustainable development with entrepreneurial activity. It is a comprehensive concept that encompasses environmental entrepreneurship, green entrepreneurship, and social entrepreneurship. However, these terms are often interconnected and difficult to clearly distinguish from one another, and at times they can be ambiguous (Majid & Koe, 2012). Sustainable entrepreneurship has been defined as an innovative, market-oriented, and personality-driven approach to creating economic and social value through organizational or market innovations that are either environmentally or socially beneficial (James Bell, 2012). Additionally, it has been described as the process of establishing ventures that align entrepreneurial activities with the creation of organizations that generate value and contribute to achieving sustainable development for the ecological community of the system (Stiglitz, 2016). It is also viewed as the innovative behavior of individuals or organizations in the business sector that regard environmental, social, or economic issues as central objectives in achieving sustainable development goals (Crals & Vereeck, 2016).

3.2.2 Objectives of Sustainable Entrepreneurship

Sustainable entrepreneurship encompasses the fundamental objectives of social entrepreneurship, including creating social impact, addressing community challenges, and enhancing social wealth. The aim of sustainable entrepreneurship is to capitalize on new opportunities and contribute to making the world a better place, reflecting the goal of achieving broader community objectives (Sam Sarpong, 2022). The core objectives of sustainable entrepreneurship include the following (Ibrahim, 2021):

i. Strategically directing goals with a focus on environmental and social considerations.
ii. Organizing creative efforts to solve problems related to the sustainability agenda, with the aim of achieving economic, social, and environmental sustainability.
iii. Creating current value for the economy, society, and the environment while contributing to the empowerment of future generations.
iv. Studying how to discover opportunities, develop new products, and exploit them, while considering the economic, psychological, social, and environmental consequences.
v. Monitoring business opportunities to identify future products and processes, contributing to the sustainability of the community, economy, and environment, thereby enhancing the well-being of future generations.
vi. Embodying a new approach to entrepreneurial value creation that promotes social justice, protects the environment, fosters economic prosperity, and ensures intergenerational equality.
vii. Pursuing new opportunities to introduce future products and processes that align with the goals of both the organization and society.

3.3 Artificial Intelligence

3.3.1 Concept of Artificial Intelligence

The concept of artificial intelligence (AI) is a relatively recent term that has garnered significant attention from individuals and organizations. This growing interest has led many entities to adopt AI as a strategy to enhance their performance. Defining artificial intelligence is challenging for researchers, as there are varying perspectives on the concept due to differences in research fields and areas of expertise. Artificial intelligence is regarded as a modern technology developed towards the end of the 20th century, encompassing a wide range of applications and software that simulate human intelligence or demonstrate intelligent behaviors to perform and improve tasks based on data and information (Bhagat et al., 2022). The term artificial intelligence, first introduced by John McCarthy in 1955, refers to a computer system capable of performing various human cognitive tasks, such as communication, thinking, learning, and problem-solving. AI mimics human-like processes such as learning, adapting, synthesizing, and using data for self-correction during complex situations. AI represents a broad term that includes various technologies and

algorithms, such as machine learning, natural language processing, data mining, and neural networks (Gulavani et al., 2022). It is defined as the simulation of human intelligence processes by machines, with the aim of developing computer systems capable of performing tasks that typically require human intelligence. The goal of AI techniques is to replicate human behavior and cognitive functions to create systems capable of performing tasks that usually necessitate human intervention. AI systems have been integrated into various sectors to improve service quality, enhance operational efficiency, and optimize resource utilization (Tulcanaza-Prieto et al., 2023). The Organization for Economic Co-operation and Development (OECD) defines AI as a machine-based system that can achieve specific goals defined by humans, such as making predictions, providing recommendations, or making decisions that impact real or virtual environments. AI systems are also designed to operate at varying levels of autonomy. The AI system lifecycle includes stages such as planning, design, data collection and processing, model development and interpretation, verification and validation, deployment, operation, and ongoing monitoring (OECD, 2020).

3.3.2 Characteristics of Artificial Intelligence

The fundamental principle behind artificial intelligence does not focus solely on solving problems faster, processing more data, or storing as much information as possible from the human mind. Rather, it is about processing information, regardless of its nature or size, in an automatic or semi-automatic manner that aligns with specific goals. Artificial intelligence is based on the concept of "creating intelligent machines that behave like humans," utilizing a comparative approach to human problem-solving, managing hypotheses simultaneously with high accuracy and speed. AI possesses several key characteristics, as outlined below (Al-Hadidi & Zayed, 2024):

i. Problem-solving and cognitive functions: AI can solve presented problems while engaging in thinking, perception, acquiring knowledge, and applying it to real-world scenarios.
ii. Visualization and creativity: It has the ability to visualize, understand, and perceive visible matters, providing innovative solutions.
iii. Distinguishing the relative importance of elements: AI can discern the relative importance of different elements in known cases, allowing for better decision-making.
iv. Learning from past experiences: AI systems can learn and improve from past experiences, making them more effective in future tasks.
v. Handling ambiguous situations: AI is capable of dealing with uncertain or incomplete information, enabling it to operate in ambiguous environments.
vi. Managing complex cases: AI is designed to process and manage difficult, intricate, or complex scenarios that may be beyond human capacity.
vii. Utilizing past experiences: AI systems can apply previous experiences and knowledge to solve new problems or adapt to new situations.
viii. Rapid response to new situations: AI is responsive to new and dynamic circumstances, enabling quick adaptation to changes in the environment.

4. Results and Discussions

4.1 Confirmatory Factor Analysis Test

4.1.1 Confirmatory Factor Analysis Test For University Business Incubators

The independent variable model of university business incubators was assessed using 13 items, in alignment with the recommendations of quality compliance indicators and structural equation modeling, as illustrated in Figure (2).

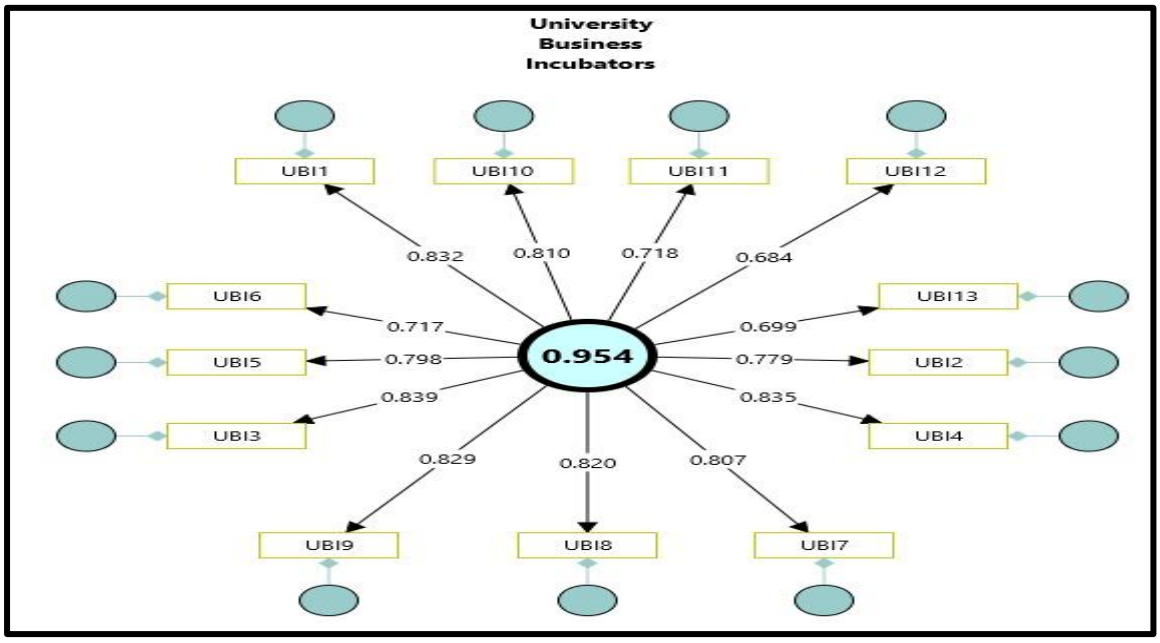

Figure (2): Confirmatory factor analysis of the variable model of university business incubators

Source: Outputs of the (Smart Pls4) Program.

It is evident from Figure (2) that the standardized loadings for all items exceed the threshold of (0.50), indicating the acceptance of all items that represent the structure of the university business incubators variable. This aligns with the required standards for the model. Consequently, it can be concluded that all items of the university business incubators variable exhibit significant relevance, providing a strong and sufficient basis for adopting the model in its final form for subsequent statistical analyses.

4.1.2 Confirmatory Factor Analysis Test For Sustainable Entrepreneurship

The dependent variable model of sustainable entrepreneurship was assessed using 13 items, in accordance with the quality compliance indicators and structural equation modeling recommendations, as illustrated in Figure (3).

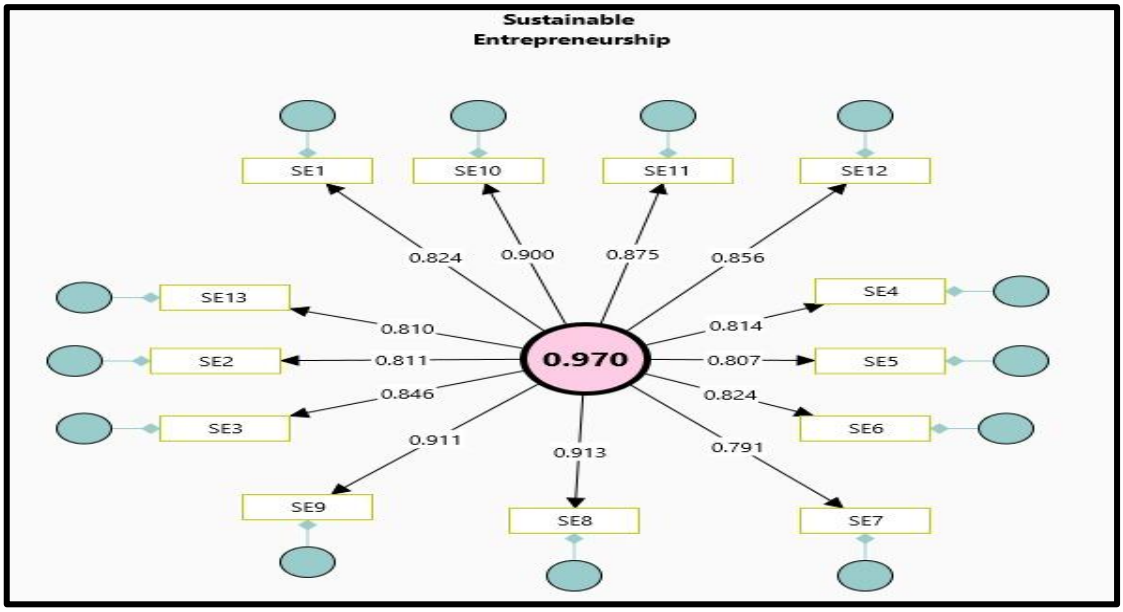

Figure (3): Confirmatory factor analysis of the variable model of sustainable entrepreneurship

Source: Outputs of the (Smart Pls4) Program.

It is evident from Figure (3) that the standardized loadings for all items exceed the threshold of (0.50), indicating the acceptance of all items representing the structure of the sustainable entrepreneurship variable, in line with the required model standards. This suggests that all items of the sustainable entrepreneurship variable demonstrate significant relevance, providing a robust and sufficient basis for adopting the model in its final form for subsequent statistical analyses.

4.1.3 Confirmatory Factor Analysis Test For Artificial Intelligence

The model of the mediating variable of artificial intelligence was assessed using 13 items, in accordance with the recommendations of the goodness-of-fit indicators and structural equation modeling, as shown in Figure (4).

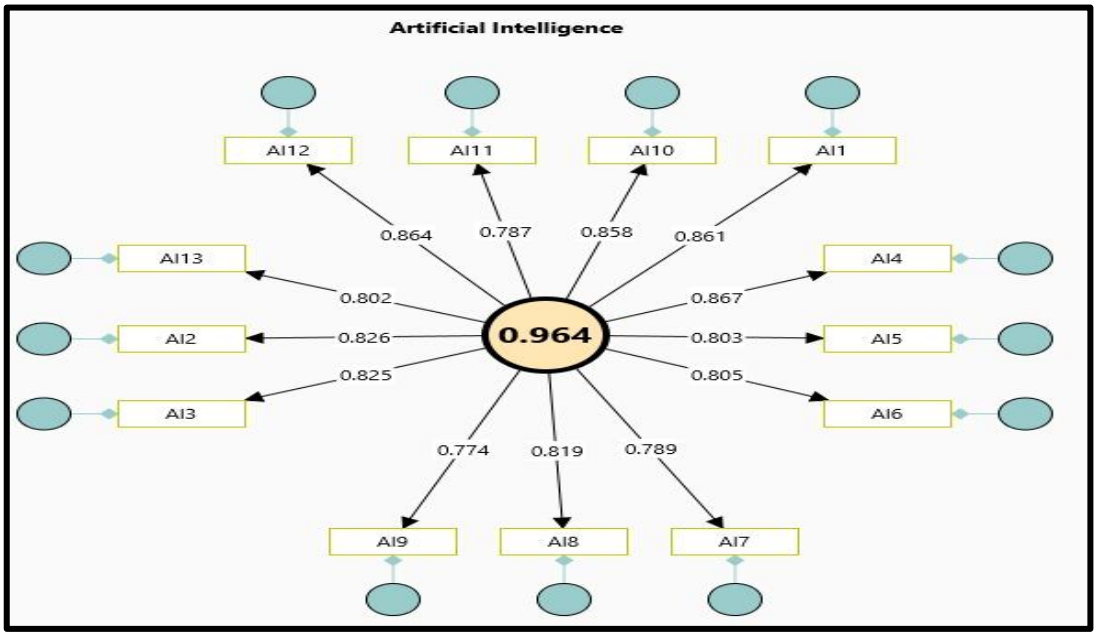

Figure (4): Confirmatory factor analysis of the variable model of artificial intelligence

Source: Outputs of the (Smart Pls4) Program.

It is evident from Figure (4) that the standardized loadings for all items exceed the threshold of (0.50), indicating the acceptance of all items representing the structure of the artificial intelligence variable. These items conform to the required model standards. This suggests that all items of the artificial intelligence variable are significantly relevant, providing a strong and sufficient basis for adopting the model in its final form for subsequent statistical analyses.

4.2 Test and Analyze Research Hypotheses

4.2.1 Testing and Analyzing the First Hypothesis

It The results of the analysis of the impact of university business incubators on sustainable entrepreneurship, as shown in Table (1) and Figure (5), were derived through simple linear regression testing. The calculated value of (F) was (231.851), which exceeds its tabulated value of (3.940) at a significance level of (0.05), indicating that the model is valid for analysis. Furthermore, the calculated value of (t) was (15.227), which is greater than the tabulated value of (t) (1.984). The coefficient of determination (R^2) was found to be (0.664), meaning that (%66.4) of the variation in sustainable entrepreneurship is explained by university business incubators. This suggests a significant effect of university business incubators on sustainable entrepreneurship. Additionally, the constant value (α) was (0.739), indicating that sustainable entrepreneurship exists even when the value of university business incubators is zero. The (β) parameter value indicates that a one-unit change in university business incubators leads to a (0.819) change in sustainable entrepreneurship. Based on these findings, the first hypothesis, which states, " There is a significant impact of university business incubators in supporting sustainable entrepreneurship," is confirmed.

Table (1): The impact of university business incubators on sustainable entrepreneurship

Independent Variable	Dependent Variable	(α)	(β)	(R^2)	(F)	(t)	(Sig)
University Business Incubators	Sustainable Entrepreneurship	0.739	0.819	0.664	231.851	15.227	0.000
Tabular (F) value = 3.940 // Tabular (t) value = 1.984 // Sample volume =138 // Sig level = 0.05							

Source: Outputs of the (SPSS V.29) Program.

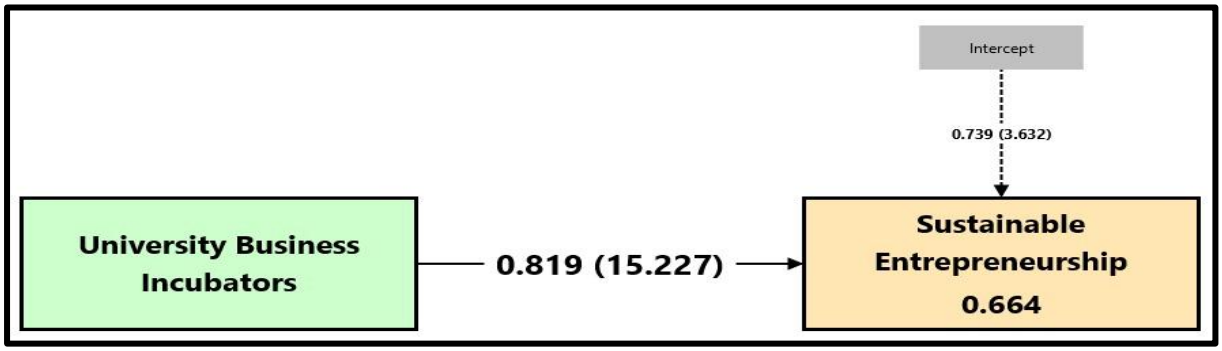

Figure (5): The impact of university business incubators on sustainable entrepreneurship

Source: Outputs of the (Smart Pls4) Program.

4.2.2 Testing and Analyzing the Second Hypothesis

It is evident from Table (2) and Figure (6) that the results of the analysis of the impact of university business incubators on artificial intelligence, through simple linear regression testing, are as follows. The calculated value of (F) was (305.824), which is greater than its tabulated value of (3.940) at a significance level of (0.05), indicating that the model is valid for analysis. The calculated value of (t) was (17.488), which exceeds the tabulated value of (t) (1.984). It is also evident that the value of the coefficient of determination (R^2) was (0.723), meaning that (%72.3) of

the variation in artificial intelligence is explained by the variation caused by university business incubators. This indicates that university business incubators have an impact on artificial intelligence. Additionally, the value of the constant (α), which signifies the presence of artificial intelligence, was (0.186), even if the value of university business incubators is zero. The value of the parameter ((β)) indicates that a one-unit change in university business incubators leads to a (0.954) change in artificial intelligence. Based on these results, the second hypothesis, which states, " There is a significant impact of university business incubators on artificial intelligence," is confirmed.

Table (2): The impact of university business incubators on artificial intelligence

Independent Variable	Mediating variable	(α)	(β)	(R^2)	(F)	(t)	(Sig)
University Business Incubators	Artificial Intelligence	0.186	0.954	0.723	305.824	17.488	0.000
Tabular (F) value = 3.940 // Tabular (t) value = 1.984 // Sample volume =138 // Sig level = 0.05							

Source: Outputs of the (SPSS V.29) Program.

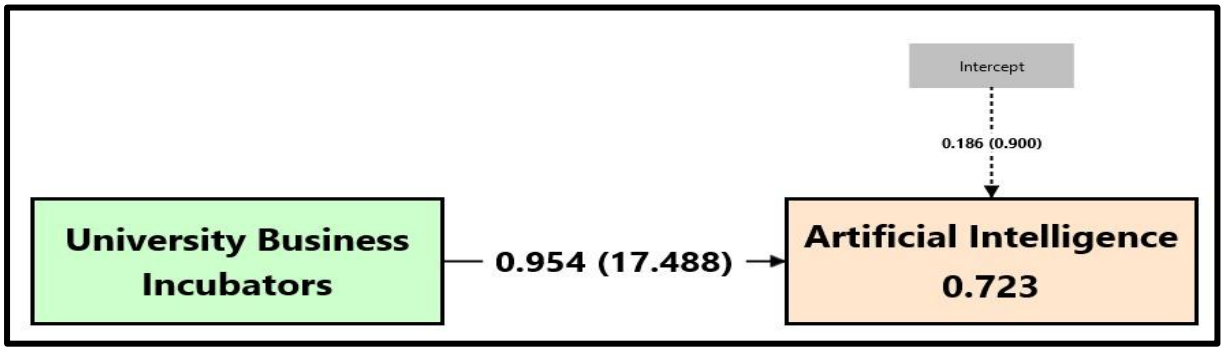

Figure (6): The impact of university business incubators on artificial intelligence

Source: Outputs of the (Smart Pls4) Program.

4.2.3 Testing and Analyzing the Third Hypothesis

The results of the analysis of the impact of artificial intelligence on sustainable entrepreneurship, as shown in Table (3) and Figure (7), were derived through simple linear regression testing. The calculated value of (F) was (565.001), which is greater than its tabulated value of (3.940) at a significance level of (0.05), indicating that the model is valid for analysis. The calculated value of (t) was (23.770), which exceeds the tabulated value of (t) (1.984). Additionally, the coefficient of determination (R^2) was (0.828), meaning that (%82.8) of the variation in sustainable entrepreneurship is explained by artificial intelligence. This indicates a significant impact of artificial intelligence on sustainable entrepreneurship. The results further show that the constant value ((α)), which signifies the presence of sustainable entrepreneurship, is (0.739), even when artificial intelligence is zero. The value of the parameter (β) indicates that a one-unit change in artificial intelligence will lead to a (0.816) change in sustainable entrepreneurship. Based on these findings, the third hypothesis, which states, " There is a significant impact of artificial intelligence in supporting sustainable entrepreneurship," is confirmed.

Table (3): The impact of artificial intelligence on sustainable entrepreneurship

Independent Variable	Dependent Variable	(α)	(β)	(R^2)	(F)	(t)	(Sig)
University Business Incubators	Sustainable Entrepreneurship	0.739	0.816	0.723	565.001	17.488	0.000
Tabular (F) value = 3.940 // Tabular (t) value = 1.984 // Sample volume =138 // Sig level = 0.05							

Source: Outputs of the (SPSS V.29) Program.

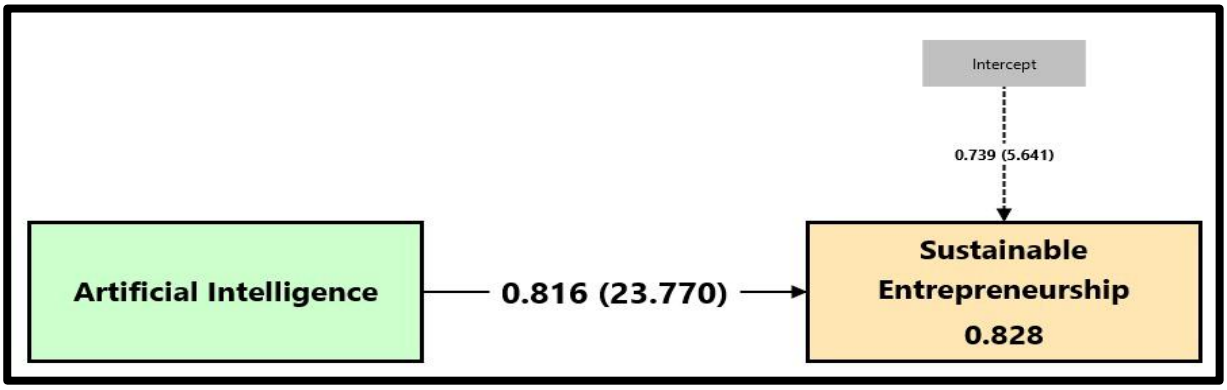

Figure (7): The impact of artificial intelligence on sustainable entrepreneurship

Source: Outputs of the (Smart Pls4) Program.

4.2.4 Testing and Analyzing the Fourth Hypothesis

After confirming the existence of the effect between the research variables, we move to the second phase, which is testing the significance of the mediating variable of artificial intelligence and whether it has an effect on enhancing the relationship between university business incubators and sustainable entrepreneurship. It is evident from Table (4) and Figure (8) that the results of the analysis of the impact of university business incubators on entrepreneurship in the context of artificial intelligence are as follows. The calculated value of (t) for university business incubators in artificial intelligence was (17.563), which exceeds the tabulated value of (1.984), indicating a significant positive effect of university business incubators on artificial intelligence. The results also show that the calculated value of (t) for university business incubators in sustainable entrepreneurship was (2.078), which is greater than the tabulated value of (1.984), indicating a significant positive effect of university business incubators on sustainable entrepreneurship. Additionally, the calculated value of (t) for artificial intelligence in sustainable entrepreneurship was (10.978), which is greater than the tabulated value of (1.984), demonstrating a significant positive effect of artificial intelligence on sustainable entrepreneurship. The previous results indicate that artificial intelligence plays a mediating role in influencing the relationship between university business incubators and sustainable entrepreneurship. The results further show that the value of the indirect effect of university business incubators on sustainable entrepreneurship was (0.670), which is greater than the direct effect of university business incubators on entrepreneurship (0.149). This suggests that the effect of artificial intelligence in the relationship between university business incubators and sustainable entrepreneurship is a partial effect, i.e., (partial mediation). Based on these findings, the fourth hypothesis, which states, " There is a significant impact of university business incubators in supporting sustainable entrepreneurship in the context of artificial intelligence," is confirmed.

Table (4): The impact of university business incubators on sustainable entrepreneurship in the age of artificial intelligence

Search variables			Direct impact	Indirect effect	(S.E)	(t)	(P)
University Business Incubators	--->	Artificial Intelligence	0.954	---	0.054	17.563	***
University Business Incubators	--->	Sustainable Entrepreneurship	0.149	0.670	0.072	2.078	0.038
Artificial Intelligence	--->	Sustainable Entrepreneurship	0.702	---	0.064	10.978	***
Tabular (F) value = 3.940 // Tabular (t) value = 1.984 // Sample volume =138 // Sig level = 0.05							

Source: Outputs of the (Smart Pls4) Program.

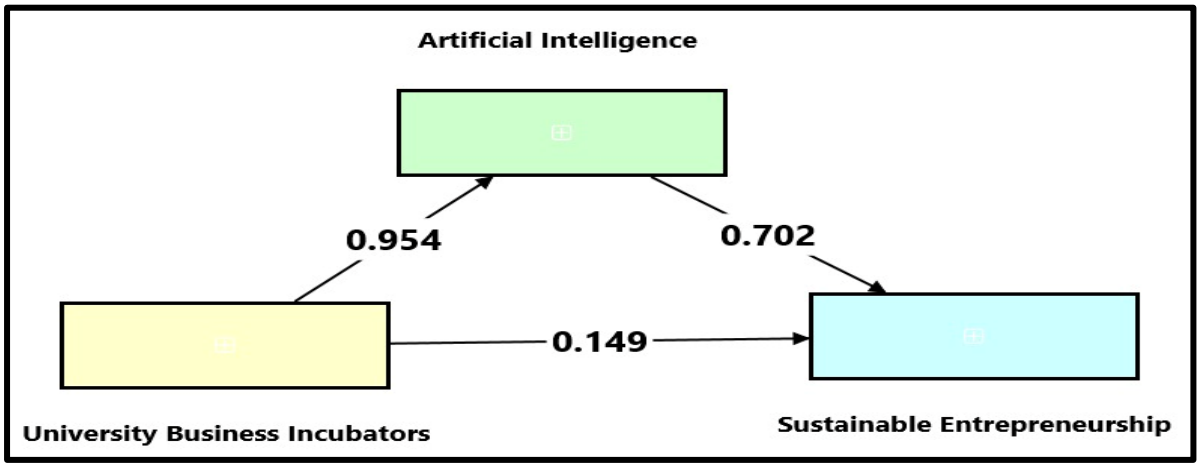

Figure (8): The impact of university business incubators on sustainable entrepreneurship in the age of artificial intelligence

Source: Outputs of the (Smart Pls4) Program.

5. Conclusions And Recommendations

5.1 Conclusions

a. The role of university business incubators in fostering entrepreneurial thinking remains limited and lacks sustainability, primarily focusing on the relative production of knowledge without emphasizing their role in launching knowledge-based projects and products driven by artificial intelligence.

b. The contribution of Arab universities in enhancing the indicators of sustainable economic development is still constrained due to the insufficient capabilities of university business incubators in nurturing entrepreneurial ideas and projects.

c. There are several barriers—regulatory, financial, human, and knowledge-related—that hinder the effectiveness of university business incubators in supporting sustainable entrepreneurship, particularly in the context of artificial intelligence.

d. The efforts of university business incubators in supporting sustainable entrepreneurship remain somewhat isolated, either within individual universities or across universities in general, lacking broader collaboration.
e. Activating the role of university business incubators in promoting sustainable entrepreneurship requires supportive policies at both the development plan level and from the Ministry of Higher Education and Scientific Research, as well as from the broader community.
f. The applications of artificial intelligence have proven to be effective in supporting sustainable entrepreneurship, improving and developing the business environment, reducing time and effort, and providing solutions to complex and challenging problems.
g. The results have shown a positive impact of university business incubators in supporting sustainable entrepreneurship within the context of artificial intelligence, particularly at the level of Arab universities.

5.2 Recommendations

a. Establishing a university business incubator in every Arab university to activate sustainable entrepreneurship in collaboration with community organizations, leveraging artificial intelligence applications. This would include providing scientific consultations and technical support to community members and organizations aiming to launch private projects.
b. Creating a specialized authority to manage the business incubator system in Arab universities. This authority would coordinate the efforts of universities, as well as government and private organizations, to support sustainable entrepreneurship in the context of artificial intelligence.
c. Directing the attention of government entities to prioritize the support for universities in establishing and activating business incubators. These incubators have a significant impact on steering higher education towards entrepreneurship, creating entrepreneurial projects that contribute to providing new job opportunities, and helping achieve sustainable development while combating unemployment.
d. Connecting innovations and applied scientific research to sustainable entrepreneurship programs by developing educational programs for university business incubators that emphasize innovation and artificial intelligence. This would involve providing financial and administrative support for emerging projects based on innovations and new technologies, while also enhancing cooperation between universities and research and development centers.
e. Focusing on providing funding for emerging projects by simplifying the procedures for obtaining financing from banks and other financial institutions, enhancing partnerships with private sector investors, and allocating a dedicated item in the university budget for initial funding to invest in emerging university-based companies.
f. Strengthening technical support for entrepreneurs by offering training and mentoring programs, as well as providing opportunities for practical training in startup environments.
g. Activating the role of business incubators in Arab universities and various research organizations to further promote and support sustainable entrepreneurship in diverse fields, in line with the principles of artificial intelligence.
h. Establishing clear policies and mechanisms for integrating artificial intelligence applications into the business environment, aimed at achieving sustainable development.
i. Establishing a marketing office within each university to promote the services offered by university business incubators, their products, scientific research, and practical experiences, both within and beyond the community. Additionally, this office should focus on marketing innovations and the results of scientific research.

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