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EXPLORING THE DYNAMICS OF INNOVATION IN THE ERA OF ARTIFICIAL INTELLIGENCE

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Abstract: Artificial Intelligence (AI) is revolutionizing the landscape of innovation, presenting both unprecedented opportunities and many challenges for individuals, organizations, and societies. The purpose of this paper is to investigate what will happen with innovation in an AI era, through a comprehensive analysis of the dynamics of innovation in the era of AI. Based on a bibliometric analysis we explore the paper annual publication number, the trend topic, the word count and the international interest for this subject. Through an in-dept analysis we observed some transformative changes that will arise: Data-Driven Decision Making, Personalized Customer Experiences, Supply Chain Optimization, Innovation in Financial Services, AI-Powered Entrepreneurship, Job Displacement and Reskilling, Ethical and Regulatory Considerations. By integrating insights from both bibliometric analyses and scenario planning exercises, we offer a nuanced understanding of the opportunities and challenges arising from AI-driven innovation and provide strategic recommendations for navigating the complex terrain of the AI era. The findings contribute to the academic discourse on AI and innovation, inform evidence-based decision-making, and inspire proactive responses to the transformative forces shaping our collective future.

JEL Classification: O30, O33, M21

Keywords: artificial Intelligence, AI, innovation, innovation management

1. Introduction

The evolution of modern society has reached a point where a new tool, Artificial Intelligence (AI), seems to transform its development capabilities. With its rapid evolution and expanding capabilities, AI has emerged not only as a powerful tool

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for automating tasks and processing data but also as a catalyst for transformative innovation across various sectors. As AI permeates deeper into the fabric of society, its impact on the innovation process becomes increasingly significant and complex.

The innovation process, long regarded as the lifeblood of economic growth and societal progress, is undergoing a profound redefinition in the era of AI. Traditional models of innovation, characterized by linear progressions from research to development to commercialization, are being reshaped by the capabilities of AI to augment human ingenuity, automate routine tasks, and unlock new realms of possibility (Gama & Magistretti, 2023). However, alongside the promises of enhanced efficiency and unprecedented breakthroughs, AI also poses formidable challenges and raises critical questions about the nature, dynamics, and implications of innovation in the 21st century (Sjodin et al., 2023).

The main *research question* address in this paper can be formulates as: *What will happen with innovation an AI-dominated era?* We seek to clarify the complexity involved in this symbiotic relationship and provide insights that might guide strategic decision-making, policy development, and future research directions by analysing the fundamental mechanisms, causes, and results of innovation in the AI era.

The purpose of the paper is to investigate the intricate interplay between AI and innovation, focusing on both the opportunities and challenges that arise as AI becomes increasingly integrated into the innovation ecosystem. Through a comprehensive review of existing literature, theoretical frameworks, and empirical evidence, we try to elucidate the dynamics of innovation in the AI era and identify key drivers, barriers, and implications for various stakeholders.

To reach our objectives, the paper is organized as follows: first, we provide a conceptual framework elucidating the fundamental concepts of AI and innovation and their interrelationships. Next, we review the existing literature on the impact of AI on different stages of the innovation process. Second, we examine the socio-economic, ethical, and regulatory dimensions of AI-driven innovation, considering implications for industry, academia, government, and society at large. Finally, we conclude with reflections on the future of innovation in the AI era and propose further research directions.

2. Materials and Methods

To investigate the dynamics of innovation in the era of Artificial Intelligence (AI), a systematic review of relevant literature was conducted. The Clarivate Web of Science database was selected as the primary source for this review due to its comprehensive coverage of academic journals, conference proceedings, and other scholarly publications across various disciplines. The search was conducted using the following keywords and Boolean operators: "artificial intelligence" AND "innovation".

The search was limited to peer-reviewed articles published in English-language up to the date March 2024. The criteria for including the papers in the study refers to studies that explicitly examined the relationship between AI and innovation, comprising diverse perspectives from the field of business, economics, and management. Articles focusing on specific applications of AI in innovation processes, theoretical frameworks, empirical studies, case analyses, and critical reflections were considered for inclusion. The graphical representation of the interrogation process was created using LucidChart software (Lucid, 2022) and is presented in Figure 1.

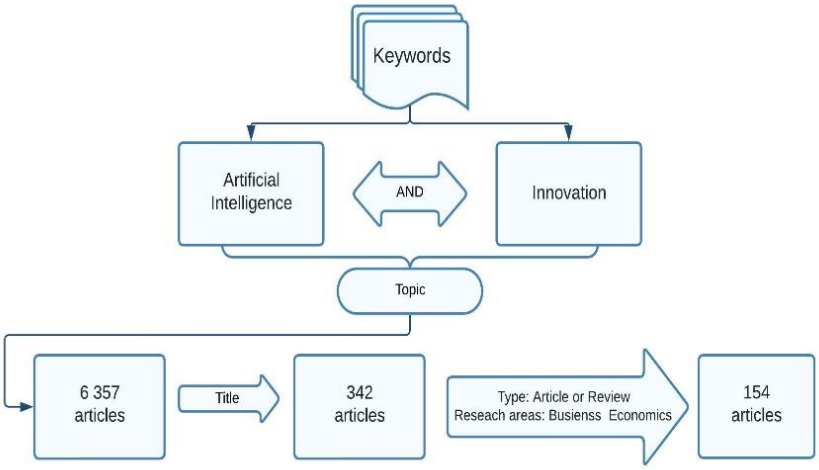

Figure 1. The flow diagram of data collection

Using the two keywords and the condition so that both of them to be present in the topic of the papers, a number of 6 357 articles were revealed. To refine the dataset, some key filters were applied. The first filter was to select only papers where the keywords appeared in the title. Additionally, the results were filtered to papers in the category type “article” or “review” and from the research areas “business economics”. Following the initial search, duplicate records were removed, and the titles and abstracts of the remaining articles were screened to assess their relevance to the research question. The full-text screening was performed to identify articles meeting the inclusion criteria. The final set of articles included in the literature review constituted the basis for synthesizing existing knowledge, identifying trends, gaps, and emerging themes in literature. By applying the filters, a dataset of 154 articles resulted.

Journal articles from the scientific dataset were exported as plain text files, having essential data such as article titles, author keywords, author names, and citation information. The exported data underwent manual standardization to ensure compatibility with the requirements of the software tools used for analysis. To analyze the bibliometric characteristics and visualize the intellectual structure of the literature on AI and innovation, two software tools were employed: Bibliometrix (Aria & Cuccurullo, 2017) and VOSviewer (Jan van Eck & Waltman, 2010).

3. Results and Interpretation

3.1. The evolution of the annual number of published articles

The annual publication trends provide valuable insights into the evolving interest in the field of AI and innovation. Figure 3 illustrates the number of papers published annually, focusing on the research topic of "wood and cement." On the horizontal line is presented the year of publication and on the vertical is presented the number of papers published each year.

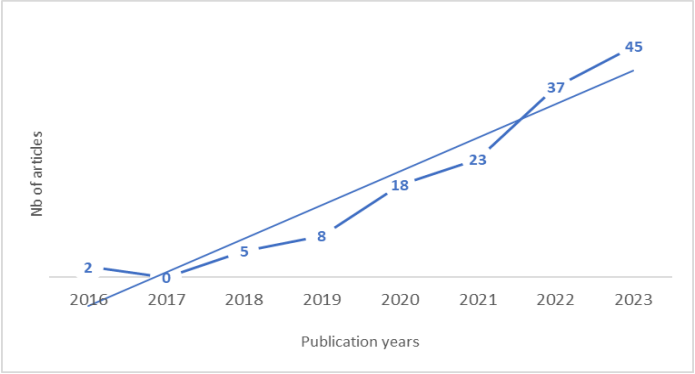

Figure 2. The evolution of annual number of published papers

Even if the article analyzed covered the years from 2016 to 2023 the upward trajectory in research publications is obvious. It can be observed that although in 2016 were published only 2 papers and in 2017 no paper was published in the last five years from 2019 the number of articles increased substantially reaching 45 papers published in 2023.

3.2. The trend topic analysis

To gain a deeper understanding of the evolving themes within the AI and innovation research landscape, we conducted a trend topic analysis, as illustrated in Figure 3. This analysis draws from data extracted from the Web of Science database and offers insights into the keywords and concepts that have gained prominence over time.

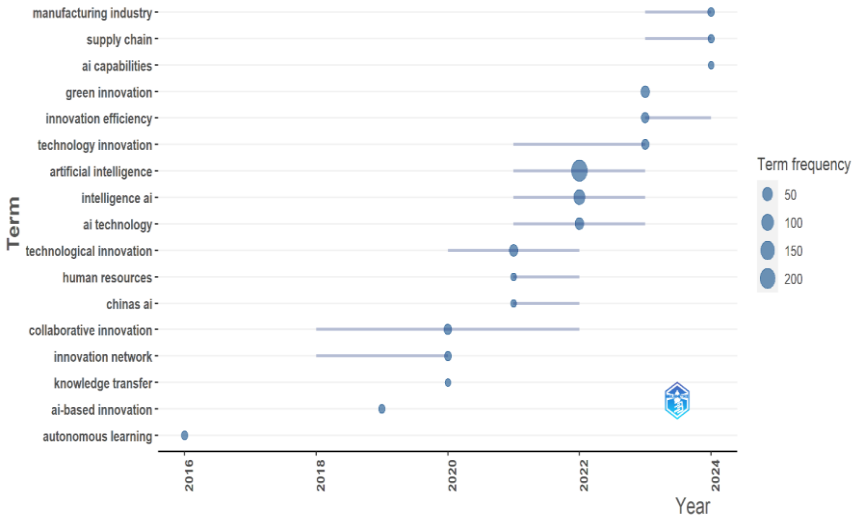

Figure 3. The trend topic analysis

Figure 3 provides a visual representation of this analysis, employing lines and bubbles to convey term frequency and temporal usage. The size of each bubble corresponds to the frequency of the associated term, with larger bubbles indicating more frequent usage.

Over the years, research on AI and innovation has evolved significantly. Early studies primarily concentrated on examining autonomous learning, knowledge transfer, innovation network or collaborative innovation. This foundational research laid the groundwork for subsequent investigations.

As the field matured, researchers explored novel possibilities of using AI as a technology and what impact it has on the human resources involved. In the same time technological innovation is one of the direction that the researchers focused. The pick point of the article intelligence studies was reached in 2022 where the term appears as the most frequently used.

Lately the trend topic reveals an interest to subject like the influence of AI on green innovation, supply chains or manufacturing industry. This trend topic analysis provides a glimpse into the dynamic nature of AI and innovation research as emerging keywords and concepts continue to gain prominence, they shape the trajectory of future investigations and innovations in the field.

3.2. The word analysis

To further analyze how are influenced the main characteristics of innovation by artificial intelligence we performed a word count analysis. With the help of the Bibliometrix software the image from figure 4 was generated. For this image we considered the abstract of the papers included in the sample database. The size of the word and positioning close to the center of the image reveal a big frequence of using that word.

In the center of the image from figure 4 we can distinguish words like impact, performance, management, knowledge, AI, future, or technology. This arrangement of the words indicates that most of the researchers when dealing with this subject wondered about the impact of AI on the innovation process. Their main concern is related to ways of improving the performance of organizations, increasing knowledge, or improving the management process.

Figure 4. The word count analysis of papers dealing with innovation and AI

AI has a grater application in the technology industry, so it is somehow obvious that words like technology, information technology or industry to be presented in the image. Other words that are visible are growth, firm performance, framework, perspective, capabilities, or digital transformation. All these words reveal the same interest in how AI will improve innovation. In general, from the words used we can identify a positive reaction to AI and even some new direction of research and development, creating a framework for AI or analyzing the big data needed to train AI. Environmental issues are also analyzed and words like sustainability, evolution or environmental innovation are also used.

For a deeper understanding of the interconnected themes and topics within the research of innovation and AI a keyword co-occurrence analysis was performed. Figure 5 presents a visual representation of the keywords co-occurrence network map, generated using the VOSviewer software. In this map, keywords are represented by bubbles, with larger bubbles indicating higher keyword frequency. Lines connecting keywords signify their co-occurrence in the same papers, while clusters of keywords sharing similar themes are delineated by distinct colors.

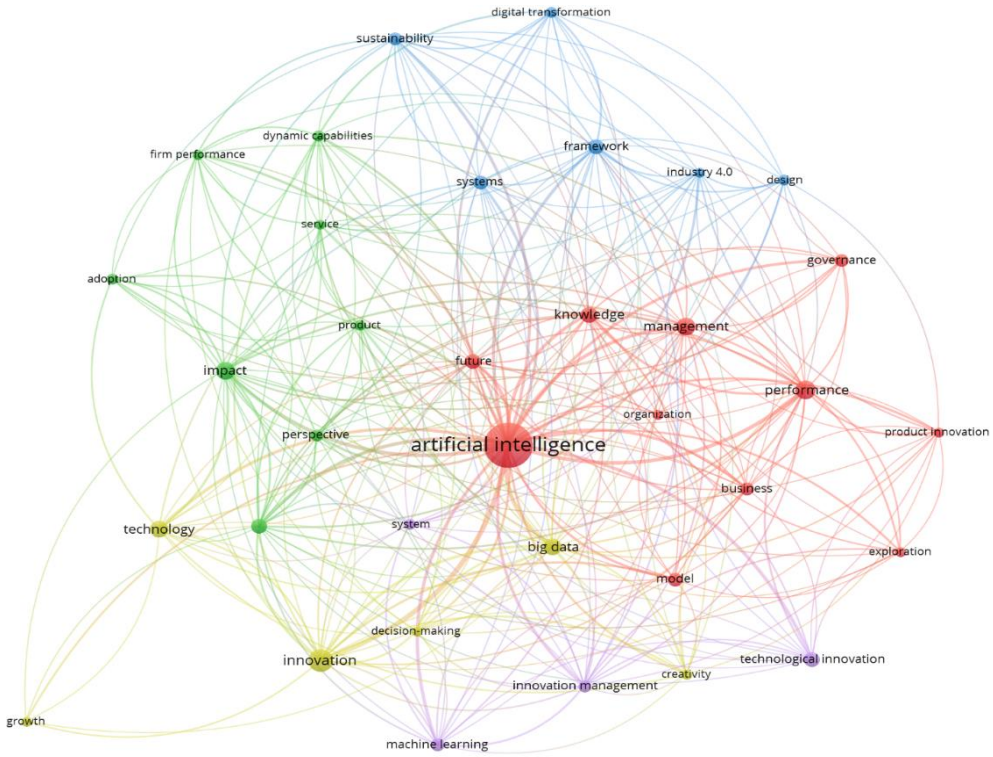

Figure 5. The keywords co-occurrence network map

The dataset analyzed in this map comprises 794 keywords, each with a minimum co-occurrence of 5 times, resulting in the inclusion of 39 papers. The map is organized into five clusters, each with its unique characteristics. The red cluster is the most extensive, featuring 11 keywords, followed by the green cluster with 8, the blue cluster with 6, the yellow cluster with 6, and the smallest cluster, the purple cluster, with 4 keywords.

The spatial arrangement of keywords on the map is determined by their frequency of usage in the analyzed papers, with the most frequently used keywords positioned at the center. For instance, the keyword "artificial intelligence," situated in the heart of the map, is the most used term, given the context of all research papers. It boasts a total link strength of 226 and an occurrence of 96. Although the keyword “artificial intelligence” dominates the entire map, other keywords can be observed in the same cluster, like performance, management, or knowledge. At the edge of the map can be observed keywords like growth, which is mainly related to growth of AI, innovation, and technology in general.

The clustering of keywords suggests the same conclusions as in case of word count and topic analysis. It can be observed a positive approach regarding the development of the AI technology and its effect on the innovation process, while at the same time the research is yet in its early stages remaining some questions regarding the perspectives and the suggests potential future avenues for exploration.

3.3. The international interest for the research topic

The field of AI and its connection to innovation continues to evolve, driven by the contributions of various authors and research teams. In this section, the focus is on an analysis of the authors’ affiliations, highlighting the global distribution of research.

Based on the sample database of selected papers a world map was generated (figure 6), with the help of Bibliometrix software highlighting the number of papers published in each country. The map is generated based on the frequency of researchers from each country appearing as authors in the selected papers. The darker the blue color, the higher the frequency of authors from that country is.

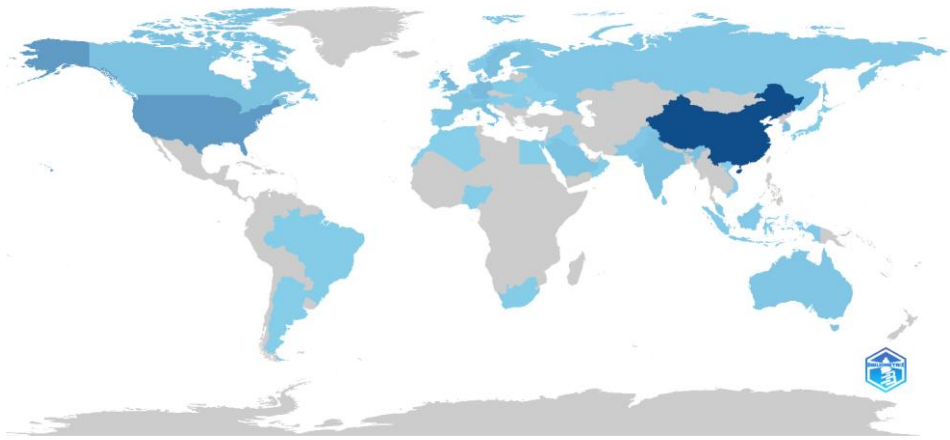

Figure 6. The top countries' scientific production

The country's scientific production map reveals a global interest for this research topic. From the entire map the most papers in this subject are written by authors form China, a frequency of 115 followed by USA, frequency of 44, and by Germany and UK with a frequency of 17.

4. Discussions – future research agenda

The field of Artificial Intelligence (AI) is in a continuous and rapid evolution, influencing almost all fields of research. As noticed so far, the interest for this subject increased substantially in the last two years when more and more researchers try to establish the impact and changes brought by an AI era. In case of innovation The AI era has undergone significant evolution across various sectors. With more and more papers addressing this subject in the following part we performed an in-dept analysis of the literature, to identify the main topics and future research agendas.

The rapid advancement and application of AI technologies have led to a paradigm shift comparable to the dawn of the internet (Wei et al., 2018). This evolution is evident in the architectural advancements of AI systems, transitioning from a "foundation-model-as-a-connector" to a "foundation-model-as-a-monolithic architecture" (Lu, 2024). As AI continues to enter in different fields, the creation of innovative intelligent products is on the rise, contributing to the realization of the AI era.

Moreover, the era of AI has not only impacted technology and industry but has also brought about fundamental reforms in economic, social, and political domains (Wang, 2022). This transformation has created new opportunities in cultural industries, emphasizing the importance of understanding the global value chain position within the AI landscape (Brem et al., 2023). The educational sector has also been significantly influenced by AI, with a focus on cultivating innovative talents equipped with the necessary skills for the new technological and economic landscape (Dopazo, 2023).

In the context of innovation and entrepreneurship education, the integration of AI technologies has led to new teaching frameworks and methodologies, reflecting the changing dynamics of the AI era (Abdelkafi et al., 2015). The evolution of AI in telecommunications and wearable electronics led a shift towards a future intertwined with AI and the Internet of Things (Arenal et al., 2020).

As AI continues to shape various industries and domains, the need for responsible AI design and management becomes crucial to ensure ethical and sustainable AI applications (Gonzalez-Esteban & Calvo, 2022). The evolving landscape of AI innovation necessitates a multidimensional approach, considering technical, managerial, and societal perspectives to harness the full potential of AI technologies (Pan et al., 2019). The impact of AI varies across different sectors, as it is focused more on exploration rather than exploitation (Johnson & Watt, 2022).

The studies published so far indicate that the development of AI technology will lead to a lot of changes in the structure of organizations. It is suggested that each organization should consider opening a division specialized in AI management (Bahoo et al., 2023). The shift to new ways of thinking and accumulating knowledge should be done through pilot tests (Goto, 2023).

There is evidence of a positive impact of AI if its potential is fully used, especially in case of continuous market changes (Sullivan & Wamba, 2024). Positive impact was observed also in case of green innovation (Liang et al., 2023) so AI can contribute to increase the environmental performance of organizations (Yin et al.,

2023). Positive impact was observed in the case of open innovation practices also (Kuzior et al., 2023; Sahoo et al., 2024). AI can improve frugal innovation that can lead to positive social transformation and overall progress (Govindan, 2022).

Studies have shown that the implementation of AI led to higher innovation results (Rammer et al., 2022). Given the unpredictable character of innovation the problem of identifying the promising innovation project with the help of AI is still a challenge (Sjodin et al., 2023). We are still discovering the potential of AI, and we can expect that AI can revolutionize innovation management. In theory it has the potential to replace the work done by humans, delivering higher quality and efficiency, providing instrumental assistance beyond human capabilities (Haefner et al., 2021). However, it is hard to believe that will eliminate humans from the innovation process (Rampersad, 2020; Truong & Papagiannidis, 2022).

The interest in this topic of research is increasing and we can expect that the potential of AI will be better understood and used. For the moment, in the business and economic sector, some transformative changes can be observed:

Automation of routine tasks. Routine and repetitive jobs will continue to be automated by AI technologies, freeing up human resources for more strategic and creative work (Babina et al., 2024). Businesses may experience a boost in production and efficiency because of this automation, freeing up resources for higher-value endeavors.

Data-Driven Decision Making. Businesses can use AI to leverage massive data for better informed decision-making (Alghamdi & Agag, 2023). Large volumes of data may be mined for insightful information by sophisticated analytics and machine learning algorithms, which enables companies to see patterns, forecast consumer behavior, and streamline processes (Yablonsky, 2019).

Personalized Customer Experiences. AI-powered personalization will show up more and more in customer service and marketing (Li, 2022). Companies will use AI to evaluate consumer behavior and preferences in order to provide recommendations, services, and products that are customized to each customer's requirements and interests.

Supply Chain Optimization. Supply chain management can be improved by artificial intelligence (AI) through demand prediction, inventory optimization, and the detection of possible bottlenecks or disruptions (Hendriksen, 2023). Businesses may benefit from lower expenses, more productivity, and better risk management because of this optimization (Belhadi et al., 2024).

Innovation in Financial Services. By facilitating developments in fields like algorithmic trading, fraud detection, risk assessment, and personalized wealth management, artificial intelligence (AI) is transforming the financial services sector (Yubo, 2021). AI is being used by both major financial institutions and fintech startups to spur innovation and improve client experiences (Santos & Qin, 2019).

AI-Powered Entrepreneurship. AI makes entrepreneurship more accessible by removing entry barriers and facilitating large-scale innovation (Siemon et al., 2022). Startups and small firms can compete with larger rivals by utilizing AI tools and platforms for tasks like chatbots for customer service, marketing automation, and predictive analytics (Chen, 2021).

Job Displacement and Reskilling. While there are many advantages to AI advancement, there are also worries about job displacement and the need for labor reskilling (Polyportis & Pahos, 2024). Companies will have to spend money on programs for employee upskilling and training if they want to guarantee that people can prosper in an AI-driven economy and adjust to the changing environment.

Ethical and Regulatory Considerations. Ethical and regulatory issues will gain importance when artificial intelligence is incorporated more deeply into commercial operations. To win over customers and stakeholders, businesses need to handle concerns like data privacy, algorithmic bias, and transparency.

In general, we can state that there is a great deal of room for innovation in the business and economic fields during the AI era to increase productivity, competitiveness, and value creation. But achieving these advantages will cost money, time, and a dedication to the moral and appropriate application of AI.

Conclusions

The era of AI has arrived and is here to revolutionize the way we carry out our human activities. By exploring the complicated interaction between AI technologies and innovation, we tried to add some clarity on how to effectively utilize AI's potential while limiting risks and maximizing social benefits.

The research results suggest that AI is significantly transforming the innovation process by automating tasks, enhancing learning and adaptability, creating new opportunities, rethinking management strategies, and acting as both an originator and facilitator of innovation, which may affect global competitiveness and the nature of human jobs. The main transformative changes identified refer to a personalized customer experiences, the supply chain optimization, more innovative financial services, AI-powered entrepreneurship, job displacement and reskilling. In this rush for change we must also develop good ethical and regulatory considerations.

The evolution of innovation in the era of AI is characterized by transformative changes that can lead to future marked by prosperity, inclusion, and sustainability.

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