White Paper on Industry 4.0

Table of Contents

Tel: 0044 (0)1480 411600
www.displaytechnology.co.uk

Industry 4.0

Introduction

Since the first Industrial Revolution, the manufacturing process has been revolutionised from water and steam-powered machines to electrical and automated ones. The term "Industry 4.0" or simply I4 was introduced by the German government in 2011, which encourages the use of modern technology in the manufacturing process. It defines that automation technology can be improved by offering different methods of self-configuration, self-optimisation and self-diagnosis. The fourth era of revolution (Industry 4.0) is all about connectivity trends, advanced material, processing technology, service orientation and collaboration in advanced manufacturing networks. It presents a unique level of control and coordination over the whole value chain of the products. Internet of things (IoT) and machine to machine communication (M2M) are merged to improve communication and automation. It creates a new set of design principles for effective and computerised control of the manufacturing process which includes

- **Interconnection**

The ability of machines, sensors, devices and people to communicate with each other with the help of the internet of things (IoT) or the Internet of People (IoP).

- **Information Transparency**

Industry 4.0 provides transparent information that enables the operators to perceive comprehensive information for decision making. The integration of all the machines and sensors allows the operator to receive a large amount of real-time data from the entire points in the manufacturing process. These key areas provide necessary information that plays a vital role in enhancing functionality.

- **Technical Assistance**

Proper technical assistance is also a key component in Industry 4.0 for supporting the operators in the problem-solving and decision-making processes. It is also a very important and effective thing while doing complex or unsafe tasks.

- **Decentralisation Decisions**

In Industry 4.0, cyber-physical systems are able to make a decision on their own and deliver their jobs as autonomous as possible. Only in exceptional cases such as interference, conflicting goals, etc. do the tasks get assigned to the higher authorities.

Tel: 0044 (0)1480 411600
www.displaytechnology.co.uk

In Industry 4.0, different processes across the entire organisation combine vertically which includes product development process, manufacturing, structuring and services. while on the horizontal side Industry 4.0 covers the internal operations and important-value chain allies. Cyber-Physical System (CPC), Industrial Internet of things (IIoT), cognitive computing, artificial intelligence and cloud computing play a vital role in automation and data exchanging.

- **Smart Factory**

The fourth industrial revolution promotes the idea of the "smart factory". In smart factories, cyber-physical systems observe physical processes that build up a virtual copy of the physical world for de-centralised decisions, with the help of the internet of things (IoT), various systems connect and communicate with each other both internally and across organisations.

- **Predictive Maintenance**

Due to the utilisation of the latest technology and IoT sensors, Industry 4.0 provides predictive maintenance. It helps the owners and operators in avoiding any type of machinery failure and damage.

- **3D Printing**

The Fourth Industrial Revolution is highly dependent on 3D printing technology. 3D printing allows the rapid production of prototypes and geometrical structures which simplifies the product design process. It increases flexibility and helps the companies to adopt high customisation artifices.

- **Smart Sensors**

Smart sensors are the core instruments not only for Industry 4.0 but also for other smart trends like smart mobility, smart cities, smart homes and smart production. These highly sensitive devices generate data across different points for the monitoring of complex processes. As Industry 4.0 offers wireless communication, it reduces the installation cost and effort and helps to analyse a dense array of sensors. The importance of smart sensors for Industry 4.0 has been acknowledged by various experts and led to the statement "Industry 4.0: nothing goes without sensor systems".

The requirement for Industry 4.0 is to transform the traditional machines into self-learning machines to enhance the overall performance and maintenance management. Industry 4.0 points at the erection of smart manufacturing platforms for the application of industrial-network information. Real-time monitoring and analysis of data, tracking the position of the product and store the instruction for effective controlling of the production process are the foremost needs of Industry 4.0.

Tel: 0044 (0)1480 411600
www.displaytechnology.co.uk

Benefits of adopting Industry 4.0

Industry 4.0 transforms the structure of industrial competition. That may seem like an exaggeration of a futuristic view, but it's not. Industry 4.0 comes about not only as an alternative to the use of emerging technology but also to radically modify the production equation. Without compromising efficiency, expense, or pace, Industry 4.0 can make significantly higher agility and blend in a factory. That will enable the business to evolve faster and earn higher profits.

Consumers have always sought low-cost, flawless quality and instant availability. Customers increasingly want more of that for a tailored, personalised, or exclusive commodity, however. Usually, at the cost of others, suppliers may sell one or two of them. As tradeoffs, expense, quality and speed were seen. You might get quality for a custom product, but often not at a cheap price or fast delivery. In the coming years, Industry 4.0 will transform the way industrial processes operate. It is important, though, to weigh the advantages and challenges that an enterprise might possibly face.

- **Customisation**:

An essential aspect of Industry 4.0 is the development of a customer-oriented market that is scalable and can satisfy the needs of the population and growing demands, rapidly and efficiently. The barrier between the producer and the consumer will be broken and communication will actually occur exclusively between them. Manufacturers would not have to connect with consumers within factories, industries and internationally, which in fact fastens the cycles of manufacturing and distribution.

- **Optimisation:**

Optimisation of output is a big benefit of Industry 4.0. A 'Tech Factory' with hundreds of thousands of smart devices that can optimize themselves would lead to virtually zero downtime in manufacturing. For companies that use large and high processing plants as machinery in the semiconductor industries, this is highly important. The company would prosper from being able to use output efficiently and continuously; cost-effective and improved efficiency. According to the PwC report, "Digitized goods and services produce additional annual revenue of approximately EUR 110 billion for European industries."

- **Pushing Research:**

The implementation of Industry 4.0 technology will affect research in numerous fields, such as IT defence, which will have an impact on the education Industry in particular. New skill sets would require a new Industry. As a result,' Education and Training' will take a different form that targets all sectors that need skilled labor.

Tel: 0044 (0)1480 411600
www.displaytechnology.co.uk

- **Performance:**

Businesses can make choices more efficiently and maintain efficiency with fewer individuals and more automation. Automation helps to retain high quality and it's an environment that improves performance more.

- **Agility Operation:**

Industry 4.0 takes agility to the next stage with an emphasis on high blends, limited batches and even one-off development. It speeds up processes in manufacturing processes when goods know their own requirements.

- **Innovation:**

Since Industry 4.0 production facilities are manufactured to handle high mixes and low volumes, they are best suited for the launch of new products and design experiments. The intense exposure of smart products and devices from IoT streams makes for a better comprehension of what functions in both product and process design.

- **Consumer Experience:**

The flexibility and deep availability of knowledge available with Industry 4.0 ensure that suppliers can provide improved support to consumers. Self-service opinions on the activity could be possible in some situations. Detailed, but in-context, MES data can be the basis for solving problems between consumers and producers easily.

- **Cost:**

Although Industry 4.0 would entail initial investment, the prices will fall once the intelligence is integrated into goods and processes. Fewer production issues lead to reduced loss of materials, less staffing and running costs. The pace and ability to smoothly manage such a high combination would also reduce costs.

- **Revenues:**

Industry 4.0 places suppliers on a road to becoming a trusted provider to new clients, with improved production, reduced prices, higher mix and the opportunity to satisfy customers well. It also brings new avenues of serving broader customers, selling personalised, higher-margin products and offering services that complement the products with intelligent products and operations.

Tel: 0044 (0)1480 411600
www.displaytechnology.co.uk

Using even more modern innovations will lead to the next stage of benefits. All the extra tracking, control and optimisation would help businesses who can have a digital twin to their activities. Many who can really use big data/machine learning can see trends to predict challenges and prevent them. Manufacturers who take Industry 4.0's decentralized intelligent manufacturing strategy are the ones that would be able to perform profitably in the most growing international markets. The others will not.

How it has revolutionised different sectors

Industry 4.0 utilizes state of the art technologies to make the manufacturing process more rapid, compliant and responsive to customers needs. It merges the internet, wireless communication, smart sensors, software and other venerable technologies to intensify the production system and promote customer satisfaction. Industry 4.0 allows rapid change according to the market requirements. Along with personalized products, it also enhances operational efficiency in a loop of continuous improvement. Ease of communication between machines and people helps in creating intelligent products and procedures. In short, Industry 4.0 directs the connectivity of physical objects with the virtual world in the real-time environment.

1. Factories

Industry 4.0 revolutionised the manufacturing process in the factories. It improves the manufacturing process by enabling the automatic exchange of information between robots, conveyors, actuators, sensors and robots. With the help of this technology, factories become intelligent enough to predict maintenance and control its production process. Decentralisation systems provide an effective way for different manufacturing processes such as product design, product services, product planning, etc. with the help of self function modules. Such factories are generally termed as smart factories.

2. Products

Industry 4.0 supports the product with embedded sensors, processors and identifiable components. These active components not only provide functional guidance to the customer but also convey user's feedback to the manufacturing system. This assists in monitoring product performance and communicates useful information like which part needs to be replaced. These smart products have all the information regarding itself, production conditions, utilisation, delivery time, lifetime, location and other relevant information.

Tel: 0044 (0)1480 411600
www.displaytechnology.co.uk

3. Customers

Like in manufacturing, Industry 4.0 also provides a lot of advantages to the customer end. It allows the customers to order with any number even if only one regardless of its functionality. Additionally, the customers could change their order during production without any extra charges. Smart production helps the customer to not only understand the production information but also make changes according to their own behavior.

4. Business

Industry 4.0 imparts a significant impact on the global economy. It is one of the key factors in the GDP (Gross Domestic Product) growth. It makes it easier for different companies to collaborate and share data about customers, manufacturers, suppliers and other individuals in the supply chain. The digital economy helps in raising productivity, competitiveness and sustainability. Real-time data about POS (point of sales) and inventory gives an insight into the business situation. The location and condition of each product can easily track and control with the help of smart sensors. Equipment settings are self-adjusted based on various ambient conditions like material used, machining process, etc. Products can be customised according to customer needs and required specifications. Sensitive components can be monitored remotely and maintenance can be foretold precisely. The perks brought by the fourth industrial revolution to the business sector are summarised as follows:

- **Increased Business Competitiveness**

Industry 4.0 extensively increased global competitiveness through a variety of cooperation and confederation of firms. The rapid progression of technology indicates that products will no longer be produced by the workers in the future but by autonomous robots.

- **Increased Productivity and Revenue**

Industry 4.0 promises lowering operational costs, enhanced efficiency and high accuracy and precision which eventually increased the revenue and profits. It completely revolutionised the conventional manufacturing process and increased productivity level. It is one of the key factors in GDP and revenue growth.

- **Optimised Manufacturing Process**

The term, smart factory, optimised the manufacturing process with the help of communication protocols. Cyber-Physical production systems allow the production facilities to swiftly react to customer demands, machine costs, maintenance costs and unexpected stoppages. Industry 4.0 also provides smart logistics, marketing intelligence and friendly customer assistance which plays a vital role in the entire value chain. The integration and establishment of different facilities add value to the end product. It not only covers the indoor integration but also different business models across countries, making a global network.

Tel: 0044 (0)1480 411600
www.displaytechnology.co.uk

➢ Accelerated Technology Development

Industry 4.0 presents a wide range of innovative platforms for the development of technologies. Additionally, services and manufacturing facilities can be developed further. For example, with a variation of mobile phone applications, developers utilised APIs to integrate different applications. This helps in improving Current GPS, RFID, Accelerometer and even the RFIDs embedded in a state of the art smartphones.

➢ Better Customer Service

Industry 4.0 renders effective and precise monitoring of customer feedback. This not only improves customer services but also helps the owner to predict the actual needs of end-users.

5. Inventory Systems

Inventory is a key factor in the business world because it is directly linked with cash flow. It may be an invisible or invisible form. Inventory exists everywhere in the visible form such as work in raw-material, work in progress (WIP) and Finished goods. On the other hand, communication medium which includes bandwidth, protocols and servers are termed as a non-visible form of inventory. Therefore managing visible, as well as a non-visible form of inventory, is the leading method of a successful business. In the setting of the supply chain, suppliers own raw material inventory, work in progress (WIP) inventory and finished product inventory. The distributed and retailers both have semi-product and finished goods inventory. In each level of the supply chain, the inventory must be kept so that it improves the satisfaction level of down stages by reducing specific costs and improving efficiency level. The impact of Industry 4.0 can be summarised into four different parameters.

➢ Inventory Process

Industry 4.0 facilitates automating the purchasing and fulfillment process. With the help of digital real-time information, I4 assists in the automatic triggering of suppliers' orders with the right quantity at the right time. By utilising state of the art technology, inventory systems are able to predict when and how much an individual customer demands which type of product by executing artificial intelligence's algorithms on data analytics.

➢ Inventory Classification

ABC inventory distribution is commonly employed in inventory management. ABC inventory classification based on the ranking of each product by dollar value in descending order. For example, Class A consists of those 20% products that accumulated 80% dollar value in inventory, while class C is a set of 50% goods that compulsively added 10 % dollar value in the inventory. The remaining 30% product that accumulated a 10% dollar value of inventory refers to class B. In the environment of Industry 4.0, products not only carry location information but also their dollar value. It empowers the automatic classification of ABC inventory for smart products.

Tel: 0044 (0)1480 411600
www.displaytechnology.co.uk

➢ **Inventory System Parameters**

For inventory systems, supply load time, carrying cost, purchasing price, customer demand and selling price are some of the key factors that collectively determine the dynamics of the inventory system. Though it is very difficult to determine some parameters like supply lead-time, customer demand, etc. it is common to take rough estimation for the modeling of inventory systems. Determination of exact product delivery time is a very challenging task for the manufacturers. Besides the uncertainty of supply load-time, inventory management also faces other complex problems from suppliers like, dynamic pricing and minimum order quantity (MOQ). Industry 4.0 enables all the parties to communicate and share real-time information on time. For example, producers in any country around the world are informed timely where the product is and when it will arrive at a specified location. Industry 4.0 significantly improves the supply lead-time parameter of the inventory system.

➢ **Inventory System Review**

There are two types of inventory reviews currently utilised by different organisations: Continuous and Periodic review. In the continuous review, the inventory is continuously monitored and reviewed over time and a new order placed when it crosses the critical point. Periodic on the other hand, the inventory is observed after a specified time frame. The continuous review needs real-time information about the inventory. That's why the continuous review demands a state of the art information system. Most companies prefer a periodic review of the inventory system because of lesser cost. As in Industry 4.0, real-time sharing of information is involved, it provides a great incentive for manufacturers to start practicing the continuous review.

Our Services

The technology transition of Industry 4.0 is characterised not only by the use of data during manufacturing or the integration into the supply chain of a broad range of production processes. To satisfy individual consumer desires, it also entails analysing and incorporating the overall life cycle of goods and processes.
Companies will create global networks in the upcoming years that will combine their equipment, distribution infrastructure and processing facilities in the form of cyber-physical systems that can be controlled in real-time. Intelligent IoT sensors allow for the collection and analysis of data via cloud interfaces and I/O links, allowing ideal industrial requirements to be continuously monitored and maintained.
The Internet of Things (IoT) is quickly gaining momentum and firms are modifying their IT facilities to suit the latest IoT standards. Data centers help process vast volumes of data associated with the process of digital transformation, similar to the stage where the data originally comes. Some enterprises have begun to introduce new data-center technology and delivery methodologies as part of this IT revolution.
Another key strategic technology in the development of Industry 4.0 is engine control. For all, including system engineers and component suppliers, the quest for effective advancement in the field of motor control is a priority.

Tel: 0044 (0)1480 411600
www.displaytechnology.co.uk

The development of power management systems, particularly integrated DC / DC converters, meets accurate requirements in all device contexts. This includes the array of input voltages, values of output voltage, output power, performance, input and output electrical separation and industrial specifications. Industry 4.0 requires high-performance industrial machinery parts, varying from better energy savings to stable service in harsh conditions, thus reducing form factors. In these modern smart factories, energy storage, performance and motion control are a few fields of main significance.

Digital Power Supplies:

Energy management has taken on a new meaning with the evolution of Industry 4.0, as the adoption of IoT, data mining and cloud computing leads to dynamic, automated and linked manufacturing networks and environments. In order to achieve maximum energy efficiency, the operation of all parts of the power system in the smart factory, in particular the DC / DC converters, must progressively be adequately and correctly defined by engineers.

The demand for DC / DC converters is expanding. The DC / DC converter market will also prosper from the introduction of advanced components, such as silicon carbide (SiC) MOSFET drivers, driven by steady growth in conventional applications, including communications, computers and various industrial sectors and the introduction of many new and innovative power architectures. SiC systems are a preferable option in diverse applications with their excellent thermal characteristics.

Embedded Systems:

The development of Industry 4.0 would be primarily based on Artificial Intelligence (AI) technologies, integrating hardware and software into smart embedded systems. Usually, though, these smart technologies are typically alluded to as a whole scale of fuzzy barriers, where when one element stops and the other begins is tough to determine. For example, the Internet of Things (IoT) was proposed to apply only to individually recognisable interoperable related items with Radiofrequency Identification (RFID) technologies within the first years of the implementation of this theory. However, later on, as the networking of these networks expanded and technological advances (NB-IoT, LoRa, Wifi, ESP, Raspberry Pi,) and technologies were added, the concept expanded with it to encompass all these developments, extended to quantify, locate, place, track and control artifacts, now relating to IoT more as a complex global network linking self-conscious artifacts.

1. Cyber-physical systems:

Cyber-physical systems (CPS) are engineered systems that are constructed from the synergy of digital and physical components and rely on them[2]. Growing CPS, which must be stable and responsive, would be organised, dispersed and related. The connection of engineered systems will be transformed by CPS, much as the Internet has changed the way individuals engage with data. In production, via smart prognostics and diagnostics using big data from numerous networked sensors, systems and processes, CPS can increase efficiency and quality. In cyberspace, each physical part and computer would have a twin model. For

Tel: 0044 (0)1480 411600
www.displaytechnology.co.uk

reliable intelligence and performance, each system and device will anticipate and avoid possible failure and further self-aware, self-predict, self-compare and further self-reconfigure and self-optimise.

2. Sensors for IoT:

The incorporation of sensors/actuators, RFID tags and networking technology has been said to serve as the base of IoT and therefore Industry 4.0.0. In accordance with that line of reasoning, sensors settle the concepts on which smart objects can be visible, connect and engage with each other, with users and/or other network agents from a computational point of view.

Radio Frequency Identification Systems (RFID) are essential parts of Industry 4.0 in the form of identification, sensing and networking applications. We have to discriminate between passive RFID tags, active tags (on-board power source feeds the on-board receiver and transmitter, allowing for an improved radio range) and semi-active or semi-passive tags (on-board power source feeds the on-board receiver and transmitter, allowing for an improved radio range) and semi-active or semi-passive tags (on-board power source feeds the microchip), while the transmission is either active (semi-active) or back-scattered (semi-passive).

3. Big Data and Cloud Computing:

In these embedded systems, the wide transmission of data demands techniques that promote automation and Big Data can be a solution to that, by improving essential factors such as mobility, versatility and energy consumption, providing them with temporally and spatially autonomous access. In conclusion, the use of data mining helps to sustain decision-making analysis, modeling, simulation, fusion and computing and science prognosis. On the other hand, cloud computing is essentially a large-scale, low-cost, scalable processing unit focused on measuring and storing IP connectivity. The need for cloud computing is focused on the need to create a certain relationship between identification devices for vast volumes of information storage and the need for a centralised system to facilitate this storage and subsequent review.

Industrial Monitors:

In applications for the Internet of Things (IoT) and Industry 4.0, more and more users need to be able to visualise and process data from embedded systems. Data visualisation and process control assists with the Human Machine Interface (HMI) at all stages of the decision-making process and is best handled.

What's HMI? Generally, it is used to define any user interface linking users to a computer, device, or system, such as an LCD display. For instance, in industrial processes, an LCD monitor screen helps users to communicate with a computer or tool. HMI helps close the void between how consumers communicate with data from the process and automation.

A common alternative is to incorporate an LCD monitor framework to fill this distance where it works into the implementation phase of the factory floor and Industry. The first major decision is whether to go for consumer displays or industrial-grade displays when it comes to LCD panel options for the factory floor.

Tel: 0044 (0)1480 411600
www.displaytechnology.co.uk

It might appear like commercial monitors are the better choice when reviewing different monitor prices at current prices, but it's a very common mistake. It's a mistake made by so many clients, which ends up costing you time and money. But why? The clear answer: commercial monitors are not built or installed to survive the robust use and environment of applications of Industry 4.0. In specific, we are investigating three reasons why introducing an industrial-grade LCD monitor rather than commercial monitor alternatives is the right choice.

- ## Constructed for extreme, robust conditions

First and foremost, LCD monitors of industrial-grade are built and constructed for just that industrial environments that go hand-in-hand with most application environments of Industry 4.0. For office and retail settings, commercial monitors are designed and they work perfectly in such settings. However, they do not hold up in tougher, manufacturing conditions where they have to content themselves with high vibration, variations in temperature, variations in strength, soil, dust, a high rate of use and much more.

- ## Built to meet requirements for Industry 4.0

In addition to being engineered and constructed for rugged conditions with heavy turbulence, temperature variations and more, industrial-grade displays in different industries, such as complex cleaning standards, can also withstand robust specifications. To shield internal parts from external elements, including soil, mud, oil, or cleaning chemicals, industrial monitors are tightly covered. Many industrial applications have cleaning standards, including those concerning food and beverage processes. Industrial monitors may satisfy these criteria based on individual device scores.

- ## Cost reduction with clear longevity of up-time and system

So, what happens in an industrial setting when you go for a commercial-grade monitor? It is only a matter of time before the monitor fails. This suggests that the whole operation goes through downtime when removing or restoring the display. Your machine is down and the whole operation came to a stop during the monitor repair. Consistency is lacking and it is therefore inefficient for the workplace. It all simply comes down to you asking yourself: what's the cost of being down of your device? The installation of an industrial LCD monitor helps eliminate all these expensive complications and, honestly, helps prevent a lot of sorrow. Monitors designed for extreme environments with a durable, industrial architecture must meet much more requirements than consumer products. You get a premium product with durability.

Display Technology Ltd manufactures a wide variety of industrial monitors built to handle activity in harsh conditions, in varying sizes. The industrial-grade LCD monitors provide a lifetime of 50,000 hours of backlight, high IP-rated bezel, large temperature support, flexible mounting options and are also simple to install for different scenarios of use.

Tel: 0044 (0)1480 411600
www.displaytechnology.co.uk

Conclusion

The Industry 4.0 or we can say that Internet of things (IoT) has truly revolutionised the industrial field. Technology has grown more complex than ever. Businesses will now build products and internal approaches that a decade ago were difficult to consider. Many of those developments may have been slow to keep up with the manufacturing industries. However, the fourth industrial revolution, going their way, can no longer be overlooked by their leaders. Just as the assembly line of Ford led to tremendous growth in the Industry back in the day, within the industrial sector, IoT, Big Data and AI are poised to change the whole supply chain. Is the organisation able to respond to those changes? We are here to help you in this regard. In this article we have provided a complete overview of Industry 4.0 and the advantages of adopting this technology in different fields. Moreover, how Display Technology Ltd as an organisation can provide solutions in Digital Power, Embedded AI systems and the Industrial Monitors is also discussed.

Tel: 0044 (0)1480 411600
www.displaytechnology.co.uk

References

[1] H. Lasi, P. Fettke, H.-G. Kemper, T. Feld, and M. Hoffmann, "Industry 4.0," *Business & information systems engineering,* vol. 6, no. 4, pp. 239-242, 2014.

[2] S. Vaidya, P. Ambad, and S. Bhosle, "Industry 4.0–a glimpse," *Procedia Manufacturing,* vol. 20, pp. 233-238, 2018.

[3] A. G. Özüdoğru, E. Ergün, D. Ammari, and A. Görener, "How Industry 4.0 changes business: A commercial perspective," *International Journal of Commerce and Finance,* vol. 4, no. 1, p. 84, 2018.

[4] Y. Lu, "Industry 4.0: A survey on technologies, applications and open research issues," *Journal of industrial information integration,* vol. 6, pp. 1-10, 2017.

[5] A. Ciffolilli and A. Muscio, "Industry 4.0: national and regional comparative advantages in key enabling technologies," *European Planning Studies,* vol. 26, no. 12, pp. 2323-2343, 2018.

[6] J. H. Ortiz, W. G. Marroquin, and L. Z. Cifuentes, "Industry 4.0: Current Status and Future Trends," in Industry 4.0-Current Status and Future Trends: IntechOpen, 2020.

[7] X.-M. Yuan, "Impact of Industry 4.0 on Inventory Systems and Optimisation," in Industry 4.0-Impact on Intelligent Logistics and Manufacturing: IntechOpen, 2020.

[8] S. Vaidya, P. Ambad, and S. J. P. M. Bhosle, "Industry 4.0–a glimpse," vol. 20, pp. 233-238, 2018.

[9] B. Tjahjono, C. Esplugues, E. Ares, and G. J. P. M. Pelaez, "What does Industry 4.0 mean to supply chain?," vol. 13, pp. 1175-1182, 2017.

[10] J. Nagy, J. Oláh, E. Erdei, D. Máté, and J. J. S. Popp, "The role and impact of Industry 4.0 and the internet of things on the business strategy of the value chain—the case of Hungary," vol. 10, no. 10, p. 3491, 2018.

[11] R. Y. Zhong, X. Xu, E. Klotz, and S. T. J. E. Newman, "Intelligent manufacturing in the context of Industry 4.0: a review," vol. 3, no. 5, pp. 616-630, 2017.

[12] V. Roblek, M. Meško, and A. J. S. O. Krapež, "A complex view of Industry 4.0," vol. 6, no. 2, p. 2158244016653987, 2016.

[13] G. Aceto, V. Persico, and A. J. J. o. I. I. I. Pescapé, "Industry 4.0 and health: Internet of things, big data, and cloud computing for healthcare 4.0," vol. 18, p. 100129, 2020.

[14] S. Erol, A. Schumacher, and W. Sihn, "Strategic guidance towards Industry 4.0–a three-stage process model," in International conference on competitive manufacturing, 2016, vol. 9, no. 1, pp. 495-501.

[15] G.-J. Cheng, L.-T. Liu, X.-J. Qiang, and Y. Liu, "Industry 4.0 development and application of intelligent manufacturing," in 2016 international conference on information system and artificial intelligence (ISAI), 2016, pp. 407-410: IEEE.