Journal of Economics and Administrative Sciences
2024; 30(141), pp. 154-172

P-ISSN 2518-5764
E-ISSN 2227-703X

Journal of Economics and Administrative Sciences (JEAS)

Available online at http://jeasiq.uobaghdad.edu.iq

The Fourth Industrial Revolution: A Historical and Conceptual Review

Basma Mahdi Hamad*
Department of Business Administration
College of Administration and Economics
University of Baghdad, Iraq
basma.mahdi@uobabylon.edu.iq
***Corresponding author**

Maha K. Jawad
Department of Business Administration
College of Administration and Economics
University of Baghdad, Iraq
maha.k@coadec.uobaghdad.edu.iq

Received:2/7/2023 **Accepted: 10/9/2023** **Published Online First: 30 /6/ 2024**

Abstract:

The economic and social progress of countries around the world is linked to the development of industry. Industrial organizations also seek to improve their production processes to meet the continuous changes in customer demands and commodity specifications and improve their competition in the market. The most prominent challenges that organizations face are digital technological developments that play an important role in improving production processes and making them more flexible and efficient. The adoption of new technologies is an inevitable response. According to the world's manufacturing leaders, the developments represent the emergence of a new revolution in manufacturing, referred to as the Fourth Industrial Revolution (Industry 4.0), which represents the process of fully digitizing production processes.

This paper aims to provide an overview of the historical development of the industrial revolutions that led to the emergence of Industry 4.0, with a presentation of international initiatives in this regard and a discussion of the most prominent proposals on its concept. A qualitative analysis based on a literature review was used to achieve the goal and answer the question: How did the historical development of Industry 4.0 lead to the emergence and development of the concept, and what are the basic characteristics that distinguish it from previous industrial revolutions? The reasons that led to the fourth era of the industrial revolutions are due to a group of different interrelated factors, including technological progress, economic factors, changing consumer expectations, government initiatives, and the availability of data.

Paper type: Literature review.

Keywords: The Fourth Industrial Revolution, Industry 3.0, Industry 2.0, Industry 1.0, Concept of Industry4.0,

P-ISSN 2518-5764
E-ISSN 2227-703X

1.Introduction:

In the history, there have been three economic revolutions. If businesses keep providing individualized, high-quality products to consumers and make their workplaces more pleasant for employees, then people's standard of living will continue to rise. In retrospect, the motivation for the term "revolution" was not technological novelty but rather the effect of changes in working and producing processes.

Today, four Industrial Revolutions are frequently referenced, as this mostly occurred after defining "Industry 4.0" to be congruent with its definition. Accordingly, there are several researchers at present calling the First Industrial Revolution "Industry 1.0", the Second Revolution "Industry 2.0", and the Third "Industry 3.0". There are numerous discrepancies in the literature regarding the actual dates of these uprisings. It was recognized by all that the first industrial revolution began with the advent of machinery around the middle of the eighteenth century, and many periods were indicated by researchers as representing the length of each industrial revolution, usually ranging from four to ten decades (Ciulli, 2019). The term "Industrie 4.0" appeared, which was introduced at the Hannover Fair in Germany in 2011, and from this, the term "Industry 4.0" was derived, and it represents the Fourth Industrial Revolution, as many believe that the technologies that have been developed recently will allow organizations to enter a new computerized era to manufacture and manage large systems that were too complex to be integrated, monitored, and controlled before the advent of Industry 4.0 (Krajewski et al, 2022).

In light of the rapid digital developments, the world stands today on the cusp of a Fourth Industrial Revolution, and its extends to a change in knowledge in production processes and the use of digital technologies. Industrial organizations should keep pace with these developments to meet changes in customer demands and market competition. One of the most prominent features of this revolution is the digitization of entire production processes through advanced technologies, including machines, infrastructure, and even people. This leads to the creation of networks that are described as fast, innovative, and interconnected, which leads to the development of electronic value chains. It is expected that smart factories will become traditional shortly, as the implementation of technologies such as the Internet of Things (IoT) and Cyber-Physical Systems (CPS) leads to smarter (products, production processes, and supply chains), and allows the creation of a smart environment along the entire value chain, allowing for flexible and adaptable operations. Academics and industry practitioners believe that implementing Industry 4.0 concepts will result in considerable benefits for the whole supply chain. Organizations may also improve their capabilities to predict customer needs and be able to withstand market changes and competition. This "Revolution" is not seen as confined to advanced economies, but is a global movement that organizations cannot afford to ignore.

The research aims to investigate the historical context and conceptual aspects of the Fourth Industrial Revolution to contribute to the current body of knowledge about Industry 4.0 by conducting a literature review and providing the historical development and conceptual understanding.

1.1 Literature review:

A succession of momentous and transformative epochs, collectively known as the industrial revolutions, have been recorded in the chronicles of human history. Humanity has been thrust into new spheres of innovation, production, and connection by these epochs of dynamic change, each marked by revolutionary technological developments and vast societal upheavals. Over centuries, these industrial revolutions have emerged and drastically transformed not only economies and industries. These landmark achievements span time, space, and civilizations to attest to the power of human creativity to take us to new heights.

P-ISSN 2518-5764
E-ISSN 2227-703X

The first three economic revolutions changed the way people lived and worked. The change from agrarian to industrial societies began with the First Industrial Revolution, which was sparked by machinery and steam power. The Second Industrial Revolution, which was driven by improvements in mass production, power, and transportation, set the stage for cities to grow and for the world to become more connected. The Third Industrial Revolution brought about computers, robotics, and digital connections, which changed the way businesses worked and made way for the digital age. Each of these events caused big changes in how the economy worked, how things were made, and how people interacted with each other. This changed the course of human history.

The first to adopt and support the idea of Industry 4.0 and its support by the German Government, and this was reflected in the "High-Tech Strategy for Germany 2020". This strategy represents the comprehensive German national concept of research, development, and innovation in Germany and aims to ensure consistency in German innovation policy and promote prosperity and economic growth in Germany. It is intent on expediting the translation of scientific discoveries into marketable products, processes, and services, and enhancing the overall environment for innovation. The German Government and many other European countries have paid urgent attention to Industry 4.0 (Ghobakhloo, 2018).

Zhou (2015) indicated that the term "Industry 4.0" is defined as "the use of electronic physical systems in industrial manufacturing systems". It could be similar to what General Electric is doing, referred to as the industrial internet. In America, there are many indications that Industry 4.0 is being used in practice, and over the past years it has been an active area of action research, similar to how the internet created uncertainty in the consumer sector in the 1990s, and it emerged later as dominant and important advances in technology phenomena, therefore Industry 4.0 is a potential hit and not a fuss.

We can comment that Industry 4.0 is not just a term or situation that is addressed, studied, and applied and its importance diminishes over time, due to what it has achieved and what it will achieve in the future benefits manufacturing organizations. Hence, to remain competitive in a volatile and highly competitive market, all manufacturing businesses must prepare to embrace the Fourth Industrial Revolution.

Many kinds of literature often show the concepts of Industry 4.0 and smart manufacturing interchangeably, (Ramakrishna et al., 2017) referred to "digital manufacturing" and "smart manufacturing" as typical interchangeable terms for Industry 4.0. They are often mentioned in the manufacturing industry as also a set of advanced enabling technologies that assist in making efficient and accurate decisions in real-time by introducing various digital technologies, as well as convergence with existing manufacturing technologies (Kang, 2016), and based on the concept of a smart factory, smart factories have a completely new approach to production (Crnjac et al, 2017). These terms, according to the researchers, are related to information and communication technology. This allows all partners in the value chain to digitally communicate in real-time and analyze data, which allows for achieving mass customization of products, and smart coordination between partners to meet demand and supply, achieve shorter delivery times, and finally cost savings (Ramakrishna et al., 2017).

This article reviews the existing literature on two aspects. Firstly, the historical development deals with the Fourth Industrial Revolution. The second part dealt with the presentation of the most prominent literature dealt with the concept. Even though there have been many contributions published, an area of study is growing, which is in line with the trend of digitizing the industrial sector.

1.1.1 The Historical Development of the Fourth Industrial Revolution:

The historical development of the industrial revolutions will be presented through the most prominent literature dealt with as a means of understanding the development in production processes that led to the emergence of the term (Industry 4.0) and studying and analyzing what the researchers dealt with regarding the concept to reach results useful in achieving the goal.

P-ISSN 2518-5764
E-ISSN 2227-703X

According to (Olaniyi, 2016) Industrial Revolution is defined by Merriam-Webster dictionary as "a rapid change in the economy characterized by the general introduction of power-driven machinery or a major shift in the types and techniques of use of this equipment now in use". It could represent a sudden fundamental change in industrial organization: the giving up of the first, second, and third industrial changes, which were replaced by the fourth industrial change in the transition, and Indicated that before the Fourth Industrial Revolution, Western civilization had previously undergone three industrial revolutions, which can also be described as devastating leaps in industrial processes leading to vastly higher production. Programming will facilitate effective communication. The research examines the Fourth Industrial Revolution's impact on developing nations' transportation systems, focusing on Industry 4.0 technologies and challenges. The study examined urbanization, environmental sustainability, and economic development, and highlighted the potential for technological advancements to improve transportation systems.

Ghobakhloo (2018) indicated that the duration of the first three industrial revolutions was close to 200 years. Steam engines, hydropower, and mechanization were key factors in the first industrial revolution. Henry Ford, who first publicly introduced mass manufacturing nearly a century ago, championed the assembly line technology that powered the Second Industrial Revolution. The introduction of computers and automation in manufacturing processes propelled the Third Industrial Revolution, which occurred in the 1970s. In terms of Industry 4.0, it is thought to involve the use of cyber-physical systems in manufacturing. A thorough and content-based review of the literature is done in the study which, shows a strategic plan for the future of the manufacturing industry as it moves toward Industry 4.0. The study looks at how digital technologies are changing the world. The roadmap shows a multi-step plan that includes raising knowledge, using technology, integrating it, and coming up with new ideas. The study identified the key enablers, challenges, and opportunities that come with implementing Industry 4.0, with a focus on the need for stakeholders to work together, for the workforce to grow, and for regulations to be changed. By giving a detailed roadmap, the study provides manufacturers a structured way to deal with the challenges of adopting Industry 4.0 and take advantage of its possible benefits for more competitiveness and sustainability.

Kaczmarczyk et al. (2018) noted that steam-powered mechanical manufacturing tools, electrified mass production, and functional electronic systems and computers all contributed to the first three industrial revolutions. Unlike previous revolutions, which were primarily concerned with industrial production, the current, or fourth, revolution also introduced substantial changes to various disciplines beyond the conventional understanding of the term. As a result, the procedure practically represents a new philosophy with the potential to revolutionize many areas of business, technical standardization, safety, education, legislation, science, research, the labor market, the social system, and associated domains.

Robert and Ziga (2019) dealt with the historical development of industrial revolutions, adopted in their study a review of the literature, and indicated that all industrial revolutions are associated with relatively slow production growth during their technological development stage, and this is due to the saturation of new and current technology.

Popkova et al (2019) indicated that all industrial revolutions share characteristics that allow them to be classified as revolutions and not only as a result of industry evolution. Because the accumulation of a significant volume of fully new technologies for industrial production (industrial technical breakthroughs) is a precondition for the birth of any industrial revolution, gradual economic progress occurs as a result of the accumulation of various technologies. When these technologies achieve a particular level of development and are ready for adoption (practical use) in industrial production, the move from quantity to quality occurs.

P-ISSN 2518-5764
E-ISSN 2227-703X

Ajah et al. (2019) referred to the fact that following on the heels of the digital revolution that began in the middle of the past century, a Fourth Industrial Revolution is currently underway. This exponentially growing fourth revolution is characterized by the convergence of technologies that eradicate traditional boundaries across the physical, digital, and biological realms. The breadth and complexity of these shifts indicate that entire production, management, and governance systems are undergoing radical revisions. This conceptual paper examines the nature of the Fourth Industrial Revolution, defines its driving forces, examines the intersection between Nigeria and the Fourth Industrial Revolution, and offers insight into the kinds of information technology expertise that will be in high demand in a fully digital economy.

According to (Pinheiro et al., 2019), industrial revolutions are a result of theories and scientific discoveries that alter the industry's shape. These revolutions involve the creative use of information, improved production methods, and the expansion of technologies. These revolutions are driven by technology and its developments, allowing rapid progress and contributing to the development of science and knowledge. Kuhn's model of scientific revolutions suggests that revolutions occur when previous theories or technologies fail to explain events or provide necessary technological solutions. Industrial revolutions are often triggered by innovations and inventions, requiring new perspectives and tools to replace old ones. The research assesses the relationship between Industry 4.0 and previous industrial revolutions through the lens of complexity theory. It examines that how Industry 4.0 is characterized by advanced technologies and digitalization, connects with the historical evolution of industrial revolutions. The study analyzes the complex interplay between technological advancements, societal changes, and economic impacts across different industrial eras by applying complexity theory.

From Origins to 4.0, it is explored the evolution of tribology in industrial settings(Ciulli, 2019). Tribology, the study of friction, wear, and lubrication, has played a pivotal role in improving the efficiency, reliability, and longevity of machinery and mechanical systems, focusing on its role in improving the efficiency, reliability, and durability of machines and mechanical systems. The study examined the evolution of tribological principles from early civilizations to the current era, highlighting its potential to address issues like energy use, environmental damage, and maintenance costs. The combination of tribology with Industry 4.0 technologies, such as IoT, data analytics, and automation, is transforming manufacturing by enabling predictive maintenance, real-time monitoring, and product design. Overall, the paper highlights the significance of tribology in the development of industries, from its early days to the current era of Industry 4.0.

Pałaka et al. (2020) indicated that briefly introducing the concept of Industry 4.0 required the creation of a historical perspective on industrial revolutions based on existing literature. Industrial revolutions have always been caused by the creation of a new tool or the discovery of something that made new things possible. The industry has gotten a boost from the creation of new skills. When it was no longer possible to make a device better, a new idea was needed. Since hundreds of years ago, this trend of growth and discoveries has worked. Industry 4.0 will change the way people work in a way that is different from other industrial shifts. It won't make it possible to fully automate every part of the business. It will more likely change how people, machines, and tools talk to each other.

Luca and Dolga (2021) examined how industrial systems evolved and changed as a result of the Fourth Industrial Revolution (Industry 4.0), which followed the Third Industrial Revolution (Industry 3.0). The study focused on the transition from mechanization and automation to digitization and connectivity by analyzing the key traits and technology associated with each stage. This study mentioned the advantages of Industry 4.0, such as improved productivity, adaptability, and creativity, as well as its drawbacks and ramifications, including the need to retrain workers and assure cyber security.

P-ISSN 2518-5764
E-ISSN 2227-703X

It offers a thorough review of the changeover from Industry 3.0 to Industry 4.0, emphasizing the fundamental alterations taking place in the industrial sector as well as the opportunities and issues that result from this paradigm shift.

Alcácer et al. (2021) tracked the maturity of Industry 4.0 and referred in their review of the first industrial revolutions to the fact that the rise of electronic and computer technology in the 1970s gave rise to the third revolution, sometimes known as the digital revolution because of its impact on the automation of manufacturing. After it became clear that the old oil- and factory-based sectors weren't going to solve the world's economic and social ills, a slew of new communication and energy technologies were developed. At present, the objective of the fourth industrial revolution is to introduce computerization and interconnection into conventional industries to support a higher level of automation, hence increasing operational productivity and efficiency. Their study identified some of the barriers that impede the transformation of Industry 4.0, including the lack of vision and strategy to face the near future, which starts with senior management, and the fact that companies must possess the required work skills in their work groups to prepare the digital environment and have a long-term proactive vision regarding infrastructure.

1.1.2 The Concept of Industry 4.0:

Many authors dealt with the term (Industry 4.0) with several opinions. Some of them refer to it as the Fourth Industrial Revolution, often known as "Industry 4.0". Academically, there is still very little research in this field, especially at the local and regional levels, and this concept includes many modern technologies and the latest scientific developments, which have a great impact on the current industrial reality, especially in light of the industrial changes in various countries of the world, especially in the advanced industrial countries, and that by changing the industry pattern dramatically and rapidly to comply with the great changes in the business world.

Leyh et al. (2016) presented the definition that Industry 4.0 describes as "the shift from centralization to decentralization in production, which is characterized by self-control and flexibility, and the digitization of production processes and products to allow the sharing and distribution of information along the value chain". They also focused on the integration and exchange of data in value chains by presenting the System Integration Maturity Model Industry 4.0 (SIMMI4.0), which contributes to the classification of information technology systems by organizations focusing on industry requirements.

According to (Roblek et al, 2016), Industry 4.0 is defined by several areas that will have a substantial impact, including "Production digitalization, automation, management information systems, and production planning, as well as data collection systems from manufacturing lines and machinery that connect manufacturing locations in the broader supply chain". Furthermore, this study presented the basic components of Industry 4.0, namely: smart factories, new systems for developing goods and services, distribution and procurement, smart products, self-regulation, human requirements adaptation, Cyber-Physical Systems (CPS), and digital sustainability.

Crnjac et al. (2017) indicated in depth how Industry 4.0 idea has changed over time, from when it was just an idea to when it was put into practice. The study looks closely at the basic ideas that make up Industry 4.0. These include advanced digital technologies, connectivity, automation, and the sharing of data. It probably talks about how these ideas change the way manufacturing and other industries work by making it possible to make decisions based on data in real-time, for machines to talk to each other easily, and to make "smart" production systems. The study could also look at how Industry 4.0 has changed different industries and how its introduction has presented both challenges and opportunities. In the end, the goal of the study is to provide a full picture of how Industry 4.0 went from an idea to an important part of modern industry practices.

P-ISSN 2518-5764
E-ISSN 2227-703X

Some researchers dealt with aspects of the fourth industrial revolution and its impact on the industry and referred to it as "an integrated network of machines and devices with sensors and built-in programs that enable prediction, control, and improvement of business practice". It was regarded as a "new paradigm for managing the value chain through the product life cycle" and defined as "a comprehensive system of information technologies, people, machines, and tools that enables the controlled flow of goods, services, and data through the value chain, with independent processes and a high ability to convey detailed and useful information that allows decision making" (Saucedo et al, 2017).

Ebru et al (2017) stressed the direction in which the industry is developing 4.0, and defined it as "the application of intelligence, self-controlled, and interconnected processes and systems". Researchers additionally emphasize the importance of beginning creative activities. Smart and networked technologies must be used, that increase the added value of manufacturing, as these technologies provide more flexible, dependable, and efficient manufacturing processes.

According to (Nosalska et al., 2019), the impact of Industry 4.0 on the manufacturing landscape is evident as an increasing number of companies around the world have tried to adopt and implement their digital technology. It has been an area of research and study by many academics. However, no concise and commonly acknowledged definition appears to exist. Several terms are still pending. In their studies, they utilize the term "Industry 4.0", as an example of "concept", "program", "phenomenon", and "idea", however, the term "concept" is the most widely used and common in the academic community.

Silva et al. (2019) focused on the empirical facts surrounding the actual use of the Industry 4.0 concept by various businesses. Industry 4.0 concepts include the use of cutting-edge technologies like automation, data interchange, and the Internet of Things. Therefore, this report will likely investigate how businesses are implementing these ideas. look into the difficulties, gains, and results that businesses encountered when they adopted Industry 4.0. The research aims to contribute to a better understanding of the actual impacts and effectiveness of this transformative concept in diverse industrial contexts by analyzing real-world cases, shedding light on the strategies, successes, and obstacles encountered by organizations as they navigate the complexities of incorporating Industry 4.0 technologies.

Chaitanya (2020) addressed the concept of Industry 4.0 through a review of the literature and indicated that it represents the "integration of advanced technologies and digitization in the industrial sector", and examined the main features, benefits, and challenges associated with the implementation of Industry 4.0 and highlighted the possibility of enhancing communication and cooperation between humans and machines, as well as the need to raise workforce skills and organizational adaptability to take full advantage of the benefits of Industry 4.0. Also defined Industry 4.0 as "a specialization Internet of Things applied in the manufacturing/industrial environment. It assumes a real-time data collection leading to the issue of handling and analyzing huge data and cybersecurity".

Salah et al. (2020) investigate how the notion of Industry 4.0 might be taught to students of industrial engineering. The principles of Industry 4.0 are emphasized, including automation, data interchange, and digitalization, and this is emphasized in the context of the educational framework. The research's ultimate goal is to assist educators better explain Industry 4.0 and its complex manufacturing concepts and technology to their students. The project seeks to provide students majoring in industrial engineering with the knowledge and skills necessary to deal with problems and take advantage of the opportunities presented by Industry 4.0 through the use of novel instructional approaches.

P-ISSN 2518-5764
E-ISSN 2227-703X

Węgrzyn (2020) delved in his study into how the adoption of the Industry 4.0 paradigm is causing fundamental shifts in the manufacturing industry. The revolutionary effects of Industry 4.0 defined by digitization, automation, networking, and data exchange on the fabric of the manufacturing sector are analyzed. Changes in production methods, supply chain administration, employee responsibilities, and general industrial operations are all investigated, as the implications of these shifts brought about by the rise of Industry 4.0 technology. The study's overarching goal is to shed light on how the notion of Industry 4.0 is causing widespread change in the industrial sector by investigating the aforementioned transitions.

Rupp et al. (2021) focused on defining Industry 4.0 from a technological perspective, identified its main technological components, and explored the different dimensions of the implementation of Industry 4.0, by analyzing a wide range of scholarly articles. They provided insights into the mainstream technologies driving Industry 4.0, including the Internet of Things (IoT), electronic physical systems, big data analytics, artificial intelligence (AI), and robotics.

Yang and Gu (2021) discussed the concept of Industry 4.0 as a "transformative revolution that requires both advanced technologies and national strategies". The study confirmed two aspects: the first is the need for countries to adopt comprehensive strategies to effectively harness the potential of Industry 4.0 and maximize its benefits, and it highlighted the importance of adopting technology, including digitization, automation, artificial intelligence, and communication, in enabling the fundamental transformations brought about by Industry 4.0. The second is the importance of national strategies that include policies and regulations, infrastructure development, and manpower skills development to create an environment conducive to the implementation of Industry 4.0. The study recommended the comprehensive approach necessary to fully embrace the opportunities offered by the Industry 4.0 revolution.

To investigate the impact of Industry 4.0 on the development of the "Construction 4.0" idea, (Kozlovska et al., 2021) undertake a thorough literature review. It digs into the implementation and adaptation of Industry 4.0 principles in the building industry, including digitalization, automation, and data exchange. The research looks at how these innovations are changed the way that buildings are built by encouraging more productivity, teamwork, and creativity. Incorporating Industry 4.0 technology into construction processes and projects has the potential to drastically alter the industry, as is made clear by this study's synthesis of the relevant literature.

Gajdzik and Wolniak (2021) used literature reviews and empirical case studies from Poland. This investigation explored how Industry 4.0 projects have affected corporate operations. The impact of Industry 4.0, a term encompassing cutting-edge technology like automation, data analytics, and networking, on several facets of doing business is discussed. The impact of Industry 4.0 initiatives on the strategies, processes, and performance of various businesses is expected to be investigated in this study. The research seeks to provide a holistic understanding of how the adoption of Industry 4.0 technologies is shaping and transforming business operations in the Polish context by combining findings from the literature with those from real-world case studies. They confirmed that there are industries in which technological progress is achieved more quickly and easily, and there are industries in which it is difficult to implement new solutions. Therefore, the concept of Industry 4.0 is gradually applied in organizations through the investment of implemented projects in various sectors and fields, and selective implementation of technical solutions typically of Industry 4.0 is common in both manufacturing organizations and individual industries.

P-ISSN 2518-5764
E-ISSN 2227-703X

Nunes et al. (2022) noted that an accurate understanding of the concepts and scope of Industry 4.0 and knowledge sharing will be crucial in shaping the future of the transition from existing business models to smart manufacturing. The study looks at the effects and challenges of Industry 4.0 in the manufacturing sector in a planned way. It does this by looking at a lot of existing literature and drawing conclusions from it. The idea of Industry 4.0, which is based on technological advances like automation, data analytics, and the Internet of Things, is studied in terms of how it affects manufacturing processes and practices. The study looks at both positive effects, like increased efficiency and innovation, and problems, like skill gaps and worries about cybersecurity. They reached seven potential impacts of Industry 4.0 on manufacturing: (environment, competitiveness, economy, education, labor market, ans business as well as social models). In addition, this study identified six potential challenges facing manufacturing in embracing digital transformation: (management, government, implementation, manpower, employment, and security). By looking at a wide range of literature, the study hopes to provide a full picture of how Industry 4.0 is changing the manufacturing landscape, including both its potential to change things and the challenges that need to be overcome for it to work.

According to Brisco, (2022), the ability to adapt new circumstances digitally as they arise is known as "digital transformation". Industry 4.0 technologies are widely regarded as cutting edge, cutting edge solutions to today's problems. Companies are frequently unprepared for change because the demands of day-to-day operations prevent them from preparing for it or from having the foresight to anticipate it. Deciphering the digital upheaval that Industry 4.0 has brought about is the study's main objective. The drivers of digital transformation, the nature of the transformation itself, and the degree to which businesses are ready to change all crucial components of the whole picture. Researched topics include how these technologies are influencing industrial contexts in terms of business models, operations, and interactions. Research on the digital transformation of Industry 4.0 is meant to shed light on how technology is influencing business models, driving innovation, and transforming the dynamic between producers and consumers.

2. Material and Methods:

The analytical approach is one of the specialized methods used to describe scientific studies and research. It was used in this study. Its goal, depending on the type of scientific study, is to clear up any confusion about phenomena or problems to face reality, aid with task organization, find the causes, and get the desired results. Scientific study doesn't use just one method. Researchers try to get the most out of these methods by focusing on the pros and addressing the negatives. This method is based on breaking down research problems into their main parts. This makes it easier and more accurate for the researcher to diagnose the problem and figure out what caused it to happen. The analytical approach and the description approach cross paths directly or indirectly. The descriptive method is based on choosing a specific phenomenon and coming up with study or inquiry questions that address it. The analytical method adds to it and makes the results more accurate. During the research process, it depends on breaking up, dividing, evaluating, and getting to the bottom of the situation. In other words, the methods of the descriptive approach are supported by the principles of the analytical approach.

The principles of the analytical approach encompass systematic breakdown, evidence-based examination, logical reasoning, holistic understanding, and the application of quantitative and qualitative techniques. These principles guide the process of comprehensively analyzing complex subjects and deriving meaningful insights for informed decision-making and problem-solving.

P-ISSN 2518-5764
E-ISSN 2227-703X

3. Discussion of Literature review:

3.1 Discussion of Historical Development of the Industry 4.0 Literature Review:

A study (Olaniyi, 2016) exploring this topic fills in an important gap in our knowledge of how new technologies related to Industry 4.0 might assist solve transportation problems in developing countries. This study could lead to new ways to make transportation systems more efficient, connected, and environmentally friendly. This would be in line with the global trend of technology-driven improvements. However, the complexity and variety of developing countries, which have different amounts of infrastructure, economic conditions, and technology use, could be a weakness. This complexity could make it hard to extrapolate generalizable findings and recommendations, and it would require careful contextualization to make sure that offered solutions would work and be useful.

Ghobakhloo (2018) examines the development of industrial revolutions, focusing on Industry 4.0, which combines cyber-physical and industrial production systems. The study outlines a multi-stage roadmap for the industrial sector, focusing on expertise growth, new technologies, and novel ideas. It emphasizes the importance of collaborative stakeholder involvement, workforce expansion, and regulatory reforms as facilitators, difficulties, and possibilities for Industry 4.0 implementation. The research provides manufacturers with a systematic framework to navigate the complexities of Industry 4.0 adoption, capitalize on its benefits, and improve their competitiveness and sustainability in a dynamic industrial environment.

Kaczmarczyk et al. (2018) reveal how important steam-powered mechanical tools for making things, electric mass production, and working electronic systems and computers were to the first three industrial revolutions. ,Nevertheless the Fourth Industrial Revolution is very different because it goes beyond traditional industrial production and causes big changes in many different fields. This new novel revolution brings about a paradigm shift that could change everything, including business, technical standardization, safety protocols, education systems, legal frameworks, scientific research, the way the labor market works, social structures, and all the areas that are connected to them. By going beyond industrial output, the Fourth Industrial Revolution has become a broad philosophy that could change many parts of society and the world. This is a big change from the revolutions that came before it.

The study of Robert and Ziga (2019) is an in-depth literature review that looks at the history of industrial revolutions. The study found that all industrial revolutions followed the same pattern, with slow production growth when new technologies were being made. This is caused by two things working together: the saturation of current technology and the early stages of emerging technology. The study shows that new technologies often have limited uses at first, which means that they aren't used as much as they could be. One thing that stands out is that the creation of new technologies is very expensive. This in-depth look at the challenges that drive technological progress and the transitional phases that can be seen in different industrial revolutions. This provides us valuable insights into how technology changes and what that means for economic and industrial change.

Popkova et al. (2019) view points out that all industrial revolutions have something in common and that this makes them real revolutions rather than just the results of growth in the industry. The researchers inform that one of the most important things that need to happen for an industrial revolution to happen is for a large number of completely new technologies geared toward industrial production, which they entitle “Industrial Technical Breakthroughs”, to come together. This collection of different technologies makes it possible for the economy to grow over time. As these technologies develop and reach a point where they are ready to be used in real-world industrial production. There is a major shift from focusing on numbers to focusing on quality. This insightful study looks at the basic conditions and processes that set apart industrial revolutions. It shows how do technological innovations play a key role in driving shifts from incremental progress to revolutionary changes in economic and industrial landscapes?

P-ISSN 2518-5764
E-ISSN 2227-703X

The work of Ajah et al., (2019) clarifies how the changing environment of the Fourth Industrial Revolution, which is still going on, is built on the foundations of the digital revolution, which started in the middle of the 20th century. The researchers explain what is this growing of the Fourth Revolution ?how are technologies that break down traditional boundaries among the physical, digital, and biological spheres coming together? Because of the size and complexity of these convergences, they point to a paradigm shift that goes beyond small changes and truly changes how production, management, government works? Through a conceptual exploration, the paper looks at what is the Fourth Industrial Revolution all about? what is driving it, how it fits into the context of Nigeria? and how is the demand for specific information technology skills going up? which is important in a fully digital economy? This academic discussion provides a nuanced look at the Fourth Industrial Revolution's many effects, including its potential to change things and what that means for both global and local contexts. It also talks about how the need for expertise is changing in an age of unprecedented technological convergence.

Pinheiro et al (2019) view point out that industrial revolutions are major changes in the way industries work. They are caused by theories, scientific discoveries, and improvements in technology. These revolutions are marked by new ways of using knowledge, better ways of making things, and a bigger role for technology in society. Most of the time, new problems arise when old theories and tools no longer work. To solve these problems, you need new ideas and tools. In this study, the relationship between Industry 4.0, which is based on advanced technologies and digitalization, and previous industrial revolutions is looked at. The complexity theory lens is used to look at the complex relationship between technological progress, changes in society, and economic effects during different industrial revolutions.

Ciulli (2019) provides a comprehensive exploration of the historical evolution and modern significance of tribology within industrial contexts. The study underscores tribology's pivotal role in enhancing machinery efficiency, reliability, and longevity, tracing its development from early civilizations to the contemporary Industry 4.0 era. Notably, the paper highlights how tribology addresses critical challenges including energy consumption, environmental impact, and maintenance costs. Moreover, the integration of tribology with Industry 4.0 technologies is emphasized as transformative, enabling predictive maintenance, real-time monitoring, and optimized product design. Overall, the research underscores tribology's enduring importance in shaping industries across historical epochs and into the cutting-edge landscape of Industry 4.0.

Pałaka et al (2020) get to the heart of Industry 4.0 by putting it in the context of the history of industrial changes and supporting it with a lot of existing literature. The researchers pointed out that industrial revolutions are always started by new tools or findings that make new things possible. Each change was sparked by the introduction of new skills and knowledge that sped up the growth of the industry. As progress hit a wall, the search for new ideas became the driving force. This pattern of change has been going on for hundreds of years. However, Industry 4.0 stands out by changing the way work is done in a way that its predecessors didn't. Unlike previous revolution, it doesn't just aim for full automation. Instead, it changes how do people, computers, and tools work together? This academic discussion shows how Industry 4.0 is changing by looking at its effects on work processes, communication, and the complicated relationship between technology and human knowledge from a historical point of view.

The study by Luca and Dolga, (2021) looks at how industrial systems change in the setting of the Fourth Industrial Revolution (Industry 4.0), which is coming after the Third Industrial Revolution (Industry 3.0). The researchers carefully look at the change from mechanization and automation to digitization and connectivity. Looked at the unique features and technological foundations of each step of evolution. The study focuses on the benefits of Industry 4.0, such as increased output, adaptability, and creativity. It also goes into detail about the problems and effects that come with it, such as the need to retrain workers and improve cybersecurity. Through its thorough analysis.

P-ISSN 2518-5764
E-ISSN 2227-703X

The study provides a sharp look at the key change from Industry 3.0 to Industry 4.0. This shows how the industrial sector is going through big changes. It also explains the many different opportunities and complex challenges that come with this paradigm shift. This assists us understanding how is technological innovation changing the industrial environment in a more nuanced way?

Alcácer et al. (2021) methodically follow the development of Industry 4.0, placing it in the perspective of previous industrial revolutions. They highlight the digital revolution's impact on automation and the integration of computing and networking technologies. The study emphasizes the importance of forward-thinking leadership, a skilled workforce, and well-planned infrastructure upgrades for Industry 4.0's full potential.

In conclusion, all the studies that were presented in the first aspect agreed that the first industrial revolutions (Industry 1.0, Industry 2.0, and Industry 3.0) contributed to the formation of the concept of the new revolution (Industry 4.0) through technological progress, as all revolutions share in being a response to the needs and challenges of their era. Industry 4.0represents a convergence of innovations from previous industrial eras, with a focus on automation, communications, and digitization to drive manufacturing and production processes forward. Industry 4.0 is a concept of reactive organizational and technological changes and self-management of production systems combined with the integration of value chains and the development of new business models driven by customer needs and mass customization requirements enabled by the core of the revolution represented by innovative digital technologies, connectivity, and IT integration.

3.2 Discussion of the Concept of Industry 4.0 Literature Review:

Leyh et al. (2016) offer a comprehensive view of Industry 4.0 by defining it as a transformative shift from centralized to decentralized production, marked by self-control, flexibility, and digitization of production processes and products. This paradigm is crucial in fostering information sharing along the value chain, thereby enhancing collaboration and efficiency across industries. Their emphasis on the integration and exchange of data aligns with the current trends of interconnectedness. The research on SIMMI 4.0, a maturity model for classifying enterprise-wide IT and software landscape with a focus on Industry 4.0, provides a structured approach for organizations to assess and align their IT systems with Industry 4.0 requirements to promot data exchange and collaboration. However, challenges may arise from implementation complexity, variations in industries, technologies, organizational cultures, and a learning curve. Despite these challenges, SIMMI 4.0 can drive efficient IT system integration and can be mitigated through careful planning and customization.

Roblek et al (2016) provide a full picture of Industry 4.0, showing how it has many different parts and affects many different areas. Their definition highlights important areas like digitalizing production, automating it, using management information systems, and collecting data. All of these things assist to make manufacturing processes more efficient and connected across supply lines. When the main parts of Industry 4.0 are broken down such as smart factories, new product development systems, and cyber-physical systems, the roles of technology-driven creativity, self-regulation, and human adaptation become clear. This big-picture view shows how all of these parts are linked and how they could change industries by combining technology, information, and people's ability to adapt to a digital world that is changing quickly.

Crnjac et al (2017) delve into the evolution of the Industry 4.0 concept, tracing its trajectory from inception to practical implementation. The study looks closely at the basic ideas that make up Industry 4.0. These include advanced digital technologies, connection, automation, and sharing data. Explores how these ideas have changed manufacturing and other industries by making it possible to make decisions based on data in real time, for machines to talk to each other easily, and to set up clever production systems. The study also looks into how Industry 4.0

P-ISSN 2518-5764
E-ISSN 2227-703X

is changing different industries, as well as the challenges and opportunities it brings. In the end, the study seeks to provide a full picture of Industry 4.0's journey, showing how it went from being an academic idea to a major force in modern industrial practices.

Saucedo et al, (2017), shows how Industry 4.0can change things by combining technology, people, and processes to make a dynamic and responsive ecosystem that changes the way businesses work. This whole system makes it possible for things, services, and data to move smoothly through the value chain. It encourages independent processes and provides detailed, actionable information to assist people for making smart decisions.

Ebru et al. (2017) emphasize the trajectory of Industry 4.0 development and define it as the implementation of intelligent, self-controlled, and interconnected processes and systems. The researchers underscore the pivotal role of utilizing smart and networked technologies in initiating creative activities. These technologies are seen as integral to elevating the value of manufacturing by rendering processes more flexible, reliable, and efficient. The focus on harnessing these advancements aligns with the essence of Industry 4.0, which revolves around the integration of intelligent systems and technologies to catalyze innovation and productivity across industries.

Nosalska et al. (2019) highlight the discernible impact of Industry 4.0 on the global manufacturing landscape, evident in the growing adoption of digital technologies by companies worldwide. While extensively studied, the lack of a universally accepted and succinct definition remains a challenge, resulting in diverse terminologies. The author employs terms such as “Industry 4.0” to signify a “concept”, “program”, “phenomenon”, and “idea”, with “concept” emerging as the most prevalent and widely used within the academic community. This sheds light on the nature of Industry 4.0 discourse and the ongoing effort to encapsulate its transformative essence, prompting ongoing discussions about its multifaceted manifestations and implications for industries. A structured framework for understanding complex phenomena can help people communicate better, make better decisions, and bridge the gap between technological advances and organizational effects. However, combining these aspects into a single framework can be challenging, leading to simplicity or adaptability issues. Achieving a balance between technological information and organizational operations requires careful calibration and consideration of different industries and situations. This study has the potential to provide valuable insights on aligning technological innovations and organizational strategies but requires customization and consideration of specific situations.

The study by Silva et al., (2019) show some important benefits and things to think about. On the plus side, the study's focus on how Industry 4.0 is used in different companies that provide us important information about how cutting-edge technologies like automation, data interchange, and the Internet of Things are used in the real world. By looking into the problems, benefits, and results that businesses face after adopting Industry 4.0, the study provides the theoretical ideas a more real-world feel. By looking at a wide range of industrial cases, the study assist us understanding the real effects and effectiveness of Industry 4.0 in different situations. It also shows the strategies, successes, and problems that organizations face as they try to figure out how to use these new technologies. Nevertheless, the specificity of the cases studied could be a problem because they might not cover the full range of Industry 4.0 uses. Also, the study may need more synthesis to find larger patterns or insights because it focuses on real-world cases. Still, the study is a useful link between theory and practice. It shows what are the real-world effects of Industry 4.0 technologies as well as the practical challenges and opportunities that businesses face them?

The study (Chaitanya, 2020) on Industry 4.0 highlights the potential of new technologies and digitization in the industrial sector. It highlights the need for training workers and organizations to adapt to Industry 4.0, which involves real-time data collection, handling, analysis, and cybersecurity. However, current literature may not cover the latest changes and the need for worker skills improvement. The study provides a comprehensive understanding of

P-ISSN 2518-5764
E-ISSN 2227-703X

Industry 4.0 and emphasizes the importance of collaboration between humans and machines for successful implementation.

Salah et al. (2020) offer notable advantages and considerations. On the positive side, the research addresses a critical need for effective pedagogical approaches to teach the intricate concepts of Industry 4.0 to students of industrial engineering. The project's objective to equip industrial engineering students with the knowledge and skills necessary to navigate the challenges and opportunities presented by Industry 4.0 aligns with the evolving demands of the job market and the industrial landscape. However, potential limitations could arise from the need to continuously update instructional content due to the rapid evolution of Industry 4.0. Moreover, the research's effectiveness in achieving its educational goals would need to be assessed through the actual application of the proposed instructional approaches. Despite these considerations, the research stands to significantly contribute to bridging the knowledge gap between industrial engineering education and the transformative requirements of Industry 4.0, fostering more prepared and adaptive graduates.

Wgrzyn (2020) study brings up several good points and things to think about. The study digs deep into the important effects of the Industry 4.0 paradigm, such as how digitization, automation, networking, and data sharing are changing the manufacturing industry in revolutionary ways. The study of changes in production methods, supply chain management, employee roles, and industrial operations provides us useful information about how Industry 4.0 technologies will change things. However, it might be hard to keep up with the fast and constant changes in the ever-changing Industry 4.0 landscape, which could make it possible that some of the results will change over time. Also, even though the study wants to shed light on the big changes, it might need a closer look at specific case studies or real-world applications to provide a more complete picture of the challenges and possibilities that come with using Industry 4.0. Still, the study assists us to learn more about how Industry 4.0 is changing the manufacturing industry by shedding light on its potential to change things.

Rupp et al (2021) take valuable contributions and considerations. On the positive side, the study's focus on defining Industry 4.0 from a technological standpoint offers a structured and clear perspective on its fundamental components. The identification of key technological elements serves as an invaluable guide to understanding the core technologies driving Industry 4.0. The comprehensive analysis of scholarly articles enhances the credibility of the findings and ensures a broad exploration of perspectives. However, potential limitations could arise from the possible omission of emerging or less-discussed technologies that might also be influential in Industry 4.0. Moreover, the study's technological focus might not fully encompass the organizational and human aspects that are equally vital for Industry 4.0 successful implementation. Nonetheless, the research effectively maps out the technological landscape of Industry 4.0, offering an insightful foundation for further investigations into its practical applications and implications.

Yang and Gu (2021) provide important ideas and points to think about. On the plus side, the study shows how all-encompassing the Industry 4.0 revolution is by pointing out how both new technologies and effective national strategies are needed. By showing how is important it for countries to have comprehensive plans that include the adoption of technology as well as policies, regulations, infrastructure, and the development of skills? The study adds to our understanding of the many steps that need to be taken to fully embrace Industry 4.0. The focus on using technologies like digitization, robotics, artificial intelligence, and communication shows how are they important to the transformative potential of Industry 4.0? On the other hand, it could be hard to put different strategies into place and make sure they work together in different countries with different contexts and goals. Still, the study is helpful for countries that want to take advantage of the opportunities offered by the Industry 4.0 revolution by combining the use of technology with well-thought-out national strategies.

P-ISSN 2518-5764
E-ISSN 2227-703X

Kozlovska et al. (2021) contain several advantages and considerations. The research's thorough study of the literature allows for a full look at how Industry 4.0 ideas are being used and changed in the construction industry. By looking at things like digitalization, automation, and data sharing, the study provides useful information about how are these new technologies changing the way building is done? The study also shows how has Industry 4.0 technology the potential to change the building industry in a big way, boosting productivity, collaboration, and creativity. However, it might be hard to keep up with how quickly Industry 4.0 technologies and how are they used in the building industry and changed? This could be a problem. Even though the literature review provides a synthesis, practical case studies or empirical data could have given more nuanced information about how Industry 4.0 affected the growth of the "Construction 4.0" idea.

Nunes et al. (2022) have a lot of good points and things to think about. On the plus side, the study shows how is important to understand the ideas and scope of Industry 4.0 and to share knowledge and make the change in smart manufacturing. The systematic method of the study, which is based on a lot of previous research, makes it possible to look at the effects and challenges of Industry 4.0 in the manufacturing sector in depth. The study shows how technological advances like automation, data analytics, and the Internet of Things can change the way Industry 4.0 works. It also looks at how these changes affect industrial processes and practices. Good things (increased speed), new ideas, and problems (skill gaps and worries about cybersecurity), provide a balanced view of the subject. Many different ways of Industry 4.0 could affect manufacturing to make clear by describing possible effects in different areas and pointing out potential problems. However, relying on the current literature could be a problem because it might not cover the most recent changes and nuances of the rapidly changing landscape of Industry 4.0. Even though the goal of the study is to provide a complete picture, practical case studies could add to their results by showing how they can be used and what they mean in the real world. Still, study is a big part of understanding the complicated relationship between Industry 4.0 and manufacturing. It shows how it could change things and what obstacles need to be overcome for it to work.

There are many reasons to value findings(Brisco, 2022). Positively, the study dives into the vital idea of digital transformation within the context of Industry 4.0, addressing the adaptability needed by organizations to deal with ever-changing conditions. The importance of this study in today's ever-changing environment is highlighted by its emphasis on understanding the digital disruption brought by Industry 4.0. The research sheds light on the many facets of digital transformation through investigating its causes and characteristics as well as the degree to which firms are ready for change. To better appreciate how technology is reshaping businesses, it is helpful to examine how Industry 4.0 technologies are influencing business models, operations, and interactions. However, there may be restrictions due to the difficulty of the topic, as digital transformation covers a wide range of fields and settings. Despite this, the study makes a sizable contribution to revealing the disruptive potential of Industry 4.0 technologies, illuminating how are companies rethinking their strategies, introducing innovations, and reimagining their connections to suppliers and customers in the rapidly changing digital era?

Finally, from studying the historical development and the concept of Industry 4.0, it became clear to us that it included two groups of integrated factors that formed the concept. The first group is related to technological factors, which are a common factor in all revolutions. The technologies of Cyber-Physical Systems and the Internet of Things are among the most prominent technologies that lead to the realization of a smart factory that produces goods that meet or exceed customer expectations. These technologies also work by creating a network that allows communication between the parties of the network in real-time, and this contributes to make independent decisions, along with a set of other technologies that allow the operation of production systems that are characterized by their intelligence because they are linked to the network and with each other.

P-ISSN 2518-5764
E-ISSN 2227-703X

As for the second set of factors related to business models, realizing the dimensions of Industry 4.0through the realization of comprehensive horizontal, vertical, and engineering integration leads to the integration of the value chain across the entire network as a result of real-time communication, data collection, and processing capabilities, along with intelligent decision support systems such as these. This environment provides rise to new methods of creating value, leads to the emergence of new business models, and achieves the primary goal of producing smart goods and services.

4. Conclusions:

The reasons that led to the fourth era of the industrial revolutions are due to a group of different interrelated factors, including technological progress, economic factors, changing consumer expectations, government initiatives, and the availability of data. These factors converge to create an enabling environment for the adoption and integration of transformative technologies, leading to the emergence of Industry 4.0. This revolution has characteristics that distinguish it from previous industrial revolutions, including seamless communication between machines, devices, systems, and even individuals. This is because connection allows for the exchange of data in real-time, blurring the lines between the physical and digital worlds through electronic physical systems, making better decisions through data analytics and artificial intelligence to derive insights from huge amounts of data generated by interconnected devices. It is decentralized decision-making unlike previous revolutions where decision-making was centralized. Industry 4.0 enables individual devices and components from independent decision making leading to more agile and responsive systems, mass personalization, and human-machine collaboration.

There is a need for the adoption of Industry 4.0 technologies by local industrial organizations to catch up with the global community, as they lead to higher productivity, enhance competitiveness, create new jobs, foster innovation, and contribute to economic growth and development. Embracing these transformative technologies is essential for businesses and economies to thrive in an ever-changing global landscape. Since there is a global interest through strategic initiatives to adopt digitization technologies by global industrial organizations, it is not a media bubble or a phenomenon that lasts for a while and ends. However, a revolution in the field of technology and manufacturing methods is based on foundations and principles. This is a subject that should be addressed in conceptual and empirical studies to bridge the knowledge gap.

Authors Declaration:

Conflicts of Interest: None

-We Hereby Confirm That All The Figures and Tables In The Manuscript Are Mine and Ours. Besides, The Figures and Images, Which are Not Mine, Have Been Permitted Republication and Attached to The Manuscript.

- Ethical Clearance: The Research Was Approved By The Local Ethical Committee in The University.

References

1.Ajah, I. A. and Chigozie-Okwum, C. C. (2019). Exploring the Benefits of the 4th Industrial Revolution: The Nigerian Experience. *International Journal of Science and Technolog.* Vol. 8 (1), No.17. pp. 22-23. DOI: http://dx.doi.org/10.4314/stech.v8i1.3.

2.Alcácer, V., Rodrigues, C., Helena, C. and Virgilio C. (2021). Tracking the Maturity of Industry 4.0: the Perspective of a Real Scenario, *The International Journal of Advanced Manufacturing Technology.* Vol. 116. pp. 2161–2181. DOI.org/10.1007/s00170-021-07550-0.

3.Brisco, R. (2022). Understanding Industry 4.0 Digital Transformation. International Design Conference. Published online by Cambridge University Press. pp. 2423-2432. Doi.Org/10.1017/Pds.2022.245.

4.Chaitanya, V. B. (2020). A Study on Industry 4.0 Concept, *International Journal of Engineering Research & Technology* (IJERT). Vol. 9, No. 04. pp. 613-618.
5.Ciulli, E. (2019), Tribology and Industry: From the Origins to 4.0, *Journal Frontiers in Mechanical Engineering*, Vol.5. 1-12. DOI: 10.3389/fmech.2019.00055.
6.Crnjac, M., Veža, I. and Banduka, N. (2017). From Concept to the Introduction of Industry 4.0. *International Journal of Industrial Engineering and Management* (IJIEM). Vol. 8. No. 1, pp. 21-30.
7.Ebru, G., Umut, Ş. and Eren, P.E. (2017). Software Process Improvement and Capability Determination. *SPICE „* CCIS 770, pp. 128-142. DOI: 10.1007/978-3-319-67383-7_10.
8.Gajdzik, B., Grabowska, S. and Saniuk, S. (2021). A Theoretical Framework for Industry 4.0 and Its Implementation with Selected Practical Schedules. *Energies*, Vol. 14.No. 940. Pp. 1-24. doi.org/10.3390/en14040940.
9.Ghobakhloo, M. (2018). The Future of Manufacturing Industry: A Strategic Roadmap Toward Industry 4.0". *Journal of Manufacturing Technology Management.* Vol. 29 No. 6, pp.910-936, DOI 10.1108/JMTM-02-2018-0057.
10. Kaczmarczyk, B., Václav O., Zdeněk, B. and Jakub A. (2018). An Industry 4.0 Testbed (Self-Acting Barman): Principles and Design. *IFAC PapersOnLine.* Vol.51. No.6 .pp.263–270.
11. Kang, H. S., Ju Y. L., Sang S. C., Hyun K., Jun H. P., Ji Y. S., Bo H. K., and Sang D. N. (2016). Smart Manufacturing: Past Research, Present Findings, and Future Directions. *International Journal of Precision Engineering and Manufacturing-Green Technology*, Vol. 3. pp. 111–128. DOI: 10.1007/s40684-016-0015-5.
12. Kozlovska, M., Klosova, D. and Strukova, Z. (2021). Impact of Industry 4.0 Platform on the Formation of Construction 4.0 Concept: A Literature Review. w. *Sustainability*, Vol. 13. No. 2683.pp. 1-15. https://doi.org/10.3390/ su13052683.
13. Krajewski, L. J. and Malhotra, M. K.(2022), Operations Management: Processes and Supply Chains, 13th edition, Published by Pearson Education.
14. Leyh, C., Schäffer, T., Bley, K. and Forstenhäusler, S. (2016), SIMMI 4.0: a Maturity Model for Classifying the Enterprise-Wide IT and Software Landscape Focusing On Industry 4.0, Proceedings of the Federated Conference on Computer Science and Information Systems, pp. 1297-1302.
15. Luca, D. and Dolga, V. (2021), From Industry 3.0 to Industry 4.0, *The International Journal of Engineering and Science (IJES)*, Vol., 10, No. 9, PP 44-49. DOI:10.9790/1813-1009014449.
16. Nosalska, K., Piątek, Z., Michał, M., and Rządca, R. (2019). Industry 4.0: Coherent Definition Framework with Technological and Organizational Interdependencies, *Journal of Manufacturing Technology Management*, Emerald Publishing Limited. Pp. 1-26. DOI 10.1108/JMTM-08-2018-0238.
17. Nunes, T., Fernanda B., Zanini, R. R., Rosa, A. F., Porto, V. and Lizandra G. L. (2022). Impacts and challenges of industry 4.0 in manufacturing: a systematic literature review. *The Journal of Engineering and Exact Sciences*, Vol. 08. No. 11.pp. 1-17. Doi.org/10.18540/jcecvl8iss11pp16294-01e.
18. Olaniyi, A. A. (2016). Impacts of the Fourth Industrial Revolution on Transportation in the Developing Nations. *International Journal of African and Asian Studies*, Vol.26. pp.67-73.
19. Pałaka, D., Paczesny, B., Gurdziel, M., and Wieloch, W. (2020), Industry 4.0 in Development of new Technologies for Underground Mining. E3S Web of Conferences 174, 01002 (2020) Vth International Innovative Mining Symposium. doi.org/10.1051/e3sconf/202017401002.
20. Pinheiro, P., Graeml, A R and Jurandir, P. (2019), Industry 4.0 and Industrial Revolutions: an Assessment based on Complexity, *Faculty of Mechanical Engineering*, Belgrade, Vol. 47, No 4. Pp.1-17. DOI:10.1080/0951192X.2020.1736714.

21. Popkova, E. G., Yulia V. R. and Aleksei V. B. (2019). Fundamental Differences of Transition to Industry 4.0 from Previous Industrial Revolutions", in Popkova, Elena G., Industry 4.0: Industrial Revolution of the 21st Century", Pp.21-30, Published by Springer.
22. Ramakrishna, S., Khong, T.C. and Leong, T.K. (2017). Smart Manufacturing. *Procedia Manufacturing*, Vol. 12, pp. 128-131. DOI: 10.1016/j.promfg.2017.08.017.
23. Robert, K. and Ziga T. (2019), Construction 4.0–Digital Transformation of One of the Oldest Industries. *Economica And Business Review*, Vol. 21, No. 3, 393-410. DIO.org/10.15458/ebr.92.
24. Roblek, V., Meško, M. and Krapež, A. (2016). A Complex View of Industry 4.0. *SAGE Open*, Vol. 6, No. 2, pp. 1-11. DOI: 10.1177/2158244016653987.
25. Rupp, M., Max, S., Markus M., Rainer B., and David, K. (2021). Industry 4.0: A Technological-Oriented Definition Based on Bibliometric Analysis and Literature Review. *J. Open Innov. Technol. Mark. Complex*., Vol.7, No. 68. Pp. 1-20. https://doi.org/10.3390/joitmc7010068.
26. Salah, B., Khan, S., Ramadan, M. and Gjeldum, N. (2020). Integrating the Concept of Industry 4.0 by Teaching Methodology in Industrial Engineering Curriculum. *Processes*, Vol. 8, 1007. Pp. 1-16. doi:10.3390/pr8091007.
27. Saucedo Martinez, J. A., Magdiel P., José A. M., Tomás E. S. and Pandian V. (2017). Industry 4.0 Framework for Management and Operations: A Review, *Journal of Ambient Intell Human Comput*, published by springer, DOI 10.1007/s12652-017-0533-1.
28. Silva, V. L., João L. K., Regina N. P., Jaqueline D. S. and Alana C. (2019). Implementation of Industry 4.0 Concept In Companies: Empirical Evidences, *International Journal of Computer Integrated Manufacturing*, pp.1-18. DOI: 10.1080/0951192X.2019.1699258.
29. Wang, S., Wan, J., Li, D., and Zhang, C. (2016). Implementing Smart Factory of Industrie 4.0: An Outlook. *International Journal of Distributed Sensor Networks*. Vol. 2016, Article ID 3159805, pp1-10. http://dx.doi.org/10.1155/2016/3159805.
30. Węgrzyn, G. (2020). Structural Changes in the Manufacturing Sector as an Effect of Implementing the Concept of Industry 4.0. *Studies of the Industrial Geography Commission of the Polish Geographical Society*. Vol. 34. No. 4. pp·114- 125. DOI 10.24917/20801653.344.7.
31. Yang, F. and Gu, S. (2021), Industry 4.0, A Revolution That Requires Technology and National Strategies, *Complex & Intelligent Systems*, Vol. 7. Pp. 1311–1325, https://doi.org/10.1007/s40747-020-00267-9.
32. Zhou, K. (2015), Industry 4.0: Towards Future Industrial Opportunities and Challenges, 12th International Conference on Fuzzy Systems and Knowledge Discovery (FSKD), published by IEEE.

Journal of Economics and Administrative Sciences
2024; 30(141), pp. 154-172

P-ISSN 2518-5764
E-ISSN 2227-703X

الثورة الصناعية الرابعة: مراجعة تاريخية ومفاهيمية

بسمه مهدي حمد
جامعة بغداد / كلية الادارة والاقتصاد/ قسم ادارة الاعمال
بغداد/ العراق
basma.mahdi@uobabylon.edu.iq

مها كامل جواد
جامعة بغداد / كلية الادارة والاقتصاد/ قسم ادارة الاعمال
بغداد/ العراق
maha.k@coadec.uobaghdad.edu.iq

Received:2/7/2023 **Accepted: 10/9/2023** **Published Online First: 30 /6/ 2024**

مستخلص البحث:

يرتبط التقدم الاقتصادي والاجتماعي للبلدان في جميع أنحاء العالم بتنمية الصناعة. كما وتسعى المنظمات الصناعية إلى تحسين عملياتها الإنتاجية لمواجهة التغيرات المستمرة في طلبات الزبائن ومواصفات السلع فضلاً عن تحسين المنافسة الشديدة في السوق، من أبرز التحديات التي تواجهها المنظمات هي التطورات التكنولوجية الرقمية التي تلعب دوراً مهماً في تحسين عمليات الإنتاج وجعلها أكثر مرونة وكفاءة من خلال اعتماد التقنيات الحديثة كاستجابة حتمية للابتكار والتطوير التكنولوجي. وفقاً لقادة التصنيع في العالم، فإن التطورات تتمثل في ظهور ثورة جديدة في التصنيع، يشار إليها بالثورة الصناعية الرابعة، والتي سيكون لها تأثير مباشر على الحياة الاجتماعية وقد حظيت باهتمام الأوساط الأكاديمية والصناعية، فهي تمثل عملية تحويل عمليات الإنتاج إلى الرقمنة الكاملة، وتقع على عاتق المجتمع الأكاديمي مسؤولية توضيح المفهوم والأسباب التي أدت الى حدوثها.

تهدف هذه الورقة إلى تقديم لمحة عامة عن التطور التاريخي للثورات الصناعية التي أدت إلى ظهور (الصناعة 4.0) ، مع عرض للمبادرات الدولية في هذا الصدد ومناقشة أبرز المقترحات حول مفهومها. تم استخدام التحليل النوعي القائم على مراجعة الأدبيات لتحقيق الهدف والإجابة على السؤال: كيف أدى التطور التاريخي لـ (الصناعة 4.0) إلى ظهور المفهوم وتطوره، وما هي الخصائص الأساسية التي تميزه عن الثورات الصناعية السابقة؟ اذ تعود الأسباب التي أدت إلى العصر الرابع للثورات الصناعية إلى مجموعة من العوامل المترابطة المختلفة، بما في ذلك التقدم التكنولوجي ، والعوامل الاقتصادية ، وتوقعات المستهلكين المتغيرة ، والمبادرات الحكومية، وتوافر البيانات.

نوع البحث: مراجعة أدبية.

المصطلحات الرئيسة للبحث: الثورة الصناعية الرابعة، الصناعة 3.0، الصناعة 2.0، الصناعة1.0، مفهوم الصناعة4.0.

* البحث مستل من اطروحة دكتوراه (رقمنة عمليات الانتاج على وفق متطلبات الثورة الصناعية الرابعة)