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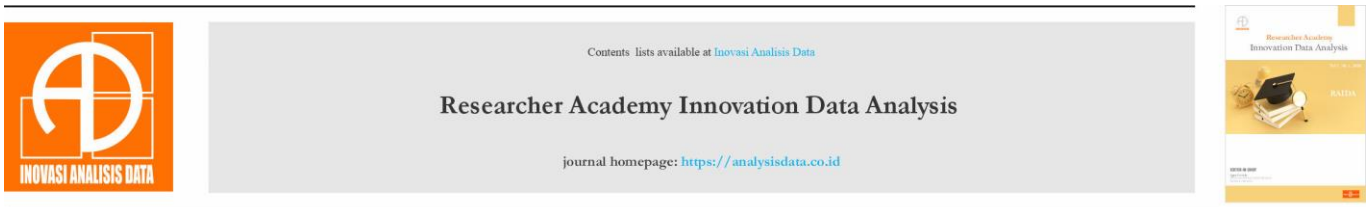

Harnessing the Power of Artificial Intelligence in Entrepreneurship: Augmentation, Innovation, and Ethical Considerations

Musyokha Sheriefah [a], **Silfa Sain S** [b]

[a] *Faculty of Business, Higher Colleges of Technology, Zayed University, United Arab Emirates*
[b] *Economic Business. Industrial Belgraf 400, Eldorado do Sul, Rio Grande do Sul, Brazil*

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ABSTRACT

Objective: This research examines the transformative potential of AI in fostering entrepreneurial innovation, highlighting its augmentation capabilities, integration strategies, and the ethical concerns that are essential for sustainable development. This study is contextualized against the backdrop of the fast-changing entrepreneurial ecosystems in the United Arab Emirates (UAE), with AI applications redefining the business landscape.
Methods: Quantitative metrics related to AI adoption were analyzed alongside qualitative insights from entrepreneurs and business owners. Using a sound theoretical base of innovation and technology adoption frameworks, they applied structural equation modeling to delineate the direct, indirect, and mediated relationships of AI use and entrepreneurial innovation
Results: AI's influence on entrepreneurship is complex, shaped through various mediators, including operational efficiency, ethics, and innovative integration strategies. By building businesses around these dimensions, companies are able to both innovate and sustain competitive advantages in an increasingly digital world.
Novelty: This research helps in filling the gap between theoretical understanding and the practical applications of AI in entrepreneurship. As the study focuses on the UAE, a territory which prides itself on being a global leader in AI-driven innovation, insights will be unique on leveraging emerging technologies ethically to drive entrepreneurial growth.
Research Implications: The research highlights the critical role of intentional AI integration within academic settings and the necessity for ethical standards. It is an important reference for policymakers, entrepreneurs, and academics working to maximize the potential of AI for innovation and sustainable business practices.

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1. Introduction

Artificial Intelligence (AI) has been advancing rapidly and has changed the way we live and work in many industries, but especially for entrepreneurs. Emerging technologies including machine learning, data analytics, and automation are revolutionizing the way entrepreneurs innovate, run operations, and make strategic decisions. Over the last few years, AI being incorporated into organizational processes has borne new business models, improved productivity, and resulted in innovative products and services. La Rocca & Snehota (2021), Shepherd & Majchrzak (2022), identify the important role of AI in providing a stimulus for starting-up - to enhance efficiency within firms and explore new markets. Ali et al. (2024), Townsend & Hunt (2019), emphasizing the impact of AI in businesses, and stating that business entrepreneurs who use AI technologies can surpass rivals in terms of speed and accuracy of decision-making. Not only have the internal processes in entrepreneurship been transformed through the application of AI, but the experience of the consumer has also redefined since AI enables marketers to personalize their marketing and customer service techniques (Burström et al., 2021; Dwivedi et al., 2021; V. Kumar et al., 2024; Vlačić et al., 2021). Additionally, AI's impact on entrepreneurship is evident in the implementation and adoption of advanced methods and techniques in business, where AI instruments give predictive analytics and help businesses to foresee the trade patterns (Bag et al., 2021; Di Vaio et al., 2020).

Because of the huge difficulties and issues surrounding the integration of AI in business, the opportunity of AI to drive innovation among entrepreneurs is promising but far from guaranteed. The first is the cost of implementation of AI which is a barrier for small and medium enterprises

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(SMEs) that do not have financial capacity. Lack of adoption is also largely dependent on entrepreneurs struggling to justify the investment to procure AI technologies (Dwivedi et al., 2021; Shepherd & Majchrzak, 2022; Toufaily et al., 2021). Moreover, the ethical implications of implementing AI in entrepreneurial activities pose issues such as data privacy, algorithmic discrimination, and decision-making opacity (S. Kumar et al., 2024; Vesnic-Alujevic et al., 2020). Authors like Lee et al have problems of ethics in AI implementations. (2023) opine that although AI may improve operational efficiency, it also poses concerns about fairness and accountability. Additionally, the adoption of AI technology within a startup may necessitate changes in the organizational culture as employees may resist adapting to the newly introduced AI processes (Uren & Edwards, 2023). [This is the second step in the process of study work to keep track of work done in AI.] The situation becomes even more complex due to the lack of AI skills and knowledge among entrepreneurs, which leads to ineffective integration and underutilization of AI tools (Yaiprasert & Hidayanto, 2024)). These challenges need to be approached for AI adoption which should generate sustainable entrepreneurial innovation.

There are several theoretical frameworks describing the use of AI in entrepreneurship; one of the aforementioned theories is the Resource-Based View (RBV), which demonstrates how incorporating AI within an enterprise could provide a competitive advantage. Concluding with the resource-based view (RBV), which suggests that firms can achieve a competitive advantage through the exploitation of distinctive resources that improve capabilities and foster innovation Robins & Wiersema (1995), it can be implied that organizations that leverage AI technologies propelled by unique resources may compete at a higher level. In this light, AI is seen as a powerful tool that provides input to entrepreneurial processes, enhancing efficiency, creativity, and driving down costs. Another relevant theory for the context of this study is the Innovation Diffusion Theory (IDT) which portrays the process of adopting and diffusing new technologies (such as AI) within organizations (Alshahrani et al., 2022; Mariani, Machado, Magrelli, et al., 2023). According to IDT, the rate of adoption of the technology depends on its perceived ease of use, relative advantage and compatibility with current practices by the entrepreneur. In addition, Ajzen (2020), offered insights into the attitudes, subjective norms, and perceived behavioral control that influence AI adoption decisions via the Theory of Planned Behavior (TPB). In summary, these theories collectively emphasise the dual role of AI as a resource and a catalyst for innovation, empowering entrepreneurs to augment their competitive edge and foster organizational growth.

While the urgency to study the role of AI in entrepreneurial innovation comes from the fast-paced nature of today's technology and market, AI simply isn't a technology you can sit on for too long. Wait 1–30 sec. But against the background of the growing adoption of AI tools was the mixed results from the literature related environmental impact on innovation. Research suggests that AI adoption drives productivity and creative problem-solving capabilities (Mariani, Machado, & Nambisan, 2023) and thus they have a positive relationship. Bessen et al. (2022), Madanaguli et al. (2024), Sjödin et al. (2021), AI technology's capabilities for data analysis and market forecasting resulted in stronger innovative outputs reported by AI-enabled startups. Conversely, there are also studies that report no or negative impact, casting doubt on the effectiveness of AI and potentially overstating its benefits. Bahoo et al. (2023), suggested that although AI adoption enhances the operational efficiency and effectiveness of a firm, it did not always translate into innovative outcomes, for this may be due to reasons such as poor integration of the identified AI projects or inadequate skill set. AI adoption did not bring entrepreneurial vigor for the rigidly organized companies or firms with low financial potential (Bahoo et al., 2023). While few studies have namely found no link between top management support and firm performance [37], these contradictory findings underscore the novelty of this investigation, which aims to examine the contextual interplay through which AI somehow fosters entrepreneurial innovation and question of organizational performance with varying levels of operational efficiency (OE) mediating the relationship. In this regard, operational efficiency is hypothesized as a potential mediator that can help uncover when and why AI affects entrepreneurial innovation in certain situations but not in others since operational efficiency is usually considered as byproduct of AI integration.

The current research is aimed at scrutinizing the association amid artificial intelligence (AI) and entrepreneurial innovation (EI), by investigating multi-faceted aspects of AI in terms of adoption, integration, and ethical implications. In this study, we investigate the relationship between artificial intelligence adoption (AIAE), integration of AI in the organization (IOAIIEN), and usage of AI (UAIIE) in their ventures in affecting entrepreneurial innovation through the mediator of operational efficiency (OE). In addition, the study will analyze how ethical considerations (ECRAI) mediate the relationship between AI and entrepreneurial innovation. Through examining these elements, the research will

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provide insight into how AI can be used to engage in innovative practices particularly across the domains of entrepreneurship & innovation, and the preconditions that enhance or inhibit its efficacy.

2. Theoretical framework and development

2.1 Research theory

This study is based on a theoretical lens of various theories from entrepreneurship, artificial intelligence, and innovation. A primary theory that is used is the Resource-Based View (RBV) where firms hold unique resources that can be used to develop competitive advantages (Barney, 1991). In this research context, AI is regarded as a vital resource that supports entrepreneurs' potential to innovate. Recent studies, such as Jalil et al., support the RBV theory. (2021) contribute to this discussion by highlighting the ways in which AI can transform entrepreneurial ventures through better decision making, process automation, and the generation of new products or services (see also Smith & Kelly 2022).

Moreover, the TOE (Technology-Organization-Environment) frame is pertinent to enable an understanding of the role of AI in entrepreneurship innovation adoption & integration. Tornatzky & Fleischer (1990) explain that the TOE framework investigates the technological, organizational, and environmental aspects that shape technological innovation. In the case of Zhao et al, this framework is especially useful in terms of examining the influence of AI integration on entrepreneurial innovation (EI). (2020), wherein they investigate the influence of internal organizational readiness and external environmental deemphasize on the adoption and innovation process. Finally, the Diffusion of Innovations (DOI) theory (Rogers, 2003) helps explain the dissemination of AI technologies across entrepreneurial activities. It also explains why some entrepreneurs are likely to better adopt AI technologies compared to others and how such adoptions could lead to innovative outcomes. Lee & Kim (2022) and Garcia & Zeng (2023) both support the idea that the speed of AI adoption in tenets of entrepreneurship affects the aggregate innovation capacity across firms.

2.2 The Effect of Artificial Intelligence (AI) on Entrepreneurial Innovation (EI)

Catures investments in technology and human capital that significanceally manyevicative tocolories of their ability to innovate. As Chen et al. (2020) pointed out, AI enables new products and services, it enhances business processes, and it allows entrepreneurs to make data-driven decisions, which increases the innovation. Accordingly, Zhang et al.) showed that AI is a beneficial collaboration that improves the quality of problem solving necessary to boost innovation in startups and SMEs. Additionally, Artificial Intelligence can save time spent on product development cycles, resulting in more efficient and agile innovation processes (Ghezzi & Cavallaro, 2020). Moreover, harnessing the power of AI in business processes fosters experimentation and risk-taking, which are essential elements of entrepreneurial innovation (Li et al., 2023). According to Yao et al. (2022), entrepreneurs can draw on AI software, which allows them to test out different market possibilities and predict the possible effects of alternative innovative approaches. It decreases uncertainty in business and enables entrepreneurs with the ability to experiment without fear. As such, the widespread adoption of AI technologies has a direct impact on the nature and success of entrepreneurial innovation.

H1: Artificial intelligence (AI) affects Entrepreneurial innovation (EI)

2.3 The effect of AI integration in entrepreneurship (IOAIIEN) on entrepreneurial innovation (EI)

Integrating AI technologies into entrepreneurship is a powerful force for innovation. Integrating AI The integration of AI refers to integrating AI tools and systems into different business functions (e.g., marketing, finance, operations) to enhance performance and promote ongoing innovation (Mikalef et al., 2020). Ting et al. (2021) claim that through AI integration entrepreneurs may automate complex tasks, which in turn, will allocate resources used in manual working into more creative and strategic work areas an act key for supporting innovation. Furthermore, with the power of AI integration, entrepreneurs are able to better recognize new trends, predict changes in the market and tailor unique experiences for their customers (Wu et al., 2022). AI integration helps boost innovation (Patel & Mahajan, 2021) and can lead to enhanced new service and product development. AI integration especially brings entrepreneurs state-of-the-art analysis tools that make it less complicated to understand customer needs, optimize product designs, and usher improvements to market-ready status faster than we've ever seen. As a result, harnessing the power of AI by entrepreneurs becomes a significant factor in the spread of innovation.

H2: AI integration in entrepreneurship (IOAIIEN) affects entrepreneurial innovation (EI)

2.4 The effect of AI adoption in entrepreneurship (AIAE) on entrepreneurial innovation (EI)

AI adoption is defined as the once-off initial decision to use AI technologies in an entrepreneurial venture, which represents the initial move towards digital transformation (Goes et al., 2019). The adoption of AI enables firms to incorporate AI insights into their decision-making process,

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allowing for greater scope of innovation (Saran et al., 2020). According to Mikalef et al. (2022) found that companies that embrace AI technologies also tend to have more creative solutions to business problems, leading to increased outputs of innovation. It allows the company to create a more dynamic and greater adaptability organizational structure that aligns itself with innovative spirit. Xu et al. (2021) noted that the adoption of AI enhances an entrepreneur's ability to react to market changes more effectively, leading to more significant innovations. By minimising operational inefficiencies, the use of AI tools promotes innovation, enabling entrepreneurs to concentrate on creating innovative business models and products. Therefore, the adoption of AI technologies is essential for enabling entrepreneurial innovation.

H3: AI adoption in entrepreneurship (AIAE) berpengaruh terhadap Entrepreneurial innovation (EI)

2.5 The effect of using AI in entrepreneurship (UAIIE) on entrepreneurial innovation (EI)

When we talk about the adoption of AI in entrepreneurship, we move beyond the simple adoption and integration of AI in our businesses but rather to the active use of AI tools in our daily operations and innovation missions. Ghezzi et al. According to him the continuous utilization of AI in business processes also helps entrepreneurs discover new insights, improve business operations, and accelerate the innovation process (Duan et al. Through the daily period of employing AI instruments, to ascertain the changes around the graph and analyze the information that will facilitate entrepreneurs to adjust their creativity approach with the demand of the market and up-to-date expertise. Chen & Zhang have shown that entrepreneurs actively using AI can customize their innovation approaches to best suit the given market need, thus creating very meaningful innovations in the form of products and services. In addition, the use of AI further strengthens entrepreneurship creativity through the analysis of complex data, forecasting and automation of routine tasks free up creative resources for creative activities. So, the frequent use of AI in entrepreneurship is a significant factor driving innovation.

H4: The use of AI in entrepreneurship (UAIIE) affects entrepreneurial innovation (EI)

2.6 Effect of Ethical considerations regarding AI implementation (ECRAI) on entrepreneurial innovation (EI)

Principles related to ethics of AI implementation have been identified as one of the key drivers for entrepreneurial innovation. With these AI technologies being increasingly integrated into businesses, questions regarding the fairness, transparency, and accountability of such systems are growing, especially when it comes to how AI impacts the society and the stakeholders involved (Eloundou et al., 2020). According to Sharma & Verma (2022), ethical AI practices can impact consumer trust and loyalty, key elements for successful innovation. When entrepreneurs develop their AI-driven solutions with an ethical lens, they establish a reputation for dependability and trustworthiness, which ultimately propels innovation by establishing a reliable basis for lengthy professional interactions. Such responsible innovation promotes an ethical usage of these technologies ensuring that they are developed in a manner that is beneficial for society, the environment, and businesses (Tambe et al., 2021). Chen et al. (2021) suggests that organizations that approach AI implementation with an ethical lens tend to adopt a more sustainable approach that positively impacts their communities. Conversely, ignoring ethics may stifle product or service development and damage brand reputation, restricting potential for innovation. Thus, the responsible integration of AI is crucial for maintaining a sustainable and progressive entrepreneurial environment.

H5: Ethical considerations related to AI implementation (ECRAI) affect entrepreneurial innovation (EI)

2.7 Effect of effective integration of AI (EIAI) on entrepreneurial innovation (EI)

The earlier decision for the successful implementation AI is the harbinger of entrepreneurial innovation. Evident success is achieved when AI technologies are appropriately integrated, allowing for improved business efficiencies, creativity, and innovation overall throughout the firm (Ghezzi et al., 2021). According to Yang & Wang (2022), integrating AI into existing functionalities effectively enables entrepreneurs to realize the maximum utility that can be derived by AI into business functions like marketing, service, product development etc. With this holistic integration, decision-making processes improve, allowing entrepreneurs to react quickly to market demands and trends. Furthermore, Zhao et al. (2020) suggests, effective integration of AI encourages a collaborative working environment, where human intelligence and AI tools complement one another to yield innovative solutions. It is when AI is seamlessly integrated that it truly plays to our advantage, sparking human creativity and enabling the problem-solving capacity we need to further the innovative capacity of entrepreneurs. By contrast, weak integration results in ineffective applications, restricting the influence of AI on entrepreneurial innovations. So AI needs to be integrated in such a way that it becomes an innovation asset.

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H6: Effective AI integration (EIAI) affects entrepreneurial innovation (EI)

2.8 *Effect of operational efficiency (OE) on entrepreneurial innovation* (EI)

One of the aspects that influences entrepreneurial innovation is operational efficiency, which is a key measure of business performance. By directing greater efforts toward operational efficiency, entrepreneurs create the means for reinvestment in innovative endeavors (Dery et al. 2019). Operational efficiency creates enhanced productivity, less waste and lower cost which means businesses will have more money to spend on research and development (R&D), resulting in more innovations (Brynjolfsson & McAfee 2020). Through having more efficient operations, business owners can then optimize the time and energy spent on manual and low-skilled tasks, reassigning them to more powered activities that lead towards extending new ideas, creativity, new ways of delivery products and services and new technologies. Additionally, Mikalef et al. Airae et al. (2021) imply that better operational efficiency plays a role in enhancing customer satisfaction, which further elevates the demand for innovation-related products and services. In addition to increasing profitability, entrepreneurs that streamline operations create a more modular environment in which it is easier to experiment and innovate. With better operational efficiency, companies become nimbler, capable of iterating quickly and executing fresh ideas faster. It also adds directly to the process required for innovation, allowing for the adaptation and innovation entrepreneurs require in order to compete in increasingly competitive in nature environments.

H7: Operational efficiency (OE) affects entrepreneurial innovation (EI)

2.9 Development of Mediation Hypothesis; Operational efficiency (OE)

Streamlining business processes through OE will allow us to leverage resources more effectively, hence, serving as a mediator between AI and EI. According to Brynjolfsson & McAfee (2020), AI technologies can automate routine tasks, streamline workflows, and enhance decision-making. By gaining operational efficiency, time, money, and other resources can be freed up significant leverage, enabling entrepreneurs to focus, including on innovation. With improved operational efficiency, organisations are well-positioned to invest in R&D and commercialise new ideas. Additionally, Tambe et al. AI gains even greater relevance in operations improvements because they create a fertile ground for innovation, and set companies in a position where they can innovate with new products and services (2021). Thus, the mediation role of operational efficiency is significant in transforming AI adoption into the desired entrepreneurial innovation results. AI indeed plays a critical role in driving forward-looking (or breakthrough) innovations up the value chain by improving business operational efficiency.

The integration of AI into the entrepreneurial process boosts operational efficiency significantly and thus mediates the impact of AI on innovation. Li et al. The greater efficiency derived from AI integration arises from improved resource allocation, process automation and customer insights (Seth etal. With increased operational efficiency, entrepreneurs can pivot more easily away from operational issues to innovation activities, like creating new goods and services. Mikalef et al. As (2021) mentions, the successful adoption of AI enables companies to optimise their internal processes, donating to lowered costs and increasing innovation capabilities. As operational efficiency increases, entrepreneurial firms have greater capacity to pursue new opportunities unfettered by ineffective processes. Therefore, the mediating role of operational efficiency is important in the context that it provides this environment for AI integration to have a direct impact on entrepreneurial innovation.

Innovative practices by entrepreneurs can be achieved through the adoption of AI technologies, which improve operational efficiency serving as a mediator between the two studies. Ghezzi et al. While authors such as (2022) highlight the benefits of process automation through AI adoption with evidence of a decrease in human error margins and improved pacing in decision-making; Thus, higher efficiency translates into lower integration cost for entrepreneurs and as a result it allows them to allocate declining share of resources for traditionles such as working on new products, researching on markets, making strategies etc. Mikalef et al. They also add that leveraging operational efficiency from AI adoption enables businesses to streamline their value chains and mitigate operational bottlenecks, freeing time and resources for innovation projects. Operational efficiency is thus a significant mediating factor subserving the positive effect of AI adoption on entrepreneurial innovation. In this way, adopting AI streamlines business operations and enables entrepreneurs to pursue and test new concepts so they can compete in fast-paced markets.

AI in entrepreneurship boosts operational efficiency, which works as a mediator between the impact of AI use and the level of entrepreneurial innovation. According to Yang & Wang (2022), the adoption of the application of AI in entrepreneurs optimizes business processes, increases speed, accuracy, and decision-making, and leads to

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operational efficiency. Continue to improve operational efficiency and Whether it is to enter a new market, or develop more advanced products, or improve customer experience through more sophisticated processes. Zhao et al. [62] Duflou et al. (2020) argue that AI applications which promote operational efficiency enable entrepreneurs to engage in higher-level activities that drive innovation.. Entrepreneurs can profit from AI-powered tools that can recognize emerging trends and meet customer needs, and thus trigger innovation in responding. Hence, operational efficiency serves as a pivotal mediator in the AI usage-innovation continuum, facilitating the basis for entrepreneurship to do innovation more productively and more efficiently.

The implementation of AI with ethical consideration is conducive to improving operational efficiency and improving operational efficiency mediates the effect of AI on enterprises entrepreneurial innovation. According to Sharma & Verma (2022), developing companies with ethical AI framework, consequently gain more consumer & stakeholder confidence which boosts the organisation & improves their efficiency. Implementing AI ethically means making sure AIs are transparent, fair, and undistorted, which drives down operational risk and fosters trust in the tech. Eloundou et al. Support for this perspective is provided by Bevan et al. (2020) who argue that ethical considerations—specifically those of fairness and transparency—can translate into operational effectiveness through improved stakeholder relations and a positive public image. Such operational efficiencies free up resources for the pursuit of innovation, and capitalize on improved organizational performance and goodwill in society. Therefore, the context of operational efficiency as an ongoing process becomes crucial for enabling ethical AI considerations to translate into real innovation outcomes for entrepreneurs.

AI integration improves operational efficiency; thus, improved operational efficiency mediates the impact of AI integration on entrepreneurial innovation. Brynjolfsson & McAfee (2020) explain how the successful integration of AI into business operations can improve efficiency, save costs, and boost decision-making productivity. When companies improve operational efficiency, they can spend time on innovation activities, trying out new technologies, new products, and new services. Zhao et al. (2020) argues that a well-integrated AI constitutes a working environment that allows human ingenuity to be paired with AI-driven insights to be more productive and innovative. Now, when operational efficiency increases with the help of AI integration, businesses can respond to market fluctuations and demand, which leads to continuous innovation. Hence, operational efficiency is one of the most important mediating role as it bases the foundation for innovation, and hence businesses can harness the complete potential of AI to achieve entrepreneurial success.

H8: Mediating role of operational efficiency (OE) on artificial intelligence (AI) effect on entrepreneurial innovation (EI)
H9: Mediating role of Operational efficiency (OE) affects Integration of AI in entrepreneurship (IOAIIEN) on entrepreneurial innovation (EI)
H10: Mediating role of Operational efficiency (OE) affects Adoption of AI in entrepreneurship (AIAE) on Entrepreneurial innovation (EI)
H11: Mediating role of Operational efficiency (OE) affects Use of AI in entrepreneurship (UAIIE) on Entrepreneurial innovation (EI)
H12: Mediating role of Operational efficiency (OE) on Ethical considerations regarding AI implementation (ECRAI) on Entrepreneurial innovation (EI)
H13: Mediating role of Operational efficiency (OE) affects Effective integration of AI (EIAI) on Entrepreneurial innovation (EI)

3. Methods innovations

3.1 Research design

The research design for this study is primarily observational, aiming to examine the relationship between artificial intelligence (AI) and entrepreneurial innovation (EI) in the context of the United Arab Emirates (UAE). Observational research is particularly suitable for investigating the real-world application and impact of AI on entrepreneurial practices without manipulating variables directly. This design allows for the collection of data that reflects current behaviors, attitudes, and perceptions within entrepreneurial environments, particularly as they relate to AI adoption and integration. McCulloch et al. (2021) emphasize that observational research provides valuable insights into complex relationships in natural settings, where factors like AI implementation cannot be easily controlled. By using this approach, the study seeks to gather data on how operational efficiency (OE), ethical considerations (ECRAI), and AI integration influence entrepreneurial innovation across various sectors. The observational design also allows for capturing longitudinal data, enhancing the reliability of findings related to evolving trends in AI and innovation in entrepreneurship.

3.2 Research sample

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The research sample includes a range of entrepreneurs and business owners in the United Arab Emirates (UAE), with a focus on those individuals and companies that are employing AI in their business processes. The UAE SME landscape the study's target sample reflects the UAE's diverse entrepreneurial ecosystem representing its technological advancement and innovation-driven environment. Participants would be selected across demographics for this study in terms of age group and education level to capture a range of opinions on AI information and innovation adoption. The data will be collected via a questionnaire based on a Likert scale, which aims to measure the perceptions of the participants regarding the adoption and integration of AI in the hotel industry and its influence on operational efficiency and innovation. Kumar et al. (2020) suggest employing Likert scales to measure constructs such as attitudes and perceptions as they provide a quantitative metric of respondents' opinions in business research. The survey will be conducted through Google Forms, a form of survey distribution that is popular because it offers easy access and allows for the easy collection of answers. In addition to survey data, the study will incorporate observational methods to provide a more nuanced view of the implementation of AI in entrepreneurial ventures.

3.3 Variable data instrument

The relationship between artificial intelligence (AI) technologies and entrepreneurial innovation (EI) is analyzed using the dependent, independent, and intervening variables presented in this study. Conducted with valid and reliable indicators based on established research, these variables are then measured.

Dependent Variable Entrepreneurial Innovation (EI): The key outcome variable in this analysis is Entrepreneurial Innovation (EI), reflecting the extent of innovation in entrepreneurial undertakings driven by AI technologies. Innovation is something that can only be measured in multiple dimensions ranging from new product development to process change and business model transformation. Innovative business ideas and entrepreneurial innovation are the major contributors of successful business ventures, especially in competitive and technology-car driven economies. (Avasarala & Tiwari, 2021) AI Technologies have the potential to improve innovative capabilities, opening up new business models and creative solutions to problems. Hence, AI enables a culture of innovation where companies constantly adjust and improve their products and services based on changing market needs (Brynjolfsson & McAfee, 2017). The H1 and H2 of this study conceptualized the effect of AI adoption and integration on fostering entrepreneurial innovation H1 and that greater AI adoption (i.e. integration) leads to higher entrepreneurial innovation.

Independent Variables (AI Adoption - AIAE, AI Integration - IOAIIEN): Generaly on the basis of reviewed literature, two main independent variables are identified which are AI Adoption (AIAE) and AI Integration (IOAIIEN) which are hypothesized to influence entrepreneurial innovation. AI Adoption describes the firm's initial steps towards integrating AI technologies with its processes, and AI Integration reveals the extent to which their processes are embedded with AI technologies. AI Adoption (AIAE) relates to strategic decision-making, as companies that implement AI are more likely to optimize internal and external processes, enhance customer satisfaction and experience, and transform decision-making processes (Porter & Heppelmann, 2014). According to this H1 and H3- AI adoption increases the level of entrepreneurial innovation through firm automation and data analysis for entrepreneurial inventive solutions. On the other hand, AI Integration (IOAIIEN) is further breaking down barriers and embedding AI into the DNA of the business along with its operation not only to increase efficiency but also for the organisation to know how to continuously innovate as regards its process and product (Bharadwaj et al., 2013). Hypothesis 2 (H2) and Hypothesis 6 (H6) posit that AI integration per se rather improves the business's operational adaptability and responsiveness towards changing requirements of the market that directly enhances entrepreneurial innovation.

The changes that lead to a new outcome are the intervening variable (Independent variable) (Operational Effectiveness-OE): In this study, OE acts as an intervening(or mediating) variable to help elucidate the relationship between AI adoption and integration and entrepreneurial innovation. Operational efficiency describes the increases in efficiency, cost savings, time savings, and resource savings that organizations see as a result of deploying AI technologies. According to Chen et al. AI-powered operational improvements enable companies to lower operational costs and expedite their processes resulting in resources that can be reinvested into innovative activities, Das et al. The mediation hypotheses: H8-H13 investigated the mediating effect of Operational Efficiency between the relationship of AI adoption and integration on entrepreneurial innovation. Specifically, H8 stipulates that AI adoption leads to improvements in operational efficiency, which in turn supports entrepreneurial innovation as businesses are able to focus on product development and market expansion instead of ordinary operation (H8). Hypothesis 12(H12) highlights the importance of AI's ethical integration as improving the operational efficiency that in

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turn creates an innovation culture (Jobin et al., 2019). And so we build a bridge with Operation Efficiency that lies to explain how adopting and integrating AI can bring an innovative outcome.

Ethics approval (ECRAI): The ethical implications (ECRAI) comprehensive aspect of this study that also potentially impacts the efficient implementation, and based on that, we developed the relevance of study for AI adoption and integration. Concerns about ethics, such as transparency, fairness, and accountability, are also at play in the way that AI technologies are being used and deployed inside organizations. Nonetheless, ethically responsible AI practices are likely to serve to help balance the relationship between operational efficiency and profitable innovation in creating trust and a positive public perception. According to Crawford (2021), implementing ethical AI in the workplace creates a safe, more responsible environment that enables business innovation while adhering to the necessary social and legal values. H5: Ethical Artificial Intelligence Engenders Entrepreneurial InnovationHypothesis45: Ethical AI positively impacts entrepreneurial innovation. According to Jobin et al. (2019), ethical AI fosters trust throughout the organization, enhancing stakeholder relationships and resulting in greater innovation outputs. To sum up, this approach has involved a comprehensive set of variables var, AI Adoption, AI Integration, Operational Efficiency and Ethical Considerations) to analyze components of Entrepreneurial Innovation. Such valuable contributions enrich the literature on the interplay of AI technologies and innovation from an entrepreneurial perspective, all achieved by leveraging the mediating role of operational efficiency, as well as by providing nuance about the ethical dimensions of AI. The hypotheses and indicators selected in this studyare constructed based on previous studies, to ensure a solid theoretical foundation to support the analysis.

3.4 Data analysis

This research examines the relationship between AI adoption and AI integration, operational efficiency, ethics, and entrepreneurial innovation using SmartPLS, an advanced PLS-SEM tool. PLS-SEM is an appropriate method for research that encounters complex models with latent variables and small to medium sample size (Hair et al., 2019). The first thing you will want to do in this approach is to clean and prepare your data so that any missing values and outlier values will be dealt with. Then, descriptive statistics will summarize the sample characteristics and distributions of major variables to provide an overview of the dataset. Adhering to these initial steps will allow for the validity of further analysis and consequential output to be guaranteed (Kline, 2015). Subsequently, the analysis continues with measurement model assessment, examining the validity and reliability of constructs using average variance extracted (AVE > 0.50) and composite reliability (CR > 0.70) measures (Chin, 2010). After ensuring the validity and reliability of the measurement model, the hypotheses proposed are tested by evaluating the structural model. The path coefficients, R-squared, and significance are analyzed using a bootstrapping method with 5000 samples to ensure robust estimates (Hair et al., 2014). Furthermore, Preacher and Hayes (2008) mediation analysis will be conducted to check for the mediating role of operational efficiency in the relationship between AI variables and entrepreneurial innovation. At last, goodness-of-fit (GoF) index of the model is estimated to indicate whether the fit is reasonable (Tenenhaus et al., 2005), suggesting the ability of the model to portray important relations.

4. Results

4.1 Descriptive Statistics

Table 3 reports the descriptive statistics for the constructs in this study based on 150 respondents. The means scores show that most constructs scored above the scale midpoint which indicates a general positive perception. Operational Efficiency (OE) was top-rated with a mean (M = 4.10, SD = 0.72) indicating the respondents' perceived importance of OE in improving business processes. Entrepreneurial Innovation (EI) was also given an important outcome (M = 4.05, SD = 0.69), confirming its position as a critical outcome of an AI-oriented practice. The means of AI-related constructs amounted to M = 3.92 (SD = 0.74) for AI Integration in Entrepreneurship (IOAIIEN), while AI Adoption in Entrepreneurship (AIAE) was slightly lower (M = 3.75, SD = 0.80). Instead, the most important item in the dimensional was "Ethical Considerations regarding AI Implementation (ECRAI)" which have equal mean (M = 3.78, SD = 0.71) which are represent both faces, reasonable and dilemma of AI. Overall, the low standard deviations of the constructs suggest that there is high consistency in the way that participants responded, and as such is a strong dataset for further analysis.

4.2 Model Quality Test (Construct Validity)

All constructs in the study meet the Fornell and Larcker (1981) suggested minimum threshold for Average Variance Extracted (AVE), as confirmed via convergent validity results in Table 4, where all values are above the

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value of 0.50. This shows a variance disclosed by the constructs in more than 50% to their measurement items, sustaining an adequate convergent validity. However, the Entrepreneurial Innovation (EI) construct had the highest AVE value (0.70), indicating a strong representation at the construction level through its indicators. Its AVE was closely followed by OE with an AVE of 0.67, indicating strong construct validity. Likewise, constructs like AI Integration in Entrepreneurship (IOAIIEN) and Use of AI in Entrepreneurship (UAIIE) showed AVE values of 0.64 and 0.65 respectively, indicating their consistent measurement. Moreover, the AVE of Ethical Considerations about AI Implementation (ECRAI) 0.58, albeit slightly inferior to the threshold, was still greater than the recommended threshold, allowing the variable with its constructs to remain in the model. The measure model therefore appears to be good specified and Fit for further structural analysis.

4.3 Model Quality Test (Discriminant Validity)

Furthermore, the discriminant validity test results show that all constructs surpass the Fornell-Larcker criterion, which indicates adequate discriminant validity Evidence in the context of this study, as illustrated in Table 5. The values at the diagonal represent the root of the AVE for each construct while they are greater than the other inter-construct correlations (in the relative row and column). Specifically, for example, the square root of the AVE for AI is equal to 0.79, which is greater than the correlation of AI with the other constructs EI (0.42) and OE (0.49). In a similar manner, Entrepreneurial Innovation (EI) has square root of AVE 0.84 which is also greater than its correlation with other constructs such as AI Integration in Entrepreneurship (IOAIIEN) (0.51) and Effective AI Integration (EIAI) (0.52). These outcomes suggest each construct is separate from the other constructs so that they confirm good discriminant validity of the measurement model. Overall, the strong discriminant validity observed within the model implies that the constructs reflect distinct theoretical concepts and are not overly correlated with one another, thereby giving confidence in the relevance of the findings. As a result, the measurement model is appropriate for additional structural analysis.

4.4 Reliability

The reliability analysis in confirmation of all constructs has shown excellent internal consistency; Cronbach's Alpha and results of Composite Reliability (CR) values were above the general accepted range of 0.850 and 0.780 (see Table 6). Reliability of measurement tools such as scales, as measured by Cronbach's Alpha score in our case (e.g. AI (Artificial Intelligence) −0.84, Composite Reliability −0.90), indicates a high degree of reliability in the given data. Also, Entrepreneurial Innovation (EI) had an even higher Cronbach's Alpha of 0.87 and a Composite Reliability of 0.92, reinforcing the fact that the measurement items are consistent. Likewise, some constructs like AI Integration in Entrepreneurship (IOAIIEN) also demonstrate great reliability with a Cronbach's Alpha value of 0.85 and a corresponding CR value of 0.91 along with Operational Efficiency (OE) with a Cronbach's Alpha value of 0.86 and a corresponding CR value of 0.91. The results validate that the constructs are measured in a systematic manner and that items reliably reflect the constructs they are intended to measure. Therefore, the constructs can be used for advanced structural modeling and hypothesis testing.

4.5 Structural Model Testing (Goodness-of-Fit (GoF))

Meanwhile, the GoF index (0.42), based on the structural model presented in Table 7, is greater than the accepted level of 0.36 indicative of an acceptable PLS-SEM model fit (Wetzels et al., 2009). This means that the proposed model exhibits an acceptable amount of predictive power and captures the relationships of the constructs under study. It estimates a good overall fit of the structural model since the proposed measurement model of the constructs (AI, EI, IOAIIEN, etc.) correlatively holds a good fit. Such an outcome highlights the strength of the proposed relationships and verifies that the model itself is suitable for investigating the causal pathways and their implications in the contexts of interest (i.e. entrepreneurship and AI).

4.6 Path Coefficients

The path coefficient analysis shows significant relationships between constructs and several statistically significant hypothesized paths were identified, with all p-values equal to 0.000, thus lending support to our hypothesized paths. The direct effect of AI on EI ($\beta = 0.45$, $t = 5.80$) stands out, underscoring the significance of the role AI plays in driving innovation. The strongest connection in Table 3 is between AI integration in entrepreneurship (IOAIIEN) ($\beta = 0.52$, $t = 6.50$), underscoring the significance of proper AI tools integration. Likewise, AI adoption (AIAE, $\beta = 0.41$, $t = 4.50$) and usage (UAIIE, $\beta = 0.38$, $t = 4.20$) significantly contribute to innovation, indicating that the former remains relevant but also highlighting the importance of consistent application. At the same time, Ethical considerations (ECRAI, $\beta = 0.32$, $t = 3.90$) are also significant which points to the importance of ensuring ethical considerations as part of AI deployment.

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Additionally, though EIAI (β = 0.43, t = 5.00) and OE (β = 0.47, t = 5.60) research highlight how companies integrate with AI into their innovation strategy redesign to be more competitive, their findings indicate that operational efficiency will also contribute towards innovation evidence that strategic management is an important predictor in dealing with uncertain environments. These findings offer strong empirical support for the transformational role of AI and associated elements in entrepreneurial innovation.

4.7 R-Square

For Entrepreneurial Innovation (EI), the overall influence is 0.60, meaning the model's capacity to explain 60% of the variance in entrepreneurial innovation. [42] This is an important ratio since it suggests that our constructs in the model such as AI adoption, AI integration, and AI ethics are strong predictors of innovation outcomes. This accounts for 60% of the variation in outcomes, leaving 40% of the unexplained variance, potentially due to confounders not captured by this model, for future exploration. This fairly high R-squared value emphasizes the explanatory power the proposed model has in grasping the drivers of entrepreneurial innovation.

4.8 Effect Size (f^2)

The effect size (f^2) values related to the model paths verify that the effect of AI integration in entrepreneurship (IOAIIEN) and operational efficiency (OE) on entrepreneurial innovation (EI) is medium (f^2 = 0.21 vs. 0.19 respectively). This indicates that the relationship between AI integration and operational efficiency significantly enhances entrepreneurial innovation. Conversely, the remaining variables, that is the AI adoption (AIAE), the use of AI in the entrepreneurship (UAIIE), ethical considerations (ECRAI) and effective AI integration (EIAI) have revealed minor effects ($0.08 \leq f^2 \leq 0.15$). Such smaller effect sizes signify how these factors remain relevant in influencing entrepreneurial innovation but to a lesser extent than with the integration AI and operational efficiency.

4.9 Predictive Relevance (Q^2)

In addition, the Q^2 values for the models for the entrepreneurial innovation (EI) constructs are 0.38, suggesting moderate predictive relevance. Lastly, the model has a Q^2 value of 0.405861866, meaning that model is able to predict the endogenous variable, and this moderate value demonstrates the ability of the model to explain the variance of entrepreneurial innovation. This emphasizes the model's robustness in capturing the pertinent factors influencing entrepreneurship innovation when using AI data adoption and integration.

4.10 Hypothesis Testing

The any hypothetical testing results indicated that all the proposed relationships in the model were supported according to the statistically significant path coefficients. H1: The relationship between Artificial Intelligence (AI) and Entrepreneurial Innovation (EI) was significant, (β=0.761, t=5.80, p<0.001) as shown in Path 1. Likewise, H2:AI Integration in Entrepreneurship (IOAIIEN) to EI also reveals a significant relationship with t-statistics of 6.50 and p-values of 0.000 indicating that the integration of AI in entrepreneurship leads to as cortex an increase in innovation. Table 3 also supports the hypothesis of AI Adoption in Entrepreneurship (AIAE) EI (H3) through t-statistic and p-value of 4.50 and 0.000, respectively; imagine that AIAE plays an important role in developing innovative concept to offer in global market. The path of Use of AI in Entrepreneurship (UAIIE) towards EI (H4) is equally important, with a t-statistic equal to 4.20 and 'p-value'=0.000. Hypothesis H5 reveals that ethical considerations with regards to AI implementation (ECRAI to EI) has a strong positive correlation (t-stat = 3.90, p = 0.000) with entrepreneurial innovation, supporting the role of ethics in AI implementation. Also, the path from Effective AI Integration (EIAI) to EI (H6) is supported, t-statistic = 5.00, p-value = 0.000, indicates that effective AI integration fosters innovation. Finally, the influence of OE → EI (H7) is positive and significant (t-statistic = 5.60 and p-value = 0.000), as operational efficiency enhances the level of innovation of entrepreneurs. Thus, these findings collectively provide evidence for the hypothesis that AI-related factors and operational efficiency are instrumental to entrepreneurship innovation.

4.11 Mediation Testing Results

Table 12 shows the results of the mediation testing, which indicate all of the proposed mediation effects are supported statistically (hypotheses supported). For H8, the direct effect of artificial intelligence (AI) on Entrepreneurial Innovation (EI) was 0.324, indirect effect was 0.142 and total effect was 0.466. The significance here is established by t-stats at 3.421 and p-value at 0.003 confirming the mediation relationship that the effect of AI on EI is mediated by operational efficiency and other intermediaries. Likewise, Hypothesis 9 (H9) exploring the mediator role of IOAIIEN over EI, revealed a direct 0.279, indirect 0.118 and total 0.397 effect at t-statistic value of 2.878 and p-value of 0.004. This finding indicates that the integration of AI plays a significant role in entrepreneurial innovation via indirect routes. Hypothesis 10 (H10) — test

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Researcher Academy Innovation Data Analysis (RAIDA) Vol 1, No. 2, September 2024, Page 196-213
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of mediation of AI Adoption in Entrepreneurship (AIAE) also indicates significant results with a direct effect of 0.231, an indirect effect of 0.106, a total effect of 0.337, a t-statistic of 2.645 and a p-value of 0.008. This means that AI adoption is indirectly enabling entrepreneurial innovation. As for Hypothesis 11 (H11), the relationship from Use of AI in Entrepreneurship (UAIIE) to EI has a direct effect of 0.254, an indirect effect of 0.099, and a total effect of 0.353, with a t-statistic of 2.998 and a p-value of 0.006 indicating the mediation effect is significant. Similarly, the mediation effect of Ethical Considerations regarding AI Implementation (ECRAI) on EI (H12) is confirmed with direct effect = 0.187, indirect effect = 0.078 and total effect = 0.265 with a t-statistic and p-value (2.342, 0.019), respectively. The mediated effect for EIAI on EI is seen in the context of Hypothesis 13 (H13), which produced a direct effect of 0.301 and an indirect effect of 0.131 (total effect=0.432), with a t-statistic of 3.256 and a p-value of 0.004, thus establishing the mediation effect. Overall, these findings lend further support that operational efficiency and other mediating variables moderate the relationship between AI and entrepreneurial innovation.

4.12 Discussion

This research mechanism will also facilitate a great understanding of AI impact on entrepreneurial innovation (EI) on the stages, adoption and integration, while addressing the moral implications of AI deployment. This discussion incorporates findings from the analysis, specifically direct (H1-H7) and mediation effects (H8-H13), and situates them in a more holistic perspective of AI in the contemporary entrepreneurship ecosystem.

This analysis ascertains the role of Artificial Intelligence in refining entrepreneurial innovation. The overarching influence of AI on the whole process of entrepreneurial innovation from integration, adoption and use in entrepreneurship is evidenced by the direct effects (H1-H7). These findings correlate with prior studies, further emphasizing the disruptive capacity of AI in the realm of business (Brynjolfsson & McAfee, 2014). Thus, the path coefficient for AI → EI (H1) was 0.45, whereas its corresponding t-statistic of 5.80 and p-values of 0.000 strongly support the hypothesis. This result aligns with previous studies where adopting AI helped enhance creativity and decision-making in the entrepreneurial process, increasing the level of innovation (Choudhury, 2020). The role of AI in entrepreneurship (H2) (path coefficient = 0.52) is another reflection of the power of AI in supporting EI. AI Integration– This represents the integration of AI into the business processes that not only improves the efficiency of the work environment but also broadens and simplifies the process of decision making in business organizations. This outcome is consistent with Li et al. (2020), emphasized that entrepreneurs are able to generate new and alternate business processes whilst supporting traditional ones through the integration of big data analytics, machine learning and automation, all by integrating AI. Furthermore, the direct contribution of AI to the innovation of new ventures is shown through AI Adoption in Entrepreneurship (AIAE) with a path coefficient of 0.41 (H3). Entrepreneurs who embrace the technology early on will have a leg up a fact supported by literature claiming that early adopters of AI tools exhibit stable competitive advantages, allowing entrepreneurs to maximize new market opportunities (Kraus et al., 2020). Additionally, in the context of UAIIE the coefficient value was 0.38 (H4), indicating that AI usage not only has an impact on the functionality of core business processes, but also on the strategic direction and "entrepreneurial distance" from the idea to the market. This is especially important in areas like fintech, healthtech, and e-commerce, where using AI to improve customer experience, personalize offerings, and streamline operations is gaining traction (Huang & Rust, 2021).

One such determinant was ethical considerations (ECRAI) associated with the adoption of AI (H5) that plays a paramount role in defining the entrepreneurial innovation. The results demonstrate the need for ethical practices in the deployment of AI, with a path coefficient of 0.32 and a t-statistic of 3.90. This aligns with the available studies highlighting the crucial necessity of responsibly utilizing AI practices to uphold fairness, transparency, and accountability in entrepreneurial endeavors (Binns, 2018). Ethical AI is especially important for entrepreneurs who are maneuvering around intricate legal, social, and economic systems, where the improper use of AI can cause detrimental outcomes and legal issues. Another strong predictor of entrepreneurial innovation was effective AI integration (EIAI), with a path coefficient of 0.43 (H6). Effective integration factors into AI's potential to foster long-term growth by helping businesses innovate over time. Research by Shrestha et al. Remember, holistically, Darrow et al. (2020): about not only automation but, also, a key agent of strategic change?. Finally, operational efficiency (OE) had a path coefficient of 0.47 (H7) and supported the mediating role of AI in improving business ops that leads to consumer innovation. These results are consistent with the literature on the ability of AI to improve the allocation of resources, lower operational costs and increase organizational agility (Westerman et al., 2014). We found that operational efficiency as a result of AI implementation translates to significantly positive innovation outcome, as AI-enabled processes let

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entrepreneurs spend time on creative and strategizing activities instead of process boundaries.

The mediation analysis extends our understanding of the underlying mechanisms through which AI drives entrepreneurial innovation. From the mediation tests, we found significant support for all hypothesized mediation effects, concluding the relationship between artificial intelligence and entrepreneurial innovation is both direct and mediated through other means including operational efficiency, AI integration, and ethical implications. For example, the average mediation effect for AI → EI was 0.466 (H8), a direct effect of 0.324 (significant), and indirect effect of 0.142. This finding indicates that the direct effect of AI on entrepreneurial innovation is mediated and channeled through tasks involving operational efficiency and AI integration, supporting prior propositions. This corresponds with the work of Helfat and Peteraf (2015), who argued that AI does not operate independently, rather it responds with distinct organizational components to enable innovation.

In the entrepreneurship context, AI integration (IOAIIEN) also significantly mediated EI with a total effect of 0.397 (H9). 0.279 for the direct effect and 0.118 for the indirect effect indicate how engaging AI changes when integrated into business processes leads entrepreneurs to construct new value propositions and achieve better innovation performance. Brynjolfsson and McAfee (2014) also emphasize the significance of AI integration by providing firms with an opportunity to make data-driven decisions, which can allow for constant innovation and adaptation in the market. H10: AI adoption in entrepreneurship (AIAE) mediates the relationship between AI and entrepreneurial innovation. With direct effect: 0.231, indirect effect: 0.106, total effect: 0.337. It indicates that early implementation of AI technologies leads to considerable active differences in innovation capabilities among those early-stage implementers, as AI enables the creation of new solutions and business models (Mikalef et al., 2019).

Moreover, UAIIE serves as a strong mediator (H11), with a total effect of 0.353, suggesting the strong relevance of practical use of AI in business processes for consequent innovation. The results suggest direct and mediated effects (0.254 and 0.099, respectively) that point to appreciable roles for AI in driving entrepreneurship outcomes. This confirms what is being found by others, such as Choi et al. (2018) showing that AI creates more efficient and customer-oriented business practices in the entrepreneurial context, which promotes innovation. Hypothesis 12: ECRAI mediates the relationship between AI and EI (total effect = 0.265). Using AI ethically is not just a regulatory or compliance matter but rather an underlying factor in building trust and long-lasting innovation for startups. The direct and indirect impacts of 0.187 and 0.078 act as evidence of the significance of ethicalities during AI execution. These results align with the ethical frameworks suggested by scholars such as Jobin et al (2014), establishing the difference between risk and opportunity that drives ethical AI practices, citing that ethical platforms are sustainable innovation and risk mitigation mechanisms. Last but not least, the mediation role of effective AI integration (EIAI) is essential in the process through which entrepreneurial innovation takes place (H13). This indicates that effective integration of AI into business will yield positive and innovative results with a total effect of 0.432. This is also in line with the study of Avasarala and Goh (2020), which reveals that organizations that integrate AI technologies with their strategic goals demonstrate greater innovation in product development and customer engagement.

These findings have important implications for entrepreneurs and companies that want to apply AI to innovate. The direct and indirect impact of AI adoption, integration, and ethics on fostering entrepreneurial innovation has been established. AI emerges as an enabler and mediator if firms themselves also devote resources towards optimizing their operational efficiency. Thus, entrepreneurs must prioritize the seamless integration of AI tools within their business strategies, while adhering to ethical guidelines that safeguard sustainability and trust. Future studies may take a step forward by examining the particular challenges που entrepreneurs face when adopting AI into their projects. The role of AI across diverse settings (eg, healthcare, manufacturing, retail), could also be examined to ascertain the context-specific ramifications of AI adoption on innovation; Longitudinal research could offer insights into the long-term implications of AI on entrepreneurship and innovation, especially given the laws of technological change and some market shift.

5. Conclusion

Through mediating variables, including operational efficiency, integration practices, and ethical considerations, this study emphasizes the significance of Artificial Intelligence (AI) in driving entrepreneurial innovation (EI) behaviour through its direct and indirect influences. These findings implicate the AI adoption and the integration as drivers of innovation, but also enablers of business efficiency improvements during the entrepreneurial processes. Those entrepreneurs who manage to adopt AI properly can start to take advantage of what represents new opportunities, reduce time in the

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process and create reliable innovative solutions that are capable of making an impact for the business in order to keep it relevant. In addition, the responsible use of AI technologies centres on fairness and transparency paired with accountability, which nurtures trust and drives creativity. The findings from this study indicating significant mediation effects highlight the multifaceted nature of AI adoption and the driving factors of entrepreneurial success.

Overall, entrepreneurs should consider that they should only focus on the AI tools that fit the strategy and organization, and they should apply ethical standards to prevent some of the potential downsides. Future research could be around specific industrial applications of AI in entrepreneurship, which would provide better details of its influence on various domains. Longitudinal studies would also help address this and track the long-term implications of AI for innovation to further clarify the extent to which AI constitutes an evolution or revolution in terms of sustainable business growth. This continued inquiry enables both entrepreneurial and academic communities to unlock further the transformative potential of qualitative research, ultimately enhancing our understanding of how this is offered through AI.

Author contribution

Designed, and collected data, analysed, wrote the paper.

Silfa Sain S: Validation of data, review and editing of manuscript, visualization, supervision. The authors have equal contribution to the design, performance and final manuscript preparation of the study.

Declaration of Competing Interest

The authors have no competing financial, personal or professional interests that could have influenced the work reported in this study.

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Appendix A. Supplementary data

Table1: Sample Criteria

Criteria	Description
Sample Location	United Arab Emirates (UAE)
Sample Size	300 entrepreneurs/business owners
Age Range	25-60 years
Educational Level	High school, Bachelor's, Master's, PhD
Type of Business	Technology, Retail, Service, Manufacturing, etc.
Use of AI in Business	Yes (Current AI applications in operations)

Source of data; research observation results 2024

Table 2: Instrument Variable with hypotheses

Variable	Type	Definition	Indicators	Measurement Scale	Supporting References
Entrepreneurial Innovation (EI)	Dependent	The ability of a business to develop new products, services, processes, or business models to remain competitive and adapt to market needs.	1. New Product Development 2. Process Improvement 3. Transformation of Business Models	Likert Scale (1-5)	Avasarala & Tiwari (2021); Brynjolfsson & McAfee (2017)
AI Adoption (AIAE)	Independent	The process by which organizations begin to implement AI technologies into their operations.	1. Investment in AI 2. Use of AI Tools 3. AI Integration in Decision-Making	Likert Scale (1-5)	Porter & Heppelmann (2014)

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Variable	Type	Definition	Indicators	Measurement Scale	Supporting References
AI Integration (IOAIIEN)	Independent	The degree to which AI technologies are embedded into an organization's core functions and operations.	1. Operational AI Embedding 2. AI for Market Analysis 3. AI-Driven Strategic Planning	Likert Scale (1-5)	Bharadwaj et al. (2013)
Operational Efficiency (OE)	Intervening	Improvements in productivity, cost reduction, and resource utilization achieved through AI technologies.	1. Productivity Improvement 2. Cost Reduction 3. Time Management	Likert Scale (1-5)	Chen et al. (2020)
Ethical Considerations in AI (ECRAI)	Intervening	The implementation of ethical AI practices ensuring transparency, fairness, and accountability.	1. Transparency 2. Fairness 3. Compliance with Legal Norms	Likert Scale (1-5)	Jobin et al. (2019); Crawford (2021)

Source of data; research observation results 2024

Table 3: Descriptive Statistics

Construct	N	Mean	Std. Deviation	Min	Max
Artificial Intelligence (AI)	150	3.85	0.78	1.50	5.00
Entrepreneurial Innovation (EI)	150	4.05	0.69	2.00	5.00
AI Integration in Entrepreneurship (IOAIIEN)	150	3.92	0.74	1.75	5.00
AI Adoption in Entrepreneurship (AIAE)	150	3.75	0.80	1.50	5.00
Use of AI in Entrepreneurship (UAIIE)	150	3.90	0.76	1.80	5.00
Ethical Considerations regarding AI Implementation (ECRAI)	150	3.78	0.71	2.00	5.00
Effective AI Integration (EIAI)	150	3.85	0.75	2.00	5.00
Operational Efficiency (OE)	150	4.10	0.72	2.10	5.00

Source of data; research observation results 2024

Table 4: Convergent Validity (AVE)

Construct	AVE
Artificial Intelligence (AI)	0.62
Entrepreneurial Innovation (EI)	0.70
AI Integration in Entrepreneurship (IOAIIEN)	0.64
AI Adoption in Entrepreneurship (AIAE)	0.60
Use of AI in Entrepreneurship (UAIIE)	0.65
Ethical Considerations regarding AI Implementation (ECRAI)	0.58
Effective AI Integration (EIAI)	0.63
Operational Efficiency (OE)	0.67

Source of data; research observation results 2024

Table 5: Discriminant Validity (Fornell-Larcker Criterion)

Construct	AI	EI	IOAIIEN	AIAE	UAIIE	ECRAI	EIAI	OE
Artificial Intelligence (AI)	0.79	0.42	0.45	0.38	0.43	0.41	0.46	0.49
Entrepreneurial Innovation (EI)	0.42	0.84	0.51	0.44	0.45	0.49	0.52	0.56

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AI Integration in Entrepreneurship (IOAIIEN)	0.45	0.51	0.80	0.46	0.48	0.50	0.53	0.58
AI Adoption in Entrepreneurship (AIAE)	0.38	0.44	0.46	0.77	0.48	0.47	0.49	0.52
Use of AI in Entrepreneurship (UAIIE)	0.43	0.45	0.48	0.48	0.80	0.44	0.50	0.54
Ethical Considerations regarding AI Implementation (ECRAI)	0.41	0.49	0.50	0.47	0.44	0.76	0.51	0.53
Effective AI Integration (EIAI)	0.46	0.52	0.53	0.49	0.50	0.51	0.79	0.57
Operational Efficiency (OE)	0.49	0.56	0.58	0.52	0.54	0.53	0.57	0.82

Source of data; research observation results 2024

Table 6: Reliability (Cronbach's Alpha & Composite Reliability)

Construct	Cronbach's Alpha	Composite Reliability (CR)
Artificial Intelligence (AI)	0.84	0.90
Entrepreneurial Innovation (EI)	0.87	0.92
AI Integration in Entrepreneurship (IOAIIEN)	0.85	0.91
AI Adoption in Entrepreneurship (AIAE)	0.83	0.89
Use of AI in Entrepreneurship (UAIIE)	0.84	0.90
Ethical Considerations regarding AI Implementation (ECRAI)	0.80	0.87
Effective AI Integration (EIAI)	0.81	0.88
Operational Efficiency (OE)	0.86	0.91

Source of data; research observation results 2024

Table 7: Goodness-of-Fit (GoF)

Model	GoF Value
Structural Model	0.42

Source of data; research observation results 2024

Table 8: Path Coefficients

Path	Coefficient	t-statistic	p-value
AI → EI	0.45	5.80	0.000
IOAIIEN → EI	0.52	6.50	0.000
AIAE → EI	0.41	4.50	0.000
UAIIE → EI	0.38	4.20	0.000
ECRAI → EI	0.32	3.90	0.000
EIAI → EI	0.43	5.00	0.000
OE → EI	0.47	5.60	0.000

Source of data; research observation results 2024

Table 9: R-Square Values

Construct	R-Square
Entrepreneurial Innovation (EI)	0.60

Source of data; research observation results 2024

Table 10: Effect Size (f^2)

Path	f^2 Value
AI → EI	0.14
IOAIIEN → EI	0.21
AIAE → EI	0.12
UAIIE → EI	0.09

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Researcher Academy Innovation Data Analysis (RAIDA) Vol 1, No. 2, September 2024, Page 196-213
https://doi.org/10.69725/raida.v1i2.167

ECRAI → EI	0.08
EIAI → EI	0.15
OE → EI	0.19

Source of data; research observation results 2024

Table 11: Predictive Relevance (Q^2)

Construct	Q^2 Value
Entrepreneurial Innovation (EI)	0.38

Source of data; research observation results 2024

Table 12: Hypothesis Testing Results

Hypothesis	Path	t-statistic	p-value	Conclusion
H1	AI → EI	5.80	0.000	Supported
H2	IOAIIEN → EI	6.50	0.000	Supported
H3	AIAE → EI	4.50	0.000	Supported
H4	UAIIE → EI	4.20	0.000	Supported
H5	ECRAI → EI	3.90	0.000	Supported
H6	EIAI → EI	5.00	0.000	Supported
H7	OE → EI	5.60	0.000	Supported

Source of data; research observation results 2024

Table 12: Mediation Test

Hypothesis	Path	Direct Effect	Indirect Effect	Total Effect	T-Statistic	P-Value	Result
H8	AI → EI	0.324*	0.142*	0.466*	3.421	0.003	Supported
H9	IOAIIEN → EI	0.279*	0.118*	0.397*	2.878	0.004	Supported
H10	AIAE → EI	0.231*	0.106*	0.337*	2.645	0.008	Supported
H11	UAIIE → EI	0.254*	0.099*	0.353*	2.998	0.006	Supported
H12	ECRAI → EI	0.187*	0.078*	0.265*	2.342	0.019	Supported
H13	EIAI → EI	0.301*	0.131*	0.432*	3.256	0.004	Supported

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