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ARTIFICIAL INTELLIGENCE AND INNOVATION PRACTICES: A CONCEPTUAL INQUIRY

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ARTICLE INFORMATION

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ABSTRACT

Discourse on artificial intelligence runs noticeably along with the developments of computing technology. At the same time, the business environment become more uncertain, ambiguous, and competitive, which requires organizations to innovate for their sustainability continuously. This paper aims to broaden the body of knowledge on innovation management, particularly in relation to the application of artificial intelligence. The behavioural Theory of the Firm is used as a framework for writing this conceptual inquiry. To do so, artificial intelligence can assist organizations in processing information needed by companies to create incremental and radical innovations. Specifically, artificial intelligence is useful in overcoming barriers to innovation (during information processing and search processes) and in the process of generating and developing ideas and solutions. Furthermore, the process of adopting artificial intelligence in innovation management areas is determined by the level of organizational capability in information processing, which consists of three levels, namely exploitation, expansion, and exploration. Then, economic, technological and social forces are argued as factors that can push organizations to adopt artificial intelligence. At the same time, the challenges faced in the adoption process can come from technical aspects of technology, individual elements, and characteristics of interaction between technology and humans. The final part of this manuscript describes the future research agenda that can be carried out related to artificial intelligence and innovation management.

1. Introduction

Artificial Intelligence (AI) has become a "trending topic" lately. Not only in the field of Information Technology (IT), conversations about artificial intelligence are also increasingly discussed in the business context. On the one side, AI is believed to be a new resource for business organizations to create new products and services or tools for optimizing the value added to existing products and services. On the other side, the presence of AI may emerge as a threat because of its disruptive effects. The main fear of AI is the potential for human replacement and substantial changes to business processes.

In the Volatility, Uncertainty, Complexity, and Ambiguity (VUCA) era, the ability of the management team to orchestrate innovation activities becomes one of the pillars of the organization in achieving competitive advantage. Academics and practitioners have a common understanding that innovation contributes to the creation of a company's competitive advantages (Denton, 1999) and has a positive effect on the company's performance (Tidd, 2001). Excellent innovation management is believed to be a catalyst for the growth of creative ideas and innovative solutions to problems faced by the company. Moreover, qualified innovation management will be able to sow the seeds of ideas and solutions into concrete outputs that provide value to consumers and companies.

In the field of operation and innovation management, Bughin et al. (2017) estimate that AI technologies have the potential to replace more than half of the tasks typically performed by innovation managers. The conventional approach of human-based and human-centred innovation management presents some areas for improvement, primarily in the limitations of the individual's ability to fully address information needs and to overcome their complexity (Eggers & Kaplan, 2009). Individuals typically have cognitive limitations which bind their ability to absorb and process information. This handicap becomes more apparent with the increase in the volume of information available and the speed of information production. Therefore, it is important to look at the potential interaction (and adoption) of AI in the process of managing innovation.

This paper will discuss how the development of AI has the potential to influence the management of innovation in organizations. For this purpose, this paper will begin by describing the obstacles faced by innovation managers, especially in handling and overcoming complexity caused by limited information processing capabilities. The point of view of organizational behaviour theory will be used to discuss various types of problems faced by organizations in managing innovation. Furthermore, it will explain how different levels of information processing capabilities through AI can help innovation managers encourage companies to become more digital. In the next section, we will discuss various factors that drive organizations to adopt AI in the innovation process, and then followed by a presentation of various challenges that may be faced in the process of applying AI. In the final section, the prospect of future research in the field of innovation management related to AI will be discussed.

2. Artificial Intelligence and Innovation

Nowadays, the role of human resources is very substantial in the practice of innovation in various companies, both as objects and subjects of innovation. Humans still possess a dominant role in organizing innovation policies and delivering innovation processes. Both practitioners and academia affirm the presence of AI as a critical factor in the changes in the innovation process (Bughin et al., 2017; von Krogh, 2018). The rapid development of technology, especially machine learning, reinforces this belief.

Along with the rapid change in technology, AI has changed the innovation process (Haefner et al., 2021). The prevailing conception previously saw humans as the main axis of innovation because of the unique characteristics that an individual possesses, such as being creative, proactive, and risk-takers, which are believed to be the basic criteria for being innovative (Amabile, 2020). However, with the rapidly changing and massive business environment and concurrently accompanied by technological developments which allow the availability of large amounts of information in more diverse sources and in a fast time

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availability, it puts humans as not only the sole factor for the emergence of the competitive organizations.

Hajli & Featherman (2018) affirm that in a situation full of change, high uncertainty, complexity, and ambiguity, organizational competitiveness is influenced by two factors, namely the ownership of relevant and credible information and the organization's ability to solve problems. In some sectors, the situation becomes increasingly complex when the cost of innovation is getting more expensive, which causes increased innovation risks. For example, what happens in the pharmaceutical industry where the process of developing new drugs requires greater costs? A similar pattern exists for semiconductor companies where the demand to produce exponentially increasing storage capacity requires companies like Intel to allocate multiple costs of innovation. Therefore, the way innovation is managed faces major challenges, and the presence of AI and machine learning offers a cost advantage in information processing.

Many people use AI and machine learning interchangeably without considering that they are different. Machine learning is one of the types of AI which can learn from data in order to make its own rules and solve problems. The algorithm in machine learning can be used to maximize the performance of a given task (Tarud, 2023). In addition to machine learning, various types of AI, such as purely reactive machines, limited memory machines, theory of mind machines, and self-aware machines, are introduced (Kaley, 2023). AI capabilities emphasize the programming of human cognitive skills such as learning, reasoning, and self-correction into the machine. ChatGPT, Google Maps, Smart Assistants, Snapchat Filters, Wearables, and Self-driving cars are among the most used AI in today's life.

3. Artificial Intelligence in the Perspective of Behavioral Theory of the Organization

The conception of AI began to be discussed in the 1950s in the field of computer science. In the business and management domain, discussion of the application of AI into business practice is mainly discussed using a Paradox Theory (Raisch & Krakowski, 2021). According to this theory, there are two stances of AI in business: automation vs. augmentation. Automation implies that machines will take over human tasks, while augmentation means that humans will collaborate closely with machines to perform specific tasks. However, along with an increase in AI adoption, there is a difficulty in separating augmentation and automation neatly, and therefore, creates a paradoxical tension. Over-emphasizing either augmentation or automation fuels reinforcing cycles with negative organizational and social outcomes. Hence, an alternative point of view is needed to provide a sound understanding of the dynamic implementation of AI in business (Raisch & Krakowski, 2021).

Behavioral Organization Theory (BOT) have the potential capability to complement Paradox Theory. BOT is widely known and used as a lens to understand various phenomena of organizational behaviour and decision-making. This theory, introduced by Cyert & March (1963), explains basic concepts at the cognitive level that are constructed using basic assumptions of limited rationality and cognate ideas such as satisficing, search, and organizational routines. Other concepts, such as uncertainty avoidance, quasi-resolution of conflict, problematic search, and organizational learning, are used to explain how cognitive aspects uncover phenomena in organizations. According to Augier & Prietula (2007), the presence of BOT is also very closely related to the conception of AI.

In the context of the development of AI, BOT can be used to help understand how managers manage the innovation process. As is known, the source of innovation can come from the imagination of creators and can also emerge from the answers to various problems faced by organizations or consumers. The creator's imagination is closely related to the artistic logic of the individual, while the solution to the problem is closely related to the economic logic of the creator (Purnomo & Kristiansen, 2018). For this second type of innovation, the BOT postulate allows us to understand better problem solving by seeing organizations as information processing systems composed of simple "if-then" computational algorithms. This computational algorithm is the core of AI. The logic that sees organizations as simple algorithms or combinations of various algorithms that process information is the essence of BOT. This is in line with the opinion of Simon (2019), who wrote: "If computers are organized somewhat in the image of man, then the computer (is) an obvious device for exploring the consequences of alternative organizational assumptions for human behaviour".

Information processing is a key ingredient in the innovation of an organization. One of the activities in innovation management is the action of making decisions, and to do so, managers need information processing. The role of management in information processing begins with determining the inputs needed. These inputs can be data, knowledge, and other information. Next, input processing is the undertaking and analysis of relevant data and information. The results of the processing will be used by management as a basis for decision-making. With AI, in particular machine learning, which allows machines to "learn" from data and experiences without having to be explicitly programmed, the way organizations process information can substantially change. The above stages of information processing can be accelerated, optimized, or even taken over by AI systems.

Responding to the development of IT, many companies are making efforts to adopt a variety of information and computing technologies that allow organizations to transform into more digital-minded companies. Such companies have a strong base through the integration of machine learning and computerized knowledge, which allows various processes to be automated through algorithms. This situation allows more and more information and knowledge to be stored electronically and without human involvement.

Lenka et al. (2017) emphasized the need for digital capabilities if companies want to make digitalization efforts. The amount of information and knowledge is increasing and stored electronically without human involvement. This causes social systems to become less important, especially in increasingly digitized organizations. As a result, corporate leaders responsible for managing innovation are less efficient in their roles, not only because of human limitations but also because of operations that are outside the relevant flows. In other words, managers who do not have access to information, either quantitatively or qualitatively, will be marginalized compared to previous periods. The role of innovation management will change with the rapid development of AI. This situation led to the need to integrate AI into the organization's innovation management model. Human-pivoted innovation management is expected to go hand in hand with AI algorithms in the process of creating an organization's competitive advantage.

4. Information Processing in The Innovation Process

In order to have a better understanding of how AI accelerates organizational innovation, we need to know how information is being processed to produce innovation. According to (Kijkuit & Van Den Ende, 2007), the innovation process, which is the core of attention in innovation management, consists of three stages, namely: (1) recognition, discovery, creation, and growth of innovative ideas, opportunities, and solutions; (2) the development or exploitation of diverse ideas, opportunities, and solutions; and (3) evaluation and selection of one of the most promising ideas, opportunities, and solutions. The first and second stages require a high level of creativity and out-of-the-box thinking (Martin & Wilson, 2016). While the third stage predominantly uses convergent cognition to process information more rationally.

The increasing use of electronic services and automation causes organizations to have an increasingly digital 'flavour', which will then lead to a change in the role of the innovation

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manager. In the past, when innovation managers sought to recognize or develop new opportunities and ideas, they typically faced two main challenges (Eggers & Kaplan, 2009). First, they must overcome various information processing constraints that limit the number of new opportunities or potential solutions that the company can undertake. These information-processing constraints usually occur as a result of the cognitive limitations of managers, namely, the inadequate mental capacity of managers to absorb and process information that is biologically limited. Second, there needs to be more bottlenecks from managers resulting from ineffective search routines and local searches. Managers usually look for solutions in the knowledge domain associated with the company or on the knowledge base they have mastered. This results in incremental innovation solutions because they are based on existing knowledge. To generate more creative and innovative ideas and opportunities and enable radical innovation, managers must expand their search beyond their existing domain of knowledge, especially in new and naturally more exploratory fields.

Therefore, while access to information is increasingly limited in increasingly digitized organizations, the more managers are able to process large amounts of information across a wide range of opportunity approaches and possible solutions, the more they are able to recognize the truly attractive opportunities and the most promising solutions. Moreover, because managers can move beyond the knowledge they currently have with the help of AI, they will be able to develop more innovative solutions and recognize more creative opportunities (Amabile, 2020). The solutions provided by AI cannot be directly obtained but through a series of challenging processes, nor can they eliminate all human involvement in the innovation process (Haefner et al., 2021). Systems based on AI will only succeed if they are able to help companies overcome obstacles faced by humans in the innovation process.

5. Application of Artificial Intelligence in The Innovation Process

AI has the momentum to solve previously outlined obstacles, particularly those faced by managers in the innovation process. In the information processing constraint, AI provides the opportunity to offer effectiveness at the stage of idea development and the stage of idea growth. At both stages, AI can also make the search process more effective and much more exploratory. Schematically, the application of AI in the innovation process can be seen in Table 1.

Table 1. Application of AI in Various Innovation Processes

		INNOVATION PROCESS	
		Develop Ideas	**Generate Ideas**
BARRIERS TO INNOVATION	**Information Processing Constraints**	**(I)** AI systems can identify and evaluate more information that can then be used to develop ideas.	**(II)** AI systems can recognize more problems, opportunities, and threats that may be used to generate new ideas.
	Ineffective or Local Search Routines	**(III)** AI systems can identify and evaluate more creative/ exploratory ideas.	**(IV)** AI systems can recognize and create more creative/ exploratory problems, opportunities, and threats to generate new ideas.

Source: Haefner et al. (2021)

The AI system works well in the process of generating ideas and developing opportunities. AI systems rely heavily on neural networks that require and are simultaneously capable of processing very large amounts of data. With this feature, we can see many AI systems supporting humans in the development of ideas and opportunities through processing larger amounts of information that exceed human capability and exploring areas of interest for further investigation. Even according to Roose (2019), AI-based technology has created significant economic value in companies. As seen in quadrant I above, AI systems are able to facilitate the identification and evaluation of more diverse and complex information in order to develop ideas. This certainly provides a more conducive carrying capacity to the innovation process.

The application of AI systems is carried out in various fields. In the field of material development, for example, AI is used to optimize battery and solar cell components or to accelerate the process of creating new catalysts. To create these new materials, machine learning-based methods are used to predict the most promising material options to test. This significantly accelerates the innovation process. In the pharmaceutical industry, AI is used in the research and development process, especially in protein engineering.

AI can also accelerate the process of protein engineering, which plays an important role in finding proteins that are suitable for application both technologically, scientifically, and medically. AI becomes a solution for pharmaceutical researchers because the previous method entails a protein search space that is too wide, so it takes a long time to search more deeply. AI was also used to identify treatments for various diseases, such as malaria. In addition to encouraging product innovation, AI is also used to encourage the emergence of process innovation in organizations, as in the case of Celonis. This German and American joint venture uses process mining to identify processes in organizations suitable for robotic automation. AI enables organizations to implement a wide array of administrative innovations.

Quadrant two suggests that AI can process more information to generate new ideas and opportunities that may not be seen or overlooked by individual processing capabilities. Outlier.ai, an analytics solutions company, developed a machine learning method to process raw data metrics into specific insights that humans can read. After analyzing the company's data set, Outlier was able to create a set of "stories" that summarized interesting and actionable insights for managers. Outliers' ability to spot specific patterns and anomalies that may occur from existing data is an example of AI's ability to help companies generate or recognize innovative ideas and opportunities. AI may not be able to provide a complete solution, but its presence is able to guide managers to find the most promising path to innovation.

There are some early indications that the presence of AI can help humans develop a variety of innovation activities. As seen in quadrant three, AI allows for the identification and evaluation of more creative and exploratory ideas. Opportunities and solutions can be found using anti-mainstream, non-routine approaches and freeing yourself from the constraints of habits and knowledge. Autodesk, a California-based software company, uses a variety of algorithms to create partitions on Airbus aircraft. The Generative Design method used helps create products that engineers previously could not do manually. Autodesk's algorithm is based on clay mould growth patterns and mammalian bone skeletons, creating partition designs that are not only new and efficient but also stable.

The application of AI to the product development process allows Autodesk and Airbus to come up with solutions that are more innovative than previously available options. In the field of art, AI is applied in the form of Generative Adversarial Networks (GANs). The network was developed based on 81,449 paintings that were the work of 1,119 artists between the 15th and 20th centuries. The system trains two competing networks, namely discriminator and generator, to learn about art style classification (discriminator) and stylistic ambiguity (generator). As a result, this system can create new paintings that deviate or differ from the existing style. The novelty stems from the system's ability to break out of the search routine

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and demonstrate the potential of distant search. This happens because the system has learned about the various art styles stored in the database so that it understands the domain of that knowledge and can precisely generate new and original ideas. Similar models are also applied in creative industry settings, especially the clothing fashion sector. The Design Inspiration from Generative Networks (DesIGN) method allows the emergence of original patterns, styles, shapes and styles for apparel products. DesIGN brings out designs that deviate from existing clothing styles (which have been stored in a specific dataset) and simultaneously produces realistic clothing design pieces.

AI also play a role in generating ideas and recognizing opportunities for innovation in random and unrelated domains of knowledge. The method in AI that is able to facilitate the process is commonly known as reinforcement learning. Even the rapid development of this approach gave rise to derivative concepts such as unsupervised reinforcement learning and meta-reinforcement learning. Generally, reinforcement learning involves training 'agents' in a specific virtual environment. The agent uses reward signals to learn what actions can maximize rewards and which actions can minimize rewards. The reinforcement learning approach has its drawbacks. This approach requires human intervention to create reward designs before machine learning works. Departing from these weaknesses, an unsupervised reinforcement learning approach emerges that seeks to cover this weakness by allowing agents to "learn" the reward function using a variety of observations and actions. In short, this approach allows algorithms to learn to recognize and achieve certain goals without human supervision. This will certainly open up interesting avenues for the presence of creativity and innovation. At the same time, meta-reinforcement learning focuses more on how learning can be used to improve the learning process itself. Therefore, algorithms are designed in such a way as to be more flexible and able to adapt quickly to answering new problems.

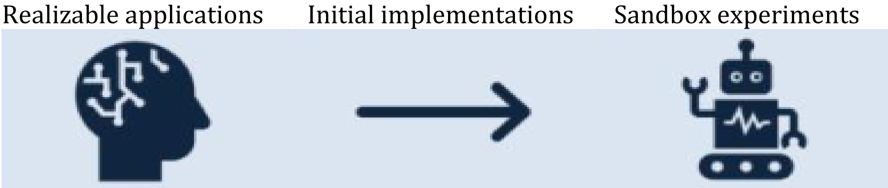
6. Three Levels of Artificial Intelligence in Building Digital Organizations

The variety of options for the application of AI, as described above, shows the extent to which AI can improve or even replace managers' roles in the innovation process. Each quadrant shows a different level of complexity. Consequently, applying AI requires different organizational capabilities in processing information. Table 2 describes three levels of information processing capability and the potential adoption of artificial intelligence.

The framework in Table 2 below assumes the dimension of the innovation process as a problem space while the dimension of the innovation obstacle is a solution space. Axten et al. (1973) define problem space as an internal representation of the task environment. Activities in the innovation process (idea development and idea creation) are considered a problem space because they are the subject of innovation, which in practice can be played by innovation managers or artificial intelligence systems. When going through the innovation process, information processing systems can continue the existing process by developing ideas and solutions based on existing problem spaces or choose to incorporate additional data, information, and knowledge to redefine the problem space, thereby opening up opportunities to generate more original ideas and solutions. The option of maintaining the status quo in a problem space is commonly known as the exploitation approach while redefining, changing, or looking differently at the problem space is known as the exploration approach.

The dimension of innovation barriers, whether in the form of barriers to information processing or ineffective search (and or too dependent on local search), can be considered as space for change to produce new solutions. Overcoming barriers to information processing does not require changing specifications in the solution space. All that is needed are steps and strategies that allow the processing of such information to be carried out more quickly and efficiently. In other words, overcoming information processing barriers indicates that such a solution space is exploited more effectively and efficiently. Meanwhile, overcoming the problem of ineffective search and being too dependent on local search requires exploring solution space that allows solutions to be presented more creatively and outside the mainstream.

Table 2. Level of Information Processing Capability in Artificial Intelligence

	LEVEL 1: EXPLOITING	LEVEL 2: EXPANDING	LEVEL 3: EXPLORING
SEARCH APPROACH	Able to successfully exploit both the problem and the solution spaces	Able to explore and redefine either the problem or the solution space	Fully able to explore and redefine both the problem and the solution spaces
CHARACTERISTICS	- Used to overcome cognitive information processing constraints - Can deal with more data - Able to process many different data sources	Either: - Able to discover new ideas and opportunities Or: - Supporting humans in developing more innovative ideas and solutions	- Exploring new avenues in the innovation process - Generate and create innovative and creative new ideas - Explore new ways of defining problems - Explore new ways of addressing problems
MATURITY LEVEL	Realizable applications	Initial implementations	Sandbox experiments
AUTONOMY LEVEL			
	Human-designed AI Systems		AI systems with increasing machine autonomy

Source: Haefner et al. (2021)

Furthermore, understanding the level of capability of AI systems in assisting humans in the innovation process requires an understanding of the technical features of the system. In general, there are two characteristics of AI systems. First, most AI systems available today are trained by individuals with special skills. Usually, there is a collaboration between individuals who are experts in the field of AI technology and individuals who are qualified in certain knowledge domains. Second, usually, AI systems are designed to perform a learning process that is optimized for a specific purpose function. This goal function is defined by humans who understand the AI system. Because an individual cannot know all possible goals, there are limitations to defining the function of an ideal goal. Consequently, in almost all applications of AI, the solution space is determined in advance by humans, so AI systems have limited ability to explore solution space autonomously.

Departing from this situation, three levels of information processing capabilities may occur. At the most basic level, we call the Exploitation level, where AI systems can help innovation managers process larger amounts of information and knowledge than they can do manually. At this level, AI systems will primarily be able to provide 'support' rather than 'replace' the role of humans in the innovation process. The ability to process more information and knowledge becomes the support function of innovation managers in managing the innovation process. AI systems are able to overcome the cognitive limitations of innovation managers in processing information that comes from a variety of sources across time and large amounts.

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At the next level, commonly known as Expansion, AI systems can perform two functions simultaneously: expanding the innovation process through generating new ideas and opportunities and simultaneously overcoming problems in search routines in local knowledge domains to lead to searches in broader domains. At this level, AI works in tandem with innovation managers. The system excels in supporting innovation managers through two areas. First, AI systems aid in the discovery of new ideas and opportunities, as described in quadrant 2 in Table 1 above. Second, the system can help innovation managers develop more creative and innovative ideas and solutions. At present, the ability of AI technology to support the above functions still needs to be improved, and only a few systems are capable and ready to support at this level.

At the highest level, commonly known as Exploration, AI systems are able to explore new avenues in the innovation process. This type of AI system is capable of performing more complex tasks; therefore, its role is not only limited to supporting innovation managers but also has the opportunity to replace innovation managers in various situations. AI systems at this level can generate and create new creative and innovative ideas through the process of exploring problem space (looking for new ways to define problems) and exploring solution space (looking for new ways to overcome problems). Therefore, AI systems at level 3 have a greater chance of taking over tasks traditionally performed by innovation managers.

Even though AI has various capabilities to help organizations develop their digital mainstreaming, managers should notice that AI is not an answer to all organizational problems. The AI's capabilities to facilitate information processing and searching rely highly on historical [or existing available] data. Problems in historical data availability, quality, and validity will limit, or at least reduce, the effectiveness of utilizing AI technology. Moreover, over-reliance on data may become another problematic issue, particularly for organizations which employ less experienced employees. They need to be equipped with the business wisdom necessary to make decisions under uncertain conditions. Last but not least, limited contextual understanding may become a fundamental limitation on AI adoption in organizations.

7. Various Factors Drive the Adoption of Artificial Intelligence for Innovation

It has been explained above the role of AI in the innovation process. In addition to providing benefits in the process of exploitation and exploration of ideas and solutions that are expected to maximize innovation outcomes, the adoption of AI could also provide benefits at the meso and macro levels. Mariani et al. (2023) explained that innovations made can contribute to organizational capabilities and competitive advantage. In macro terms, the adoption of AI has the potential to bring organizational performance both in terms of effectiveness and efficiency.

With such huge potential benefits, many organizations are considering adopting AI. As shown in Figure 1 below, 3 aspects encourage the adoption of AI in companies, namely economic, technological and social aspects. Cost efficiency considerations, time cuts for new product development, increased productivity, and assisting in decision-making are some of the driving factors from the economic aspect. The adoption of AI allows companies to reduce manufacturing costs, research and development costs, design costs and the creation of new products. With the reduction of these costs, the company expects to gain more competitive product prices. In addition, the adoption of AI also allows companies to improve the performance of their operations. Especially in manufacturing companies, the use of AI technology encourages increased productivity on product assembly lines and improved manufacturing capacity. Moreover, because AI systems generate and manage large amounts of data, the implementation of AI allows companies to transform business processes to be more effective and efficient.

Furthermore, when it comes to technology-driven innovation, time is usually the most critical element. With the rapidly changing business environment, which is attributed to high uncertainty and ambiguity, speed is one of the main aspects of winning the competition in the market. AI can assist companies in saving time in making innovations, both incremental (for example, improving existing product features) and radical innovations (such as new product development). The adoption of AI also helps companies make more optimal decisions. The use of the Hybrid Genetic Local Search Algorithm, for example, is able to identify various factors for a decision-making base that is not only faster but also more effective. An automated Multi-criteria Decision Analysis approach is also more possible by including structured data as well as unstructured data obtained from various sources, including the Internet.

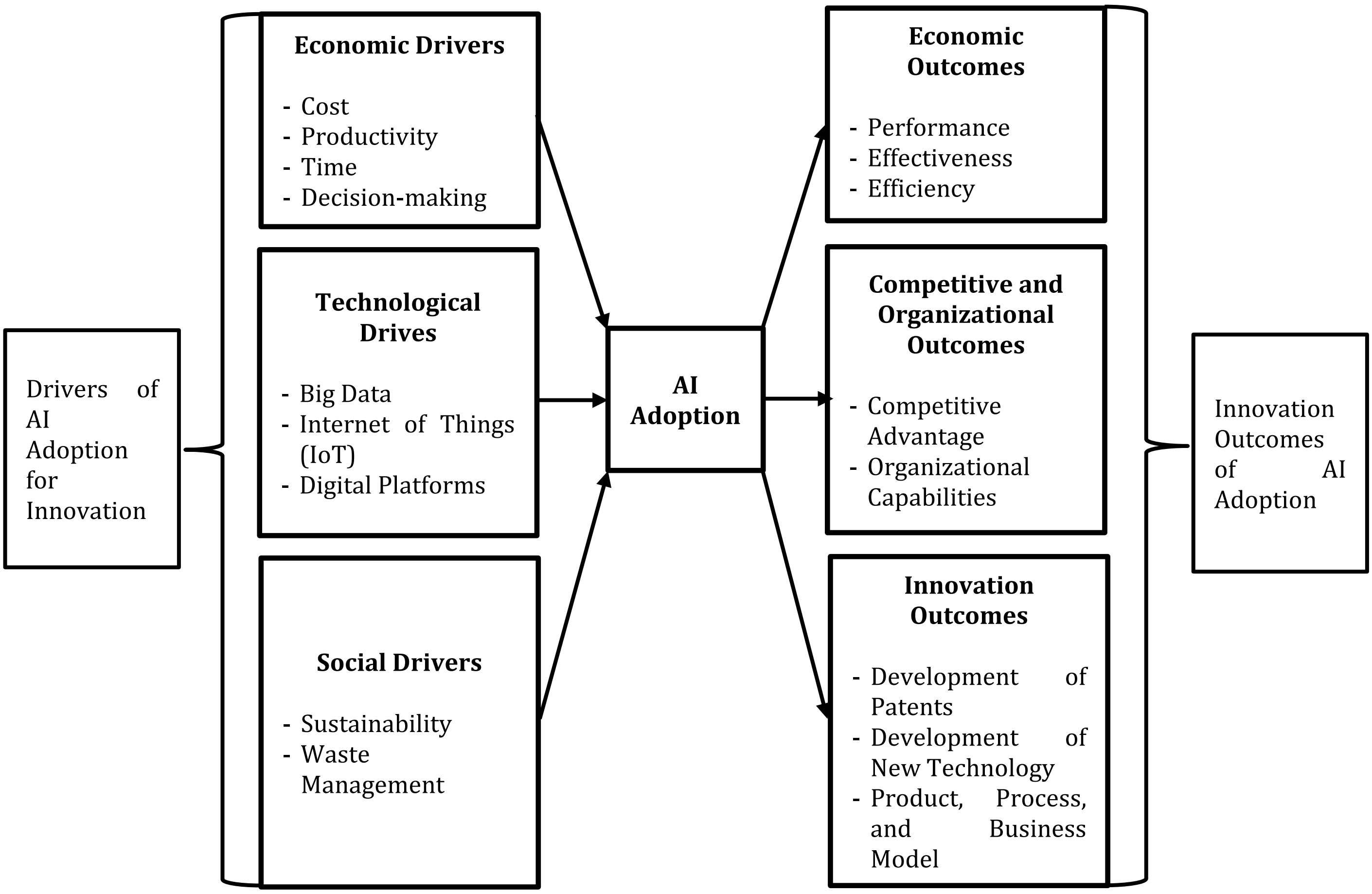

Figure 1. Driving Factors and Outcomes of Artificial Intelligence Adoption in Innovation
Source: Mariani et al. (2023)

The adoption of AI in the innovation process is also greatly influenced by the technology's ability to manage very large amounts of data, which comes from a variety of sources with a variety of formats, both structured and unstructured. From the aspect of technology, the ability and popularity of Big Data, Internet of Things (IoT) and digital platforms are the main drivers of a company adopting AI. With the use of Big Data, companies will be more helped in managing internal and external data in the process of identifying new opportunities that exist in the market and maintaining their competitive advantage. For example, companies can take, process, analyze, and present reports from consumer opinion

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and behaviour data that allow them to be used to make product adjustments. The availability of massive datasets enables AI's analytical tools to make better research & development decisions, improve products and services, and even drive innovation at the business model level. Big Data plays an important role in accelerating enterprise sensing capabilities to respond to rapid market changes. The implementation of the IoT is able to improve company productivity and provide real-time analytics that can improve operational efficiency. In the health sector, for example, IoT adoption through the use of Smart Wearable Healthcare (SWH) devices equipped with IoT technology, such as biometrics and sensors, allows the collection and monitoring of patient health more accurately and in real-time. Such data is very useful in medical care decision-making and can also be used for the development of more customized health services. In the agricultural sector, IoT applications can be applied in agricultural supply chains that allow farmers to have better planning in seeding and harvesting activities. The data can also be used in sustainable agriculture programs because it is able to detect the ecological footprint of the agricultural supply chain. A digital platform is a combination of digital applications that facilitate the exchange of information between groups of users and stakeholders. The platform provides a dynamic environment to drive customer engagement and enhance their transaction experience. For companies, data stored in digital platforms is useful for various things, such as understanding consumer buying patterns, identifying new customer needs, solving specific customer problems, and identifying ideas for new product development.

In line with the spirit of sustainable development goals, more and more companies are innovating on environmentally friendly products and trying to implement more 'green' business practices. Companies widely use AI technology to facilitate more sustainable business practices and reduce resource wastage while lowering production costs. One of the ways that companies use to improve the 'sustainability theme' at the research and development (R&D) stage is by taking data from social media platforms (Twitter, Facebook and Instagram) to identify original ideas for the development of new products. This can be done because social media stores important information about consumers' opinions about environmental issues that are their 'concern', assessments about the ecological value of a product, and the potential purchase of environmentally friendly products. In addition to being used as a database, social media can also be used by companies to promote the company's steps in sustainability campaigns, including building awareness of the environmentally friendly products they sell. The adoption of AI is also often based on the need for more responsible waste treatment and wiser use of resources. The adoption of artificial intelligence is also carried out on a wider scale in monitoring pollution, waste, and the use of electrical energy.

8. How Difficult is Adopting Artificial Intelligence in the Innovation Process?

In implementing an evolving technology, such as AI, several challenges may emerge. There are three main challenges: technical or technological, the individual who will use the technology and the interaction aspect between technology and humans. In the technical aspect, the issue of data availability and data suitability has become the main challenge (Agrawal et al., 2018), in addition to the hardware aspect as supporting infrastructure. Some AI systems require machines with super large capacities and capabilities to support data processing. For example, what happened to the Generative Adversarial Model technology, which requires data processing power equivalent to the average six months of computer use in America? In addition, the available technology is sometimes still immature/established, especially if it will be applied to professional practice for corporate needs. Most AI technologies are still developing at the level of laboratory experimentation, and only a small percentage are ready for corporate commercialization. Among those already ready, for example, is the Reinforcement Learning application developed by DiDi Chuxing, China's largest ride-hailing company that uses AI that allows adaptation to the wishes of its driver-partners.

From the individual users, the application of AI in the innovation process requires a variety of technical skills (Chui et al., 2018). The type of technical skills needed are closely related to the complexity of the AI system to be developed. A potential challenge in this aspect is the availability of human resources with relevant skill specifications. In addition to having human resources who are qualified in technical aspects, companies also need to complement the composition of the team with qualified resources in specific fields (domain experts). The problem that may arise is in the collaboration process between the two types of human resources. For example, in the case of the application of AI aimed at monitoring patients in the Intensive Care Unit (ICU) of a hospital, collaboration between IT personnel who are proficient in AI and medical personnel who are qualified in the aspect of health services is not easily done. It takes quite a long time to build the collaboration process.

The third challenge occurs in the interaction between technology and humans. The amount of human intervention can be an obstacle in the application of AI to the innovation process. While AI applications are intended to automate processes in a variety of workflows, it is rare to find that an entire business process can be fully automated. Another issue is related to the solution space that will be explored by AI systems, which usually still rely heavily on algorithms that are predetermined by the individual who implements the system. In addition to being limited in the resulting solution space, human presence can also produce fewer specific solutions. This is the case with Reinforcement Learning (where undirected reward functions will only make machines 'game' the system) and Generative Design (where the parameters entered are not strict enough to cause fewer specific results and tend to be of no benefit). Therefore, human intervention becomes necessary. However, at the same time, such interventions can be viewed as inefficiencies in the process. Human intervention can provide benefits depending on the context. The biggest challenge is to come to an understanding of when human intervention is needed and when it is not needed.

9. Prospective Further Research Agenda

Discourses on AI and innovation management occur in more than just the realm of practice. Theoretically, various research areas can be carried out to develop a body of innovative knowledge from the perspective of AI. Some future research ideas that can be done include: First, academics can conduct empirical testing related to the factors that encourage the adoption of AI in the innovation management process. Other empirical research can be conducted to examine the impact of the use of AI in innovation on organizational performance. Second, researchers can also conduct studies to see the phenomenon and process of adoption of AI in various industrial sectors, in various business sizes (corporations, medium enterprises, and small businesses), in different environmental contexts (developed or developing countries), at various stages of the business cycle (startups, growing businesses, mature businesses, or businesses that are in decline), and in different time contexts (before the pandemic, during the pandemic, and after the pandemic). Third, academics also need to investigate the various actors involved in the process of adopting AI and their specific roles. Fourth, research can also be conducted in non-business organizational settings, such as government organizations, non-profit organizations, and artistic-oriented organizations, to see the different dynamics of applying AI in the innovation process. Fifth, in addition to seeing the positive impact of the application of AI, academics can investigate various problems caused by the adoption of AI, both at the individual level (consumers and employees), organizational level, and the level of the wider social community.

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