Challenges and Limitations of Artificial Intelligence (AI): Philosophical and Managerial Perspective

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ABSTRACT

This study is to explore the challenges and limitations of artificial intelligence (AI) that face to the society, business and human lifes. Pprevious studies have conducsted various areas with engineering, ehthics, and business concern. Few studies are conducted philosophical and managerial perspective. This study reviews literatures related to the recent advancements in AI and the problems and examines the future direction of AI development and the resulting social and ethical challenges. This study suggests that a holistic approach of AI research that considers ethical, social,

and legal responsibilities alongside technological advancements is necessary.

Keywords: Artificial intelligence, Philosophical perspective, Managerial perspective, Holistic approach

INTRODUCTION

Artificial intelligence (AI) has been exploding recently in academic. Industry is also rapidly embracing AI as a viable alternative to improve the practical productivity and performance of individuals and businesses. AI originated as an academic and technological attempt to mechanically emulate human intellectual abilities. The origins of AI are not confined to a single academic discipline, but rather result from the complex interplay of historical developments in philosophy, mathematics, logic, human development, and computer science and engineering (Elman, 1990, Agrawal et al., 2018, Russell & Norvig, 2021).

AI has advanced rapidly over the past several decades and is now realizing its potential across a wide range of industries. In particular, advances in machine learning and deep learning have had a significant impact on AI research, leading to groundbreaking achievements in numerous fields, including autonomous driving (Pomerleau, 1988, Chen et al., 2024), natural language processing (Rumelhart et al., 1986, Huynh & McNamara, 2025), image recognition (LeCun et al., 1989, Ryu et al., 2025), healtcare diagnosis (Kwak & Lee, 1997, Sharma et al., 2024) and business (Davenport & Harris, 2007, Olatunbosun et al., 2025). These advancements were made possible by big data, high-performance computing, and advanced algorithms. However, few studies explore AI studies in terms of philosophical and managerial perspective.

This study is to explore the origins of the concept of AI, focusing on the philosophical and managerial background so that it provides future development of the research direction in artificial intelligence. This study aims to closely analyze current AI technology trends and discuss their impact on society, business and humab lifes. In particular, it examines the recent advancements in AI technology and the problems it can solve and examines the future direction of AI development and the resulting social and ethical challenges.

PHILOSOPHICAL BACKGROUND IN ARTIFICIAL INTELLIGENCE (AI)

From a philosophical perspective, Dreyfus (1972) critically analyzed the fundamental differences between human and computer intelligence, pointing out that AI cannot fully imitate human intuition and tacit knowledge. Since then, related studies have reexamined this concept alongside advances in modern computer science, continuously exploring the limitations and philosophical implications of AI.

Recent trends in AI can be divided into several important areas. First, rapid advancements in self-supervised learning and transfer learning have significantly improved model learning efficiency and versatility. This allows for learning using small amounts of labeled data and helps apply previously learned knowledge to new problems. Second, there have been remarkable advances in natural language processing (NLP). In particular, large-scale language models such as GPT-3 and BERT enable human-level text generation, translation, summarization, and sentiment analysis, and are being utilized in a variety of business and research fields. Third, reinforcement learning technology is playing a crucial role in fields such as autonomous vehicles and robot control, enabling efficient decision-making processes without direct human intervention. This is contributing to improving AI's ability to operate in real-world environments. Finally, there is growing interest in the ethical and social issues surrounding AI. While the advancement of AI opens up many positive possibilities, it also raises concerns about privacy, bias, and fairness. Research related to these issues is playing a crucial role in enhancing the reliability of AI systems and exploring ways to utilize them safely in society.

Aristotle's Perspective: Nous and Logos

The ideological origins of artificial intelligence can be traced back to ancient philosophy. Aristotle, through formal logic, regularized human thought processes, suggesting the possibility of systematically expressing reasoning. It can be traced back to ancient Greek philosophy, particularly Aristotle's logic. In his Organon, Aristotle systematized syllogisms, expressing human reasoning processes in clear rules and formats. This was the first systematic attempt to demonstrate that thinking, rather than relying on intuition or senses, can unfold according to a set of logical structures (Adidi, 2024, Giannakidou & Mari, 2024).

Aristotle's formal logic offered the perspective that "correct reasoning can be performed mechanically according to rules," a view that later became a core premise in artificial intelligence research, which sought to understand human intellectual activity as a computable process. In particular, his logical system is considered the philosophical foundation for the rule-based systems of modern artificial intelligence, as it suggested the possibility of symbolizing and automating reasoning.

Subsequently, medieval Scholastic philosophers inherited and developed Aristotelian logic, and in the modern era, Descartes and Leibniz sought to explain human thought as a process of more explicit rules and symbol manipulation. This ideological trend demonstrates that the formalized tradition of logical thought, begun by Aristotle, led to modern computational theory and the concept of artificial intelligence.

In Aristotle's philosophy, nous and logos are core concepts that constitute human cognition and thought. Rather than being separate concepts, they are functionally closely linked. Understanding the relationship between these two concepts is essential to elucidating the structure of Aristotle's epistemology and logic. For Aristotle, nous signifies intuitive understanding or the faculty of rational cognition. In the Nicomachean Ethics and Metaphysics, nous is defined as the ability to directly grasp universal principles (archai). In other words, nous is the cognitive ability that immediately recognizes the essence or initial principles of things without argument or inference. In this sense, nous functions as a prerequisite for cognition. On the other hand, logos signifies rational language, explanation, or argumentative thought, and is particularly closely related to the logical system developed in the Organon. Logos is the principle that enables the formation of propositions, the definition of concepts, and the process of inference through syllogism. Therefore, logos is responsible for the formal and expressive aspects of human thought.

In Aristotle, nous and logos are in a hierarchical yet interdependent relationship. Nous provides the cognitive foundation for logos to function, and logos functions to linguistically and logically develop the principles grasped by nous. In other words, nous intuitively recognizes "what is true," and logos is responsible for "how to explain and prove" that knowledge. This relationship is clearly revealed in the structure of syllogisms. While the universal principles of the major premise used in syllogisms are argued through logos, that universality itself is recognized by nous. Therefore, all arguments ultimately depend on the principles grasped by nous, and logos serves as the means to systematically develop them.

In Aristotle's philosophy, nous and logos are not opposing concepts, but rather form a complementary relationship between intuitive cognition and argumentative thought. This structure demonstrates that human reason goes beyond simple calculation or symbol manipulation to the ability to integrate principle recognition and rational explanation, and provides a philosophical foundation for attempts to formalize human thought in later logic and artificial intelligence research.

In modern times, Descartes and Leibniz argued that human thought could be explained by mechanistic principles, with Leibniz, in particular, understanding thought as a process of symbol manipulation. These philosophical discussions provided the theoretical foundation for the concept of artificial intelligence, which regards human thought as a computable entity.

Descartes' Perspective: The Relationship Between Intellectus and Reason (Ratio)

In Descartes' philosophy, the core of human cognition is explained by the functions of intellectus and reason (ratio). While this is structurally similar to Aristotle's distinction between nous and logos, its philosophical premises and functions are fundamentally reconstructed.

For Descartes, intellectus is the cognitive faculty that clearly grasps the essence of things. In his Meditations, he presents "clear and distinct ideas" as the standard for true cognition, asserting that these ideas are intuitively perceived by the intellect. Here, intellect is defined as the ability to directly grasp universal and necessary truths, independent of sense experience. In contrast, reason (ratio) is the inferential faculty that systematically connects and develops the clear ideas grasped by the intellect. In Discourse on the Method, Descartes proposes a step-by-step approach to solving complex problems through analysis, synthesis, and enumeration. This clearly demonstrates the argumentative and procedural functions of reason. In other words, reason logically organizes and expands the cognitive content provided by the intellect.

In this structure, the relationship between intellect and reason is both hierarchical and complementary, much like Aristotle's relationship between nous and logos. The intellect serves as the starting point of knowledge and provides the standard for truth, while reason systematizes that truth through inference and argument. However, unlike Aristotle, Descartes attributes this cognitive capacity to the thinking self (cogito) as a metaphysical entity.

As seen in the proposition, I think, therefore I am (Cogito, ergo sum), for Descartes, the self-knowledge of the intellect serves as the basis for all certainty. This means that, unlike Aristotle, who understood nous as the ability to perceive universal principles of the external world, the certainty of cognition originates from the subject's internal conscious structure. In Cartesian philosophy, intellect and reason are responsible for intuitive cognition and argumentative thought, respectively, which bears structural resemblance to Aristotle's functional distinction between nous and logos. However, Descartes reformulated this relationship within a subject-centered epistemology separated from the empirical world, thereby providing the philosophical foundation for modern rationalism and later artificial intelligence models of thought.

Leibniz's Perspective: Intellect (intellectus), Reason (ratio), and Symbolic Thinking

In Leibniz's philosophy, human cognition unfolds through the interaction of intellect (intellectus) and reason (ratio), a modern reinterpretation of Aristotle's relationship between nous and logos. However, Leibniz holds a unique position in that he expands this relationship beyond the simple distinction of cognitive faculties to encompass the possibility of formalization and symbolization. For Leibniz, intellect is the source of truth, the ability to recognize necessary truths. He believed that true cognition does not derive from experience, but is grounded in universal principles such as the law of contradiction and the law of sufficient reason. This recognition of principles possesses an intuitive dimension prior to reasoning, structurally corresponding to Aristotle's function of nous intuitively grasping principles.

In contrast, reason (ratio) is understood as the ability to develop principles grasped by the intellect through symbols and calculations. Leibniz sought to liberate logical thinking from the ambiguity of natural language, and to this end, he proposed the concepts of the universal character and the calculus ratiocinator. This can be seen as an attempt to reduce logos beyond mere linguistic description to a rigorous formal system. In this respect, Leibniz radically reconstructed Aristotle's logos as a computable logical system. While the intellect, corresponding to nous, still performs the role of recognizing principles, reason, corresponding to logos, is established as a realm that can be automated through symbol manipulation and calculation. Leibniz's assertion, When there's a dispute, let's calculate, epitomizes this perspective.

Furthermore, in Leibniz's epistemology, the relationship between nous and logos is hierarchical yet functionally differentiated. While the intellect provides the starting point for calculation, the calculation process itself can be performed without relying on human intuition. This philosophically justifies the mechanistic performance of reasoning and serves as the theoretical foundation for modern artificial intelligence and formal logic.

Leibniz, while inheriting Aristotle's nous-logos structure, explicitly proposed the possibility of automating human thought by symbolizing and computing logos. Thus, he can be considered a pioneering philosopher who transcends modern rationalism and develops models of artificial intelligence-based thinking.

Table 1. Philosophical Comparison of Artificial Intelligence

Category	Aristotle	Descartes	Leibniz	AI
Starting point of cognition	Principle intuition by nous	Clear cognition of the self	Necessary truth and principle of logic	Data and objective functions
Structure of thought	Nous → logos	Intuition → deduction	Principle → calculation	Input → proc. → output
Under-standing meaning	Immanent in essence	Clarity of ideas	Definition within the symbol sys	External labels
Reasoning methods	Syllogism (quali. logic)	Methodol. deduction	Formal logic/ computa.	Numerical computa. optim.
Judgment and practice	Practical intelli. (phronēsis)	Rational judgment	Calcula. decisions	Applica. of rules and prob.

According to Table 1, in the starting point of cognition, Aristotle argues that human cognition begins with the intuitive grasp of universal principles and essence through the nous (intellect, intuition). This implies intuitive understanding prior to empirical data. Descartes says that knowledge begins with clear and certain self-knowledge. The certainty of all knowledge originates from the self. Leibniz shows that knowledge is based on necessary truths and logical principles that precede experience. Universal truths and logical rules form the foundation of cognition. AIrtificial Intelligence lacks autonomous cognition and relies on data and externally defined goal functions. The starting point of cognition is limited to the environment and input values designed by humans. Thus, key comparison is that philosophers assume a non-computational and intrinsic starting point for cognition, while AI begins solely with computational and extrinsic data.

In structure of thought, Aristotle assumes that a structure that grasps principles through intuition (nous) and develops them through argumentation (logos), while Descartes argues that a structure that grasps fundamental truths through intuition and systematizes them through deductive and methodical thinking. Leibniz presents a structure that manipulates principles computationally and formally and develops thought into a symbolic system. Artificial Intelligence has a computational structure of input to processing to output that mimics thought but lacks the intuitive judgment stage. Thus, key comparison is that AI has implemented computational thinking, but it fails to perform the intuition stage (nous, evidentiality, grasping principles). In the understanding meaning, Aristotle says that meaning is inherently connected to the essence of a thing, and understanding is the intuitive grasp of its characteristics and purpose. Descartes argues that meaning arises from clear and distinct ideas and is connected to the subject's self-awareness, while Leibniz presents that meaning is formed within a system of symbols and logical definitions. Artificial Intelligence focus that meaning is limited to externally imposed labels or categories and cannot independently understand the essence of a thing. Thus, key comparison is that AI manipulates meaning but does not understand it and lacks the inherent/intuitive nature of understanding meaning.

In the reasoning methods, Aristotle focuses on developing principles grasped through intuition using syllogisms and qualitative logic. Descartes presents on building knowledge from evident truths through systematic and methodical deduction. Leibniz says manipulating and inferring principles using formal logic and computational procedures. Artificial intelligence solves problems using numerical computation, probability, and optimization algorithms. Key comparison is that AI specializes in quantitative and computational reasoning but cannot perform qualitative and intuitive logical reasoning.

In the judgment and practice, Aristotle argues that Phronēsis (practical intelligence) allows for contextual judgments tailored to the situation, while Descartes focuses on Rational judgments based on logic and evidence. Leibniz argues decisions based on computational and symbolic rules. Artificial Intelligence's judgments are based on rules and probabilities but are incapable of understanding context and reflecting on purpose. Key Comparison is that AI's judgments are computational and based on external criteria and lack the practical judgment and purposeful understanding inherent in humans.

This table and explanation demonstrate the structural differences between philosophical thinking and modern AI. Aristotle, Descartes, and Leibniz focus on non-computational elements that exist in the starting point of cognition, understanding meaning, and setting goals. Artificial Intelligence focuses on computational reasoning and automation that are possible, but intuition, understanding essence, and contextual judgment are not possible. In other words, modern AI only implements logos or computational reasoning functions, lacking the cognitive and philosophical starting point of nous.

MODERN THEORETICAL BACKGROUND OF ARTIFICIAL INTELLIGENCE

The theoretical foundation of modern AI is built by integrating mathematical, computational, and philosophical principles of computability and knowledge representation. These foundations provide theoretical justification for designing AI as a system capable of simulating some functions of human intelligence. Since the 19th century, advances in mathematics and logic have had a decisive impact on the formation of artificial intelligence. Boole proposed a method for mathematically representing logical propositions through Boolean algebra, which became the foundation of modern computer logic circuits. In the early 20th century, Gödel and Church conducted research on formal logic and computability, theoretically elucidating the limits and possibilities of mechanical computation. This research provided academic support for the possibility of mechanically implementing human reasoning processes (Nagel & Newman, 2012, Webb, 1983).

Mathematical and Computational Basis

With the advent of electronic computers in the 1940s, abstract theories entered the realm of practical implementation. Turing (1950) introduced the concept of the Turing machine, establishing a general model of computation. In "Computing Machinery and Intelligence," he posed the question of whether machines could think and proposed the Turing Test as a criterion for assessing this. This shifted artificial intelligence beyond philosophical speculation and into the realm of experimental research.

The theoretical foundation of modern artificial intelligence (AI) is built by integrating mathematical, computational, and philosophical principles of computability and knowledge representation. These foundations provide theoretical justification for designing AI as a system capable of simulating some functions of human intelligence.

At the Dartmouth Conference, McCarthy ((McCathey et al., 1956) first coined the term "artificial intelligence." The conference set forth the research goal of replicating core human intelligence functions, such as learning, reasoning, and problem solving, in machines, marking the establishment of AI as an independent academic discipline. This is generally considered the official starting point of AI research.

Modern AI is based on mathematical models encompassing logic, probability, and statistics. Boolean logic and first-order logic provide the fundamental framework for knowledge representation and rule-based reasoning, which are closely linked to the "knowledge representation" emphasized by McCarthy in his early AI research. Furthermore, probabilistic models (Bayesian networks, Markov decision processes) and statistical learning theory enable decision-making in uncertain environments and data-driven generalization, forming the mathematical foundation for modern machine learning and deep learning.

AI's practical problem-solving capabilities are underpinned by computational principles. Algorithms and optimization theory form the core of learning and decision-making mechanisms such as neural network learning, reinforcement learning, and gradient descent. The idea that computable problems can be mechanically performed can be found in Turing's theory of computability. Through the Turing machine model, Turing proposed that any computable problem can be mechanically performed. This became a crucial theoretical foundation for explaining the computational structure and design principles of modern AI systems.

Turing (1950) logically justified the computational capabilities and problem-solving potential of AI. The Turing Test provided a conceptual criterion for assessing whether a machine can perform human-like intellectual behavior, emphasizing the mechanical execution of computable problems. McCarthy (1956) defined AI as a formal implementation of human intellectual behavior and emphasized the importance of logical reasoning and knowledge representation. He argued that AI should go beyond simple computation and be capable of reasoning and problem-solving based on knowledge and rules. McCarthy's perspective directly influenced the design principles of LISP and early knowledge-based systems.

The theoretical foundations of modern AI can be understood at three levels. First, the mathematical foundation mathematically justifies AI's reasoning and learning abilities through logical and probabilistic models and learning theory. Second, the computational foundation enables problem-solving and learning processes through algorithms, optimization, and computability theory. Third, Turing and McCarthy's perspectives provide a philosophical and logical basis for AI to pursue the goals of knowledge-based reasoning and mimicking human intelligence, beyond simple computation. Through this integrated understanding, modern AI can be defined as a system that embodies computational intelligence, while simultaneously leaving non-computational elements, such as uniquely human intuitive understanding (nous) and purposeful perception (telos), unrealized.

AI DEVELOPMENT FROM A MANAGEMENT PERSPECTIVE

From a management perspective, rarly studies exploring the organizational and managerial implications of AI focused on the impact of technology on organizational structure and work processes. Zuboff (1988) analyzed the social and organizational effects of information technology and smart machines on power structures, labor processes, and decision-making, and suggested strategic implications for technology use within organizations. Davenport and Short (1990) demonstrated the potential for organizational efficiency and strategic decision-making support through business process redesign using AI and information technology, forming the foundation of modern AI management research. These studies emphasized the need for an integrated understanding of AI within the context of organizational innovation and strategic management.

The development of artificial intelligence (AI) can be understood not simply as a history of technological advancement, but as a shift in the management paradigm that has transformed corporate decision-making methods, organizational structures, and competitive strategies. From a management perspective, AI has evolved from a tool for improving productivity to a strategic resource and a core element of competitive advantage for a corporate culture transformation.

Early AI and Management Rationalization (1950s-1970s)

Early research on AI focused primarily on logic-based reasoning and problem solving. From a management perspective, it was recognized as a potential tool for management rationalization and decision-making automation. During this period, AI stood as an extension of scientific management theory and rational decision-making theory, as it could structure complex management problems into rules and logic. However, technological limitations and high costs limited its practical application in business, and AI remained largely a theoretical possibility.

Automation in early industrial settings primarily focused on mechanization and standardization, while management focused on maximizing productivity through work research and process design. Artificial intelligence during this period remained in the theoretical research phase, and management primarily utilized rule-based automation and statistical quality control. Decision-making was made by human managers, and the system was characterized as a closed system that emphasized predictability and stability.

The focus was on connecting individual automated systems into a computer network. At this stage, the role of artificial intelligence was limited, and the systems were characterized as deterministic, integrated systems operating according to predefined rules and procedures. Managerial decision-making still relied on human managers, and advanced management in factories primarily aimed at streamlining information flow and reducing production lead times.

Emergence of Expert Systems and Management Support Tools (1980s)

The 1980s saw the emergence of expert systems, marking the full-scale adoption of AI in management. Expert systems supported decision-making by storing expert knowledge in specific fields in the form of rules, leading to the advancement of management information systems (MIS) and decision support systems (DSS). From a management perspective, AI during this period was perceived as a support tool, not a strategic tool, a technology that assisted managers in making decisions. However, the cost of knowledge acquisition and the difficulty of maintaining it limited its scalability.

Expert systems, which emerged in the 1980s, began to play a significant role in the field of management. AI was utilized as a tool to support management decision-making in areas such as production scheduling, equipment maintenance, quality assessment and other managerial areas. At this stage, AI's role was limited to assisting managers' judgment rather than replacing the process itself. From the perspective of the business and factories of the future, this can be considered the initial stage of knowledge transfer from humans to systems.

As technology evolved, expert systems began to be introduced into process planning, equipment diagnostics, and quality control. AI of this era enabled manufacturing experts' knowledge to be stored in rule form and utilized across the entire system, marking the transition to a knowledge-based management and manufacturing system. Design information was automatically linked to production plans, and diagnosis and response to process anomalies were partially automated. However, difficulties in acquiring and maintaining knowledge limited scalability and adaptability.

Transition to Data-Driven Decision-Making and Competitive Advantage Tools (1990s-2000s)

Since the 1990s, with the advancement of computing power and the acceleration of data accumulation, AI has gradually evolved into a management tool focused on data analysis and prediction. During this period, companies utilized customer, supply chain, and financial data to implement AI techniques for demand forecasting, inventory management, and marketing strategy development. In business terms, this signifies a shift from intuition-driven decision-making to evidence-based management, and AI is beginning to establish itself as a core element of analytical capabilities that create competitive advantage.

Advances in information technology enabled companies to accumulate massive amounts of management data, and AI evolved into a process analysis and optimization tool that leveraged this data. Data-driven decision-making proliferated in areas such as demand forecasting, inventory management, and supply chain planning, and general management shifted from experience and intuition to analysis-driven management. While factories during this period remained largely automated, the foundation for intelligence, which continuously improved operational performance, was laid.

As sensor technology and information systems advanced, mass-scale data collection from manufacturing sites led to a gradual shift to a data-centric architecture. Artificial intelligence (AI) was utilized for production scheduling, inventory management, and quality prediction through statistical learning and optimization techniques. At this stage, advanced management systems evolved beyond a simple integrated system into an analytics-driven management/manufacturing system that continuously improves managerial performance. AI enabled optimization and prediction that considered inter-process interactions, simultaneously enhancing the efficiency and stability of management/manufacturing systems.

Digital Transformation and AI as a Strategic Asset (2010s)

With the advancement of deep learning and big data technologies in the 2010s, AI emerged as a core element of corporate strategy. AI during this period went beyond mere analytical tools to enable business model innovation and a reconfiguration of value creation methods. Platform companies leveraged AI to personalize customer experiences, maximize operational efficiency, and create new revenue streams. From a business perspective, AI is no longer viewed as a supplementary tool, but as a core competency and a source of sustainable competitive advantage.

Since the 2010s, the concept of smart factory has gained momentum with the convergence of AI, IoT, big data, and robotics. The core of management has shifted from simply maximizing efficiency to real-time decision-making and process autonomy. AI plays a key role in automated production planning, predictive maintenance, and quality anomaly detection, gradually evolving factories into cyber-physical systems (CPS) capable of self-perceiving and responding to their conditions.

The convergence of AI, IoT, and cyber-physical systems (CPS) has evolved advanced management/manufacturing systems into an intelligently integrated management/manufacturing system. From design (CAD) to production (CAM), quality control, logistics, maintenance, the entire management/manufacturing processes is now interconnected through real-time data and AI algorithms. The system has gained the autonomy to recognize its own status and adjust its processes. At this stage, CIMS has become a core implementation of the smart factory.

Organizational, Ethical, and Governance Issues and Shifting Management Paradigms (2020s and beyond)

The recent proliferation of AI is bringing about structural changes across the business environment. Algorithm-based decision-making tends to shift organizational power structures and concentrate market power in the hands of companies possessing data and technology. Consequently, in management, not only the efficiency of AI, but also its ethics, accountability, and governance have emerged as important research topics. AI is no longer simply a technology management tool but is increasingly understood as a management system that requires integrated consideration of strategy, organization, and ethics.

The factory of the future is defined as an autonomous and adaptive operating system centered on AI. The role of management is shifting from direct process control to designing and supervising algorithmic and data-driven decision-making. AI enables integrated management processes that consider not only productivity and quality, but also energy efficiency, carbon emissions management, and supply chain resilience. At the same time, new management issues, such as algorithmic dependence, accountability, and human-machine collaboration, are emerging.

The factory of the future is evolving beyond simple manufacturing integration into an expanded, integrated system encompassing supply chain, energy management, and environmental, social, and governance (ESG) factors. Artificial intelligence (AI) serves as a key intermediary linking enterprise-wide decision-making and field operations, forming a hybrid decision-making structure where human managers and AI collaborate. Thus, advanced management/manufacturing systems are being redefined beyond a technical system into a platform that integrates management strategy and business operations.

From a management perspective, the development of AI can be summarized as a process that began as a management efficiency tool, progressed through decision-making innovation, and evolved into a strategic asset and a key element in shifting management paradigms. AI is fundamentally changing the way companies compete while also posing new management challenges. Therefore, understanding the development of AI should not be viewed as a matter of technological adoption, but rather as a key task that determines the future direction of management and the sustainability of companies.

From the perspective of management and future factories, the development of AI can be understood as an evolutionary process that progresses from automation to intelligence to autonomy. AI has enabled the core goals of management to be achieved with greater precision and real-time, and the factory of the future can be seen as an integrated form of this AI-based management system. Therefore, AI should be recognized not as a simple management technology, but as a strategic core element redefining the management paradigm.

Table 2. AI literature reviews mapping

Domain	Authors
Core AI & Machine Learning	Jordan & Mitchell (2015); LeCun, Bengio & Hinton (2015); Schmidhuber (2015); Goodfellow et al. (2016); Zhang et al. (2018); Colelough & Regli (2025).
Management, Strategy & Organizations	Davenport & Ronanki (2018); Faraj et al. (2018); Haenlein & Kaplan (2019); Shrestha et al. (2019); Mikalef et al. (2021); Raisch & Krakowski (2021); Smith et al. (2025).
Business Performance & Info. Systems	Chen et al. (2012); Wamba-Taguimdje et al. (2020); Dwivedi et al. (2021); Tarafder et al. (2025).
Operations Management & Manufacturing	Lee et al. (2015); Zhong et al. (2017); Tao et al. (2018); Ivanov et al. (2019); Chen & Zhang (2020); Zahoor et al. (2024).
Supply Chain & Logistics	Min (2010); Choi et al. (2018); Dubey et al. (2020); Vann Yaroson et al. (2025).
Ethics, Governance & Responsible AI	Mittelstadt et al. (2016); Etzioni & Etzioni (2017); Floridi et al. (2018); Rahwan (2018); Cath et al. (2018); Jobin et al. (2019); Mirishli (2025).
AI & Society / Policy	Bostrom (2014); Brynjolfsson & McAfee (2014); Acemoglu & Restrepo (2020); Sun et al. (2025).

The advancement of AI can be understood as a process of deepening the integration of management/manufacturing systems from automation to knowledge, intelligence, and finally autonomy. AI has driven the management of the future beyond information integration to evolve into a management/manufacturing system capable of self-determination and adaptation. Therefore, modern management systems is an integrated management platform centered on AI, and holds strategic importance as a core foundation for future management.

Prior AI literature reviews span multiple domains, including core algorithmic foundations (Jordan & Mitchell, 2015; LeCun et al., 2015), management and organizational theory (Raisch & Krakowski, 2021; Shrestha et al., 2019), business value creation (Wamba-Taguimdje et al., 2020), operations and supply chains (Chen & Zhang, 2020; Ivanov et al., 2019), and ethics and governance (Floridi et al., 2018; Jobin et al., 2019).

DISCUSSION

Aristotle's philosophy explains human cognition and thought through the complementary structures of nous and logos. Nous is the intellectual faculty that intuitively grasps the essence and primal principles of things, while logos is the rational function that develops these principles through language and argumentation. This distinction provides a crucial conceptual framework for philosophically analyzing the operation and limitations of modern artificial intelligence.

Modern artificial intelligence, particularly machine learning and deep learning-based systems, operates through statistical pattern recognition and symbolic and numerical computation of large-scale data. This method corresponds largely to the function of logos in the Aristotelian sense, namely, the application of formalized rules and inference. AI can produce results based on given inputs, rules, or learned weights, and this process can be understood as "mechanical reasoning" in a certain sense.

However, from an Aristotelian perspective, this logos-centric operation suffers from a fundamental limitation due to its lack of nous. Nous is not simply the ability to process information; it is the ability to independently recognize what essential principles are and which concepts are valid starting points. Conversely, modern AI cannot independently establish learning goals, conceptual categories, or standards for meaning, relying on data and objective functions provided by humans. In this sense, AI learning is closer to empirical generalization within a pre-established framework than to the recognition of principles through Nous. For Aristotle, true knowledge (epistēmē) is established based on the universal principles identified by Nous, but AI outputs remain limited to reproducing probabilistic correlations without the recognition of such universals.

Furthermore, Aristotle did not separate knowledge from practice, but rather believed that appropriate judgments are made in situations through intellectual virtue (phronēsis). Conversely, modern AI derives results based on pre-defined criteria without contextual understanding or reflection on purpose. This reveals a philosophical limitation: while AI is adept at applying and optimizing rules, it lacks the ability to reflect on the legitimacy of the rules or their purpose. Aristotle's nous-logos distinction provides a valid philosophical framework for explaining why modern AI, despite its high computational power and performance, exhibits limitations in understanding, meaning, and purpose recognition. While modern AI can be viewed as an extended implementation of logos, it is difficult to see it as replacing or replicating the functions of nous. This perspective leads to understanding AI as a limited implementation of specific cognitive functions, rather than a complete imitation of human intelligence.

Second author’s recent studies have expanded upon concepts and methods of Leibniz, but also of Kepler, Newton, Pascal, Lagrange, Euler, Gauss, Riemann, Cantor, Hamilton, Poincaré, Hilbert, Einstein, Planck, Pauli, Gödel, von Neumann, Turing, Kolmogorov, Nash, Shapley, as well as Bach, Jung and many others, and made problems solvable in a generalized (conceptual, computational and operational) sense, by means of generalized science, in particular generalized mathematics, statistics, physics, chemistry and biology, including generalized linguistics, logic and stochastics, optimization, optimal control and game theory, computer science, machine learning and artificial intelligence, economic management and operational research, literature, music, arts and last but not least theology. To this end, studies may need to have embedded existing sciences and applied sciences, indeed, life itself, in the generalized space-time, with generalized lives and Eternal Life, 5 states of matter - the 5th being Spirit or Potentiality - 12 senses - including Leibniz's "apperception" - as well as generalized senses, generalized replacement and substitution effects, generalized regime-switching and paradigm-shifting, generalized spectra, tensors, prisms and crystals, and generalized space-time design, research, shift and travel.

The more deeply AI is embedded into a company's decision-making structure, organizational culture, and learning mechanisms, the more it becomes a source of competitive advantage. This advantage cannot be replicated through the introduction of external technology alone. Therefore, the core of AI strategy lies not in technology acquisition, but in organizational integration and continuous learning. AI is positioned as a strategic asset that goes beyond short-term performance improvements to create long-term competitive advantage. This study explains why AI provides a competitive advantage only to certain companies and how AI continuously recreates that advantage. In other words, AI functions simultaneously as both a resource and a capability. The more deeply AI is embedded into a managerial decision-making structure, organizational culture, and learning mechanisms, the more it becomes a source of competitive advantage. This advantage cannot be replicated through the introduction of external technology alone.

A company's competitive advantage stems from the differentiation of its internal resources and capabilities, rather than from external factors. From this perspective, AI is not simply a general-purpose technology; it becomes a strategic resource when combined with a company's unique data, algorithms, human capabilities, and organizational learning. While AI itself can be imitated, the data accumulated over time, the experience of using it within an organization, and the algorithmic operational capabilities embedded in business processes are difficult to replicate. Therefore, AI creates competitive advantage not as an independent technological element, but as a complex resource combined with a company's intangible assets. AI enables rapid detection of market changes, customer demands, and technological trends through large-scale data analysis. Second, it identifies strategic opportunities through predictive models and simulations, improving the speed and accuracy of decision-making. Third, it enables flexible response to environmental changes by reconfiguring existing resources and processes through process automation and organizational learning. In this sense, AI is not a technology that replaces dynamic capabilities, but rather a meta-capability that constructs and amplifies them.

Therefore, the core of AI strategy lies not in technology acquisition, but in organizational integration and continuous learning. AI is understood not as a simple IT tool, but as a strategic core element that creates a company's sustainable competitive advantage. When combined with a company's unique resources, AI acquires an organization’s unique characteristics, strengthening dynamic capabilities and enabling the restructuring of competitive advantage in a changing environment. Therefore, the strategic value of AI is determined not by its technical performance, but by how it is internalized and utilized within a company's resource structure and competency system.

CONCLUDING REMARKS

While AI research generates tremendous expectations for its advancements and potential, it also has several significant inherent limitations from philosophical and business perspectives. These limitations present critical challenges that must be addressed for AI technology to truly integrate into human society.

With limitations from a philosophical perspective, although AI attempts to mimic human thinking, it still has limitations in accurately replicating human experiences, emotions, intuition, and ethical judgment. For example, while AI can identify patterns and make predictions based on data, it struggles to make emotionally motivated or intuitive decisions. This discrepancy can be particularly problematic in situations requiring ethical judgment or social responsibility.

AI is fundamentally different from humans in that it is merely an algorithm that processes data and lacks consciousness. AI does not possess self-awareness or a sense of self; it simply operates as programmed. This prevents AI from pursuing human values or goals, and philosophical debates exist regarding the impact and responsibility of such systems on society. The absence of AI consciousness poses a significant challenge in defining the relationship between humans and AI, including moral judgment and social responsibility.

Since AI itself lacks moral sensitivity, there is a lack of clear standards for how AI systems should make ethical decisions. There is ongoing ethical debate over what standards should be applied when AI makes certain decisions, such as when a self-driving car selectively protects humans to avoid an accident. The question of how AI decisions can align with the values of human society is a crucial topic in philosophical thought.

With limitations from a management perspective, as AI technology becomes increasingly commercialized, efficiently converting it into a business model becomes a crucial issue. Even with advances in AI research, translating this knowledge into practical business solutions is challenging. While the technology itself may be innovative, there is often a lack of clear strategies for how to transform it into competitive products or services in the market and how to build a sustainable revenue model.

In job replacement and economic impact of AI concern, the advancement of AI raises management concerns in terms of automation and job replacement. For example, AI has the potential to replace human labor in manufacturing, customer service, and even high-skilled knowledge work. The resulting unemployment and resulting social instability are critical issues that must be addressed not only at the corporate level but also at the government level. While companies can increase productivity through the adoption of AI, they must also consider how to shoulder the resulting social responsibility.

In transparency and trustworthiness of AI concern, the black box problem of AI systems is also a critical issue from a management perspective. Many AI algorithms, especially deep learning models, often have opaque decision-making processes, making it difficult to understand why certain decisions were made. This can lead to reliability issues, and transparency and trust are crucial in business environments. Companies need strategies for designing systems that ensure customers and users can trust AI decisions, and for resolving any uncertainty that may arise during the process. In data security and privacy protection concern, AI maximizes performance by leveraging massive amounts of data, but this process can lead to privacy and data security issues.

Companies must comply with legal regulations when processing and analyzing customer data, while also establishing systems that ensure data security. From a business perspective, strategies for safely handling AI system data and managing privacy-related risks are crucial. To overcome the philosophical and business limitations of AI, the following issues must be addressed: establishing ethical standards, improving transparency in AI, fulfilling social responsibility, and responding legal and institutional compliances.

An ethical framework is needed to ensure that decisions made by AI systems align with human values and ethical standards. To this end, experts from various fields must collaborate to establish ethical judgment standards for AI and find ways to implement them technically. The development of explainable AI (XAI) is necessary to make the decision-making process of AI models transparent. This will play a crucial role in enabling companies and users to understand and trust AI's decision-making processes, and in addressing legal liability issues.

Social responsibility, considering the impact of AI on society, is crucial. Companies and research institutes must not only develop the technology but also comply with regulations and guidelines that ensure its safe and effective use in society. In particular, they must develop countermeasures for social issues such as job displacement and explore ways to minimize the negative impacts that AI may cause. Relevant laws and regulations must be promptly updated to address the legal and institutional challenges posed by the advancement of AI. In particular, it is crucial to establish a legal framework that considers the impact of AI technology on various areas, including personal information protection, the labor market, and fair trade.

While AI holds limitless technological potential, overcoming limitations and challenges from philosophical and business perspectives remains a critical challenge. To address these challenges and ensure the safe and fair integration of AI research into society, a comprehensive approach that considers ethical, social, and legal responsibilities alongside technological advancements is necessary. This will ensure that AI truly benefits humanity.

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