How can artificial intelligence assist factory operations and its impact

Wenhua Chen
School of Management, Universiti Sains Malaysia, Malaysia
School of Management, Guangzhou College of Technology and Business,China
Email: chenwenhua@student.usm.my
chenwenhua1388@hotmail.com

Noorliza Karia*
School of Management, Universiti Sains Malaysia, Malaysia
Email: lizakaria@hotmail.co.uk

* Corresponding Author

Abstract
Purpose: Given the widespread use of artificial intelligence（Abbreviation: AI）in a variety of industries and the significant impact it is having, the chief aim of this paper is to examine exactly how AI assists factory operations as well as to explore the impact of AI on factory operations, with a focus on the negative impacts.
Design/methodology/approach: Based on the literature review, the method used in this paper is known as bibliometric method. This is done by setting keywords, finding and screening thesis literature that meets the requirements in the world-renowned WOS(Web of Science) database, adopting bibliometric methods, analysing the relevant literature using tools such as the VOSviewer1.6.19 software, and finally carrying out a comprehensive review to achieve the purpose of the study.
Findings: Based on the analysis, this paper shows the basic situation of artificial intelligence, which has been applied to all aspects of factory operations and has had a great impact on factory operations, the positive impact is obvious, but the negative impact should not be ignored.
Research limitations/implications: Artificial Intelligence as an emerging product, the existing research data on AI applications is not rich enough to have the biggest support on the existing research. In addition, this paper is limited to examining general issues, which can be empirically investigated in the future.
Practical implications: The research in this paper is centered on the application of AI in factories, which is a good guide for factory operations.
Originality/value: Few scholars have specialized in how AI can help factory operations, and systematic exploration of the negative impacts of AI on factory operations is rare.

Keywords: Artificial Intelligence (AI), Factory operation, Negative impact, Process Automation, Machine learning

Introduction
Factories are an important part of the supply chain, and the performance of factory operations is directly related to the competitive advantage of the supply chain. In recent years, with the development of modern information technology, especially the occurrence of COVID-19, the environment, working methods, working styles, and working hours of business operations have changed dramatically (Tayal, 2023). AI has been deployed in a range of fields, not only as an

effective approach in areas such as machine learning, deep learning, artificial neural networks, but also has been very widely used in a wide range of industries (Cherry Bhargava, 2022), such as agriculture, industrial manufacturing, finance and insurance, services, aerospace, healthcare, food industry, and many others. The emergence, development, widespread use of AI has had a significant impact on people, businesses, society, and many scholars have recognized that AI has multiple impacts (Mariani, 2023). For example, reinforcement learning, a type of machine learning, can solve a variety of production scheduling problems, and it is often applied in combination with metaheuristics (J. Wang, 2023). The adoption of AI has revolutionized many manufacturing and monitoring processes across industries and is still growing (Cherry Bhargava, 2022). Of course, this has also had a huge impact on factory operations. Therefore, it is worth exploring and investigating how AI can assist factory operations and its impacts from a factory operations perspective to better achieve factory operations goals.

Methods

Defining keywords
In recent years, with the rapid development of modern information technology, artificial intelligence applications have become more and more common. Most of the scholars' research around the world focuses mainly on the AI technology itself, trying to play a more important role in industries such as education and healthcare. This thesis plans to use factories as the object of research to explore how AI applications can assist factory operations and the impact it has. Therefore, four keywords, namely AI, factory, employee, and employee satisfaction, were specifically chosen for data collection considering the reliability and scientific validity of the research conducted. Three combinations were conducted: (1) AI and employees; (2) AI and factories; and (3) AI and employee satisfaction.

Data collection and refinement
For an exclusive collection of papers in this field, we rely on the Web of Science database, the world's most trusted and publisher-independent global citation database. Its comprehensive platform features more than 1.7 billion citations and 159 million records, allowing research ideas to be tracked across disciplines and over time. At the same time, more than 9,000 leading academic, business, and government institutions and millions of researchers rely on Web of Science to produce high-quality research, gain insights, and make more informed decisions to guide the future strategies of their organisations and research.
Initial data collection phase:
In order to collect data randomly and ensure the randomness and scientificity of the number taken, this paper sets three different points in time and collects the number of papers from three different time periods based on the combination of the three keywords defined earlier on the scope of the related fields of management, business, engineering industry, economics, and computing (because AI applications are an emerging kind of technology and 2023 is defined as the first year of AI, so most of the data was targeted to the year 2023), as follows:

Table 1 Literature collection table

Keywords	Date of publication	Date of search	Type	Count
"artificial intelligence" and "employee satisfactory"	2019-2023	10-14-2023	Documents	11
"artificial intelligence" and "factory"	2022-2023	10-26-2023	Documents	32
"artificial intelligence"and"employee"	2023	12-26-2023	Documents	115

Refinement of data phase:

To further ensure the validity of the data, the initial collection of 158 articles was manually screened. There are two main screening criteria, one is to be closely related to the research topic of this paper, and the other is that the articles must be distributed in the Q1-4 interval of SCI. Finally, it was determined after repeated checks that 90 articles among them met the requirements. Therefore, the study will be carried out next with these 90 articles as the data base.

Data analysis

The paper is divided into five subsections discussing year of publication, country, author, citation impact and keywords.

Publication years

The research topic of this paper is becoming more popular day by day from 2019-2023, especially in 2023, there is a sudden explosion. The trend of this research topic is increasing with the advancement and general application of artificial intelligence technology.

Table 2 Publication of relevant literature 2019-2023

Publication Years	Record Count	% of 90
2023	57	63.33
2022	14	15.56
2021	13	14.44
2020	3	3.33
2019	3	3.33

Countries

The theme of this research is a cutting-edge topic of interest to scholars around the world, and the results of the core article output show that research is mainly concentrated in China, the United Kingdom and the United States of America, where China has 27 articles, accounting for 30 per cent of the total, and the first place on the list; in second and third place are the United Kingdom and the United States of America, with about 36 per cent of the number of

published articles, respectively. Other countries, such as India, France, Australia, Germany, Morocco, Italy, and South Korea, followed, but the number of published articles was small.

Table 3 Relevant literature studies on the distribution of countries around the world

Countries/Regions	Record Count	% of 90
PEOPLES R CHINA	27	30.00
ENGLAND	17	18.89
USA	16	17.78
INDIA	10	11.11
FRANCE	9	10.00
AUSTRALIA	8	8.89
GERMANY	7	7.78
MOROCCO	5	5.56
ITALY	4	4.44
SOUTH KOREA	4	4.44

Showing 10 out of 49 entries.

Authors
The authors of the relevant literature have continued to under-invest in this study, with relatively dispersed researchers and only four articles by the first author of the published article. It is expected that more and more scholars will be involved in this study as the research trend intensifies.

Table 4 Status of Research Authors

Authors	Record Count	% of 90
Prentice C	4	4.44
Abadie A	3	3.33
Chowdhury S	3	3.33
Dey PK	2	2.22
Kong HY	2	2.22
Lopes SD	2	2.22
Wang J	2	2.22
Wang XQ	2	2.22
Yin ZH	2	2.22
Yuan Y	2	2.22

Showing 10 out of 329 entries.

Citation Topics Micro
The influence factor of job satisfaction and the record count are both in the first place, which fully reflects the importance of job satisfaction in factory operation.Customer Satisfaction, Knowledge Management, Sharing Economy and other related topics are also the same.

Table 5 Status of Citation Topics Micro

Citation Topics Micro	Record Count	% of 90
6.3Job Satisfaction	14	15.56
4.1Human-robot Interaction	12	13.33
4.2Industry 4.0	8	8.89
4.8Supply Chain	6	6.67
6.3Customer Satisfaction	5	5.56
6.2Privacy	4	4.44
6.3Knowledge Management	3	3.33
4.1Internet Of Things	2	2.22
4.8Scheduling	2	2.22
6.3Sharing Economy	2	2.22

Showing 10 out of 33 entries.

Keywords

In this paper, the keywords were analysed using VOSviewer software, and the sample keywords show that the research mainly focuses on the two aspects of AI technology and the impact of AI applications, and the research aspect of the impact of AI applications is becoming more and more popular, especially employee satisfaction, job satisfaction, performance, and employee motivation have attracted more scholars to study. Meanwhile, these indicators are closely related to each other. (See Figure 1.)
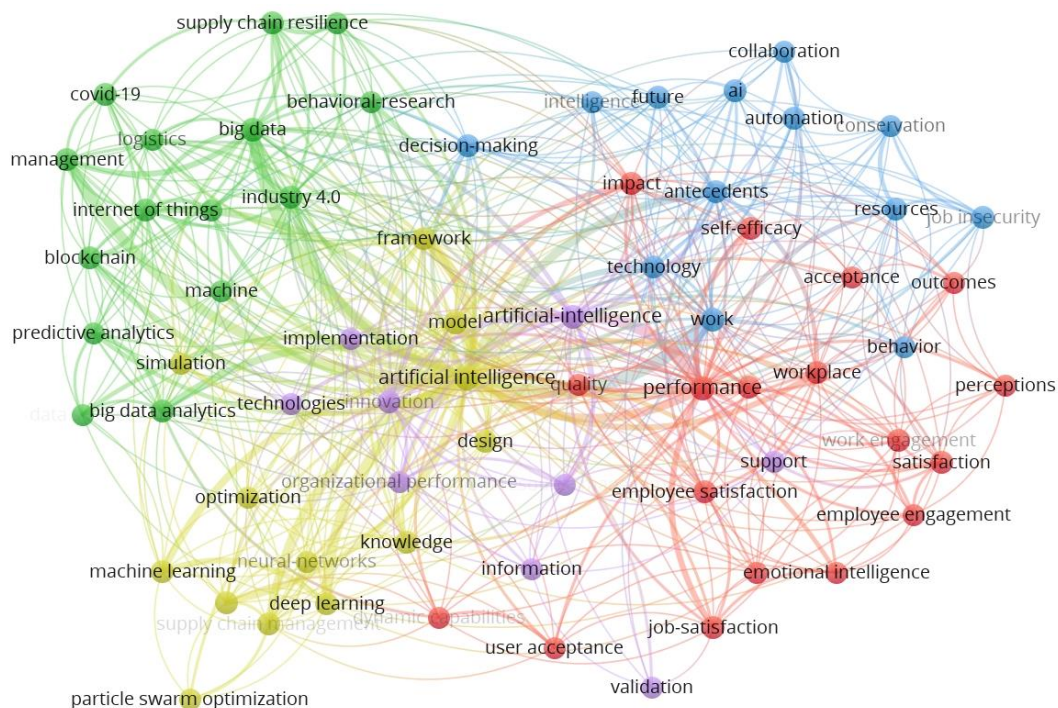
Figure 1. Related Keywords Distribution Chart

Findings

AI (Artificial Intelligence)

AI is a technology that mimics human intelligence and thought processes (Lin & Chang, 2023). AI is a method of instilling human-like thinking into electronic products of any size (Cherry Bhargava, 2022). AI has gained rapid growth globally, it belongs to a branch of computer science, an interdisciplinary science with multiple approaches to building and improving intelligent technologies, the adoption of technologies such as AI is considered the fourth industrial revolution. AI is the discipline that gives computer systems the ability to perform tasks, it is a specific application of advanced hardware and software technologies such as computers in various workplaces, and it can help various departments to perform tasks that require human intelligence, however, the development and application of AI still depend on human intelligence (Cherry Bhargava, 2022). Two solid foundations are required for the construction of AI models are the availability of important hardware resources and the accessibility of big data, respectively, while machine learning plays a very crucial role, machine learning is an important means of realizing AI that enables computers to learn and improve automatically from experience (Mariani, 2023). The main key methods for the application of AI in various fields contain mathematical planning methods (stochastic planning, fuzzy planning, robust optimization, and hybrid methods of various forms of mathematical planning), network-based models (Petri nets and Bayesian networks), subject-based modeling and multi-subject systems, automated reasoning, machine learning, and BDA (Big Data Analysis) (Baryannis ,2019).

How can AI assist in factory operations?

In the process of factory operation, reducing factory operation cost, improving factory operation efficiency, strengthening product or service quality, enhancing employee satisfaction, ensuring team stability, etc. are the operation goals that every factory should focus on. The realization of the overall operation goals of the factory depends on the scientific operation of each management department and business department of the factory. Enterprises have identified the potential of AI to operate in various departments in conjunction with their own goals and needs (Modgil, 2021), and many organizations are changing their strategies and policies to incorporate AI into their operations as a result (Singh & Tarkar, 2022). AI can be categorized into three types: process automation, cognitive insight, and cognitive engagement (Davenport & Ronanki, 2018), thus, in conjunction with the just-mentioned objectives of factory operations, this paper focuses on how AI can assist factory operations from the perspective of process automation in factory operations.

With the increasing maturity of AI technology, as well as the availability of various important hardware resources and the accessibility of big data, AI is penetrating every process of factory operations. There are differences in the AI technologies applied in different parts of factory operations. For example, the main AI techniques used in the marketing segment are Artificial neural networks, Genetic algorithms, L/modelling, Agent-based/multi-agent systems, Swarm intelligence, Simulated annealing, Association rule, Tree-based models, Support vector machines, General forms of AI, K-means clustering and Hill climbing. The main AI techniques that will be used in logistics are Artificial neural networks, Agent-based/multi-agent systems, Data mining, Simulated annealing, Automated planning, Robot programming, General forms of AI, Heuristics, etc. In the production chain, Artificial neural networks, FL/modeling, Case-based reasoning, Genetic algorithm, Agent-based/multi-agent systems, Data mining, Decision trees, General forms of AI, Gaussian, Rule-based reasoning, Automated planning, Swarm intelligence, Expert systems, etc. are frequently used. Decision trees, General forms of AI, Gaussian, Rule-based reasoning, Automated planning, Swarm intelligence, Expert systems,

and other AI techniques are often used. In supply chain (including procurement), Artificial neural networks, FL/modeling, Agent-based/multi-agent systems, General forms of AI, Physarum model, and Bayesian networks. Swarm intelligence, Data mining, Support vector machines, Stochastic simulation, and other AI techniques are always used. Among them, the most frequently used and top-ranked AI techniques are Artificial neural networks, Fuzzy logic and models, Multi-agent and agent-based systems, Genetic algorithms, General forms of AI, Data mining, Case-based reasoning, and so on. (Toorajipour, 2021)

Considering from the aspect of factory operations practice, the main content of factory operations includes operations at the business level such as marketing, logistics, production, and supply chain (including purchasing), and operations at the functional level such as human resources, finance, administration, etc. (See Figure 2).
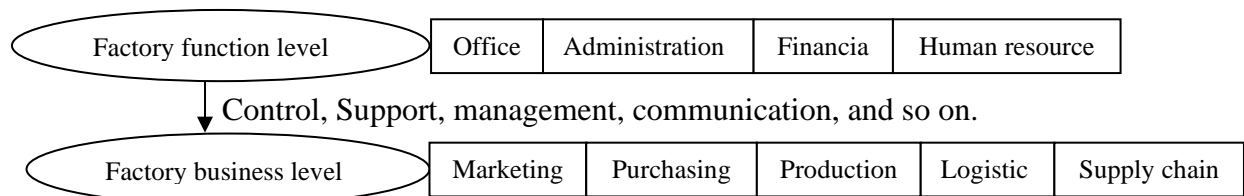
Factory function level	Office	Administration	Financia	Human resource

Control, Support, management, communication, and so on.

Factory business level	Marketing	Purchasing	Production	Logistic	Supply chain

Figure 2. Main contents of factory operation

In the flow of each major element of operation in Figure 1, we can find the shadow of AI application, which is mainly manifested in the application of one or several AI technologies combined with software and hardware. At the level of factory function operations, due to the rapid development and application of AI technologies such as artificial neural networks, genetic algorithms, voice recognition, image recognition, machine learning, deep learning, etc., the artificial function assists each function to change the traditional operation flow. At the same time, the emergence of home office and telecommuting during the COVID-19, has further spawned the application of AI at the level of factory management such as intelligent office systems, intelligent document management systems, intelligent conference systems, intelligent monitoring systems, intelligent financial reimbursement system, intelligent capital budget management system, intelligent personnel evaluation system, intelligent performance evaluation system, and so on. The intelligent and automated features of these applications are very obvious. Take the intelligent meeting system as an example, giving full play to the role of AI technology, the entire "pre-meeting - meeting - post-meeting" meeting process can be seen. The meeting process can be seen, an intelligent meeting system can automatically, intelligent comprehensive management of the meeting, the meeting plan is automatically generated, online meeting time and meeting platform are automatically booked, the whole process of the meeting is automatically recorded video, AI translation in real-time to provide, after the meeting is automatically generated meeting records and the establishment of electronic archives, which have a very good effect on the cost, efficiency, and quality of the factory meeting. Take the intelligent performance evaluation system in the field of human resource management as another example, the AI system can intelligently optimize the performance standard, real-time dynamic monitor of employee behavior, automatically collect actual business data from employees, the system intelligently make decisions and judgments according to predetermined algorithms, the management is always ready to carry out highly efficient performance evaluation of the factory employees, and the employees themselves can always pay attention to their performance, which can help the employees to carry out self-

correction and self-improvement at any time, which can greatly improves the operation and management level of the factory.

At the level of factory business operations, AI applications are even more prevalent. In the customer service aspect of marketing, AI machines based on customer service such as smart call systems, smart answering bots, smart chatbots, etc. have been emerging and have gradually replaced human labor through data training and deep learning, and these applications can provide round-the-clock customer service because they are based on computers and the Internet (Mariani, 2023). In purchasing, AI applications are mainly used in purchasing demand forecasting, which has a direct impact on decision-making, and several scholars have found that machine learning outperforms statistical methods in demand forecasting (Rozanec, 2021), with the ARIMAX technique being able to better predict peaks in demand, and neural networks being able to generate a more "smooth" and more accurate forecast, and a hybrid approach is also desirable, where a mix of machine learning techniques can create more effective forecasting techniques (Feizabadi, 2022). In production, robotic process automation is widely used, which refers to the use of AI techniques such as grasping, information aggregation, information cleansing, and communication between different applications and individuals to perform and automate tedious tasks. The main types of robots are Task Bots that perform basic tasks, Meta Bots that automate tasks based on desktop applications, and IQ Bots that have cognitive abilities and can make decisions based on data analysis (Cherry Bhargava, 2022). Through the comprehensive use of machine learning, deep learning, voice recognition, image recognition and other AI technologies, robotic process automation reduces repetitive labor and dependence on workers, simplifies cumbersome processes, and also assists in production planning, job scheduling, product quality, and product delivery. AI has a wide range of applications in the logistics field, such as inventory optimization (Elbouzidi, 2023), effective inventory management is an important part of logistics management, inventory size, variety, dynamics, and other characteristics of the obvious, relying on the traditional methods to make the optimal inventory decision-making and optimization has always been a challenge, but through genetic algorithms, machine learning, big data, and other AI technology, but can assist in efficient inventory decision-making and optimization. In addition, AI plays a greater role in transport scheme design, transport network planning, and distribution route design. In the supply chain segment, the emergence of AI has led to an unprecedented level of supply chain management, such as the emergence of an intelligent supply chain management system, which makes supply chain demand forecasting, integrated planning, resource optimization, etc. more scientific, especially in terms of supply chain resilience, AI can proactively adapt to the changes (Marinagi, 2023), and can improve the supply chain management level by more quickly Extracting customer expectations, sensing the market, using failure modes, optimizing internal and external supply chains and allowing employees to be creative through automated business processes to develop the right products, increasing supply chain resilience against extreme disruptions such as the New Crown epidemic (Modgil, 2021), maintaining supply chain stability and continuity.

Currently, with the development of AI and all kinds of modern information technology, traditional factories are gradually digital factory transformation and upgrading. The operation of digital factories is the comprehensive application of AI in factories. For example, in digital factories, AI plays a significant role by enabling real-time tracking and recording of transactions, funds, and assets within a company's core business processes. This automated system not only completes the entire business workflow but also provides early warnings for risk management, ensuring timely and effective financing services for customers (D. Wang & Yu, 2023).

The Impact of AI on Factory Operations

Artificial Intelligence (AI), especially Machine Learning (ML), is being used more frequently in plant operations (Fahle, 2020). The emergence of AI can be said to be both the best and the most unfavorable thing (Cherry Bhargava, 2022). Taking the impact of AI on factory operations as an example, we can easily find the best side of AI, which is mainly as follows: it can reduce factory operation costs, improve factory operation efficiency, ensure factory production quality, enhance factory supply chain resilience, ensure factory customer satisfaction, and efficiently realize factory operation goals and so on. The good side of AI will not be discussed too much here, because both in the academic and business world, it is easy to find and directly feel the benefits of AI, which also covers up a lot of disadvantages brought by AI. (Plathottam, 2023) highlighted AI's potential to enhance manufacturing efficiency, productivity, and sustainability. However, employing AI in manufacturing encounters various challenges, including data collection, management, human resources, infrastructure limitations, security risks, trust issues, and implementation hurdles. Additionally, (Cannas, 2023) underscored barriers to AI implementation, notably focusing on ensuring data quality, lack of specialized skills, high investment needs, unclear economic benefits, and limited experience in AI project cost analysis.

It's crucial to address these barriers to AI application, overcoming obstacles to promote widespread AI adoption in manufacturing. Simultaneously, it's essential not to overlook AI's negative impacts on factory operations. By pinpointing these negative effects, tailored measures can be taken during factory operations to mitigate them, ensuring the fulfillment of operational objectives.

The negative impacts of the application of AI in factory operations are mainly from the impacts on factory employees, mainly as follows:

AI has replaced many jobs and factory employees are afraid of losing their jobs and worried about their career prospects.

In industrial companies, 40% of employees are dissatisfied with their current jobs due to the fear of their jobs being replaced by smart machines such as AI (Singh & Tarkar, 2022). With the development of AI, the fear of losing their job has further increased and of course, job satisfaction has been deeply affected (Singh & Tarkar, 2022). AI and smart forms of technology may replace them or their current jobs and/or affect their career prospects in the future (Bankins, 2023). Employees who fear the use of AI are often concerned about the technology replacing their jobs, the potential damage to their skills and careers, and the disruption to their workflow (Wood, 2019). Low-skilled workers tend to have a greater negative impact than high-skilled workers because it is more difficult for low-skilled workers to regain their jobs. (Singh & Tarkar, 2022)

The application of AI in factory operations continues to place higher demands on employees to learn AI technologies.

Every new AI technology or machine application in factory operations is closely related to every factory employee and requires factory employees to make efforts to learn to use and operate it, and their existing skills may become obsolete as a result of these technologies (Bankins, 2023), so they need to be constantly learned and re-mastered. Factory employees are generally characterized by low educational attainment and low literacy levels, thus frequent training in new technologies and skills can put employees under a great deal of psychological stress, which in turn can lead to a decline in employee satisfaction. The effort put in by employees in learning AI technologies will subsequently affect their job satisfaction and engagement, leading to an increase in the tendency to leave and depression. (Singh & Tarkar, 2022)

Employee control systems have become more tightly controlled due to the use of AI, and employee privacy may be compromised.

Employee control is the main focus of any factory operation. The advent of AI has taken the entire employee control system to new heights. For better or worse, any AI (AI)-based management solution relies on Theory X. (Prasad, 2023), so AI-based systems have many new measures in employee management and control. To help organizations control employee performance, the control system directly monitors the behavioral activities of employees and controls the results of measuring employee activities (Singh & Tarkar, 2022). Employee control systems based on AI have the most automated features, the automated system will observe and record the behavior of the employees, it will track every move of the employees and the exposure of the employee's privacy will be an issue (Cherry Bhargava, 2022).

AI has led to changes in the way management decisions are made, and fairness has a significant impact on employees.

The application of AI in factory operations has led to a major change in the way management decisions are made in factory operations. Under an AI operations management system, if employees find that the management decision-making process is inconsistent or biased, and at the same time no channels are opened for feedback or complaints, then employees will find it difficult to believe in the fairness of the process. Of course, being fair in the workplace can also have a significant impact on employees. Firstly, there is informational fairness, which is the extent to which processes are openly and honestly described based on the AI system; and secondly, there is interpersonal fairness, which is the extent to which the AI treats and explains the process to the employee with respect. (Prasad, 2023).

Employee performance and expected results due to the application of AI will have an impact on the employees.

In AI-based factory operations, employees have a positive attitude towards AI applications when their performance and expected results are favorable. On the contrary, when employees feel the stress and anxiety caused by the use of AI, and perceive the threat posed by AI, employees' attitudes become negative, and may also cause negativity at work, reduced engagement at work, or even boycott of AI, and in severe cases, employee turnover may occur. (Bankins, 2023)

In terms of research methodology, this paper has reviewed a large number of literature related to AI and factory operations in the early stage, and in the later stage of carrying out bibliometric method, it mainly adopts the viewpoints of the literature from the top journals in recent years, and then combines with the theme of this paper to carry out a qualitative analysis.

Based on the literature review, the results of this paper show that AI has been widely used in factories and is assisting factory operations to an unprecedented degree, completely disrupting traditional manufacturing and operational processes in factories. At the same time, this study also found that AI has two sides, the good side and the bad side in factory operations, but the negative impacts of AI are often overlooked by academics and practitioners, and this paper summarized the negative impacts.

Discussion and Conclusion

AI, one of the most important technologies in the history of mankind, is changing the world. This paper finds through research that factories, which are an important part of the supply chain, are also deeply changed by AI, and it can be seen from a large number of literature reviews that AI is being widely applied to achieve the objectives of factory operations, both at the functional and operational levels of factories, such as the office, administration, human resources, finance, marketing, purchasing, production, logistics, supply chain, and so on. Of course, the study also found that AI is widely used in factory operations, which brings many benefits to factory development, however, it also has negative impacts on factory operations, mainly focusing on the negative impacts on factory employees. By analyzing and summarising

the negative impacts of AI on factory employees, this paper ultimately facilitates the adoption of precautionary measures in advance in the process of promoting the application of AI, eliminating the negative impacts on employees, and continuing to realize the objectives of factory operations.

Theoretical Implications

Few scholars have specialized in how AI can help factory operations, and systematic exploration of the negative impacts of AI on factory operations is rare.With the rise of AI, many scholars have launched research on AI. From the articles published in recent years, most of the research on AI focuses on the AI technology itself and the positive impacts. This paper is an extension and micro-application of the original theory from how AI assists factory operations to its negative impact, which enriches AI-related theories.

Practical and Social Implications

The research in this paper is centered on the application of AI in factories, which is a good guide for factory operations.In recent years, AI technology has begun to be used in a variety of industries. Factories, as an important force in the supply of social production and means of living, the application of AI technology is certainly not absent, and all aspects of factory operations, there is the shadow of AI. How exactly does AI assist in factory operations?In addition to the positive impacts of AI that can enhance productivity and replace manual work, what are the negative impacts? This paper has systematically sorted out these issues, and is expected to provide guidance for factory operations and management.

Limitations and Suggestions for Future Research

This paper has some limitations, mainly the fact that for the time being, no empirical research has been done on specific factories, but only general research. In terms of future research direction, most of the current scholars are on the application of AI and its positive impact on research, rare scholars on the negative impact of AI application, especially on the negative impact of AI on employee satisfaction research, combined with specific factory operations to carry out research scholars is even less, which is a great research space. Meanwhile, Artificial Intelligence as an emerging product, the existing research data on AI applications is not rich enough to have the biggest support on the existing research.

Acknowledgement

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