Effects of AI Applications in Manufacturing, based on Haier Corporation Case Study

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Abstract

Artificial Intelligence (AI), a system that can be considered to think like humans, act like humans, think rationally, and act rationally, has been adopted in manufacturing industry globally. In view of the rapid development of AI and the reality of Industry 4.0, this paper focuses on the application of AI in manufacturing industry taking Haier Corporation as a case study.

We propose the following hypotheses: the application of AI shortens the product RD cycle of manufacturing companies, increases their productivity, reduces the defect product rate, reduces carbon footprint, reduces the number of low-skilled employees in manufacturing, and increases the number of highly-skilled employees.

Keywords
AI; Haier Corporation; Global Lighthouse Network; Industry 4.0; manufacturing

1 Background

1.1 Introduction

In order to verify our hypotheses, we chose Haier, a well-known Chinese home appliance manufacturer and retailer, for our case study, and we received some findings. Firstly, Haier has applied AI in its smart home products to enhance energy efficiency and user experience. Secondly, the application of AI helps the company to develop products that can intelligently deal with problems that the previous products were unable to deal with. Consequently, Haier' s revenue and net profit have grown as a whole. What' s more, in the process of production, Haier has also made progress with AI. Using AI to achieve automated production, visual inspection, and data analysis has enhanced the efficiency of management methods. More concretely, the time taken to identify on-site quality issues, annual robot malfunctions, and downtime within the product production cycle has decreased and product quality levels, overall equipment effectiveness, asset utilization, tool lifespan, and overall production efficiency have increased. Lastly, the production paradigm of "objects finding objects" has improved the quality and yield of the products.

To summarize, from the application of AI in Haier, we conclude that AI application will remarkably influence the RD cycle, productivity, defect product rate, carbon footprint, and employment matters in manufacturing industry. Still, the application of AI

in manufacturing industry is a complicated issue, and there are many points to be further explored in the future.

It could be said that AI began its journey in 1950 when Alan Turing introduced a test (subsequently known as the Turing test) in his paper "Computing Machinery and Intelligence." This ultimately led to Alpha Dog defeating world champion Ke Jie in the Chinese game of Go, and Apple launching Siri, an intelligent personal mobile phone assistant [1].

At this point it is important to be clear on what AI is. Many answers to this question have been proposed in earlier literature, and in this paper we find the definition of Joost et al. to be particularly useful [2]. In the beginning, AI was defined in a broad sense: the application of techniques to increase the efficiency and effect of computers by improved programming. After a long development history from informatics to AI, there is now a more precise definition of AI: systems that think like humans; systems that act like humans; systems that think rationally; and systems that act rationally. In addition, the evolution of AI has a dual directionality, one is from informatization to manufacturing intelligence, and the other is from program to systematic organizational innovation.

With the rapid development of technology, AI is driving the transformation and upgrading of manufacturing industry globally. Fictiv recently released its annual manufacturing status report, which tracked decision-makers from hundreds of manufacturing companies in the US. 85% of them state that their companies have adopted AI solutions, and 97% of the leaders anticipate that AI will impact product development and manufacturing capabilities, as in the Fictiv Manufacturing Industry Status Report 2023 pointing out that attention to AI is necessary and valuable [3].

1.2 Applications

AI, at this stage, is already widely used in manufacturing industry in all aspects of production lines and management systems. Artificial intelligence, especially machine learning, has greatly improved productivity and management efficiency by enabling large amounts of manufacturing data generated through advanced analytical tools to be processed. The application of AI optimizes the entire manufacturing system, including system modeling and performance analysis, as well as optimal system-level control and decision-making [4]. The change in the manufacturing system is a top-to-bottom change that profoundly affects productivity for optimal resource allocation.

At the same time, AI plays a huge role in human-robot collaboration (HRC) [5], in which specially designed robotic systems and operators perform simultaneous tasks within a collaborative workspace. Robotic systems and humans can perform tasks simultaneously or even jointly, and, at the same time, AI can efficiently process massive amounts of data that humans are unable to process. These amounts of data can be transformed into information that can be made sense of, greatly improving the efficiency of human-robot collaboration.

During the production chain AI can be used for process monitoring, diagnosis, and prediction, and ML-based fault diagnosis represents the earliest adoption of AI in manufacturing [6]. In the diagnostic process, as the complexity of the process and data increases, manual feature extraction becomes difficult, and AI, in accordance with its powerful data processing capabilities, can simultaneously identify the type of fault and the severity level of the fault, and propose appropriate remedies in accordance with the program.

In addition, AI has many applications in manufacturing plants, from management systems to production lines. As technology continues to advance, artificial intelligence is gradually changing manufacturing industry as we know it.

1.3 Hypotheses Development

"Lighthouse Factory" is a program that applies Industry 4.0 technologies at scale, and it is a demonstrator of digital manufacturing and globalized "Industry 4.0" . The selection and evaluation of lighthouse factories are carried out in the context of the Global Lighthouse Network program, co-founded by

the World Economic Forum and McKinsey Company. It gathers industry-leading companies to find exemplars of intelligent and digital transformation in manufacturing. According to Lighthouse Factory philosophy, the application of AI technology may have a positive impact on OEE (Overall Equipment Effectiveness), defect product rate, and productivity [7].

Therefore, we propose the following hypotheses:

H1: The application of AI increases the OEE of manufacturing companies.

H2: The application of AI reduces the defect product rate of manufacturing companies

H3: The application of AI increases the productivity of manufacturing companies.

Meanwhile, according to the task-based analytical framework developed by Acemoglu and Restrepo (2018), the role of technological progress in the demand for high and low skills is summarized as a 'substitution effect' and a 'creation effect': technological progress directly substitutes predictable procedural tasks for low-skilled labor, and firms reduce the relative demand for low-skilled labor. Technological progress directly creates tasks that can be performed by highly-skilled labor [8], and so firms increase their demand for highly-skilled labor [9].

Based on this, we propose the following further hypothesis:

H4: The application of AI will reduce the number of low-skilled employees in manufacturing and increase the number of highly-skilled employees.

2 Case Study

2.1 Why Choose Haier?

Figure 1: Haier's Smart Home

Haier, founded in 1984, is a well-known Chinese home appliance manufacturer and retailer. Its business scope covers home appliances, the smart home, the Internet of Things (IoT), and other areas. Concerning home appliances, its related products encompass washing machines, refrigerators, air conditioners, and more. Moreover, Haier stands as one of the global leading home appliance brands and offers a wide range of products and solutions in the field of smart homes. Haier's AI assistant is primarily applied in the smart home domain and can connect various smart home devices such as smart TVs, smart air conditioners, and smart washing machines. Users can control the on/off switches, mode settings, and other operations of these devices through voice commands. Haier has also incorporated machine learning and AI technology into its smart home products, allowing them to automatically adjust the operation mode of home appliances based on user habits and environmental changes, thereby enhancing energy efficiency and user experience.

With the application of AI technology, Haier has led the product development direction of China's intelligent home appliances, and its revenue and net profit have continued to grow. Among them, revenue has grown by 32.3% in the last four years, and net profit has grown by 96.6% cumulatively in four years, which is the highest growth rate among China's top three home appliance brands.

In the manufacturing field, the "Lighthouse Factory," known as the "Oscar" of intelligent manufacturing, has been regarded as a pioneer of the fourth industrial revolution and a demonstrator of AI-enabled manufacturing due to its rigorous selection criteria. Since the World Economic Forum and McKinsey launched the global selection of "Lighthouse Factories" in 2018, as of January 13, 2023, a total of 132 factories worldwide have been selected. Among them, the Haier brand has had 5 factories selected. In 2018, the Qingdao Haier Central Air Conditioning Smart Factory became China's first and the air conditioning industry's first Lighthouse. In 2020, the Shenyang Haier Refrigerator Smart Factory became the refrigerator industry's first "Lighthouse"; in 2021, the Tianjin Haier Washing Machine Smart Factory became the washing machine indus-

try' s first "Lighthouse" ; in 2022, the Zhengzhou Haier Water Heater Smart Factory became the water heater industry' s first "Lighthouse" ; and in 2023, the Qingdao Haier Refrigerator Smart Factory was once again selected.

Figure 2: Manual Production Process

Figure 3: Automatic Production Process

2.2 AI Applications in Haier

With AI, Haier manages to improve total factor productivity [10]. In this set of before-after comparison figures, we can observe the following changes.

In Figure 2, the worker dressed in a blue uniform is an assembly line worker involved in refrigerator assembly, while the individual in a gray uniform is an inspector responsible for quality checks on the products. Figure 3 not only shows automated production but also the incorporation of AI technology for visual inspection and data analysis, contributing to enhanced efficiency in management methods.

These specifically encompass, but are not limited to, AI-powered visual inspection, deep learning for defect detection, predictive maintenance aggregating equipment and process data, machine learning for predictive maintenance, analyzing data for quality monitoring, utilizing data to enhance machine performance, and monitoring Overall Equipment Effectiveness (OEE) through digital dashboards. Through real-time monitoring and visualization of this production process, Haier factories have achieved significant improvements in average production efficiency. From material in the McKinsey China WeChat official account, this is evident in various aspects: the time taken to identify onsite quality issues has been reduced by 30%, annual robot malfunctions have decreased by 9%, downtime within the product production cycle has decreased by 10%, the rate of high-quality products has increased by 2%, OEE has improved by 3%, asset utilization has risen by 20%, tool lifespan has increased by 30%, and overall production efficiency has seen a remarkable increase of 31%.

Simultaneously, AI technology has also facilitated a shift in the production paradigm from "people to people" to "objects to objects."

Figure 4: People to People

Figure 5: Objects to Objects

In this set of before-after comparison figures, we can observe the following changes: in Figure 4, a material handler is shown needing to approach warehouse personnel to retrieve the relevant materials and distribute them to the respective workers before production can commence. However, in Figure 5, with the application of AI technology, including RFID (Radio-Frequency Identification) and automation, each component is assigned a unique identifier. With a simple scan, the refrigerator' s outer casing automatically identifies the corresponding interior unit, and the door structure effortlessly matches the appropriate cabinet. The "objects to objects" matching success rate reaches 100%, subsequently enhancing the precision and quality of the

products. The Haier Shenyang Refrigerator Smart Factory, with the implementation of this technology, achieves an annual production capacity on a single production line that is approximately double that of a traditional refrigerator production line.

3 Challenges & Solution

3.1 When does AI come in view?

Digitalization and informatization have been referred to in the manufacturing industry for decades, and it is the essential differences between AI and the earlier computer or IT revolution that first came into sight.

In the early stage, AI was taken to mean using computers more effectively by improved programming techniques [11]. With decades of development, the current more accurate definition has become "systems that think and act like humans; systems that think and act rationally" .

In a nutshell, "informatization" enables a burgeoning efficiency in production, and manufacturing intelligence enables a reduction in labor. We conclude that AI has developed from dependent programs to systematic innovation.

3.2 Research focus

At first, our attention was drawn to the influencing factors of the popularity of AI applications in manufacturing industry. A great deal of previous research into this topic has focused on user acceptance, drawing on the Technology Acceptance Model (TAM) [12]. TAM has postulated a convergence between the AI applications, perceived usefulness (the degree to which a person believes that using a particular system would enhance his or her job performance), and perceived ease of use.

In this limited research, we decided to focus on the variable perceived usefulness, and selected a leading company in the manufacturing industry, Haier, as a case study.

3.3 Contributions and limitations

While most studies focused on the theoretical effects of AI applications, our study provides a practical example of AI applications in manufacturing industry to illustrate their usefulness in enhancing work efficiency. We processed the statistics on 3 scales (OEE, defect product rate, and productivity) to evaluate the effects of AI, and specifically analyzed the technologies applied in production in the cases.

The aim of this study was twofold, the first was to identify underlying AI trends, as understanding the causes is vital in devising appropriate solutions, and the second to focus more on the financial and practical aspects, while previous studies focused more on social psychological factors.

However, this study has time limitations and other restrictive factors. Given that we couldn' t find a company with a similar size and venue to Haier as a control, we cannot rule out effects of other factors other than AI applications, for instance, size and economic trends. In that case, our conclusions are based on a single case, the Haier company, resulting in a lack of universality in the sample.

4 Division of roles responsibilities

Task	Content	Responsible Person
Article searching	Find background literature to support this subject	All
Data collecting	Get available data sets about Haier Company	Song Jing, Song Zitong
Results analysing	Conclude analysis and construct a model based on the results	Wu Jingyi, Zhao Yilin
Report Polishing	Check the final report	Shi Xuran, Zhao Yilin
Literature Reading Report Editing	Adjust the format	Song Zitong
Summarizing and report writing	Conclude our research and formulate a research report	All

Author Contributions

Conceptualization: All : methodology and formal analysis: Z.Y.L and W.J.Y.:visualisation: S.J.,W.J.Y,Z.Y.L,S.X.R.; investigation resources, data collection: S.J and S.Z.T; writing-original draft preparation: S.X.R :writing-reviewing and editing. supervision;Z.Y.L and S.Z.T.wring-case study:S.J and W.J.Y.

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Intellectual Property

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