

**The Role of Artificial Intelligence in Improving Production in Industries an Applied
Study on Industrial Firms in Saudi Arabia**

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1. Introduction

Artificial intelligence (AI) has become a key technology affecting all modern industrial production systems. Manufacturing companies have become able to increase productivity, streamline processes, and enhance the decision-making capabilities of their employees due to recent advancements in machine learning, robotics, and data analytics. AI technologies also improve operational efficiency and reduce production costs by enabling industrial enterprises to process massive amounts of data and automate complicated tasks (Jordan & Mitchell, 2015).

With the rise of the Fourth Industrial Revolution (Industry 4.0), the pace of fusion of technologies like AI, Cyber-Physical Systems, and the Internet of Things (IoT) in manufacturing activities increased significantly. Industry 4.0 promotes the creation of smart manufacturing systems in which the machines are able to communicate, monitor and control their own manufacturing processes to increase productivity and efficiency (Lu, 2017; Schwab, 2016).

AI has several applications in manufacturing, including predictive maintenance, automated quality control, intelligent supply chain management, and production scheduling. AI predictive maintenance systems improve machine reliability and reduce machine downtime by predictive analyzing machine data to detect potential machine failures (Lee et al., 2015).

Further advancements in quality assurance processes in the manufacturing sector can be attributed to Artificial Intelligence (AI) technological advancements. AI enabled systems with computer vision can identify flaws and defects in the structure of a product and assist in improving the overall structure and quality of a product and minimize the wastage due to the defective product (Kusiak, 2018).

Moreover, in the industrial sector, AI technologies assist in improving productivity and operational efficiencies of industrial enterprises. This is accomplished through the automation of mundane and recurrent tasks. Further, AI aids in the operational decision-making process that is reliant on data and driven by data. The adoption of AI technologies, in the industrial sector, is the most effective way of improving productivity, through optimizing the allocation of resources in the production process (Brynjolfsson et al., 2019; Acemoglu & Restrepo, 2020).

The application of AI technologies in the manufacturing industry allows the creation of smart factories. In smart factories, the latest technologies allow for automated regulation, management of production processes in real time, and predictive analytics. Smart factories are one of the most integral elements of Industry 4.0 and are critical in increasing competitiveness and efficiency in manufacturing (Wang et al., 2016; Zhong et al., 2017).

Though The AI technologies have the potential to impact industrial production positively, a majority of the organizations dealing with production and manufacturing processes do not successfully integrate the AI systems due to several challenges. Such challenges are technological complexity, insufficient capacity due to organizational constraints, and the challenges that exist when attempting to merge AI technologies with production systems that are in place (Frank et al., 2019).

Saudi Arabia considers artificial intelligence (AI) as a critical tool for economic diversification and technological innovation. Digital transformation with AI technologies is vital for all sectors. With the industrial sector being a major pillar in the Saudi Arabian economic development framework, integrating AI technologies is critical for improving industrial productivity and global competitiveness.

More importantly, integrating AI into industrial firms is vital for strengthening production and operational efficiency, and as a result, for enhancing industrial development and overall economic growth.

2. Problem Statement

Artificial Intelligence (AI) technologies can revolutionize industrial production by boosting productivity, efficiency, and quality. Many global manufacturing organizations have integrated AI technologies into their production systems, resulting in technological enhancement of the processes and improved operational efficiency.

However, many organizations are still struggling with integration of AI technologies in their production systems. Integration of AI technologies entails significant costs in technological infrastructure, as well as new workforce skills and organizational structure development (Dwivedi et al., 2021).

Furthermore, although numerous studies have analyzed the impact of artificial intelligence on the manufacturing sector, the majority of available research is based on the U.S., Europe, and China. Very little research has focused on the impact of artificial intelligence technologies on the industrial production efficiency in developing countries.

Besides, the successful integration of artificial intelligence technologies in industrial organizations relies on several organizational and technological factors, such as institutional pressure, technological capacity, and available resources (Bag et al., 2021).

Thus, it is imperative to study the effect of artificial intelligence technologies on production efficiency and operational performance in industrial organizations, especially in the case of Saudi Arabia.

3. Research Objectives

The primary aim of this research study is to focus on the impact of artificial intelligence on industrial production efficiency.

The study also seeks to achieve the following objectives:

1. Determine the effect of artificial intelligence technologies on industrial production efficiency.
2. Examine the degree to which the operational performance of industrial firms is affected by the adoption of artificial intelligence.
3. Determine the constraints faced by manufacturing firms in the adoption of artificial intelligence technologies.
4. Suggest strategies to enhance the adoption of artificial intelligence in industrial production systems.

4. Research Questions

This research aims to explore the following questions:

1. In what ways does automation improve efficiency in industrial production?
2. What impact does automation have on the operational performance of industrial firms?
3. What obstacles do industrial organizations face in the adoption of automation?
4. How can the incorporation of automation be improved in manufacturing industries?

5. Literature Review

5.1. Artificial Intelligence and Industrial Production

In today's world, one of the biggest technological facilitators of change in the modern industrial production system is Artificial Intelligence (AI). With the use of AI, the Modern Industry has the potential to increase productivity, automate processes, and improve the

company's operational decision-making. AI has the potential to revolutionize manufacturing by providing the ability to automate advanced decision-making and operational processes. Moreover, AI possesses advanced computational algorithms that can parse and analyze considerable amounts of manufacturing data and use the data to identify patterns in order to optimize operational processes (Jordan and Mitchell, 2015).

Production firms use sensors, machines, and production tracking systems to monitor systems and generate data. AI has the capability to parse and analyze data in real time and offer treatment options to management to allow for the optimization of production, the reduction of operational inefficiencies, and the improvement of the entire system. With AI Analytics, manufacturing firms can reduce their need for operational decision-making (Dwivedi et al). This means the ability of the firm to conduct operational predictive analytics increases. With AI, manufacturing firms can conduct operational decision-making with predictive analytics (Dwivedi et al).

One of the major movements in the Industrial Manufacturing Process with the use of AI was to eliminate the need for human involvement in processes, or to delegate the human involvement to a lesser role. With the use of AI, machines can be used to perform the monotonous processes that were previously conducted by a human and do so with greater speed, efficiency and accuracy (Davenport and Ronanki, 2018).

Workforce productivity within the manufacturing sector can also be complemented by the utilization of artificial intelligence. The introduction of AI technologies means employees can relinquish mundane tasks and concentrate on higher-order tasks that include strategic thinking, innovation, and process-improvement activities. Such changes in the roles of employees not only lead to the increased productivity of an employee but also improved performance of the organization as a whole (Acemoglu & Restrepo, 2020).

5.2. Artificial Intelligence and Industry 4.0

The continuous advancement of artificial intelligence technologies has been parallel with the development of the Fourth Industrial Revolution, otherwise known as Industry 4.0. This refers to a new era of industrial production that combines digital technologies of artificial intelligence, the Internet of Things (IoT), big data, and robotics with traditional cyber-physical systems in manufacturing (Schwab, 2016).

The Fourth Industrial Revolution (Industry 4.0) fosters a new culture of smart manufacturing whereby machines, sensors, and digital systems communicate with one another in real time to increase production efficiency. Smart systems give manufacturing companies the ability to conduct continuous production monitoring, identify process breakdowns, and perform automatic adjustments to the process (Lu, 2017).

One of the most crucial parts of Industry 4.0 is cyber-physical systems. These systems combine the use of physical manufacturing machinery with a digital control system that allows for the monitoring and control of the processes in real time. Among the most critical components of these systems is the use of artificial intelligence (AI), which helps control processes in a production facility and allows machines to adapt and make decisions autonomously with respect to variable production factors (Lee et al., 2015).

The combination of artificial intelligence with 4th Industry technologies fosters the emergence of smart factories. These are manufacturing systems with a high level of automation, where intelligent systems and technologies are used to refine and enhance production processes. Smart factories are able to better use their resources (Wang et al., 2016).

5.3.Applications of Artificial Intelligence in Manufacturing

AI technologies are vital for the development of manufacturing systems. They have a wide range of applications, which have a considerable effect on productivity, quality, and efficiency of operations.

5.3.1. Predictive Maintenance

AI-assisted predictive maintenance is a vital application of artificial intelligence in production. AI predictive maintenance systems are able to assess the performance of machinery in order to predict its failure. These systems are capable of recognizing the warning signs of a malfunction, and as a result, the downstream system undertakes maintenance operations in the order of priority (Lee et al., 2015).

Predictive maintenance systems are capable of decreasing machine downtime, increasing the reliability of equipment, and decreasing the costs associated with maintenance. This allows manufacturing companies to improve operational performance and increase production.

5.3.2. Intelligent Quality Control

Another area where artificial intelligence has made huge improvements is the quality control process in the manufacturing sector. Traditionally, quality control relied on either manual inspection of quality control or automated systems that were prone to faults or defects. Now, many manufacturers use AI and computer vision to eliminate defects in the production process. Using machine learning and computer vision, manufacturers can examine and analyze images of parts and detect defects that the human eye would miss (Kusiak, 2018). With the advent of intelligent quality control systems, manufacturers can improve quality, reduce waste, and improve the quality of the customer's experience.

5.3.3. Production Planning and Optimization

The application of artificial intelligence in production planning and production process optimization is particularly important based on the application of sophisticated analytical methods on the various available data sets related to production activities, resource utilization, and demand forecasting.

The optimization algorithms based on AI technology have enabled production companies to identify the optimal ways of developing production schedules, the optimal ways of resource utilization, and the optimal ways of minimizing the operational inefficiencies. It has been proven that the implementation of all of the above strongly positively affects the results of productive activities in the field of manufacturing and leads to the minimization of expenses related to production (Frank et al., 2019).

5.3.4. Optimizing the Supply Chain

As for the manufacturing industry, artificial intelligence (AI) has made significant contributions to the advancement of supply chain management. AI provides tools that help in the analysis of supply chain data to anticipate demand fluctuations, evaluate and optimize inventory, and improve the logistics.

AI tools strengthen the supply chain management in the event of disruptions to production. The latest digital technologies improve the analysis of supply chain risk and empower companies to identify and mitigate risks in the supply chain before they materialize. (Ivanov et al., 2019).

5.4. The Role of Artificial Intelligence in the Growth of Industries

Artificial Intelligence improves the productivity of industries by enhancing the efficiency of operations and automating the production of goods. AI technologies in organizations improve the employment of resources, the reduction of waste in the production processes, and the quality of the operational decision-making.

The positive effects of AI adoption on productivity have been demonstrated. AI technologies empower organizations to analyze and improve the production processes and automate the performance of complex tasks (Brynjolfsson et al., 2019). Analytics for AI technologies provide organizations with the ability to improve strategic decision making and the operational efficiency of the organization.

Additionally, artificial intelligence technologies enhance productivity in the workforce through human-machine partnerships in the industrial arena. Such partnerships enable organizations to use the advantages of human intelligence and machine learning (Rai et al., 2019).

5.5.Intelligent Manufacturing Systems

Intelligent manufacturing systems are considered among the highly developed offerings of actually utilizing AI technologies in the industrial production sector. Intelligent manufacturing systems combine AI, robotics, digital technologies, and analytics to create smart manufacturing systems that can function independently.

Intelligent manufacturing systems provide the ability to collect, review, and analyze operational data of all systems within an industrial firm and automatically modify the parameters of all manufacturing systems. Such systems can provide improved operational efficiency and enhanced flexibility for the firm. Improved efficiency and flexibility can be obtained in shorter time frames. These systems can also provide the ability of the firm to quickly adapt to the frequent changes in market demand and the changes in production systems resulting from the technological advancements. This ability provides improved operational efficiency and enhanced flexibility in the shorter time frames.

5.6.AI Adoption in Manufacturing

Although the application of artificial intelligence technologies provides multiple benefits, manufacturing firms encounter various limitations and barriers within AI systems. A

fundamental obstacle is the amount of money that needs to be spent to be able to utilize the technology of artificial intelligence. The accompanying costs of sophisticated digital technology, cutting-edge computer systems, and the training of workers must be accounted for in order to incorporate various AI systems.

The second obstacle is the lack of available personnel who have the needed training in artificial intelligence and data analytics. Manufacturing companies have a hard time finding workers with the skills needed to develop and operate AI-based production systems (Bag et al., 2021).

Integrating AI-based production systems and already existing production systems is the final obstacle discussed. The degree of organizational restructuring and the transformation of production processes that are needed to enable the smooth integration of AI systems is often overlooked.

5.7.Previous Studies

The impact of certain AI technologies on the productivity and operational efficiency of manufacturing systems has been studied previously.

Brynjolfsson, Rock and Syverson (2019) studied the impact of AI technologies on productivity growth. Regarding AI adoption and productivity, gaps were identified in specific sectors. The Study found that productivity could be improved through the increased use of AI in automation and AI enhanced decision-making. Additionally, the authors commented on the productivity paradox, which suggested the benefits of AI will not be realized immediately, due to the timing of organizational adjustments and difficulties with technological integrations.

Frank, Dalenogare, and Ayala (2019) studied the use of Industry 4.0 technologies in manufacturing firms. This study focused on the role that digital technologies such as AI play in the transformation of manufacturing processes. The study found that businesses that

implemented Industry 4.0 technologies in their businesses achieved improvements in operational performance, flexibility of production, and efficiency in manufacturing.

Kamble et al (2018) study the barriers surrounding implementation of Industry 4.0 technologies within the barriers. Key barriers include organizational preparedness, technological competency, and the lack of necessary technological infrastructure. For Industry 4.0 technologies to be implemented, firms have to provide the necessary technological means and infrastructure.

Dwiwedi et al (2021) look at the obstacles and the potential benefits that come with implementing Artificial Intelligence. Unquestionably, the advantages Artificial Intelligence can provide are astounding. However, the study suggests focused effort to be placed on overcoming the challenges that emerge from implementing the technology and the inability of the workforce to manage the technology.

Bag et al (2021) study the benefits and impacts of Artificial Intelligence and BDA on sustainable manufacturing. Findings from the study claim that Artificial Intelligence can improve sustainability and efficiency of operations in the manufacturing industry by enhancing the management of resources and flexibility in production.

Finally, Ivanov et al (2019) study the role of technology and Industry 4.0 in the framework of supply chain risk management. It has been concluded that Artificial Intelligence and other new digital technologies are the key enablers of the flexibility and adaptability of organizations in the face of disruptions in the supply chain.

Kusiak (2018) analyzed smart manufacturing and how artificial intelligence (AI) technologies influence manufacturing systems. The study determined that AI technologies are key enablers of intelligent manufacturing systems that can optimize process and improve efficiency.

Zhong et al. (2017) examined intelligent manufacturing technologies in the context of Industry 4.0. The study pointed out that AI technologies help manufacturing systems to improve the level of automation, operational efficiency, and production flexibility.

Based on the studies, AI technologies have the potential to enhance industrial productivity, operational performance, and efficiency of manufacturing.

5.8.Theoretical Framework

This study's theoretical foundation is the combination of several theoretical viewpoints pertaining to technological innovation and the digital transformation of manufacturing industries.

A significant part of the foundation deals with the Fourth Industrial Revolution theory, which describes the impacts of AI, robotics, and cyber-physical systems on industrial production systems (Schwab, 2016). It describes how advanced digital technologies are synergistically applied to an organization that can create intelligent production systems that improve productivity and efficiency. A further vital theoretical viewpoint is smart manufacturing, which integrates conceptualizes the use of AI, digital technology, and automation into manufacturing processes. Manufacturing processes are further refined, and better operational decisions are made, thanks to the use of sophisticated technologies (Kusiak, 2018).

Moreover, digital transformation theory underscores the significance of a digital technology in an organization's various processes and business models. The use of artificial intelligence technology empowers an organization with the capability to process big data, thereby providing information that is useful in strategic planning, and improving operational level (Dwivedi et al, 2021).

From these theoretical viewpoints, the use of artificial intelligence technology in an organization provides ample space to evaluate its impact in enhancing the efficiency of production processes and performance of operational processes.

5.9. Research Gap

Although a number of research works have analyzed the impact of AI technologies in manufacturing, there are still research gaps.

To begin with, the majority of existing research works are oriented towards the developed economies of the USA, Germany and China. Very few research works have studied the impact of AI technology on industrial productivity in the developing economies,

Also, a number of researchers have focused more on the technological side of the adoption of artificial intelligence rather than the operational efficiency of industrial production.

Third, while a number of works have considered Industry 4.0 technologies within manufacturing industries, scant empirical studies have particularly focused on the impact of artificial intelligence technologies on efficiency of production processes within industrial firms in Saudi Arabia.

Consequently, this study attempts to fill these gaps by investigating the impact of artificial intelligence technologies on efficiency of industrial production processes in Saudi industrial firms.

6. Hypotheses Development

In accordance with the theoretical framework alongside earlier studies, a number of hypotheses have been constructed in reference to the influence of artificial intelligence technologies on industrial production efficiency.

manufacturing firms streamline and improve production workflows which, in turn, lead to enhanced efficiency and productivity in the manufacturing ecosystem (Brynjolfsson et al., 2019). Hence, this leads us to the following assertion:

H1: Artificial intelligence technologies positively influence the efficiency of production processes in industrial firms to a large extent.

Additionally, artificial intelligence technologies facilitate better operating decision-making by helping firms to evaluate and interpret large data sets related to operations, while also providing the ability to forecast, which, in turn, enhances the operating performance of manufacturing firms (Dwivedi et al., 2021).

Given this, this leads us to the following assertion:

H2: The operational performance of industrial firms is positively impacted by the adoption of artificial intelligence.

Smart quality inspection systems have the ability to identify defective products more precisely than the conventional inspection systems (Kusiak, 2018). Hence, the third hypothesis is formulated:

H3: In manufacturing systems, the quality of products is improved significantly due to the use of Artificial Intelligence technologies.

Technology based on Artificial Intelligence enables companies to enhance the efficiency of their production systems, resulting in the elimination of operational inefficiencies.

Consequently, these advancements lead to a decrease in the expenses associated with production within manufacturing industries.

Thus, the fourth hypothesis is formulated:

H4: In industrial firms, operational costs are significantly reduced as a result of the implementation of Artificial Intelligence technologies.

6. Research Methodology

6.1. Research Design

This study employs a quantitative design to assess the impact of the role of artificial intelligence technologies on the efficiency of production of industrial companies. It is the most appropriate method given that it provides means of the researcher to obtain empirical data and subsequently apply statistical techniques to determine the relationships of a number of variables and how they are linked.

Data will be collected from a single instance of information respondents to a single instrument of the instance. This method of instrument is a common method of industrial and management research as it provides means for the researcher to gather information from a multitude of participants in a time efficient manner.

The design focuses on the relationships between the independent variable (Artificial Intelligence adoption) and dependent variables such as production efficiency, operational performance, improving product quality, and reducing costs.

6.2. Research Population

The research participants in this study will be managers, engineers, supervisors, and technical staff of industrial manufacturing companies in Saudi Arabia.

The participants of the research were chosen, as they are involved in the industrial production processes and are expected to have a considerable level of mastery on the use of advanced technologies in manufacturing processes.

Artificial Intelligence Technologies are heavily utilized in manufacturing industries, which is why this study focuses on industrial sectors.

6.3. Sample Size and Sampling Technique

From the industrial firms based in Saudi Arabia, around 200 participants will be chosen. In the current research, the principle of simple random sampling will be used, which is a technique that gives each person in the population an equal opportunity to be chosen.

For quantitative research, a 200-sample size is sufficient and enables the researcher to apply various techniques of statistical analysis including regression analysis.

6.4.Data Collection Method

To measure the degree of correlation between the use of artificial intelligence technologies and the efficiency of industrial production, primary data will be gathered by means of a structured questionnaire. The participants in the research will receive an email containing the questionnaire. The questionnaire consists of two main parts:

Part A: demographic data of the participants

Part B: questions on the extent of artificial intelligence utilization and the performance of industrial production

The responses will be quantified using a five-point scale, in which a participant may select: 1 = Strongly Disagree ,2 = Disagree ,3 = Neutral ,4 = Agree ,5 = Strongly Agree

6.5.Data Analysis Methods

The data will be analyzed by the use of SPSS statistical package.

The following statistical assessments will be performed for the study:

- ☐ Descriptive Statistics (Mean, Std. Deviation)
- ☐ Reliability Analysis (Cronbach Alpha)
- ☐ Correlation Analysis
- ☐ Multiple Regression Analysis

Descriptive statistics capture and summarize the results. Reliability analysis examines the internal consistency of the survey. Correlation and regression analyze the relationship between the adoption of artificial intelligence and the outcomes of production.

6.6.Reliability and Validity

To assess and guarantee the reliability of the research instrument, the internal consistency of the survey will be tested using Cronbach's Alpha. An Alpha value greater than 0.70 will be deemed sufficient. In addition, content validity will be assured by soliciting input from artificial intelligence and industrial management academic experts regarding the survey.

7. Timetable

Research Stage	Duration
Drafting the Proposal	1 month
Literature Review	2 months
Questionnaire	2 weeks
Collecting the Data	1 month
Analyzing the Data	1 month
Results & Discussion	1 month
Final Form	1month

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9. Appendix: Questionnaire

Variable	Item	1	2	3	4	5
Artificial Intelligence Adoption	Our company implements artificial intelligence technology in its production process.	☐	☐	☐	☐	☐
Artificial Intelligence Adoption	Artificial intelligence technology is incorporated in our production systems.	☐	☐	☐	☐	☐
Artificial Intelligence Adoption	Due to AI technology, our company is able to effectively analyze its production data.	☐	☐	☐	☐	☐
Artificial Intelligence Adoption	Our company is able to analyze its production data	☐	☐	☐	☐	☐

	effectively due to our investment in advanced AI technology.					
Artificial Intelligence Adoption	Due to AI technology, there is greater automation in the production process.	☐	☐	☐	☐	☐
Production Efficiency	Production efficiency is improved with the use of artificial intelligence technology.	☐	☐	☐	☐	☐
Production Efficiency	Production errors are reduced with the use of AI technology.	☐	☐	☐	☐	☐
Production Efficiency	Production scheduling is improved with	☐	☐	☐	☐	☐

	the use of AI technology.					
Production Efficiency	The utilization of equipment is improved with the use of AI technology.	☐	☐	☐	☐	☐
Production Efficiency	The output of production is increased with the use of AI technology.	☐	☐	☐	☐	☐
Operational Performance	The operational decision making is improved with the use of artificial intelligence.	☐	☐	☐	☐	☐
Operational Performance	The operational productivity is increased with the use of AI technology.	☐	☐	☐	☐	☐
Operational Performance	The monitoring of the production process is	☐	☐	☐	☐	☐

	improved with the use of AI technology.					
Operational Performance	The production planning is improved with the use of AI technology.	☐	☐	☐	☐	☐
Operational Performance	The overall operational performance is improved with the use of AI technology.	☐	☐	☐	☐	☐
Product Quality	The quality of the product is improved with the use of AI technology.	☐	☐	☐	☐	☐
Product Quality	The detection of manufacturing defects is improved with the use of artificial intelligence.	☐	☐	☐	☐	☐

Product Quality	The quality control process is improved with the use of AI.	☐	☐	☐	☐	☐
Product Quality	The production waste is reduced with the use of AI.	☐	☐	☐	☐	☐
Product Quality	The operational cost is reduced with the use of AI technology.	☐	☐	☐	☐	☐
Cost Reduction	The maintenance cost is reduced with the use of AI technology.	☐	☐	☐	☐	☐
Cost Reduction	The downtime of the machine is reduced with the use of AI technology.	☐	☐	☐	☐	☐
Cost Reduction	The utilization of resources is improved with the use of AI.	☐	☐	☐	☐	☐

Cost Reduction	With the use of AI technology, the profit is increased.	☐	☐	☐	☐	☐
Cost Reduction	Item	☐	☐	☐	☐	☐

Demographic Information

Question	Options
Gender	Male Female
Age	Less than 30 / 30–40 / 41–50 / Above 50
Education Level	Bachelor Master PhD
Job Position	Manager Engineer Supervisor Technician
Years of Experience	Less than 5 / 5–10 / 11–15 / More than 15
Industrial Sector	Manufacturing / Technology / Energy