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The Impact of Innovation Adoption of Emerging Digital Technologies within a collaborative ecosystem on Firm Innovation Performance- Focus on Emerging Economies (Middle East, Africa, and Asia)

Ololade Shonubi
The University of Brighton, United Kingdom

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ABSTRACT: *In today's fast-paced and ever-changing world, innovative technologies' rapid emergence and integration profoundly impact organisational strategies, the industry landscape, and overall economic and societal development. This article explores the adoption of specific emerging digital technologies (Artificial Intelligence (AI), Industry 4.0(I4.0), and the Internet of Things (IoT). It proposes a comprehensive framework to enhance firm innovation performance in organisations. A deep understanding of the future commercial application of these technologies is crucial for informed decision-making. Acknowledging the interconnected nature of emerging technologies, this research emphasises the importance of collaboration among various stakeholders such as businesses, academic institutions, research organisations, regulatory bodies, and government agencies. This collaborative effort forms a unique and interdependent ecosystem essential for effectively applying, adapting, and improving emerging digital technologies. This study highlights perspective and limitations, particularly in emerging economies, by investigating the determinants that impact their implementation, mainly focusing on emerging economies. A robust framework is developed to address the research objectives by combining existing technology models, including the Diffusion of Innovation Technology-Organisation-Environment and Technology Acceptance Model. A quantitative research survey targeted managers and above in large enterprises and multinationals within the Middle East, Africa, and Asia manufacturing industries. The collected responses (n=153) were analysed using Structural Equation Modelling and Chi-Square methods. The results of this study highlight the importance of the advantages of the collaborative adoption of emerging digital technologies in improving firm performance. By bridging the gaps in integrating multiple emerging technologies within the innovation ecosystem, organisations can enhance their innovation capabilities and leverage them for sustainable competitive advantage. This comprehensive framework provides valuable insights and practical guidance for organisations seeking to navigate the complex landscape of emerging digital technologies and maximise their innovation potential.*

KEYWORDS: artificial intelligence, internet of things, industry 4.0, emerging digital technologies, innovation adoption, emerging economies, Middle East, Africa, Asia, firm innovation performance

INTRODUCTION

The prevalence and demand for innovative differentiation across socioeconomic structures have been driven by various interconnected phenomena, including individuals' aspirations for personalised services in diverse industries, encompassing a wide range of manufacturing and related services like healthcare, telecoms, and financial services. Such demand has grown exponentially in developed and developing economies, resulting in unpredictable and unrestrained growth across various industries.

In order to meet the critical expectations of supply and demand, particularly in developing regions, adopting an innovation ecosystem model has become highly relevant. Emerging and evolving technologies such as IoT, AI, and I4.0 are recognized as transformative forces with dynamic modes of operation. These technologies facilitate interactions among diverse stakeholders, including businesses and organisations, that offer valuable information and resources. Consequently, they play a vital role in enabling transformational growth, as validated by several studies (Kumar et al., 2022; Qazi et al., 2022; Sangher et al., 2023; Shen et al., 2022).

As a response to deciphering the ecosystem concept, alternative frameworks have emerged, including innovation and entrepreneurial ecosystems, which transcend the boundaries of individual companies and encompass many organisations and individuals (Benitez et al., 2022). Recognizing the significance of external support and embracing new technological innovations, these ecosystems catalyse organisational digital transformation. Public and private intermediaries also play a crucial role in assisting businesses and organisations in navigating this transformative journey.

Moreover, it is worth noting that collaboration fosters innovation projects and provides access to a broader knowledge base within the innovation ecosystem. This observation is corroborated by Regona et al. (2022) and Vosman et al. (2023), highlighting the mutual dependence and interplay among stakeholders. The adoption of innovation and the ensuing cooperation are pivotal drivers in fostering growth and achieving organisational success in the evolving landscape of socioeconomic structures.

According to Bahoo et al. (2023), innovation ecosystems are formed by interconnected networks that share similar characteristics and goals. These ecosystems aim to create unique products and services or provide solutions that rely on the features of the ecosystem. They foster networks that drive growth in specific sectors or organisations, bringing together members with varying technical expertise.There has been a shift in focus from the qualities of individual firms to the co-creation of benefits and experiences through the adoption of technological and service innovations. As Bhat and Sharma (2021) highlighted, this approach promotes using innovations and resources to create value and enhance organisational performance.

An organisation's strategic development hinges on its ability to grasp and address the preferences of its customers regardless of tits business focus. Throughout the formation process, information is gathered to create value, which can be harnessed to provide services supporting the organisation’s core functions. These services encompass technical expertise and the adoption of emerging technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), and Industry 4.0. Smart manufacturing, also known as digital manufacturing, is driven by these technologies and contributes to knowledge enhancement and competitive advantage for firms, according to Polas et al. (2023).

Achieving significant growth relies on the practical ability of companies to innovate, which necessitates the development of new networks and becoming insiders within existing customer networks, thereby leveraging the strengths of these companies. Numerous corporations strive to be industry leaders in technology by introducing cutting-edge digital advancements to the market, aiming to capitalize on the advantages of innovation. However, the success of a specific innovation often relies on its integration with complementary advancements in its environment. The substantial growth is intertwined within an ecosystem of interconnected innovation resulting from these external advancements, which consequently necessitate the creation of additional elements. Therefore, according to research conducted by Nittala et al. (2022), it may be crucial to adopt a transparent approach towards internal innovation challenges and the technological innovation character of external partners in order to enhance performance.

In light of recent developments, Dearing (2020) outlines research objectives that address the question, "How can we navigate the future marketplace?". Over the past decade, companies have undergone significant shifts in their perceptions of the nature and process of innovation. Moreover, many innovations now revolve around intangible offerings that are either associated with or independent of standalone products, encompassing a high level of informational content commonly referred to as an information-centric focus. There is an evident inclination towards focusing on the characteristics and qualities of innovation performance that align with the benefits or experiences provided to companies or consumers. This collaborative creation is facilitated by leveraging emerging digital technologies and other resources, which Payne et al. (2021) call a value- and experience-centric approach.

Firms aim to extract value from their outputs to seek a competitive edge. This value is frequently benchmarked against their rivals, especially in sectors focused on generating revenue. The ability to innovate effectively is a crucial determinant of generating more significant value. Consequently, many companies aspire to be trailblazers in technology within their respective sectors by introducing new, enhanced, or revolutionary technologies. This pursuit of innovation benefits necessitates adopting a transparent approach focusing on internal innovation challenges and external partners' technological innovation, as Liu (2022) emphasised.

The rise of advanced digital technologies, such as artificial intelligence (AI), is propelling the pursuit of knowledge with a gradual and powerful influence in shaping marketing strategies, improving customer experiences, and transforming organisational approaches to drive additional revenue growth. Entrepreneurs often generate innovative ideas for advantage, necessitating thorough strategic options analysis. Accordingly, careful decisions regarding business management and execution or the performance of crucial tasks should be taken seriously. As Kopalle and Lehmann (2021) noted, emerging technologies like AI are increasingly proving invaluable tools.

Innovative services and technologies will profoundly impact industries, requirements, and the life cycle of all products by introducing novel manufacturing and operating methods that streamline processes and enhance business competitiveness within an ecosystem. Internet technologies, such as computers, automation, and robotics, have revolutionized their applications and the possibilities they offer. These include real-time monitoring of operations and processes, from equipment and materials to products, resulting in greater convenience and cost-effectiveness. Another such technology is the fourth industrial revolution, deeply rooted in information and today's business environment. Competition compels businesses to collect, analyse, and utilize information to make better decisions and thrive. Multinational organisations like Google and Amazon, equipped with sophisticated protection systems, vigorously leverage their AI technology to comprehend regional dialects in India, as most customers speak these local languages. Consequently, they recognize the need to prevent local companies like "Voxta" from capturing a larger share of the Indian market. Banalieva and Dhanaraj (2019) highlight that large organisations aggressively foster the growth of medium-sized companies by deploying cutting-edge technologies like IoT and AI to enhance their products and services, thereby creating a technological ecosystem.

Innovation and digital technology are two focal points reshaping various industries, with the fourth industrial revolution taking the lead in transforming the manufacturing industry in a remarkably unconventional manner. Manufacturing companies must innovatively utilise digital technology to modify their production methods, effectively responding to the evolving requirements of international markets and striving for sustainable expansion. Companies that embrace digital technologies in their operations will always possess a competitive edge. Subsequently, the Internet of Things (IoT) is becoming increasingly sophisticated in manufacturing and industrial systems, supporting many activities. Combining the technologies can revolutionise working conditions and drive efficiency for automation, operational effectiveness, and efficiency. Guo and Xu (2021) assert that these technologies are essential for generating more knowledge-driven manufacturing processes, including advanced equipment, devices, and customized innovations capable of interacting, triggering actions, and operating autonomously.

LITERATURE REVIEW

Adoption of Innovation and categories

Innovation can be understood as transforming novel ideas and perspectives into widely adopted practices that result in innovative developments encompassing various functions and business processes that leverage exploitative thinking. According to Bustinza et al. (2021), Innovation Management Applications (IMAs) have emerged as information management mechanisms that facilitate the development of innovative and operational features within organisations. These IMAs, including various tools and software, focused on fostering innovation that can significantly contribute to the advancement of products and services.

The subsequent innovations resulting from lifecycle approaches based on specific procedures can be characterized as action-oriented, goal-oriented, and outcome-driven activities. These collaborative efforts are essential for successful implementation. Additionally, these applications can offer cross-functional and relational benefits to organisations, both internally and externally. This universal approach to product or service innovation fosters sustainable competitive advantages for firms, as Blichfeldt and Faullant (2021) highlighted. Their study describes innovation as introducing or applying new ideas or techniques, accompanied by systematic engagement across various functions.

Innovation entails the development of unique product or service innovations through creative thinking. It goes beyond mere creation and necessitates a consistent out-of-the-box thought process that enables incremental improvements over time. Chen (2022) emphasises the collaborative interactions among multiple parties, platforms, and technologies across diverse sectors, forming an adaptable network that includes government agencies and businesses of all sizes, and such collaboration is crucial for fostering innovation.

Rapidly evolving attributes with fluid characteristics facilitate technological innovation. For example, the modern Internet acts as a platform for global connectivity, transcending traditional barriers such as politics, economics, and culture, as Bogers et al. (2021) mentioned. Therefore, internet-based technology enhances usability and the adoption of various features, including the perceived convenience of technology usage. Organisations worldwide are increasingly embracing and applying these emerging technologies, along with the internet, to drive positive change and growth, as Kasilingam and Krishna (2022) discussed.

Innovation can be seen as transforming the old into the new, transitioning from the present to the future. It involves incorporating the attributes of existing products or services and upgrading them with cutting-edge technology. Examples include the manufacturing of Liquid Electronic Display (LED) Televisions, the evolution from 2G to 4G LTE to 5G technology, the transition from CDs to streaming, and the development of pocket-sized mobile phones from large cellular devices. Haizar et al. (2020) argue that these modern versions reflect improvements, enhancements, and costs associated with recent technology. Therefore, it necessitates organisational readiness to embrace technological innovation to meet the demands of consumers.

Innovation plays a vital role in the strategic decisions of industry leaders, enabling them to adapt to the market, technology, and competition. It drives critical growth within firms and influences their strategic movements and structures. Implementing an innovation strategy successfully requires significant changes and entails risks. Innovation refers to a concept, behaviour, or thing that undergoes adoption and eventual integration. It does not have to be entirely brand new to be considered innovative.

Different types of innovation, such as product, process, and organisational innovativeness, serve as differentiators among organisations. Gunday et al. (2011) discussed understanding the role of corporate innovation behaviour and distinguishing between organisations that generate innovation and those that adopt it. For innovation-adopting-oriented organisations, innovation serves as a means to facilitate the achievement of primary goals, while for innovation-generating organisations, it is the core purpose of their existence. Adopting innovative technology in adoption-oriented organisations depends on whether it fulfils the requirements that enable its adoption. Liu et al. (2022) conclude that adopting emerging technological innovations can positively impact efficiency and firm performance.

Organisations employ various types of innovation to differentiate themselves and thrive in their respective industries and economies. The Organisation for Economic Co-operation and Development (Data, 2005) has outlined multiple types of innovation to support this drive.

Open Innovation

As Bigliardi et al. (2021) described, open innovation is a strategic approach emphasising the purposeful exchange of new ideas within and beyond an organisation. It involves changing how things are done, thinking about things differently, and utilising ideas to drive innovation. Open innovation is not limited to formalised projects or top-down decision-making processes, as it embraces the opportunities associated with emerging technologies such as artificial intelligence, the Internet of Things (IoT), and Industry 4.0.

According to Livieratos et al. (2022), open innovation encompasses a purpose-driven approach to creating research and technological advancements through the diffusion of various players, including customers, suppliers, and competitors. It recognizes the evolving needs of organisations and their industries, facilitating collaboration and knowledge exchange. Open innovation enables the continuous flow of novel ideas and the commercialisation of demand, leveraging the interconnected boundaries between new and existing industries. It represents a progressive approach that harnesses the potential of emerging technologies to drive innovation and stay competitive in the mark.

Products and service innovation

Innovation relates to the ability to adapt and be an indispensable force, enabling them to navigate changing circumstances, remain competitive, and satisfy the organisations' ever-changing demands of their customers. Blichfeldt and Faullant emphasise that organisations can generate revenue without a dominant market blueprint. Bustinza et al. (2021) describe innovation as businesses expanding by seizing opportunities as they arise. It is essential for organisations to continuously enhance innovation in order to meet customer needs, expand their customer base, and promote their services. Sun (2023) highlights Alibaba's financial product, Alipay, as an example of a multipurpose business model strategy that provides inclusive financial assistance and supports innovation growth for firms.

The watch industry provides a historical example of how product innovation can lead to transformative growth. Moon (2004) explains how Swiss Watches faced competition from low-cost manufacturers who utilized technological innovations known as "Swatch watches." This modification and introduction of various models enabled by technological advancements revolutionized the watch industry. Jeannerat and Theurillat (2021) point out that the Swatch manufacturers in Biel/Bienne, Germany, have utilized emerging Industry 4.0 technology to enhance products across multiple platforms.

The successful implementation of product innovation is evident in the case of Swatch, which became the most significant watch manufacturer in history. Morisson de la Bassetiere et al. (2021) describe how evolving technology redefined the product and exponentially transformed the watch market by optimizing design and performance. Overall, these examples highlight the importance of product innovation for organisational growth.

Process innovation

Process innovation provides many benefits, with the primary goals being to diminish production costs, elevate the product's quality, boost productivity, and amplify total efficiency for both the organisation and its stakeholders. However, despite its significance, process innovation often remains unseen by clients, as it primarily functions as an internal operation within the organisation (Seclen-Luna et al., 2021). Nonetheless, any delays or deficiencies in internal process innovation can ripple effect on product and service delivery, ultimately impacting the organisation's performance.

Process innovation involves adopting new strategies, tactics, and techniques, along with modern technologies, to revolutionize the manufacturing or delivery of products and services, which includes creating technological roadmaps and utilizing innovative production procedures. For manufacturers, process innovation entails leveraging new technologies to achieve cost savings, improved quality, faster lead times, and enhanced pricing benefits within the manufacturing process. Fukawa and Rindfleisch (2023) provide an example of Siemens using artificial intelligence (AI) to simulate organs, employing IoT connectivity with other manufacturing equipment supported by Industry 4.0 technologies. Process innovation can encompass a range of adoption strategies, such as introducing improved materials (Industry 4.0), replacing embedded hardware with computerized methods (Internet of Things), and incorporating automation (Artificial Intelligence) to enhance user convenience. By embracing process innovation, organisations can unlock substantial gains in operational efficiency and customer satisfaction.

Organisational innovation

Organisational innovation refers to adopting new processes and technologies that enable an organisation to adapt and change. It involves acquiring modern skills and knowledge and can be facilitated by emerging digital technologies. The study by Chatterjee et al. (2021) highlights that applying expertise provides a platform for organisations to adopt innovation, regardless of whether another organisation has previously implemented it. Even if the innovation is new to the organisation, it can still be considered novel and valuable. Organisational innovation allows firms to gain a competitive advantage by integrating different technologies such as administration, finance, production, and human resources.

According to Makkonen (2021), organisational innovation involves a combination of functions that promote the systematic adaptation, implementation, and engagement of innovation adoption. Therefore, it highlights the importance for organisations to be prepared and embrace the rapid advancement of technologies. Samsung, a leading global manufacturer, is an example of organisational innovation. They have built a comprehensive innovation ecosystem encompassing education and training, research and development, open innovation partnerships, and product and service diversification (including mobile devices, consumer electronics, and equipment). Samsung continuously applies emerging technologies across different business functions, internally and externally. The adoption of innovation at the organisational level emphasises how integrating technological adoption can affect the performance of a business. It offers an avenue to utilise innovative products or services.

Emerging Digital Technologies

The rapid growth of knowledge-driven technologies, emerging digital technology, has become essential today (Ceipek et al., 2021). Ciarli et al. (2021) indicate the technological and scientifically supported and encompassed innovative concepts that facilitate the development of new industries. They strongly relate to innovation, progress, and human skills across various sectors. The transformative nature of emerging digital technologies necessitates a prompt response and encourages the need for innovation. According to the studies of Acemoglu et al. (2021) and Deng et al. (2021), failure to address these challenges or lack of a strategic plan will drive organisations to face detrimental consequences.

Internet of Things and the Adoption of the innovation ecosystem - an Emerging Digital technology review

The Internet of Things (IoT) enables interconnected communication systems, creating adaptable smart objects that serve a purpose. Langley et al. (2021) emphasise "things" within IoT. Discussions about IoT occur among governments, academics, and industries, with varying approaches and outcomes. Kasilingam and Krishna (2022) highlight the digitalisation and integration of contexts characterising the new digital age under IoT values. Digital technology allows new market entrants to challenge established companies, leading to new product and service offerings. Startup firms leverage the IoT ecosystem for development, and as Roe et al. (2022) discussed, this evolution impacts resource allocation and how goods and services are developed and produced.

The IoT connects people and things, bridging the physical and digital worlds. Ghosh et al. (2021) explain that devices can make autonomous, intelligent decisions without human intervention, contributing to a better society. The Internet of Things (IoT) endeavours to establish autonomous, resilient, and secure networks for exchanging information within the context of real-world applications and objects. Consequently, this integration of Machine-to-Machine (M2M) communication, connectivity, and intelligence within individual systems holds great promise for the future. It enables devices to process information and data independently, making intelligent decisions akin to human cognition without necessitating human intervention. This progress contributes to developing a more advanced society where inanimate objects possess an inherent understanding of human desires and requirements, obviating the need for explicit human instructions (Ghosh et al., 2021).

Artificial Intelligence and the Adoption of the innovation ecosystem - an Emerging Digital technology review

Previous definitions of artificial intelligence (AI) have encompassed computers' ability to reason and make decisions like humans (Hoffmann, 2022; Jeyanthi et al., 2022). AI is rapidly evolving, with applications ranging from household robots and medical care facilities to virtual bots transforming customer service (Hoffmann, 2022). Terminologies used to categorize AI include "machine intelligence," "machine learning," "intelligent system," and "decision intelligence" (Jeyanthi et al., 2022). Software-based AI systems, such as virtual companions and biometric systems, operate in the virtual world, while hardware-based systems include cutting-edge robots, autonomous vehicles, drones, and Internet of Things applications (Jeyanthi et al., 2022).

Human-machine interaction involves gestures, sensors, touch, and voice, while automated analysis refers to AI's generation of images, text, video, and data (Kopalle & Lehmann, 2021). Digital technology researchers highlight AI's role in enhancing productivity and decision-making across business units (Kopalle & Lehmann, 2021). AI's impact on organisations includes adapting business models to market changes and the potential for positive influence on crucial decisions (Heinonen & Strandvik, 2021).

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The adoption of AI is still limited, with less than 10% of organisations implementing emerging technology (Gartner, 2017a). This scarcity of research on AI adoption motivates further investigation into the challenges businesses face when implementing AI to establish distinctness in their industry (Gartner, 2017a). The maturity of AI as a technology raises speculation and the need for cautious readiness to address its complexities and potential difficulties (Benbya et al., 2021). AI has the potential to deliver superior quality, efficiency, and results compared to human specialists and is progressively integrated with other technologies across various industries (Benbya et al., 2021). Digital technologies, such as mobile check-out systems in hotels and remote medical examinations, have been facilitated by AI adoption (Benbya et al., 2021).

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In order to succeed, organisations require innovative and advanced technologies, such as AI-driven business intelligence, to align data and make accurate decisions (Tabim et al., 2021). These technologies also enable quick responses to dynamic market conditions, supporting organisational adaptability and competitiveness (Tabim et al., 2021). AI adoption poses challenges due to its complexity and knowledge barriers, distinguishing it from other digital technologies (Haefner et al., 2021). As an innovative technology, AI demands further research to comprehend its intricacies and ensure successful implementation (Haefner et al., 2021).

Industry 4.0 and the Adoption of the innovation ecosystem - an Emerging Digital technology review

Industry 4.0 is characterized by a notable increase in speed and volume, prompting the development of new emerging approaches to effectively harness their potential in the context of the Fourth Industrial Revolution. The phenomena of smart factories and the expansion of manufacturing are strongly performance-oriented, with the rapid pace commonly referred to as Industry 4.0 in the manufacturing industry, as discussed by Rosin et al. (2022). Emerging technologies like IoT have been introduced as value-added innovations to enhance performance. Industry 4.0 has transformed the global industrial scene through advancements and inventions, with interconnected and novel production processes. It combines conventional industries with cutting-edge technologies, enabling end-to-end digitalisation and seamless data communication. This digitalisation allows for real-time information access and benefits various stakeholders involved. Digital technologies have significantly impacted value creation and delivery, reshaping developments across multiple spheres. Artificial intelligence and Industry 4.0 are widely discussed topics, with the application of sophisticated forecasting tools being crucial for informed decision-making. The architecture of Industry 4.0 involves significant data manufacturing with versatile computing capabilities, including batch and stream data processing, decentralization, and accurate regulation. This architecture enables complex industries to meet diverse requirements and enhances industrial processes' effectiveness, resilience, and expandability. Industry 4.0 has unlocked new business opportunities and is expected to bring about collaborative, structural, and methodological changes in manufacturing, influencing consumption volumes and economic development.

Developing the framework for adopting innovation, emerging digital technology, and Firm performance.

Three innovation adoption theories, Diffusion of Innovation Theory (DOI), Diffusion of Innovation Theory (DOI) and Technology Organisation Environment Theory (TOE), were combined to develop measurement items for the three dependent variables and 13 independent variables.

RQ1 : Rapid advancement
In order to measure the rapid advancement variable in the framework of this study, we will combine three factors from the Diffusion of Innovation theory, one factor from the Technology Acceptance Model, and one element from the Perceived Characteristics of Innovating approach. These factors will be used to assess the dependent variable of rapid advancement. They were Relative advantage, Compatibility, complexity, trialability and perceived ease of use.

Table 1– RQ1: Research Hypothesis

RQ1: How does the rapid advancement of Emerging Digital Technology (the Internet of things, Industry 4.0, and Artificial Intelligence) affect innovation adoption		
Factors affecting Adoption of Innovation (Variables)	**Hypothesis**	**References**
Relative advantage	RAH1: **Positive**: Relative advantage positively impacts an organisation's inclination to adopt innovation.	(Al Hadwer et al., 2021), (Yuen et al.,2021).
Compatibility	CMPH2: **Positive:** Compatibility positively impacts an organisation's inclination to adopt innovation.	(Al Hadwer et al., 2021). (Yuen et al.,2021).
Complexity	CXH3: **Negative:** Complexity negatively impacts an organisation's inclination to adopt innovation.	(Al Hadwer et al., 2021)
Trialability	TRH4: **Positive:** Trialability positively impacts an organisation's inclination to adopt innovation.	(Ullah et al., 2021)
Perceived ease of use	PEOUH6: **Positive:** Perceived ease positively impacts an organisation's inclination to adopt innovation.	(Yuen et al., 2021), (Vahdat et al., 2021),

RQ2: Organisational readiness

In order to enhance comprehension of the dependent variable of organisational readiness, variables from the Technology Environmental Organisation (TOE) Model (Tornatzky & Fleischer, 1990) will be carefully selected and applied. This selection and application of variables from the TOE Model will enhance our comprehension of organisational readiness in the study. They were as follows: Top management support, technology readiness, technology partners support, regulator support, and competitive industry pressure.

Table 2– RQ2: Research Hypothesis

RQ2: How does organisational readiness for Emerging Digital Technology (the Internet of things, Industry 4.0, and Artificial Intelligence) impact innovation adoption?			
	Factors Affecting the Adoption of Innovation	**Hypothesis**	**References**
Technology	**Top management support**	**TMSH7: Positive:** Top management support positively impacts an organisation's inclination to adopt innovation.	(Oliveira et al., 2019)
Organisation	**Technology readiness**	**TRH8: Positive:** Technology readiness positively impacts an organisation's inclination to adopt innovation.	(Oliveira et al., 2019)
Environment	**Technology partners support**	**TPSH9: Positive:** Technology partner support positively impacts an organisation's inclination to adopt innovation.	Holmstrom (2021) (Chen et al.,2021)
	Regulatory Support	**RSH10: Positive:** Regulatory Support positively impacts an organisation's inclination to adopt innovation.	(Malik et al.,2021) (Chen et al., 2021)
	Competitive Industry pressure	**CPRH11: Positive:** Competitive pressure positively impacts an organisation's inclination to adopt innovation.	(Stjepić et al., 2021) Holmstrom (2021) (Chen et al., 2021)

RQ3: Firm Innovation Performance

To assess the firm's performance in innovation, we will measure it using relevant indicators derived from past research that has consistently indicated a direct and positive correlation between innovativeness and firm performance (Anning-Dorson et al., 2018). Furthermore, some studies have emphasised the importance of considering three specific types of innovation to assess the firm's performance robustly (Anning-Dorson et al., 2018; Gunday et al., 2011). Hence, this study will assess the impact of emerging technologies such as AI, IoT, and I4.0 on firm performance by evaluating three variables: organisational innovativeness, process innovativeness, and product and service innovativeness.

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Table 3 – RQ3: Research Hypothesis

RQ3: How does adopting an innovation ecosystem (of Emerging Digital Technology, the Internet of things, Industry 4.0, and Artificial Intelligence) affect firm performance?			
	Factors Affecting the Adoption of Innovation	**Hypothesis**	**References**
Firm Performance	**Products and Services Innovativeness**	**PSI H8: Positive** The more products and service innovations were implemented, the more significant the firm's performance.	(Anning-Dorson et al., 2018)
	Organisational Innovativeness	**ORGINV H10: Positive** The higher the implementation of Organisational innovation, the more significant the firm's performance.	(Ghosh & Srivastava, 2021)
	Process Innovativeness	**PRC H11: Positive** The higher the implementation of process innovation, the more significant the firm's performance. .	(Anning-Dorson et al., 2018)

RESEARCH METHODOLOGY

Their literature review explored the adoption of innovation ecosystems and the impact of emerging digital technologies (Industry 4.0, IoT, AI) on firm performance. They establish the connections between these technologies and their influence on organisational success. To collect data for the research,d a questionnaire was developed with multiple sections. The first section encompasses demographics and general questions. In the second section, respondents are presented with specific inquiries that allow them to indicate the adoption of one, two, or all three of the emerging technologies within their organisation, offering flexibility in their selection. The questionnaire's third section includes questions adapted and modified from the measurement scale for combining theories (DOI, TOE, and TAM), as extensively explained in chapter two. Ratings for all items were obtained on a Likert scale ranging from one to five, reflecting the degree of agreement or disagreement, with "strongly disagree" to "strongly agree" as the options.

By incorporating multilayer questions in the questionnaire, the aim was to delve into managers' experiences and extract valuable information for their research. This approach has been proven helpful in organisations that implement new-age technologies, considering the need for confidentiality (Makri & Neely, 2021). The study explicitly targets managers and above, as they possess relevant insights based on their employment in large enterprises and multinational companies. Moreover, the organisations under investigation will have implemented emerging digital technologies such as the Internet of Things, Artificial Intelligence, or Industry 4.0 operations at some point or another. In summary, a comprehensive literature review on innovation ecosystem adoption and emerging digital technologies was conducted to examine the impact on firm performance. A questionnaire with various sections was designed to collect data from managers in organisations that have implemented these technologies. According to Makri and Neely (2021), this supports the efficacy of multilayer questions in gathering helpful information while respecting confidentiality.

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R.Q. 1: How does the rapid advancement of Emerging Digital Technologies (the Internet of things, Industry 4.0, and Artificial Intelligence) affect innovation adoption in organisations?

RQ2: What is the impact of organisational readiness for Emerging Digital Technology (the Internet of things, Industry 4.0, and Artificial Intelligence) on innovation adoption in organisations?

RQ3: How do emerging digital technologies (IoT, AI and 14.0) impact firm innovation performance in an organisation?

The rationale of quantitative data collection for the current study

The study employed a quantitative research technique, drawing on existing literature and similar measurement items to evaluate the research questions. A five-point Likert scale was utilised to assess the various aspects of innovation adoption discussed in previous chapters. This methodology facilitated the integration of research findings, the accomplishment of research objectives, and the ability to provide recommendations and implications based on the results. Quantitative research is a systematic approach to addressing problems, allowing for well-structured theoretical frameworks and hypotheses contributing to problem resolution. Minimizing subjectivity was crucial, given the study's focus on three continents and the integration of three emerging technologies. Zyphur and Pierides (2020) highlight that quantitative research methods provide a more objective perspective.

The term "quantitative procedures" encompasses any approach that utilises numerical data for analysis, offering decision-makers a systematic tool. The advent of technological advancements facilitating online questionnaires and digital outreach has an essential role in the creation and rapid expansion of quantitative research. Limone et al. (2022) discuss that as one of the reasons why the method’s efficacy and reach have increased. This study's quantitative method effectively conveyed quantitative findings through objective statistical methods. This approach aligned with the study's goals, as Gupta and Gupta (2022) discussed, with its application supporting adequate planning in hypothesis testing, discovering new information, and making predictions—essential factors for validating or refuting hypothesised relationships. Consequently, the study gathered evidence for or against specific theories that explain the occurrence of particular phenomena.

The rationale behind targeting managers and above for quantitative data collection.

According to Shaver (2021), the survival of a business hinges on the managers' capability to make prompt and efficient decisions. Growth, diversification, knowledge, and retention influence these decisions. The present study targeted these managers segment due to their organisations’ expertise.

The rationale behind the use of emerging continents/markets /economies within the study

According to Hoskisson et al. (2000), emerging economies are countries experiencing rapid growth and actively implementing measures such as deregulation, privatisation, and international trade to drive progress. Maurya et al. (2023) further explain that these economies are making significant advancements by adopting and utilising innovative practices in global business operations. It is an occurrence that presents both promising opportunities and challenging obstacles for organisations, making it an area of interest for studying market insights and innovation. A study by Dana et al. (2022) reveals that the continents contribute approximately 42% of the global GDP and account for 55% of the world's population. Additionally, as indicated by the research conducted by Gregoriou and Ghosh (2009), gaining insights into the proportion of GDP allocated to capital and current spending provides a valuable foundation for evaluating the growth potential. Therefore making them attractive to businesses seeking growth prospects and expansion opportunities. Several studies discussed in this section emphasise the increasing impact of emerging economies on the global economy compared to advanced economies and developing nations.

Thus, it is vital to consider the rationale behind studying emerging markets. According to Cavusgil et al. (2021) and Cavusgil (2021), emerging market economies accounted for only 30% of the global GDP in 1990 but now contribute around 42% to the global GDP. Additionally, they constitute 55% of the world's population.

Questionaire distribution

The study utilized a questionnaire method (quantitative research) to gather data from various industry management staff. The questionnaire was sent out as a test to ensure accuracy and was designed based on previous studies' questionnaires. Griffin et al. (2022) and Sammut et al. (2021) highlighted the advantages of web surveys in terms of cost-effectiveness, reach, and real-time tracking of responses. The survey was distributed using the link generated from the Qualtrics platform. The study also addressed the challenge of obtaining qualified participants by targeting large enterprises and using a continent-based search. Additionally, Carter and Del Ponte (2022) emphasised the advantages of online platforms like Qualtrics in eliminating duplicate entries and facilitating the global dissemination of surveys.

After distributing the questionnaire, an initial batch of 49 responses was received, indicating the success of the pilot testing. The researchers utilised Qualtrics as the platform for data collection and employed diverse dissemination methods such as emails and digital links. The advantage of using Qualtrics was its ability to track unfinished questionnaires, as Harrison and Hernandez (2022) supported, which enhanced the researchers' ability to complete the survey.

RESULTS AND FINDINGS

Data Collection Summary

The data collection process began by distributing the survey to 353 managers and higher-ranking individuals in manufacturing-related companies across the Middle East, Africa, and Asia. A total of 218 responses were received, with 49 utilised for the questionnaire's pilot study. Of the 169 responses after the pre-test, 153 were deemed valid for analysis. At the same time, 16 were excluded due to incompleteness or being deemed invalid, which aligns with similar cases found in previous studies such as Sun's (2023) innovation adoption study, the I4.0 studies conducted by Virmani et al. (2023) and Yavuz et al. (2023), as well as the IoT studies by Alhasan et al. (2023) and Bader et al. (2023), and AI research studies by Rawashdeh et al. (2023) and Xie et al. (2023). Lund's (2023) thorough analysis of over 800 articles spanning nineteen years unveiled that response rates fluctuated between 16.5% and 50%, with a mean of 27.8%. Ultimately, this study utilized 153 valid responses (50.3%) for data interpretation and analysis, as elaborated in the subsequent sections.

Statistical analysis

Descriptive analyses were used to explore the characteristics and distribution of variables and constructs to provide valuable insights into the nature and behaviour of the variables (Pallant, 2020). A p-value < 0.05 denotes statistical significance. All analyses were performed using the Statistical Package for Social Sciences (SPSS, IBM Corp). To evaluate the quality of the instrument, various validity tests, such as internal consistency reliability, construct validity, and convergent validity, were selected based on the mode of the questionnaire used within this study.

Reliability

The internal consistency of the Scale was assessed through Cronbach's alpha, with $\alpha > 0.8$, indicating a favourable level of reliability, consistent with previous studies (Lai & Nagapan, 2022), which also suggested a threshold of 0.7 or higher for good internal consistency.

Construct validity

The suitability of the data for factor analysis was evaluated using the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's test, as suggested by Field (2013) and Kaiser (1974). A KMO value of ≥0.8 and a statistically significant Bartlett's test p-value of <0.05 were utilized in this study. These criteria enhance the empirical evidence supporting the analysis's validity and reliability.

Convergent validity

The convergent validity of the scale was assessed using two criteria: average variance extracted (AVE) and composite reliability (CR). AVE values above 0.5 and CR values above 0.7 indicate acceptable convergent validity (Fornell & Larcker, 1981). AVE has the advantage of considering measurement error in variables (Bollen, 1989), while CR provides a more unbiased reliability estimate than Cronbach's alpha (Rosli et al., 2021).

Model diagnostic tests

In order to assess the construct validity of the five-factor scale, a confirmatory factor analysis (CFA) was employed, following the factor structure model (Tavakol & Wetzel, 2020). CFA is a commonly used approach to validate the number of factors in a scale and assess the goodness of fit between the data and the proposed model (Ho & Liang, 2021). The recommended fit indices for this analysis include CMIN/DF < 2 (1.8173), RMSEA < 0.08 (Byrne, 2016; Ho, 2006; Jia et al., 2023; Ozen & Durkan, 2016), IFI, TLI, and CFI > 0.80 (Moolla & Bischoff, 2013), and PNFI > 0.50 (Mulaik et al., 1989).

Results from the study

The results of the survey completed by 153 people are summarized in Table 1. Information collected includes age, gender, occupation, sector, nation, and the cutting-edge digital tools now in use by each organisation. The ages of those who responded ranged from 30 to 50 (39.87%) and 41 to 50 (43.79%), with 16.34% being 51 and older. The gender breakdown was as follows: 85.62 per cent male, 14.5 per cent female. Managers made up the most significant proportion of respondents (29.41%), followed by senior managers (18.95%) and department heads (17.65%). Respondents came from a wide variety of professional backgrounds, including the consumer electronics business (11.76%), the devices, hardware, and equipment manufacturing industry (30.07%), and the telecommunications industry (7.84%). The countries of respondents' residence are also included in the table. 20.92% of the sample originated in Nigeria, 15.66% from China, 14.38% from South Africa, and 9.15% from Ghana. Finally, the table showcases the cutting-edge digital tools used by the businesses of the survey's respondents. Among the respondents, 29.41% reported the Internet of Things (IoT) as the most frequently utilised technology. Artificial intelligence (AI), Industry 4.0 (i4.0), and hybrids thereof are also among the technologies discussed.

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Table 4 Demographics for the Research Study

Variable	Category	Frequency	Percent
What is your Age	30-40	61	39.87
	41-50	67	43.79
	51 and above	25	16.34
	Total	153	100.00
What is your gender	Female	22	14.38
	Male	131	85.62
	Total	153	100.00
What is your designation/ Title	CXO, Director and above	20	13.07
	Director	9	5.88
	GM, CXO, Director and above	23	15.03
	Head of the department	27	17.65
	Manager	45	29.41
	Senior manager	29	18.95
	Total	153	100.00
What is your industry?	Adhesive	1	0.65
	Construction	1	0.65
	Consumer Electronic	18	11.76
	Devices, hardware, and Equipment	46	30.07
	Financial Services	4	2.61
	FMCG	7	4.58
	FMCG	45	29.41
	Footwear	1	0.65
	Healthcare	3	1.96
	Logistics and Supply Chain	3	1.96
	Paint	3	1.96
	Pharmaceutical	9	5.88
	Telecommunications	12	7.84
	Total	153	100.00
In what country do you reside	Bangladesh	13	8.50
	China	24	15.69
	Ghana	14	9.15
	Guinea	1	0.65
	India	5	3.27
	Nigeria	32	20.92
	Pakistan	7	4.58
	Saudi	1	0.65
	South Africa	22	14.38
	South Korea	9	5.88
	Taiwan	13	8.50
	Tanzania	1	0.65
	UAE	11	7.19
	Total	153	100.00
Which emerging digital technologies does your organisation apply in their business activities	AI	5	3.27
	AI, I4.0	4	2.61
	I4.0	1	0.65
	IoT	45	29.41
	IoT, AI	27	17.65
	IoT, AI, I4.0	39	25.49
	IoT, I4.0	32	20.92
	Total	153	100.00

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Descriptive Statistics for Hypotheses

Each construct consists of multiple items (Table 2), and the table provides their means, standard deviations, skewness, and kurtosis values. These statistics offer insights into the distribution and characteristics of the data for each construct and item. The descriptive statistics reveal several noteworthy findings. Firstly, the construct of Relative Advantage had a mean score of 3.99, indicating that participants perceived adopting Industry 4.0, AI, and IoT as beneficial in terms of cost reduction, customised solutions, flexibility, and increased revenues. Similarly, the Compatibility construct had a mean score of 3.88, suggesting that participants perceived the compatibility of emerging technologies with existing business practices, objectives, and infrastructure. The construct of Trialability received a high mean score of 4.04, indicating that participants perceived the opportunity to try emerging technologies before committing to them as relatively easy. The construct of Perceived Ease of Use had a mean score of 3.83, suggesting that participants perceived the process of using emerging technology-based systems as understandable. Furthermore, participants displayed a moderately high mean score of 3.94 for the construct of Technology Readiness, indicating their general inclination to embrace and use new technologies. These findings provide insights into participants' perceptions of the advantages, compatibility, trialability, ease of use, and readiness to adopt emerging technologies in their organisations.

Table 5 Descriptive Statistics for Hypotheses and Variables.

Descriptive Statistics	**Mean**	**STDEV**	**Skewness**		**Kurtosis**	
			Statistic	**Std. Error**	**Statistic**	**Std. Error**
RA1-Q10- Industry 4.0, AI, and IoT allow our organisation to cut expenses. (HYPOTHESIS 1)	4.04	0.794	-1.270	0.196	3.182	0.390
RA2-Q11 - Industry 4.0, AI, and IoT enable our organisation to deliver tailored solutions. (HYPOTHESIS 1)	3.97	0.873	-1.211	0.196	1.965	0.390
RA3-Q12 - Industry 4.0, AI and IoT enables our organisation to be more adaptable. (HYPOTHESIS 1)	3.97	0.892	-1.290	0.196	2.466	0.390
RA4-Q13 - Industry 4.0, AI, and IoT can boost earnings and enhance profitability. (HYPOTHESIS 1)	3.99	0.835	-1.693	0.196	4.573	0.390
Relative Advantage	**3.99**	**0.848**	**-1.366**	**0.196**	**3.047**	**0.390**
CMP1-Q14 - The changes resulting from integrating IoT, AI, and Industry 4.0 are in harmony with our organisation's established business methods, including processes and procedures. (HYPOTHESIS 2)	3.78	0.845	-1.151	0.196	1.982	0.390
CMP2-Q15 - New technology adoption, such as AI, IoT, and Industry 4.0, should align with existing targets and support them. (HYPOTHESIS 2)	4.00	0.743	-0.876	0.196	1.780	0.390
CMP3-Q16 - AI, IoT, and Industry 4.0 should seamlessly integrate with our current technology infrastructure. (HYPOTHESIS 3)	3.88	0.632	-1.167	0.196	2.592	0.390
Compatibility	**3.88**	**0.740**	**-1.065**	**0.196**	**2.118**	**0.390**
CMPX1-Q17 - Proposing AI, IoT and Industry 4.0 into my organisation is challenging. (HYPOTHESIS 3)	3.75	0.662	-1.198	0.196	3.330	0.390
CMPX2-Q18- Learning emerging technologies like IoT, Industry 4.0, and AI can be challenging. (HYPOTHESIS 3)	3.74	0.759	-0.436	0.196	0.065	0.390
CMPX3-Q19 - Implementing and transitioning to AI, IoT, and Industry 4.0 in our organisation has a high cost (HYPOTHESIS 3)	3.75	0.823	-0.497	0.196	0.240	0.390
Complexity	**3.75**	**0.748**	**-0.710**	**0.196**	**1.212**	**0.390**
TRI1-Q20 - I would be permitted to trial emerging technologies for an extended period to assess their potential. (HYPOTHESIS 4)	4.00	0.500	-0.320	0.196	2.415	0.390
TRI2-Q21 - Our organisation will thoroughly test new technology before adopting it. (HYPOTHESIS 4)	4.10	0.709	-0.489	0.196	0.194	0.390
TRI3-Q22 -I would like the chance to try new technologies before deciding to try them. (HYPOTHESIS 4)	3.99	0.649	-1.013	0.196	3.499	0.390
TRI4-Q23 Evaluating emerging technologies before committing would be a good idea(HYPOTHESIS 4)	4.07	0.603	-0.391	0.196	1.170	0.390
Trialability	**4.04**	**0.615**	**-0.553**	**0.196**	**1.819**	**0.390**
PEOU1-Q25 - Using an emerging technology-based system (IoT, AI and Industry 4.0) is highly comprehensible. (HYPOTHESIS 6)	3.82	0.555	-1.219	0.196	2.659	0.390

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PEOU2-Q26 - I am capable of utilising Emerging technology-based systems within our organisation. (HYPOTHESIS 6)	3.86	0.702	-1.645	0.196	4.947	0.390
PEOU3-Q27 – Our organisation can readily create products and services leveraging emerging technologies. (IoT, AI and Industry 4.0). (HYPOTHESIS 6)	3.80	0.689	-1.926	0.196	5.303	0.390
Perceived Ease of Use	**3.83**	**0.649**	**-1.597**	**0.196**	**4.303**	**0.390**
TR1-Q28 - My organisation typically embraces new technologies to achieve its work-related goals. (HYPOTHESIS 7)	3.97	0.823	-1.305	0.196	3.102	0.390
TR2-Q29 - I have confidence that the machines will perform as instructed. (HYPOTHESIS 7)	3.94	0.860	-1.269	0.196	2.467	0.390
TR3-Q30 - Products and services with new technologies are more user-friendly. (HYPOTHESIS 7)	3.92	0.839	-1.271	0.196	2.688	0.390
Technology Readiness	**3.94**	**0.841**	**-1.282**	**0.196**	**2.752**	**0.390**
TMS1-Q31 - Top management fully supports the integration of IoT, AI, and Industry 4.0 innovations. (HYPOTHESIS 8)	3.92	0.734	-0.877	0.196	1.791	0.390
TMS2-Q32 – A manager at the management level encourages the adoption of IoT, AI, or Industry 4.0 innovation. (HYPOTHESIS 8)	4.03	0.786	-0.788	0.196	1.094	0.390
TMS3-Q33 - Our managers have a solid grasp of how IoT, AI, and Industry 4.0 can improve business performance. (HYPOTHESIS 8)	3.76	0.723	-1.090	0.196	1.812	0.390
TMS4-Q34 - Our top management is inclined to allocate to IoT, AI or Industry 4.0. (HYPOTHESIS 8)	3.94	0.651	-0.666	0.196	1.397	0.390
Top Management Support	**3.91**	**0.724**	**-0.855**	**0.196**	**1.523**	**0.390**
TPS1-Q35 – Partner support is the importance of technological partner support during the migration to an AI, IoT, and Industry 4.0-enabled system. (HYPOTHESIS 9)	3.17	1.037	-0.777	0.196	-0.295	0.390
TPS2-Q36 - Obtaining assistance and reliable services from our vendors/partners has not been complex (HYPOTHESIS 9)	3.10	1.089	-0.705	0.196	-0.554	0.390
TPS3-Q37 - Partner support is vital for the prompt resolution of technical issues. (HYPOTHESIS 9)	3.33	0.909	-0.909	0.196	0.082	0.390
TPS4-Q38 - We maintain strong vendor/partner relationships. (HYPOTHESIS 9)	3.21	0.603	-0.125	0.196	-0.443	0.390
Technology Partners Support	**3.20**	**0.910**	**-0.629**	**0.196**	**-0.303**	**0.390**
RG1-Q39 - Regulatory policies actively promote the integration of advanced technologies like AI, IoT, and Industry 4.0. (HYPOTHESIS 10)	3.33	1.020	-0.973	0.196	0.120	0.390
RG2-Q40 - Regulatory policies offer financial incentives to promote the adoption of the specified technologies. (HYPOTHESIS 10)	3.32	0.758	-0.427	0.196	-0.334	0.390
RG3-Q41 - Government assistance is essential for us to innovate. (HYPOTHESIS 10)	3.75	0.672	-0.585	0.196	1.435	0.390
RG4-Q42 - The stability of government policies is essential for our organisation. (HYPOTHESIS 10)	3.84	0.567	-0.232	0.196	0.436	0.390
Regulatory Policies	**3.56**	**0.754**	**-0.554**	**0.196**	**0.414**	**0.390**
CPR1-Q43 – I know competitors already use IoT, AI or Industry 4.0 in their business. (HYPOTHESIS 11)	3.86	0.717	-0.334	0.196	0.101	0.390
CPR2-Q44 - Our organisation had to use IoT, AI or Industry 4.0 to stay ahead. (HYPOTHESIS 11)	3.86	0.761	-0.398	0.196	0.005	0.390
CPR3-Q45 - Industry competition has applied pressure, leading to the consideration of the necessity for technological adoption. (HYPOTHESIS 11)	3.89	0.703	-0.417	0.196	0.352	0.390
CPR4-Q46 - The industry's transition towards utilizing Industry 4.0, IoT, and AI would compel our firm to follow under pressure. (HYPOTHESIS 11)	3.92	0.668	-0.438	0.196	0.623	0.390
Competitive Industry Pressure	**3.88**	**0.712**	**-0.397**	**0.196**	**0.270**	**0.390**
ORGINV1-Q47 - Our organisation remains current with the latest technological developments in our field. (HYPOTHESIS 12)	3.98	0.739	-0.961	0.196	2.048	0.390
ORGINV2-Q48 - Our organisation is structured to support strategic partnerships and foster enduring business collaborations. (HYPOTHESIS 12)	3.91	0.692	-1.207	0.196	3.769	0.390
ORGINV3-Q49 - Our organisation innovatively updates procedures and processes for executing firm activities. (HYPOTHESIS 12)	3.95	0.710	-1.497	0.196	5.043	0.390
Organisational Innovativeness	**3.95**	**0.714**	**-1.222**	**0.196**	**3.620**	**0.390**
PRC1-Q50 - Management is prompt in embracing new approaches and methods. (HYPOTHESIS 13)	3.81	0.750	-0.148	0.196	-0.350	0.390
PRC2-Q51 - Our organisation has created several innovative management approaches to improve customer service speed and quality in the last five years. (HYPOTHESIS 13)	3.76	0.698	-0.571	0.196	1.217	0.390

PRC3-Q52 - We adjust our service processes to fulfil customers' requirements. (HYPOTHESIS 13)	3.71	0.800	-0.603	0.196	1.267	0.390
Process Innovativeness	**3.76**	**0.749**	**-0.440**	**0.196**	**0.711**	**0.390**
PSI1-Q53 - We surpass competitors by introducing new products and services. (HYPOTHESIS 14)	3.96	0.677	-0.596	0.196	1.780	0.390
PSI2-Q54 - Our organization consistently sets its products and services apart. (HYPOTHESIS 14)	3.95	0.849	-1.076	0.196	2.201	0.390
PSI3-Q55 - Our organisation has surpassed others in introducing products and services during the past five years. (HYPOTHESIS 14)	4.08	0.725	-0.760	0.196	1.604	0.390
Products and Services Innovativeness	**4.00**	**0.751**	**-0.811**	**0.196**	**1.862**	**0.390**

Assessment of Data Suitability for Factor analysis

The KMO (Kaiser, 1974) and Bartlett's Test (Bartlett, 1950) provide an assessment of the suitability of the data for conducting a factor analysis. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy is used to evaluate the overall data quality for factor analysis. This research reported the KMO measure as 0.781 (Table 3). The KMO measure ranges from 0 to 1, with values closer to 1 indicating better suitability for factor analysis. Therefore, a KMO value of 0.781 suggests that the data is adequate for factor analysis.

Additionally, Bartlett's Test of Sphericity is performed to determine whether the correlation matrix is significantly different from an identity matrix, indicating the presence of underlying factors. The test statistic for Bartlett's Test is reported as approximately 6075.143 at P <0.001, indicating that the correlation matrix is significantly different from an identity matrix. Therefore suggesting that there are underlying factors present in the data. In summary, the KMO measure indicates that the data is adequate for factor analysis, and Bartlett's Test confirms the presence of underlying factors. These results provide support for conducting factor analysis on the dataset.

Reliability and Convergent validity of the constructs

The results of a measurement model analysis, which examines the reliability and validity of the measured constructs, are presented in Table 4. The analysed constructs encompass CMP (Compatibility), CMPX (Complexity), CPR (Competitive Industry Pressure), ORGINV (Organisational Innovativeness), PEOU (Perceived Ease of Use), PRC (Process Innovativeness), PSI (Products and Services Innovativeness), RA (Relative Advantage), RG (Regulatory Policies), TMS (Top Management Support), TPS (Technology Partners Support), TR (Technology Readiness), and TRI (Trialability). When VIF values are lower than 10, loot in Table 3 suggests the absence of multicollinearity, indicating that the items are not strongly correlated. The factor loads of the items, exceeding the threshold of 0.7, confirmed the robustness and direction of the relationship between each item and its underlying construct. All Cronbach's Alpha values surpassed the threshold level of 0.80, demonstrating that the items within each construct adequately measure the same underlying concept. The Composite Reliability, with a measurement above 0.70, assessed the reliability of the constructs by considering both the internal consistency of the items and the correlations between the constructs. By exceeding the threshold of 0.50, the Average Variance Extracted (AVE) evaluated convergent validity, illustrating the amount of variance captured by the construct concerning the measurement error.

Table 6 KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.781
Bartlett's Test of Sphericity	Approx. Chi-Square	6075.143
	df	1035
	P-Value.	<0.001

Table 7 Reliability and Convergent Validity of the Constructs

Items	VIF*	Factor Loadings	Construct	Cronbach's Alpha	CR**	AVE***
CMP1	4.13	0.931	CMP	0.927	0.953	0.872
CMP2	3.239	0.930				
CMP3	3.751	0.940				
CMPX1	1.732	0.750	CMPX	0.892	0.929	0.816
CMPX2	7.158	0.969				
CMPX3	6.989	0.973				
CPR1	3.306	0.949	CPR	0.929	0.907	0.802
CPR2	4.000	0.874				
CPR3	3.344	0.924				
CPR4	3.050	0.832				
ORGINV1	1.825	0.864	ORGINV	0.846	0.907	0.764
ORGINV2	2.186	0.881				
ORGINV3	2.234	0.878				
PEOU1	2.493	0.899	PEOU	0.925	0.953	0.871
PEOU2	5.863	0.943				
PEOU3	6.356	0.956				
PRC1	5.067	0.955	PRC	0.947	0.953	0.871
PRC2	4.043	0.932				
PRC3	5.782	0.963				
PSI1	3.926	0.945	PSI	0.846	0.907	0.766
PSI2	1.488	0.735				
PSI3	3.645	0.931				
RA1	1.494	0.805	RA	0.713	0.823	0.538
RA2	1.336	0.699				
RA3	1.335	0.717				
RA4	1.303	0.707				
RG1	2.563	0.864	RG	0.9	0.93	0.769
RG2	2.058	0.806				
RG3	3.332	0.909				
RG4	4.111	0.923				
TMS1	7.724	0.944	TMS	0.956	0.968	0.883
TMS2	7.262	0.945				
TMS3	5.800	0.941				
TMS4	4.791	0.929				
TPS1	2.980	0.845	TPS	0.917	0.935	0.784
TPS2	3.910	0.871				
TPS3	3.316	0.897				
TPS4	2.443	0.926				
TR1	8.257	0.971	TR	0.972	0.982	0.947
TR2	8.503	0.973				
TR3	8.802	0.975				
TRI1	2.977	0.845	TRI	0.908	0.935	0.783
TRI2	4.079	0.893				
TRI3	2.993	0.884				
TRI4	4.862	0.916				

VIF*= Variance Inflation Factor
CR**=Composite Reliability
AVE*** = Average Variance Extracted

Model Fitness

A confirmatory factor analysis (CFA) was employed following the factor structure model proposed by Tavakol and Wetzel (2 to assess the construct validity of the five-factor scale). CFA is a widely utilized method for verifying the number of factors within a scale and examining the goodness-of-fit between the data and the proposed model (Ho & Liang, 2021). Previous studies by Byrne (2016) and Ho (2006) recommend specific thresholds for fit measures: CMIN/DF < 2 (1.8173), RMSEA < 0.08, IFI, TLI, and CFI > 0.80 (Moolla & Bisschoff, 2013), and PNFI > 0.50 (Mulaik et al., 1989). Referencing Table 5, all the fit measures, including CMIN/DF (1.8173), RMSEA (0.0733), IFI (0.8664), TLI (0.8593), CFI (0.8654), and PNFI (0.7123), closely aligned with the observed data, indicating an acceptable fit without inconsistencies.

Table 8 Model Fitness

	Absolute Fit Measures		**Incremental Fit Measures**			**Parsimonious Fit Measures**
	CMIN/DF	RMSEA	IFI	TLI	CFI	PNFI
General range	<3.0	0, 1	0, 1	0, 1	0, 1	0, 1
Best reference standards	<2.0	<0.08	>0.80	>0.80	>0.80	>0.50
References	(Byrne, 2016; Ho, 2006; Ozen & Durkan, 2016)		(Moolla & Bisschoff, 2013)			(Mulaik et al., 1989)
The result of the study	1.8173	0.0733	0.8664	0.8593	0.8654	0.7123

FINDINGS

Rapid advancement is highly correlated with higher relative advantage (RA2, RA3, and RA4), with coefficients estimated to be 0.8882, 0.9156, and 0.8173, respectively (Table 6). Similar statements about perceived ease of use, compatibility, complexity, trialability, and trialability can be made. We learn from this research that many factors—relative advantage, compatibility, complexity, trialability, and perceived ease of use—play essential roles in driving this rapid development. Businesses that adopt new technologies and place a premium on these elements have significant gains in efficiency and productivity. These findings additionally suggested that several factors significantly affect an organisation's responsiveness to changing conditions, including technology readiness, senior management support, technological partner support, regulatory rules, and competitive pressure. Higher readiness levels are associated with factors including being technologically prepared, having strong support from top management, securing help from technology partners, benefiting from conducive regulatory policies, and experiencing reduced competitive pressure. The results also show that structure, process, and product/service innovation are crucial to a business's success. Businesses generally perform better in the market when they demonstrate more significant innovation in their processes, products, and services. These results clarify the relationships between independent factors and the outcomes of interest with positive and significant association significant at P<0.001. All the developments from this research are graphically represented in Figure 1.

Table 9 Regression estimate weights of the constructs with associated S.E, C.R and P-Values.

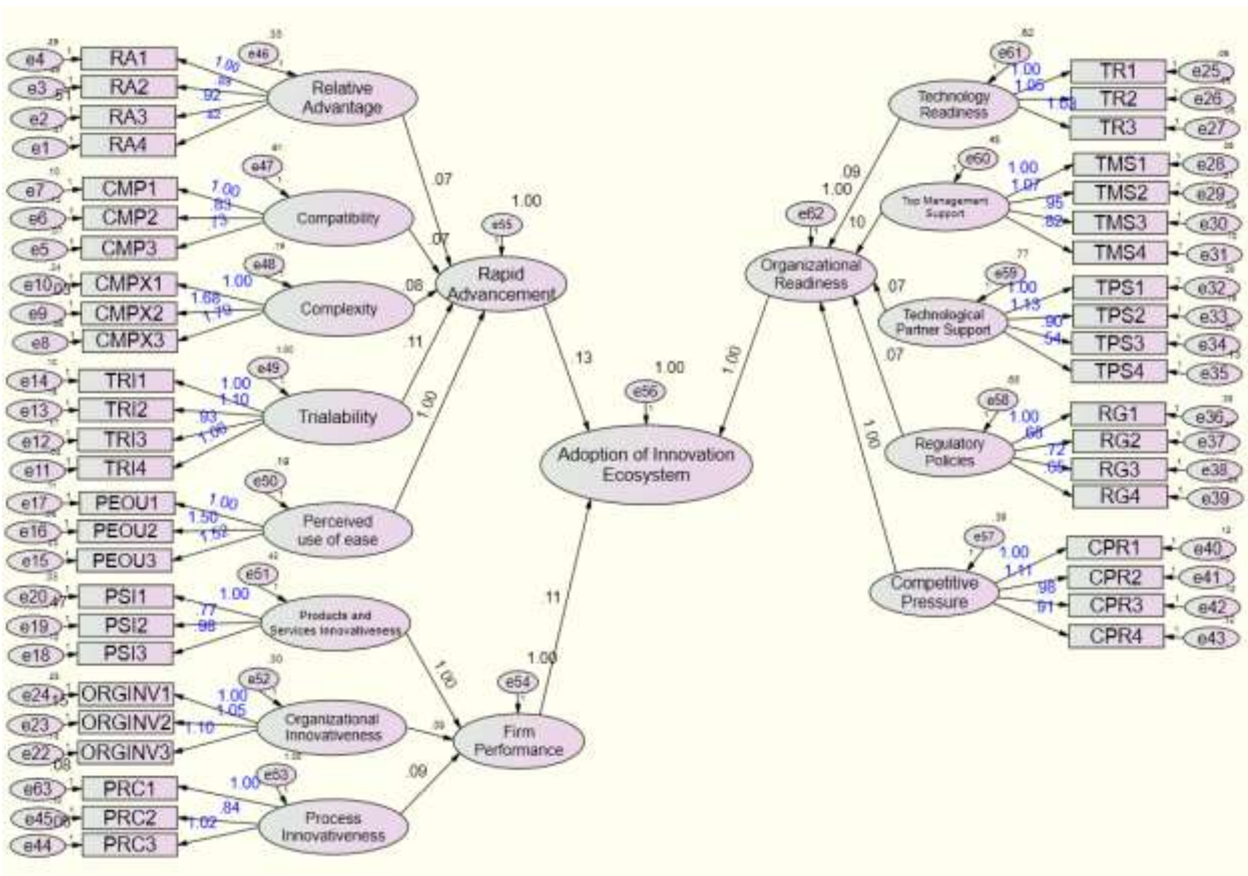
Dependent Variables	**Hypothesis**	**Independent Variables**	**-**	**Regression Relationship**	**Estimate**	**S.E.**	**C.R.**	**P-Value**
Rapid Advancement	**H1**	**RA1**	<---	**Relative Advantage**	**1**			
		RA2	<---	**Relative Advantage**	**0.8882**	**0.1667**	**5.3278**	***
		RA3	<---	**Relative Advantage**	**0.9156**	**0.171**	**5.3557**	***
		RA4	<---	**Relative Advantage**	**0.8173**	**0.157**	**5.2056**	***
	H2	**CMP1**	<---	**Compatibility**	**1**			
		CMP2	<---	**Compatibility**	**0.8262**	**0.0517**	**15.9778**	***
		CMP3	<---	**Compatibility**	**0.7273**	**0.0425**	**17.0968**	***
	H3	**CMPX1**	<---	**Complexity**	**1**			
		CMPX2	<---	**Complexity**	**1.6784**	**0.1653**	**10.151**	***
		CMPX3	<---	**Complexity**	**1.7895**	**0.1757**	**10.1873**	***

	H4	TRI1	<---	Trialability	1			
		TRI2	<---	Trialability	1.0977	0.041	26.7959	***
		TRI3	<---	Trialability	0.9265	0.0402	23.0518	***
		TRI4	<---	Trialability	1.0561	0.0302	34.9666	***
	H5	PEOU1	<---	Perceived use of ease	1			
		PEOU3	<---	Perceived use of ease	1.5165	0.1069	14.1797	***
		PEOU2	<---	Perceived use of ease	1.4982	0.1075	13.9314	***
Organisational Readiness	H6	TR1	<---	Technology Readiness	1			
		TR2	<---	Technology Readiness	1.0485	0.0374	28.0325	***
		TR3	<---	Technology Readiness	1.0262	0.036	28.4957	***
	H7	TMS1	<---	Top Management Support	1			
		TMS2	<---	Top Management Support	1.0662	0.0455	23.4504	***
		TMS3	<---	Top Management Support	0.9457	0.0461	20.516	***
		TMS4	<---	Top Management Support	0.8233	0.0447	18.4213	***
	H8	TPS1	<---	Technological Partner Support	1			
		TPS2	<---	Technological Partner Support	1.1305	0.0764	14.7946	***
		TPS3	<---	Technological Partner Support	0.8984	0.0654	13.7447	***
		TPS4	<---	Technological Partner Support	0.5417	0.046	11.7768	***
	H9	RG1	<---	Regulatory Policies	1			
		RG2	<---	Regulatory Policies	0.6751	0.0707	9.5523	***
		RG3	<---	Regulatory Policies	0.7243	0.0592	12.2321	***
		RG4	<---	Regulatory Policies	0.6549	0.0501	13.0644	***
	H10	CPR1	<---	Competitive Pressure	1			
		CPR2	<---	Competitive Pressure	1.1119	0.0711	15.6354	***
		CPR3	<---	Competitive Pressure	0.9813	0.0681	14.4186	***
		CPR4	<---	Competitive Pressure	0.9116	0.066	13.8211	***
Firm Performance	H11	ORGINV1	<---	Organisational Innovativeness	1			
		ORGINV3	<---	Organisational Innovativeness	1.0971	0.1187	9.2412	***
		ORGINV2	<---	Organisational Innovativeness	1.0501	0.1139	9.2189	***
	H12	PRC1	<---	Process Innovativeness	1			
		PRC2	<---	Process Innovativeness	0.8376	0.0315	26.5657	***
		PRC3	<---	Process Innovativeness	1.0211	0.0311	32.8586	***
	H13	PSI1	<---	Products and Services Innovativeness	1			
		PSI3	<---	Products and Services Innovativeness	0.9797	0.0809	12.1095	***
		PSI2	<---	Products and Services Innovativeness	0.7665	0.0985	7.7843	***

S.E. is an estimate of the standard error of the covariance.

C.R. is the critical ratio obtained by dividing the covariance estimate by its standard error; when the critical ratio (CR) is > 1.96 for a regression weight, that path is significant at P<0.05.

Figure 1 Quantitative Path Analysis Using A Structural Model



A total of 218 responses were received, with 49 of them utilised for the questionnaire's pilot study. Of the 169 responses after the pre-test, 153 were deemed valid for analysis. At the same time, 16 were excluded due to incompleteness or being deemed invalid, which aligns with similar cases found in previous studies such as Sun's (2023) innovation adoption study, the I4.0 studies conducted by Virmani et al. (2023) and Yavuz et al. (2023), as well as the IoT studies by Alhasan et al. (2023) and Bader et al. (2023), and AI research studies by Rawashdeh et al. (2023) and Xie et al. (2023). Lund's (2023) extensive analysis of over 800 articles spanning nineteen years revealed that response rates varied between 16.5% and 50%, with an average of 27.8%. Ultimately, this study utilized 153 valid responses (50.3%) for data interpretation and analysis, as elaborated in the subsequent sections.

DISCUSSION

RQ1: Rapid advancement

Technological advancement has emerged as a critical factor driving rapid growth in businesses worldwide. Among the various emerging technologies, artificial intelligence (AI) has gained significant attention due to its potential to transform industries and improve service delivery. According to McKinsey (2020), a high percentage of organisations leverage AI within their business operations. This trend highlights the vast developmental benefits of technology.

The fourth industrial revolution, characterised by AI, IoT, and I4.0 integration, has revolutionised human productivity and enhanced organisational performance. Cardona et al. (2023) emphasise that the fourth technological revolution is a significant driver enabling other technologies to evolve and facilitate continuous innovation. Its ability to connect various technologies allows faster processing, intelligent decision-making, and improved service delivery. As a result, organisations increasingly recognise the importance of embracing a diverse portfolio of innovation, including AI, I4.0, and IoT, to achieve superior performance.

To achieve superior organisational performance, companies must adopt and effectively utilise a portfolio of diverse types of innovation. AI offers tremendous business potential as a critical component of the fourth industrial revolution due to its ability to enable automation, data analysis, and intelligent decision-making, improving operational efficiency, cost savings, and enhanced customer experiences. By leveraging AI, organisations can gain insights from large volumes of data, make accurate predictions, and optimise their processes.
In addition to AI, Industry 4.0 and IoT are integral parts of the technological revolution, and integrating these systems makes it possible to augment operational efficiency and productivity. Furthermore, IoT connects various devices and sensors, enabling organisations to gather data from multiple sources and make informed decisions.

By adopting a portfolio of diverse types of innovation, including AI, I4.0, and IoT, companies can leverage the potential of emerging technologies and drive firm innovation performance. These technologies allow organisations to automate processes, optimize operations, and deliver enhanced products and services. The rapid growth of emerging technologies, driven by the fourth industrial revolution, has significantly influenced firm innovation performance. Companies worldwide increasingly adopt AI, I4.0, and IoT to achieve superior organisational performance. The integration of these technologies allows for faster processing, intelligent decision-making, and improved service delivery. Organisations must embrace a diverse portfolio of innovation and leverage the potential of emerging technologies, and by doing so, they can drive innovation, optimize operations, and deliver enhanced value to customers.

RQ2: **Organisation Readiness**
The readiness of organisations to adopt and utilize emerging technologies is crucial for their innovation performance and overall firm growth. This academic discussion explores the relationship between organisational readiness, emerging technologies, and firm innovation performance.

This study also found that AI-driven innovation practices directly impact firm performance, similar to the studies of Bahoo et al. (2023). By leveraging the capabilities of AI, organisations can optimize resources, reduce costs, and enhance productivity, ultimately leading to sustained growth. The study highlights that organisations can achieve continuous improvement, maximize resource utilization, and foster high innovation performance by capitalizing on AI.

However, it is necessary to apply caution that innovation alone does not guarantee a competitive advantage. Furthermore, Akter et al. (2021) argue that AI is essential for organisations to maintain market share and drive organisational growth. This viewpoint aligns with research studies such as Alekseeva et al. (2021), which found a significant positive impact of emerging technologies on firm innovation performance. Evaluating specific emerging technologies to understand their potential to enhance innovation performance is crucial.

Ciasullo and Lim (2022) discuss how intelligent technologies implemented in industries have increased productivity and facilitated the emergence of new business models. These advancements have opened up new avenues for economic development. Industry 4.0 has become a proven technique for firms to adopt as an innovative tactic, and this study found that combining Industry 4.0 with other technologies has significant relevance to the need of organisations to strategically Incorporate the Internet of Things (IoT), a fact that Rehman et al. (2023) emphasises as a crucial determinant of firm innovation performance. The IoT plays a key role in expanding a firm's portfolio of products and services, leading to reduced operating costs and augmented market share. By incorporating IoT technologies strategically, organisations can enhance innovation capabilities and drive overall performance.

RQ3: Firm Innovation Performance

In the context of adopting emerging technologies and firm innovation performance, Bahoo et al. (2023) emphasise the significant impact of AI-driven innovation practices on the overall performance of organisations. The argument is that when organisations effectively leverage the capabilities of AI, they can achieve resource optimization, cost reduction, and enhanced productivity, leading to sustained growth. Thus, adopting AI-driven innovation practices enables continuous improvement, efficient resource utilization, and the creation of an environment conducive to fostering high levels of innovation performance.

However, Akter et al. (2021) caution that innovation alone does not guarantee a competitive advantage, highlighting the need for organisations to adopt AI to maintain market share and drive organisational growth. Their findings align with research studies such as that of Alekseeva et al. (2021), who also noticed a significant positive impact of emerging technologies on firm innovation performance. Importantly, Alekseeva et al. (2021) emphasise the necessity of evaluating specific emerging technologies within the context of firm innovation performance.

Thus, these studies collectively suggest that adopting emerging technologies, particularly AI, can improve firm innovation performance. By leveraging the capabilities of AI, organisations can optimize resources, reduce costs, enhance productivity, and foster a culture of continuous innovation. However, organisations must assess the suitability and potential impact of specific emerging technologies on their innovation performance to maintain a competitive edge in the market.

Implications to Research and Practice

Implications for research

Organisational Preparation and Change Management: Research should focus on understanding how proactive management of challenges related to algorithmic bias, data ethics, and ethical use of artificial intelligence (AI) impacts firm innovation performance. Studies can explore the relationship between cultural shifts, staff training, corporate restructuring, and the successful adoption of novel digital technologies and how these factors influence a firm's ability to innovate effectively.

System Integration and Interoperability: Research can investigate how the use of connected system integration and collaboration can affect firm innovation performance and includes studying how compatibility issues and investments in integration solutions affect operational efficiency and financial gains and, ultimately, how these factors contribute to the firm's innovation capabilities and outcomes.

Workforce Transformation: Research should examine the link between employee skills, adoption of emerging technologies and firm innovation performance, which includes exploring the effectiveness of training development programs in fostering a culture of innovation within the organisation and their impact on improved firm performance. Studies can also investigate how workforce transformation initiatives contribute to the firm's ability to generate innovative ideas, products, and services.

Implications for Practice

Organisational Preparation and Change Management: Organisations should proactively manage challenges related to algorithmic bias, data ethics, and the ethical use of AI to enhance firm innovation performance. Companies can create an environment that fosters innovation and effectively deploys emerging technologies by implementing cultural shifts, staff training, and corporate restructuring. Establishing clear guidelines and practices for AI's just and accountable application can contribute to improved innovation outcomes.

System Compatibility and Interoperability**:** Organisations should prioritise meticulous system integration and collaboration to drive firm innovation performance. By addressing compatibility issues and investing in integration solutions, companies can optimize operational efficiency and achieve financial gains directly impacting their ability to innovate. Emphasising interoperability and standardisation efforts can further enhance the organisation's innovation capabilities.

Workforce Transformation: Firms should align employee capabilities with emerging technologies to boost firm innovation performance. Implementing reskilling and upskilling programs enables employees to adapt to an environment conducive to technological advancements within the organisation. By nurturing a skilled and adaptable workforce, companies can enhance their capacity to generate innovative ideas, products, and services, positively impacting firm innovation performance.

CONCLUSION

The need to keep up with the competition, shareholder expectations, and revenue growth affects organisational readiness and makes it suitable to prepare real-world companies for shifting environments. If decision-makers cannot comprehend the ability of technological change, they will have difficulty applying it to their companies' strategy, business model, or manufacturing system, causing a deterrent to the adoption of innovation.

Attaining firm innovation performance involves comparing existing practices, tools, and technologies in any working environment or organisation with the new ideas or approaches introduced. Organisations can make practical decisions regarding adopting innovative or novel ideas or technology using relative advantage, which can be evaluated through surveys from companies already using the technology or a detailed analysis of theoretical implementation.

The study contributes valuable insights to scholars, governmental bodies, practitioners, and stakeholders from various sectors, emphasising the potential for competitive advantage, the motivation for innovation, and promising prospects attainable through the synergistic amalgamation of emerging technologies within the ever-evolving contemporary global landscape.

Future research

- Additional investigations should involve thorough qualitative interviews and extensive analysis of real-life examples to examine the effects of an organisation's innovation performance on partnerships within technological innovation ecosystems.
- Future studies should aim to fill the current gaps in accurately measuring the competitive advantages gained by organisations through integrating emerging technologies. Engaging in comparative research analysis would facilitate a deeper understanding of the subject.
- Future studies should evaluate the relationship between combined technologies, individual nations and industries and the impact on the transformation of the future economy.

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