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Using AI to Build Smart Factories and Their Impact On the Sustainable Development of Society

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Abstract

Artificial intelligence has a substantial impact on the development of smart factories. Companies can improve production efficiency, flexibility and productivity by implementing various AI technologies such as machine learning, data analysis, automation and robotics. Artificial intelligence enables automation and optimisation of production processes to increase product quality and reduce production customisation costs and time. With communication technologies, intelligent factories can connect different systems and devices in the Internet of Things, enabling real-time monitoring and analysis of data and rapid responses to changes in the production environment. In addition, artificial intelligence analyses data that can help predict problems in production processes, optimise production and adjust production according to demand and various parameters. That makes intelligent factories more flexible and agile, which is crucial in a modern dynamic world. With artificial intelligence, intelligent factories can become more thoughtful, innovative and competitive, making significant advances in industrial development.

Keywords: smart factories, smart manufacturing, industry 4.0, artificial intelligence, sustainable development, progress, internet of things

INTRODUCTION

Smart factories are the industry's future, and we need to understand their embeddedness in society as an integral part of it and a necessity to maintain stability and progress. Transforming traditional factories into smart ones is a long-term process, as companies and countries often underestimate the investment in Industry 4.0. In most cases, companies are sceptical at the start of the transformation, as the benefits of digitisation, automation and robotics are not visible in real-time because only the results of more detailed analyses for each work process can show in which areas the new technology enables progress and savings. It is essential to find individual solutions for each process, which means a significant investment by companies in technology and human capital. Companies that wanted to take the easy route and invested only in advanced technologies rather than human resources to make it easier to manage advanced systems did not choose the right approach. Companies quickly realised that investing in new advanced technologies and the human capital that manages them was essential. Smart factories will enable a more competitive and innovative industry that can adapt quickly to change and meet market demands (Dixon, 2024).

The industry is witnessing increasing pressure to improve its agility and versatility to adapt to highly modularised, customised and dynamic production requirements. Key concepts within Industry 4.0 have emerged as a significant focus in the manufacturing sector in response to the rise of digitisation and smart manufacturing, as it is becoming a central pillar of digital transformation. With the advancement of big data technology, data-driven modelling with artificial intelligence (machine and deep learning) will improve product quality and increase production efficiency through self-optimisation and predictive actions (Ryalat, ElMoaqet and AlFaouri, 2023).

Sustainability is a multidimensional concept encompassing megatrends in three categories: environmental, which includes climate change, emissions and energy and resource scarcity; social, which illustrates demographic change and human well-being; and economic, which focuses on value creation and developing new business models. Innovative factory technologies improve energy management and emissions reduction, optimise resource efficiency and support workplace well-being. They also create more opportunities for innovation and improvements in services and products (Mehdi Sajadieh, Ho Sin, and Do Noh, 2022).

Environmental disruption, climate warming, and air and water pollution increasingly affect people's lives and health, and energy and resource scarcity burden production and policymakers. Traditional production does not meet current environmental requirements, consuming the resources of future generations and damaging the environment. Therefore, sustainability is paramount, leading to sustainable manufacturing development (Meng, Yang, Chung, Lee and Shao, 2018).

Flegel (2018) argues that resource efficiency is not just a necessity but leads to new materials, technologies and business models. The need to reduce transport and logistics costs is driving the trend towards urban manufacturing. Circular economy trends are slowly materialising due to political decisions, market dynamics and consumer behaviour, mainly by extending the life cycle of products through service, repair and reuse.

The research focuses on theoretical and practical starting points based on a review of scientific literature, data from companies working on such systems and personal experience and knowledge in smart factories, smart manufacturing in production processes, sustainable development, knowledge creation, artificial intelligence and modern advanced technologies. The key driver of the research is to introduce the concept of smart factories, artificial intelligence, and its systems, thus contributing to the awareness and necessity of the spread of intelligent factories. The research aims to underline the importance of the spread of smart factories that strive for continuous education and sustainable development of society. The study aims to understand the importance of society at the national level, emphasising the necessity of shared responsibility and the realisation of long-term sustainable development by positioning smart factories as an aspect of modern society.

The research asked ourselves two research questions:
- RV1: How can smart factories contribute to sustainable development?
- RV2: To what extent do the advantages of smart factories allow them to expand?

OVERVIEW OF INDUSTRIAL REVOLUTIONS

The world has been marked by four industrial revolutions, and from the early machine tool process to today's automated manufacturing industry, the manufacturing industry has made great strides. Through

numerous inventions and repeated experiments, manufacturing and industrialisation systems have reached their fourth generation of industrial revolution (Groumpos, 2021).

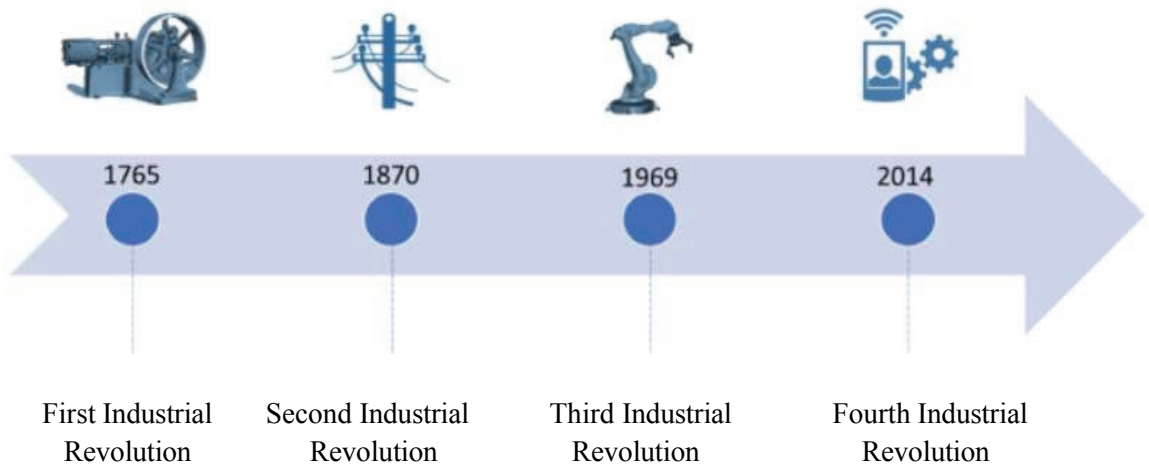

Figure 1: Chronology of Industrial Revolutions
Source: Fuyal, Bista in Bista, 2020.

The Industrial Revolution began in the United Kingdom. In the first half of the 18th century, cotton was developed from a working-class cottage industry to a machine-based economy. James Hargreaves discovered the spinning jenny in 1764 and stimulated the emergence of machine processing. The invention of coal, iron and textiles was crucial for the first Industrial Revolution. The invention of the steam engine created a new type of energy (Phuyal, Bista and Bista, 2020).

The centralisation of research and capital was structured around an economic and industrial model based on new large factories during the second economic revolution between 1830 and 1914. Technological progress led to the emergence of a new source of energy, electricity, gas and oil, and consequently, the internal combustion engine. Chemical synthesis was developed, bringing synthetic fabrics, dyes and fertilisers. Chemistry also started with new artificial materials such as antiseptics, disinfectants, phenol, and silicic acid. Electric generators, vacuum pumps, gas-powered lighting systems, and electrical transformers only deepened technological development (Phuyal, Bista and Bista, 2020).

The period after 1969 is known as the Third Economic Revolution, as electromechanical systems were upgraded to computer-based control systems with PLCs. Industrial robots were a vital invention and their implementation in industrial automation. Transistors, microprocessors, telecommunications, nuclear power and computers were developed during this period, leading to space exploration (Phuyal, Bista and Bista, 2020).

In 2011, a group of business politicians and academic experts coined the term Industry 4.0 as the fourth industrial revolution to boost Germany's competitiveness in manufacturing, with a strong focus on interconnectivity through the Internet of Things, machine learning and real-time data processing. Industry 4.0 includes artificial intelligence, automated robots, flexible manufacturing automation systems, additive manufacturing and augmented reality (Phuyal, Bista and Bista, 2020).

Industry 5.0 is seen as a new production model that focuses on the interaction between people and machines and fosters collaboration between increasingly precise machines and the innovative potential

of people. For more sustainable production, developed processes that re-purpose and recycle resources and reduce the environmental impact of manufacturing industries. Smart manufacturing allows designers to protect files in the cloud with robust access control and use manufacturing resources in different locations. Industry 5.0 is an innovative technology that enables 3D symmetry in a designed innovation system. The future direction for Industry 5.0 helps to keep people at the centre of the system and technologies (Adel, 2022).

THE POWER OF ARTIFICIAL INTELLIGENCE IN SMART FACTORIES

European companies are revamping their production processes by adopting automation and artificial intelligence capabilities that make factories more innovative and sustainable. European manufacturers are exploring emerging technologies that enable intelligent products and solutions provided by smart factories with Industry 4.0 connectivity. There is an increasing focus on implementing supply chain sustainability strategies due to government pressure worldwide (Metrology News, n.d.).

Deep learning, part of the machine learning family, is gaining importance in academia and industry. Inspired by the structure of the human brain, deep learning primarily uses multi-layer neural networks to classify data and predict trends. The rapid development of computational capabilities reduces the time and makes it feasible to obtain results and analytics in real time. In manufacturing, machine learning applications can be divided into the following aspects: quality control, fault diagnosis by detecting, identifying and estimating the size of the fault, predictive analytics for failure prediction, condition monitoring and service or operation planning. However, if the technology is intelligent in other aspects but energy-expensive, it isn't easy to apply it more widely (Meng, Yang, Chung, Lee and Shao, 2018).

Smart factories can create, acquire, classify, share and apply knowledge to increase global market efficiency and competitiveness. Integrated software is an interconnected suite of multiple applications that share a common database and user interface and deal with accounting, finance and inventory management tasks. An innovative method of collecting and processing big data, it mainly uses analytical tools that comprise the display of information for support and decision-making. The Internet of Things (IoT) is a dynamic global network of physical objects, systems, platforms, and applications that can communicate and share intelligence, the environment and people. A cyber-physical system is a combination of computing and physical processes in the form of embedded systems and networks to monitor the control of physical processes. Cloud computing includes tools and applications such as data storage, servers, databases, networking and software that provide access to computing resources over a network. Neural networks are a collection of algorithms modelled on the human brain and used to identify patterns by interpreting data obtained from different sensors. Direct machine-to-machine communication is a technology that uses ICT to connect machines in various locations, most of which are controlled by software. Cybersecurity protects systems, networks, and software applications during digital attacks, and it is usually designed to access, monitor, and destroy sensitive information. Artificial intelligence is the ability of a digital computer or computer-controlled robot to perform tasks typically associated with a human. Digitisation usually refers to taking analogue information and encoding it into zeros and ones so that computers can store and process the data (Adamik and Fernandez, 2021). networks and software applications during digital attacks, usually designed to access, monitor and destroy sensitive information. Artificial intelligence enables a digital computer or a computer-controlled robot to perform tasks typically associated with a human. Digitisation usually refers to taking analogue information and encoding it into zeros and ones so that computers can store and process the data (Adamik and Fernandez, 2021).

New generations of intelligent factories will support new multi-species and small-batch customised production methods. Artificial intelligence enables higher value-added production by accelerating the integration of manufacturing and information and communication technologies, including computing, communication and control. The characteristics of a customised smart factory are self-sensing, performance optimisation, dynamic reconfiguration and intelligent decision-making. AI technologies will enable manufacturing systems to sense the environment, adapt to external needs and acquire process knowledge, including business models such as intelligent manufacturing, network collaboration and extended service models. That enables the concept of an AI-driven architecture for customised smart factories to be realised. State-of-the-art AI technologies allow the operation of smart factories based on intelligent manufacturing equipment, intelligent information system interactions, flexible production line design, machine learning, the Internet of Things and support for big data. Businesses are offered the possibility to increase production flexibility and efficiency with the support of AI (Wan, Li, Dai, Kosiak, Martinez-Garcia and Li, 2020).

DEFINITION OF SMART FACTORY

A smart factory is a cyber-physical system that uses advanced technologies for data analysis, automated process control and continuous learning. An intelligent factory interconnects a network of machines, communication mechanisms and computing power. Smart factories and smart manufacturing are part of a technological transformation known as Industry 4.0 or the Fourth Industrial Revolution. The first three Industrial Revolutions were born out of innovative new technology that completely changed how we work and produce, starting with the steam engine, the conveyor belt and the computer's power. Today, the fourth revolution is driven by digital transformation and intelligent automation (SAP, n.d.).

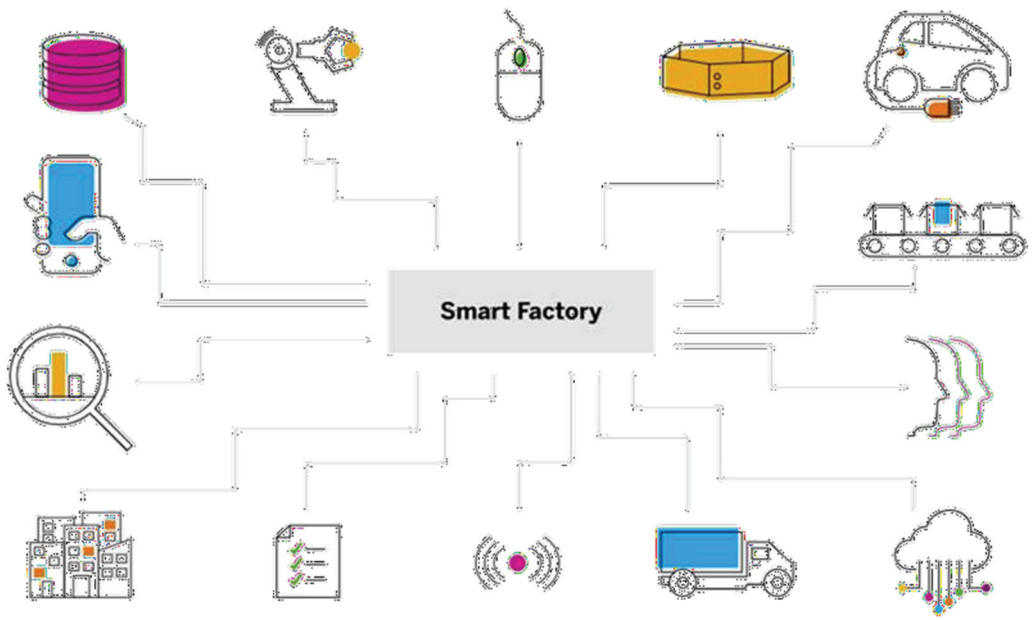

Figure 2. Operation of the smart/intelligent factory
Source: SAP, n.d.

An intelligent digital factory combines machines, people and large databases into a single, digitally connected ecosystem. A smart factory not only organises and analyses data but it also learns from experience. It interprets and extracts insights from data sets to predict trends and events and to recommend and implement workflows and automated processes for intelligent manufacturing. The

smart factory is subject to continuous process improvements for self-management and self-optimisation as it can learn to be more resilient, productive and safe (SAP, w.y.).

Biela-Weyenberg (2023), in his article, states that an intelligent factory uses interconnected systems and machines to generate data, often in real-time, to improve end-to-end production processes and help machine operators, line supervisors, engineers, company managers and other decision-makers. The author states that factories have used robotics and automation for many years. However, these devices are not considered part of an intelligent factory unless they use fully integrated systems and machines that combine the physical and digital worlds.

SMART MANUFACTURING

IoT-enabled manufacturing process monitoring is a critical component of smart factory operations in improving the quality of the parts produced. By harnessing data from connected devices and sensors, factories can optimise production processes, reduce downtime and enhance product quality to increase production efficiency and profitability. Monitoring the production process in smart factories involves collecting data from sensors and devices installed on production lines and equipment (Adamik and Fernandez, 2021).

This data can track key performance indicators such as production, machine utilisation and product quality. Factory managers can quickly identify bottlenecks, inefficiencies, and other parameters affecting the production process by monitoring this data in real time. Devices and sensors that support the Internet of Things (IoT) can monitor and control various aspects of the production process, including production lines, machines, equipment, and other inventory. Sensors can monitor temperature, humidity and other environmental conditions in the factory. Another example of monitoring the production process is monitoring the supply chain during the actual production process, such as tracking inventory levels, monitoring the supply chain in terms of part production optimisation process, transporting raw materials and finished products throughout the factory and the supply chain (Soori, Arezoo and Dastres, 2023).

Smart manufacturing can be defined as a combination of intelligent use of people capabilities, technology use, and the deployment of a self-learning manufacturing system. Intelligent manufacturing entities focus on customer-oriented product quality, service, delivery times and reliability through a manufacturing organisation that is flexible, digitised, automated and fully integrated with the organisation and the value chain. The aim is to create maximum efficiency, flexibility and value creation for machine operators and other employees (European Commission, n.d.).

In their article, Zhong, Xu, Klotz and Newman (2017) state that IoT-enabled manufacturing mainly refers to advanced principles where manufacturing resources are converted and manufacturing logic is flexibly implemented. Within the manufacturing environments of this logic supporting the Internet of Things (IoT) are the human-to-human, human-to-machine and machine-to-machine connections and are realised for intelligent sensing. The on-demand use and efficient sharing of IoT information resources is a modern Industry 4.0 concept as it strives for continuous efficiency.

Digitisation and automation of the production process are necessities in today's industry. The manufacturing industry is increasingly changing from mass production to customised production. Therefore, rapid advances in manufacturing technologies and applications across industries are helping to increase productivity. Here, Industry 4.0 is defined as a new level of organisation and control over

the entire product lifecycle chain, which is increasingly geared towards individualised market requirements. Industry 4.0 is a visionary yet realistic concept that includes the Internet of Things (IoT), Industrial Internet, smart manufacturing and cloud manufacturing (Vaidya, Ambod and Bhosle, 2018).

The diagram shows the interconnection of an intelligent manufacturing system used in Industry 4.0. The innovative manufacturing system integrates product design, analytics, manufacturing process, inventory and supply chain system, product customisation, real-time processing units, product delivery system and end customers using cloud computing to enable on-demand manufacturing with product customisation to maintain an efficient supply and demand ecosystem (Phuyal, Bista and Bista, 2020). Hermann (2018) states in his research that the fourth industrial revolution integrates manufacturing with the latest information and communication technologies. That allows the production of a product according to the customer's requirements manufactured at a competitive mass production price. The technical basis is formed by intelligent, digitally connected systems in the production process. Industry 4.0 defines the entire product lifecycle, dealing with the idea, development, production, use and maintenance, right through to recycling and end-of-life.

Figure 3. Smart manufacturing component scheme
Source: Fuyal, Bista in Bista, 2020.

THE CONCEPT OF SUSTAINABLE DEVELOPMENT FOR THE INDUSTRY OF THE FUTURE

The Source-System-Service concept is proposed to achieve sustainability in smart factories, where the energy used or its source is clean, abundant, renewable, cheap and environmentally friendly. The system includes energy efficiency improvement, integration of machines and factories, and more purposefulness with less waste and litter. The service step means recycling reliable and clean products (Meng, Yang, Chung, Lee, and Shao, 2018).

New production technologies also contribute to achieving reliable, sustainable processes. Additive manufacturing reduces the number of production steps, significantly reducing waste and energy consumption. An essential characteristic of sustainable production, as opposed to conventional production concepts, is the simultaneous consideration of environmental dimensions and economic and social aspects. The idea of sustainable production cannot be realised by focusing solely on the design direction for sustainable production. Therefore, building an integrated sustainability system that covers process, product, and system levels is necessary. The system should include different directions, such as design for functionality, design for environmental impact, design for continuous improvement and design for social impact and economy. Proper implementation of an integrated approach aims to achieve various benefits such as reducing energy consumption, developing new renewable resources, eliminating toxic and severe health problems, improving product sustainability, achieving an efficient waste management system, and improving process quality (Abubakar, Abas, Thomas, Soliman, Luqman, & Hegab, 2020).

Smart manufacturing and sustainable manufacturing share many common intersections, as a critical objective of intelligent manufacturing is to increase the sustainability of production. Production costs are crucial in implementing production activities and influencing producers' management strategy. The scarcity of natural resources increases energy prices as industrial energy consumption is vital to total energy consumption. The requirement to balance ecosystems and leave enough resources for future generations puts a lot of pressure on production, so sustainable production aims to change the traditional way of production to less toxic emissions that are more environmentally friendly while reducing the consumption of natural resources. Improving energy efficiency means more energy saving and less consumption of natural resources, so energy efficiency is also a solution for sustainability (Meng, Yang, Chung, Lee, & Shao, 2018).

ADVANTAGES AND RISKS OF SMART FACTORIES

Industry is the main driving force of any country's national economy. The more advanced and thriving the industry is, the better their economy and, consequently, all other stakeholders related to the industry. With the ever-growing competition in innovation and its integration into the economy, short reaction times to changes and developments in the markets, low prices of materials and products, and the increasing desire for optimisation, the modern and advanced concept of smart factories is a crucial tool for any economy. Smart factories are also a good indicator of the growing awareness of sustainable development, contributing to greater energy efficiency, waste reduction and more sustainable production. However, social and economic aspects must be considered, including protecting jobs and providing training for workers facing automation. It is also essential to ensure that the digital transformation in the industry does not increase disparities between different population groups but undermines inclusion and sustainable development for all (Forbes, 2023).

3.1 Advantages of smart loads

The evolving modern world helps us rapidly develop new technologies every step of the way, which is why introducing and implementing modern technologies is paramount for developing intelligent factories. Modern smart factories are automated and robotic, increasing productivity and improving product and inventory traceability. The connectivity of devices and systems allows for better remote control and management. The introduction of advanced artificial intelligence and machine learning technologies enables data processing. These contribute to more sustainable production, resource use and consumption, increased production flexibility and faster response to changing markets. Most

importantly, sustainable production reduces environmental impacts as it improves employees' health (Alhammadi, Alsjuf, Semeraro and Obaideen, 2024).

Automating production and self-learning processes is an excellent advantage of intelligent factories, as employees can focus on more complex tasks and human error can largely be eliminated or reduced. Advanced automation enables pre-detection of failures, which allows us to make informed decisions about planned outages, lower costs of breakdowns, and more efficient planned production or production of products (Neonex industry performance, n.d.).

Schlick (2020) states in his study that the advantages of intelligent factories are increased productivity and cost savings. The main motive for transforming a company into an intelligent factory is efficiency through the consistent use of digital design and control systems from start to end of the production process. That increases the transparency of production processes, which allows the intelligent factory to be flexible, making it easier to plan, implement, and realise changes and market requirements. The production system, based on information and communication technologies, enables adapted mass production and thus creates new customer benefits.

In his article, Immerman (2018) states that smart factories have a solid competitive advantage by successfully introducing new technologies and strategies into intelligent solutions and services. Increasing operational efficiency will incentivise the next generation of the Industrial Revolution to make organisations even more profitable and production more efficient. With Industry 4.0, quality products, security, and user experience will be boosted with greater visibility and simplicity of operations, creating value for customers and businesses. The author argues that new services, products and software are developed with each technological revolution, creating new product categories and jobs. With new technologies, increased profitability and economic growth, the lives of people and society are improving; as income increases, better health solutions increase the quality of life.

The implementation of intelligent factories and Industry 4.0 will make a pivotal contribution to reducing greenhouse gas emissions. As a result of vertical integration, algorithms of different parameters will strictly control traceable olive footprint data and emissions data, and the control and effectiveness of emission reductions will be even more effective. Smart factories will use Industry 4.0 systems to control waste volumes more efficiently and improve energy efficiency (Sony, 2020).

3.2 Risks of smart factories

As with any other advanced technology, intelligent factories face weaknesses and risks. Smart factories are increasingly vulnerable to cyberattacks as they are connected to a network and information technology that affects the data security of the production system and the entire system. Problems can also be caused by technical failures and malfunctions in the intelligent factory system, leading to production delays or equipment failure. Due to the rapidly changing advanced technology and equipment maintenance of smart factories, highly skilled personnel are needed, which can be challenging for companies. Starting an intelligent factory requires significant equipment, infrastructure and personnel training investments, leading to substantial initial investments. Collecting and processing large amounts of data is a crucial element of intelligent factories, so the question rightly arises about protecting employees' privacy and data security and all critical data in the company (Adamik and Fernandez, 2021). To avoid all these risks, it is essential that companies carefully plan and implement their strategy to establish smart factories and follow best practices in IT security and management (Rao, 2021).

Herman (2018) states in his research that many information systems are used in Industry 4.0 in various companies and must be interconnected to function effectively. This area's standardisation could simplify this task, allowing for many connected partners. That may result in smaller companies being blocked by large capital injections. Nixima Technology (n.d.) warns that the significant weakness of smart factories is the high initial implementation costs, so many SMEs cannot afford the high costs of introducing new technologies. Clever and innovative technology is also very complex, meaning poorly designed systems could reduce profits or result in losses.

Rudra (w.y.) states in his article that with the transition to digital transformation in production, there is a greater need for highly skilled employees. As a result, existing solutions will gradually disappear, and some industries will not be able to survive due to the introduction of new technologies. Moreux (2017), in the European Union's The European Files, warns that cybersecurity is key to Industry 4.0 success and is a primary concern. The author believes that a successful cyberattack could cause significant industrial damage, as smart factories are closely interconnected, both physically and virtually. A cyberattack no longer targets only intangible assets and systems but can cause substantial material damage that can risk people's lives and property.

The success of intelligent factories and Industry 4.0 requires the full implementation of Industry 4.0, which creates problems because Industry 4.0 must be designed for different production structures and company sizes, and the question of the allocation of financial resources by states also arises. The Industry 4.0 concept should not be implemented in isolation, thus avoiding sustainable results, as synchronisation and coordination with existing production equipment and processes could lead to complex processes and costs (Sony, 2020).

METHODOLOGY AND APPROACH TO RESEARCH

The research focuses on theoretical starting points based on a review of literature in the field of artificial intelligence and intelligent factories to improve the sustainable development of society. We summarised and cited the authors' theoretical starting points using the compilation method. First, we identified the topic and goal of the research with a clear definition of the article's topic. When searching for scientific literature, we used scientific articles, monographs, reports, and literature dealing with artificial intelligence in smart factories and its impact on sustainable development. When searching, we used different databases due to the relevance of the research itself. The research also showed limitations that affected the scope of the research. The field of artificial intelligence for constructing smart factories and their impact on sustainable development has not yet been sufficiently researched, as smart factories evolve depending on resources, guidelines, level of investment and investor interests, and national policies. The research found that research is higher where the development of smart factories is higher. The limitations were also due to the diversity of approaches and/or methodologies of the authors, as they have partial views on the topic covered,and with the aim of the research, we used the research and findings of many authors. We identified findings and trends in the studied field through critical literature analysis. The organisation and synthesis of research are based on a logical sequence and illustration of the topic under consideration. The article aims to show the impact of artificial intelligence on the construction of smart factories and the sustainable development of society. The research aims to emphasise the importance of transforming conventional factories into smart factories, as they enable the reduction of environmental impacts and enable humans to devote themselves to more substantial roles in understanding the power of artificial intelligence for the sustainable development of society and the preservation of the planet for future generations.

DISCUSSION ON RESEARCH ISSUES

The RQ1 research question asks how smart factories can contribute to sustainable development. As a society, we are increasingly aware of how important it is to preserve the natural environment in which we live. Industry 5.0 is considered a new production model that focuses on human-machine interaction and involves fostering collaboration between increasingly precision machines and people's innovative potential (Adel, 2022). We are increasingly aware that AI can help us reduce future generations' excessive consumption of natural resources. Nevertheless, if technology is intelligent from other points of view but energy-expensive, it is difficult for different authors to use it more widely (Meng, Yang, Chung, Lee and Shao, 2018). Many companies are reluctant to think about transforming traditional factories into smart factories. The authors emphasise that innovative factory technologies improve energy management and emission reduction, optimise resource efficiency and support workplace well-being (Mehdi Sajadieh, Ho Sin, & Do Noh, 2022). It is quite clear that we want to maintain a stable natural environment with higher added value. Artificial intelligence enables us to produce with higher added value by accelerating the integration of production and information and communication technologies. With the support of artificial intelligence, companies are offered the possibility of greater production flexibility and efficiency (Wan, Li, Dai, Kosiak, Martinez-Garcia and Li, 2020).

The RQ2 research question was: The extent to which the advantages of intelligent factories allow them to expand is relatively conserved. The rapid expansion effects of smart factories are not sufficiently explored for all manufacturing and service areas, and, in some instances, the cost aspect exceeds the owners' capabilities. Governments and institutions should contribute more to promoting such guidelines through awareness-raising and ideas from researchers and investment. Traditional production does not meet current environmental requirements, as it consumes the resources of future generations and harms the environment. Therefore, it is essential to support the development of sustainable production, according to the authors (Meng, Yang, Chung, Lee, & Shao, 2018). Smart factories create more opportunities to innovate and improve services and products (Mehdi Sajadieh, Ho Sin, & Do Noh, 2022). Improving energy efficiency is very important, which means more energy savings and less use of natural resources, so energy efficiency is also a sustainable solution, according to the authors (Meng, Yang, Chung, Lee, & Shao, 2018). It should be noted that smart factories are increasingly vulnerable to cyberattacks as they are connected to a network and information technology that affects the security of data, both production and the entire system (Adamik and Fernandez, 2021). Rao (2021) warns that to avoid all risks, companies must carefully plan the implementation of strategies for establishing smart factories and follow best practices in security and IT management.

CONCLUSION

Growing general awareness of society can help understand and benefit from the safe use of AI and other information systems. The key to success is only the complete implementation of Industry 4.0, which ensures system security, protecting company data quantities and protecting personal data. Industry 4.0 places man as a central element in planning the future of the modern innovative world. System tools, artificial intelligence systems, technological solutions, and innovations are adapted to benefit humans and place them in the primary role of the progress of the modern innovative world and modern society.

In Industry 4.0, the concepts of smart factories and intelligent manufacturing differ. Smart factories refer to the concept of a fully digitised factory where advanced technologies such as the Internet of Things, artificial intelligence, robotics and process automation are used. An intelligent factory combines data and information, enabling better control and optimisation of production processes. Smart manufacturing,

on the other hand, means using technologies and concepts such as digitalisation, automation and connectivity to manufacture individual products or components. In smart manufacturing, advanced technologies can be used to improve quality, reduce costs and increase the productivity of the production process.

Introducing smart factories into society considering sustainable development guidelines poses a rather complex challenge for companies, countries, and society. Raising awareness among governments, businesses and the local community about the importance of intelligent factories, sustainable development, and Industry 4.0 is one of the essential elements of their deployment. The training of employees and other stakeholders will play a key role, but at the same time, investing in research that brings new technologies should be of great importance. Of course, states and companies must provide the appropriate technological infrastructure for implementing intelligent factories, including investments in new advanced and modern technologies. In all this, cooperation and partnership between the public and private sectors, NGOs and, above all, development academic institutions should not be neglected, as joint efforts will lead to better results and more efficient implementation of smart factories and industry 4.0.

Integrating the sustainability principle reduces energy consumption, optimisation of resources, waste recycling, and production planning with a lower environmental impact. At the same time, governments and businesses should promote innovation and the development of green technologies through appropriate financial instruments. Monitoring progress in intelligent factory implementation and sustainable development and monitoring key performance indicators on results can help improve approaches and strategies.

The methodology of researching the topic under consideration is designed so that the current research enables and predicts further research possibilities in the field under consideration. In further research in the field and topic, the key guiding principle should be the involvement of all potential stakeholders, including employees of intelligent factories, local communities, countries and environmental organisations. The interdisciplinarity of research based on integrating technology, science, economics, social sciences, and ecology can lead to more comprehensive, applied and advanced research. The more the field of artificial intelligence to build smart factories and take into account the sustainable development of society is explored, the more likely stakeholders are to decide to accelerate the development of smart factories, which in turn can lead to a more sustainable society and the preservation and development of the planet.

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