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INDUSTRY 4.0: HYPE OR HIKE

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ABSTRACT

Industry 4.0 has been a hotly debated topic for the industrial business leaders. Though some companies have been enjoying the benefits of Industry 4.0 still there are a lot of space in adapting Industry 4.0. This research has been designed to identify the challenges and barriers for adapting Industry 4.0 in Pharmaceutical and construction business. For this research SLR (Systematic Literature Review) methodology has been used and 78 articles scanned for the SLR. There are several challenges and barriers have been identified. The conclusion has been provided with the several practical implications of this research in future.

Key Words: Industry 4.0, Supply Chain Management, Digitalisation, challenges & Barriers.

1 INTRODUCTION

1.1 Research Background

When it comes to the future of industry as well as our daily lives, "industry 4.0" is an important topic. The term "Industry 4.0," also known as the "fourth industrial revolution," was coined at the "Hannover Messe" in 2011 (Kuila et al, 2021). Industry 4.0 has the potential to develop new values, new business models, and new ways of communicating between factories, consumers, and services, according to the results of the meeting (Kagermann & Wahlster, 2013). A roadmap for the Internet of Things (IoT), which considers the idea that physical items may identify themselves and communicate with other devices through the internet, is defined by the current developments and best practises in Big Data and Analytics, artificial intelligence, and robotics. By doing this research, we hope that we will be able to better understand the challenges, benefits and drawbacks of IoT adoption.

1.2 Research Problem

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There has been an increase in manufacturing complexity; innovation cycles have shrunk; human efforts are increasingly unable to keep up with the increasing complexity of industrial processes. To address these issues, the next industrial revolution (Industry 4.0), which includes the Internet of Things (IoT), Big Data Analytics, and Cyber-Physical Systems (CPS), has been implemented (Liu & Xu, 2017). The industry is aware of Industry 4.0, but many companies are unsure of how to take use of the technology that make it possible. The literature does not provide a clear path for industry leaders to follow when it comes to using Industry 4.0 technology in their businesses. This study focuses on the Internet of Things (IoT) component of Industry 4.0. There are two sub questions to the first research question. Using the data from the second research question, companies can better understand how to go about deploying IoT.

First, in the industrial realm,

Q1: what are the current IoT application trends? What are the components of the Internet of Things?

Q2: What are the advantages and disadvantages of industrial IoT?

2 Literature Review

2.1 Industry 4.0 Overview and Definition

Previously, three industrial revolutions had taken place prior to the arrival of the fourth Industrial Revolution, which is also referred to as Industry 4.0. They are referred described as revolutions since they cause disruption in manufacturing processes. The properties of these four revolutions are depicted in Figure 1.

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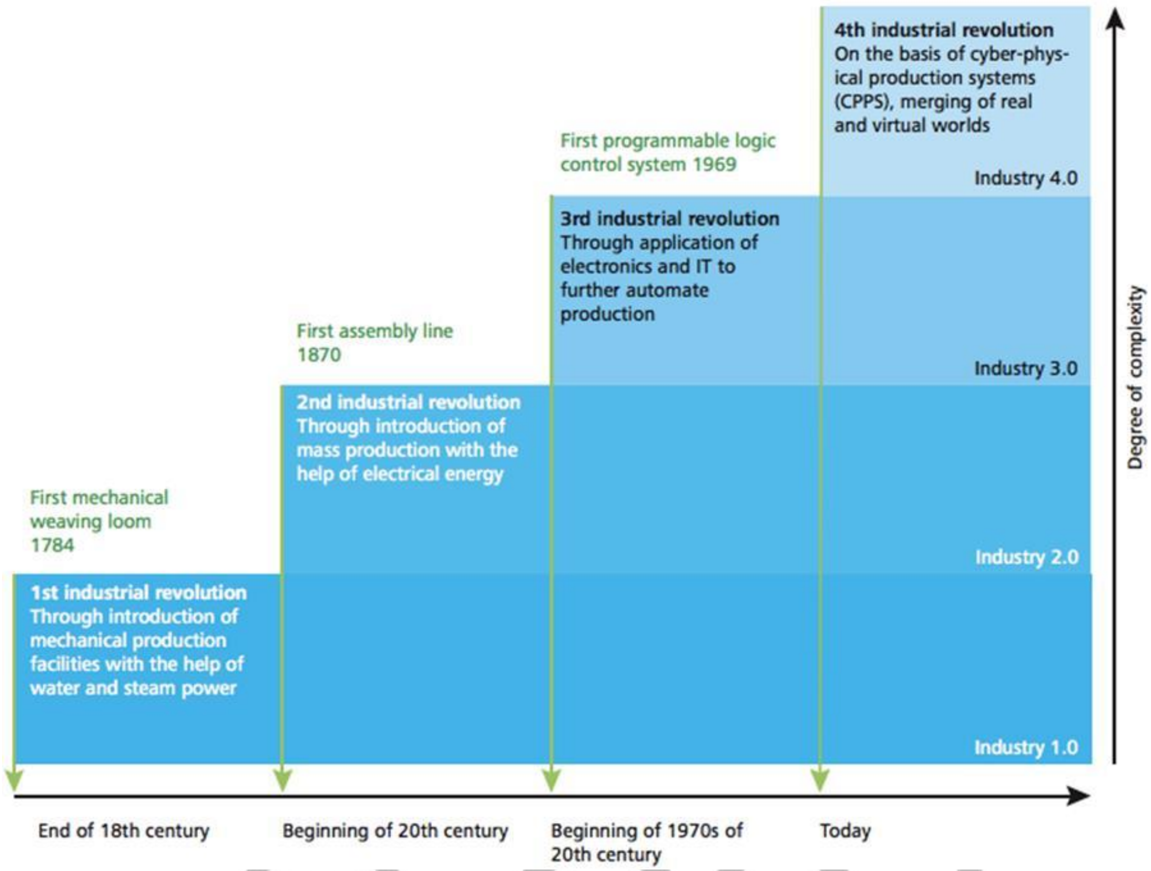

Figure 2.1: Deloitte, 2015: History of Industry 4.0

Following the three previous industrial revolutions, Norbury (2015) and Gilchrist (2016) identified various concerns linked with them, prompting the need for the Fourth Industrial Revolution to solve these issues. Among these difficulties are the following:

1. The inability of human efforts to deal with the complexity of current industrial processes and systems.
2. A rise in the number of complex goods
3. A reduction in the length of time it takes to develop new ideas
4. Markets that are prone to fluctuation

It is referred to as the "fourth industrial revolution" because it is the "next stage in coordinating and controlling the whole value stream along the lifecycle of a product" under the "Industry 4.0" model. Xu and Liu (2017). "Further development stage in the organisation and administration of all value chains engaged in the manufacturing business" is what Deloitte (2015) defined as Industry 4.0. According to Blanchet et al. (2014), "the idea of constant digitization and connectivity of all producing units in an economy" lies at the heart of Industry 4.0. Using the Internet of Things (IoT) to stimulate the collecting and exchange of data across machines and components is a different definition of Industry 4.0 provided by Shrouf et al. (2014).

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Also, the integration of IoT and Cyber Physical Systems (Cyber Physical Systems) is projected to occur with the arrival of industry 4.0, a phrase that refers to the "integration of computation and physical processes" (Lee, 2007). Industry 4.0 will fundamentally alter the way we create, produce, plan, decide, operate, and provide services over the next few years. As part of the "development of system of systems" (DIN/DKE, 2016), industry 4.0 aims to take advantage of the advances made in "information and communications technologies" for the benefit of manufacturing companies.

2.2 Industry 4.0 Characteristics

Several studies, including Liu and Xu (2017); DIN/DKE (2016); Deloitte (2015); and Kagermann & Wahlster (2013), have identified three primary characteristics of Industry 4.0 as follows:

1. **Horizontal Integration**: In the context of value creation networks, it refers to the integration of customers, business partners, and occasionally new business models, as well as various smart factories. Thus, credibility and adaptability are established along the entire value chain, from manufacturing to delivery to the end user.

2. **Vertical Integration**: The "factory" is the most important requirement for vertical integration. It will involve the networking of smart items as well as the networking of intelligent factories. Processes in the factory will also be smart, for example, smart logistics, smart production, smart marketing, and other smart activities in the factory, to name a few examples: Smart factories will make it possible to concentrate on the demands of customers and to tailor these needs to their own requirements.

3. **End-to-End integration of Engineering (EEE**): "through the full product life cycle value chain": Vertical and horizontal integration help make this possible. Meaning that products and services are planned, designed, and manufactured with an integrated approach to engineering.

2.3 Industry 4.0 Deployment Precursors

In order for a firm or an industry to attempt to implement the principles of Industry 4.0 (technologies) inside its operations, it is expected that certain structures will need to be in place (Gilchrist, 2014; Drath & Horch, 2014). Figure 2 depicts some of the most critical needs and organisational structures.

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Figure 2.2: Precursors for Industry 4.0 deployment.

There may not be an immediate return on investment from the implementation of Industry 4.0 technologies; therefore, a long-term approach to the adoption of these technologies may be desirable (Gilchrist, 2016). Step-by-step implementation of Industry 4.0 and associated technologies is necessary for the protection of investment; in doing so, it is crucial to identify the needs of the corporate value chain and connect this with the deployment plan of Industry 4.0. (Drath & Horch, 2014). The implementation of Industry 4.0 must be done in a way that does not disrupt production. Industry 4.0 will also necessitate the training and hiring of personnel who can handle the new technology that will be implemented (Gilchrist, 2016). Training or hiring experts in big data analytics is necessary, for example, to get the most out of large data. To summarise, protecting the intellectual property of companies implementing Industry 4.0 necessitates protected access to production-related data (Drath & Horch, 2014). In order to protect the company, environment, and people from cyber dangers, it will be necessary to connect machines, robots, and things.

2.4 Technologies of Industry 4.0

Industry 4.0's enabling technologies have been highlighted by numerous writers and publications. Industry 4.0 has fewer academic publications than other well-established subjects because it is a newer field. This was discovered through a review of the literature. In order to better comprehend Industry 4.0 and its enabling technologies, a mix of academic papers and reports from consulting firms were used. Enabling technologies are depicted in Figure 2.3.

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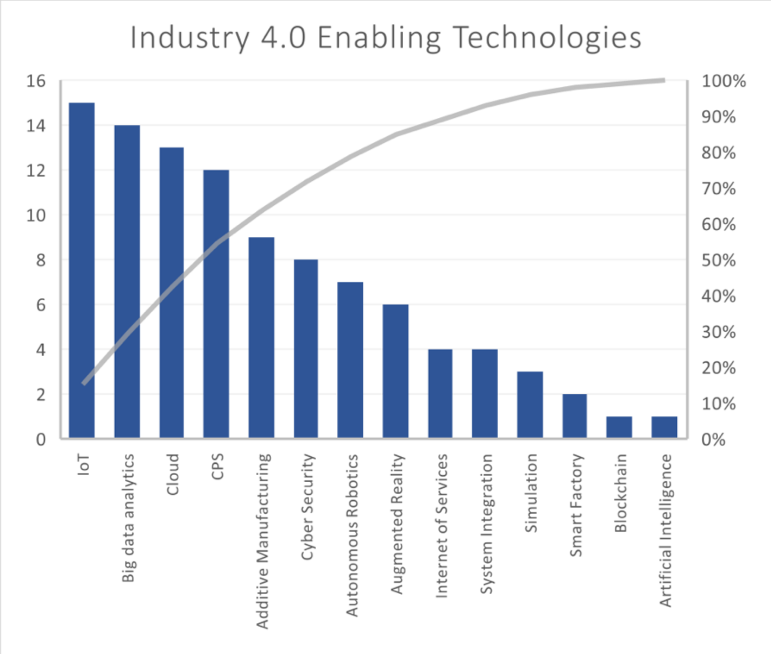

Figure 2.3: Industry 4.0 enabling technologies

Of the 15 articles on Industry 4.0 technology published, seven were written by consulting firms, seven by academics, and one was a book. All the material that was analysed contained references to IoT. A total of 14 of the 15 literatures referenced Big Data and Analytics, while Cloud technology and Cyber-Physical Systems (CPS) were referenced 13 and 12 times respectively. Additive manufacturing (nine), cyber security (eight), augmented reality (seven), and autonomous robotics (six) are also prominent in the literature (6). There are, therefore, nine primary enabling technologies of Industry 4.0 that are depicted in the diagram in Figure 4. CPS, IoS, and smart factories are not considered important technologies because CPS encompasses all the stated enabling technologies, whereas smart factories are the results of achieving Industry 4.0, according to the literature. The Internet of Things (IoT) and Internet of Things (IoS) are closely related.

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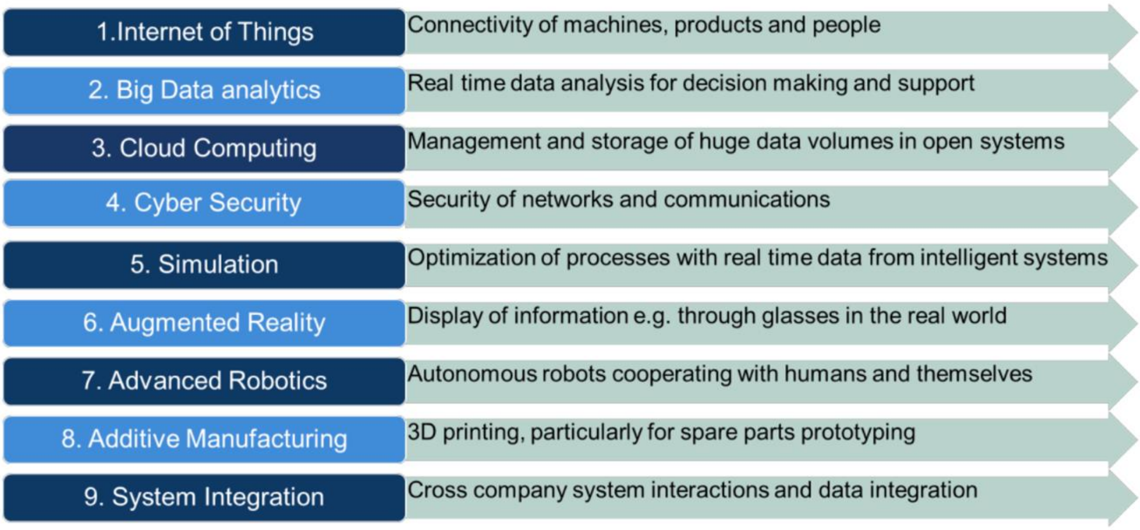

Figure 2.4: Industry 4.0 model

2.4.1 Big Data and Analytics

Large volumes of data are generated as a result of the rapid growth of the internet, as well as the interconnection of things/objects and humans, and traditional data processing systems are unable to handle the volume (Gilchrist, 2016). Big Data is the term used to describe this massive amount of data. Big Data analytics is the process of analysing large amounts of data in order to provide insights and value. When it comes to improving the quality of production and products, reducing energy consumption, and increasing equipment service in an Industry 4.0 environment, big data analytics play a significant role (Lee, et al., 2014 and Russman, et al., 2015).

2.4.2 Cyber-Physical Systems

Developing global business networks through the convergence of the physical and digital worlds was defined by Shafiq et al. in 2015. CPS, for example, leverages IoT to link and communicate in real time, which could lead to the monitoring of physical behaviours and the creation of virtual representations of real worlds to allow decentralised decision making (Liu & Xu, 2017).

2.4.3 Cloud Technology

It is a "method for communicating information with collaborators...characterized by its speed, allowing administrators to save data and install new systems to monitor and control processes via digital platforms." If you're interested in Industry 4.0, cloud technology can be used to promote data exchange, improve system performance, and save costs (by bringing systems online). The results of (Kang, et al., 2016).

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2.4.4 Additive Manufacturing (AM)

In this case, it is known as 3D printing. A CAD file can be turned into a real product using AM, which is defined as a process that uses light, ultrasonic vibration, lasers, and electron beams to glue or connect materials (Kang, et al., 2016). Industry 4.0 is embracing additive manufacturing as a means of producing customised or personalised items in small batches. Material and resource savings as well as improved customer experience, part and production flexibility are all advantages of AM in the context of Industry 4.0. (Kang, et al., 2016).

2.4.5 Autonomous Robotics

Robots have been used in manufacturing environments for some time now, but in the context of Industry 4.0, their use and collaboration will continue to improve. Interaction with one other and with humans (Cobots) will be possible (Russman et al, 2015) (Kuila & Patki, 2022).

2.4.6 Cyber Security

To put it another way, cybersecurity technologies "manage and defend processes and systems that operate on the internet, notice changes and vulnerabilities, and verify who has access to the system as an authorised user" (Albers, et al., 2016). Because of Industry 4.0's emphasis on ubiquitous computing, security is a top priority, and businesses are working together to combat cybercrime and attack (Russman et al, 2015).

2.4.7 Augmented Reality (AR)

A combination of physical and virtual aspects can be achieved using intelligent devices in Augmented Reality (AR). Based on methods to improve maintenance measures, AR is used in production systems to reduce costs (Saucedo-Martinez, et al., 2017). Even though AR systems are still in their infancy, firms will leverage the technology to help people better their decision-making and the way they work as the concept of Industry 4.0 becomes more widely discussed (Russman et al, 2015).

2.6 Internet of Things (IoT) Introduction

2.6.1 IoT History

When Kevin Ashton, the co-founder of the MIT's Auto-ID centre, was giving a presentation on supply chain management in 1999, he coined the term "Internet of things" (Ashton, 2009). With the advancement of technology (internet, computers, data generation), he felt that people, objects (things), and the environment should be able to interact more. Shrouf et al. (2014) claim that Industry 4.0 is built on the foundation of the Internet of Things (IoT). The Internet of Things (IoT) and its sibling, the Internet of Services (IoS), are expected to be the driving forces behind Industry 4.0. (Gilchrist,

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2016). The Internet of Things (IoT) aims to make life easier for its users by enabling them to communicate with their surroundings and everyday things via more advanced communication technologies (Chaouchi, 2010).

2.6.2 Internet of Things Definition

It is the Internet of things phenomenon that is made up of the two words internet and things. According to Chaouchi et al (2013), the "things" element of the IoT was well-represented. Everything on the Internet of Things is made up of atoms, hence everything is characterised as a set of atoms. Figure 5 shows the list of things which could connected.

Figure 2.5: List of things that could be connected

The internet of things (IoT), according to the Oxford Dictionary, is "a global computer network that provides a range of information and communication capabilities, consisting of interconnected networks that use established communication protocols." Putting the two concepts together basically says that everything in our environment is connected in some way. The Internet of Things (IoT) has been described by several authors in the literature. An IoT network is a network that connects physical objects with each other and with humans and the virtual world. The ultimate purpose of the IoT is to create value through data exchange, data processing, data exploitation, and human-machine interaction. As a result of this and other studies (Atzori et al., 2010, Khodadadi et al., 2016, It doesn't matter how many different definitions there are for the Internet of Things; its fundamental purpose is to make human lives easier than they've ever been, regardless of how many different definitions there are (Ortiz, et al, 2014).

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Domain	Description	Examples
Industry	This involves activities which involves commercial and financial transactions between companies, businesses and other entities	Construction, banking, logistics, transportation. Agriculture
Smart City	These are related to the protection of the environment and natural resources and development of cities and people	energy management, Smart mobility, smart buildings, Public safety and environmental protection
Health and wellbeing domain	Activities relating to the tracking, identification, data gathering and sensing of the health of human beings	Medical and healthcare, independent living
Consumer	Actvities relating to people's wellbeing, satisfaction and entertainment	Healthcare, home automation, telematics, media and entertainment
Business	activities relating to financial interaction between businesses	Logistics, industrial automation
Public	activities relating to the environment which includes plants and animals	energy management, environemtal management and traffic management
Personal and Social	activities relating to social wellbeing of individuals	Home energy management, ubiquitous healthcare
Enterprise	network of things within a work environment	Environmental monitoring, smart environment
Utilities	activities relating to service optimisation rather than end user consumption	Smart metering, smart grid, Security surveillance
Mobile	these activities are related to mobiity and logistics	Smart logistics and smart transportation
Transport and Logistics	activities relating to the moveemnt of peple and goods from one place to another; as well as activities related to the supply chain	Logistics, assisted driving, mobile ticketing, augmented maps
Smart Environment	activities relating to the intelligence of contained objects e.g home, industrial plant or a leisure ground	comfortable homes and offices. Industrial plants, smart museum and gym
Futuristic domain	these are related to potential applications for the future	robot taxi, city information model, enhanced game room

Table 2.2: Benefits of IoT in different industries

(Source-PWC, 2020)

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2.10 IoT Industrial application in the construction industry.

In the industrial domain programmes that deal with commercial and financial transactions between both individuals and corporations, as well as corporations and their customers (Borgia, 2014, Sundmaeker et al., 2010). Construction is a type of industry that has these kinds of partnerships with other businesses, governments, and customers. There are numerous obstacles to overcome in the construction sector, such as low-skilled labour, sluggish technology uptake and a lack of environmental sustainability policies. IoT may assist the industry (Ridell, 2016). The construction industry is also taking advantage of the Internet of Things (IoT) in order to achieve long-term advantages. When it comes to building, a US company named Deconstruction has come out with an app called mBuilder sensor that can monitor the humidity levels on the site, as well as the noise levels. It alerts decision-makers when environmental harm reaches a predetermined level, allowing them to take appropriate action and make necessary changes (Kang, et al, 2015).

Human Condition Safety (HCS), a start-up company funded by AIG, is another key application in the construction industry. IoT is being used to improve working conditions and reduce job dangers in the construction industry by this start-up company. Wearable technology with sensors that can alert the wearer if the employees are in a "risk zone" or a "hazardous position" can make this possible.

Just two examples of how the Internet of Things is being used in the real world are smart metres and intelligent lighting systems in commercial buildings (Sundmaeker et al, 2010). It is becoming increasingly common to employ Building Information Modeling (BIM) software because it makes use of Internet of Things (IoT) technology to collect and analyse massive data sets on temperature trends, human mobility, and energy use patterns (Levy, 2017). The Internet of Things may be used on construction sites to track tools and equipment, warn workers when repairs are needed, and more (Burger,2016).

2.11 Internet of Things Challenges

Architecture, privacy, security, standardisation, data management, data mining, and technical and business obstacles are some of the primary issues discussed in the literature. Industry 4.0's issues have been covered in eight articles on a variety of themes, as seen in Table 6. Architecture, privacy and security will be the focus of this section because of their prominence in the literature. The term "data issues" will be used to refer to topics pertaining to data management and data mining.

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Challenges	Number of Publications
Architectural challenge	5
Privacy	8
Security	7
Standardisation	5
Socio-ethical considerations	2
Data management	3
data mining	4
Chaos	1
Energy efficient sensing	2
technical challenge	1
business challenge	1

1. Security

Security is one of the most pressing issues (Aztori, et al, 2010, Alaba et al, 2017, Borgia, 2014). There are billions of devices in the IoT network, and security will be a major worry as the network grows (Gubbi, et al, 2012). The benefits of IoT, such as a rise in possible cyber-attacks, come with a price, though. Security of the entire IoT system encompassing data and services, according to Borgia, (2014), requires the following:

1. Privacy, 2. Authentication, 3. Integrity, 4. Availability, 5. Authorisation, 6. Confidentiality.

Due to the widespread use of wireless networking, security breaches are a major concern (Aztori, et al, 2010; Munir & Stankovic, 2014). Eavesdropping and other types of security breaches are common on wireless networks (Aztori, et al, 2010). Hardware may be required to enable the integrity, encryption, authentication, authorization, and privacy of IoT devices and communications in order to tackle security concerns (Stankovic, 2014). Training IoT developers and encouraging users of IoT devices to take advantage of their device's built-in security features will also be critical (Lee & Lee, 2015).

2. Architectural Challenge

A user centric IoT architecture is what referring to here, and it may be used to construct new apps by utilising data and IoT infrastructure (Gubbi, et al, 2012). A variety of IoT reference architectures are required due to the wide range of IoT application areas and the wide variety of IoT devices (Chen, et al., 2014; Gubbi, et al, 2012). IoT architectures must be able to accommodate a wide range of technologies, including RFID, tags, smart devices, and objects, because of the constant requirement for connectivity (Chaouchi, et al., 2013). (Chen, et al, 2014).

3. Privacy

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The Internet has long been plagued by the issue of privacy, and the Internet of Things will be no different. Internet of Things (IoT) adoption comes with the risk of losing privacy (ITU, 2005). IoT consumers benefit from privacy protection, but service providers are often "counter-productive" to privacy protection since they use the data, they acquire to improve their operations and give better service to their clients (Lee & Lee, 2015). Studies have been conducted in this area to try to find a solution or lessen the impact on privacy. Privacy brokering is an idea put out by Aztori et al. (2010) and Lioudakis et al.

4. Data Issues

The data generated by Internet of Things (IoT) devices must be analysed in order to be of any use (Lee and Lee, 2015). Data privacy, data management, and data mining all have their own set of concerns that must be addressed (Internet Society, 2015; Alaba et al, 2017; Borgia, 2014; Lee and Lee, 2015). Big data management can be a challenge due to data's distinct properties. In order to deal with the increasing volume of data, new architectures will be needed that can handle both personal and industrial data (Gartner, 2014). These data sets will necessitate the use of an online system to analyse and process them in real time. In order to extract useful data from unstructured data, such as images or videos, updated data mining algorithms and techniques are required (Lee and Lee, 2015).

5. Standardisation

Because of the importance of standards, all Internet of Things (IoT) customers can benefit from IoT services equally (Chen et al, 2014). Using technologies such as RFID, WSNs, ZigBee, NFC, and so on will allow you to accomplish this goal. Standards for Internet of Things applications may hinder their widespread adoption (ITU, 2005). Standards developing organisations (SDOs) have been working hard to build standards for IoT technologies, but there hasn't been an appropriate framework for these standards to be integrated (Aztori, et al, 2010). Many SDOs, on the other hand, are working with other organisations like the Industrial Internet Consortium, the Open Interconnection Consortium, and the ZigBee Alliance to speed up evaluating, developing, adapting, and integrating IoT standards.

3 Results and Discussion

3.1 Industry 4.0

3.1.1 Bigdata

Quantitative tools based on big data can help businesses identify patterns and develop new insights that can be used to tailor services, improve decision making, and foresee future trends. This gives them a competitive advantage (Barton and Court, 2012; Speranza, 2016). A survey of supply chain professionals found that 51% of them believed that 'big data' and data analytics would have the greatest impact on their

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strategies between 2021 and 2026, and 35% believed that predictive demand modelling would be the most affected by Big Data (JLL, 2016). IoT, which will connect billions of physical objects and processes to the Internet, is also closely related to Big Data (Speranza, 2016). As a result, it is predicted that big data will have a significant impact on the desired business outcomes and logistics transformation in the next few years (Chung, 2016; DHL, 2016a; Malisuwan et. al, 2016).

By implementing big data, the pharmaceutical industry can improve its service offerings. In order to help with drug development and product viability decisions, systems can be built using the intelligence of big data (PricewaterhouseCoopers, 2016a).

Stock markets around the world are being transformed by big data, which is reshaping how investors make investment decisions. Computers can now make accurate predictions and human-like decisions based on large amounts of data thanks to machine learning, which employs computer algorithms to search for patterns. The stock market is constantly monitored by the business archetype. Using the most up-to-date pricing information, analysts can make more informed decisions and avoid costly mistakes caused by human error and bias. Algorithmic trading, in conjunction with big data, provides traders with highly optimised insights for maximising their portfolio returns. Using big data analytics, predictive modelling can be enhanced to more accurately predict investment returns and outcomes. For financial trading, access to big data and improved algorithmic understanding results in more accurate forecasts and a better ability to mitigate the inherent risks.

As a result of the use of big data, financial institutions can reduce operational risk, combat fraud, as well as alleviate information asymmetry and achieve regulatory and compliance objectives. Banks have access to real-time data, which may be useful in spotting fraud. However, banks can take immediate action to alert their customers of potential security threats, such as blocking transactions made with the same credit card in two different cities within a short time span. Beyond the claim details, insurance companies have access to information from social media, past claims, criminal records, and telephone conversations. It can flag a claim for further investigation if it discovers anything suspicious. Real-time big data processing enabled Alibaba to develop an effective fraud risk monitoring and management system. It uses machine learning to identify bad transactions and detect fraud signals in real time.

3.1.2 Challenges of big data implementation

The lack of trust between supply chain partners in exchanging data electronically is a major roadblock to Big Data implementation (SMMT, 2017a). An executive survey of industrial companies found that 75% of those polled believed that operating a digital business increased their risk of exposure to security and trust risks (Accenture, 2017). When it comes to making the necessary investments in IT integration, there is an element of risk (DHL, 2016a; SMMT, 2017a). Seventy percent of the respondents to the SMMT study planned to make significant investments in internal IT integration, and 53 percent planned to make significant investments in external IT integration with

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supply chain partners (SMMT, 2017a). According to SME's investment funding was a major issue (SMMT, 2017a). It is also true that not all companies are willing to engage in more intensive data sharing practises simply because they lack the trust necessary to justify IT integration with suppliers and customers (SMMT, 2017a).
There is a knowledge and skill gap when it comes to digital strategy design and implementation when it comes to data quality and appropriate data science skills (DHL, 2016a; SMMT, 2017a). As a result, employers will have to ensure that their employees are equipped with the knowledge and skills necessary to take advantage of Big Data (PricewaterhouseCoopers, 2016a). Decision-making risks may arise as our society relies on causation-driven understanding of Big Data, which requires companies to base decisions on correlations (Fawcett and Waller, 2014). This risk can be mitigated by employing analytical human data skills to drive deeper and more nuanced analysis (Fawcett and Waller, 2014).

As part of the Basel Committee on Banking Supervision's (BCBS) Fundamental Review of the Trading Book (FRTB) regulations, financial institutions must adhere to strict access and reporting requirements. Security and confidentiality of user data are two other major concerns raised by the adoption of cloud computing. Even though some companies have set up private cloud networks, the cost of such projects is prohibitive for many. Big data initiatives have been held back by the inability to connect data from different departments and organisations, resulting in complicated analytics and stumbling blocks to their implementation.

3.2.1 Additive Manufacturing / 3D-Printing

Using 3D printing as a manufacturing process for products with high customisation and complexity but low volume is a possibility, according to Khan and Mohr, 2015. There is disagreement over how long it will take for the supply chain to become widely understood. in industries where 3D printing is used, the adoption of 3D printing has evolved over time. According to AT Kearney, 3D printing will be less important than other disruptive technologies in the short term (AT Kearney, 2015). Despite DHL's five-year forecast, a survey by Ernst & Young found that 38% of companies plan to use 3D printing in serial production within the next five years, despite the logistics company's prediction (DHL, 2016b; Ernst and Young, 2016b). Also, by 2025, McKinsey predicts that the 3D printing market will grow between USD 180bn and USD490bn (McKinsey, 2013; DHL 2016b).
There are some who believe that additive manufacturing (AM) will have as big an impact on the economy as the industrial and information revolutions (Anderson 2012; Khan and Mohr, 2015; DHL, 2016b). Its impact will be felt in a variety of ways, including new manufacturing methods. Small batches can be produced because there is no need for a tool changeover (Khan and Mohr, 2015). "Batch Size One" production: mass production of highly customised goods tailored to the individual customer's needs (DHL, 2016b). Speed factories, utilising cutting-edge robotics, automation, and 3D printing technologies, could be created to quickly produce customised goods in this

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manner (DHL, 2016b). The amount of material used in the manufacturing process can also be reduced by up to 95%, resulting in lower expenses associated with waste generation (Fawcett and Waller, 2014). Late-stage postponement can help the supply chain adapt to market shifts by tailoring individual offers to each customer (Khan and Mohr, 2015). Overproduction, inventory costs, out-of-stock costs, and trans-shipment costs can all be reduced with a shorter product development process (Fawcett and Waller, 2014). As manufacturing becomes more decentralised and closer to the point of consumption, production locations may shift (Tuck et al., 2007; Huang et al., 2013; Khan and Mohr, 2015; AT Kearney, 2015). Reduced lead times and greater responsiveness to changes in demand can be achieved through the relocation of manufacturing (Hopkinson and Dickens 2001; Ruffo et al., 2007; Reeves 2008; Petrovic et al., 2011; Vyas, 2016). Supply chain management will be simplified using on-demand production (Khan and Mohr, 2015). To put it another way, supply chains will become more environmentally friendly as they emit less carbon dioxide (Vyas, 2016).

Due to advances in 3-D printing's precision, detail, and surface finish, medical applications such as hearing aid moulds, dental crowns, and prosthetic limbs are increasingly being used. (Berman, 2012). The Food and Drug Administration (FDA) approved the first 3D printed pill, Spritam, in 2015. (Ben-Ner and Siemsen, 2017; KPMG, 2017b). Doctors will soon be able to use 3D printing and modelling to help them find and identify plaque in the arteries so that they can prevent heart attacks (KPMG, 2017b; Ben-Ner and Siemsen, 2017).

3.2.2 Challenges of AM implementation

When it comes to 3D printing, one of the most important concerns people have is safety (Khan and Mohr, 2015). The legal checks associated with traditional supply chains can be bypassed when harmful objects, such as weapons, are produced (Khan and Mohr, 2015). Ben-Ner and Siemsen (2017) also predict an increase in the production of counterfeit parts because anyone with access to a CAD design and a printer can produce them (Ben-Ner and Siemsen, 2017). Using 3D printers, it is possible to merge the design, manufacturing, and distribution processes, creating a possible blur between the purchase and creation of a new item (Khan and Mohr, 2015). Liability issues may arise as a result because the current legal framework does not consider copying physical objects when determining who is responsible in the event of defective products or production of harmful products (DHL, 2016b).

3.3.1 Robotics

Logistics and supply chain professionals can expect a significant impact from robotics soon, with implementation occurring in as little as four to five years (DHL, 2016a). There has been an increase of 17 percent per year in global sales of industrial robots from 2010 to 2014. (AT Kearney, 2015).

The emergence of e-commerce, a shrinking labour pool, and an increase in robotics research are all contributing to this explosive growth (DHL, 2016c). Online retail in

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Europe is expected to grow at a rate of ten percent per year, which will put a greater strain on logistics workers because online retail requires more labour per item sold than brick and mortar (Forrester, 2015; DHL, 2016c). Since 2000, the number of warehouse jobs has increased by approximately 700%. (Galluzzo, 2015). There is a shrinking logistics workforce due to shrinking populations in the Western world, and it is expected that Germany will have a labour shortage of up to ten million workers by 2020. (Strack et al., 2014; Chung, 2016; DHL, 2016c). Because of this, the current e-commerce growth and logistics labour requirements cannot be maintained (Galluzzo, 2015).

Thanks to generous government support, robotics has been given a fighting chance in the face of a severe labour shortage (DHL, 2016c). In addition to government stimulus programmes, venture capital investments, and large enterprise players such as Google and Amazon, this funding has been affirmed (DHL, 2016c). More complex tasks involving more complex movement and change sequences can now be performed by robots thanks to advancements in artificial intelligence (AI) (AT Kearney, 2015). As a result, Gartner Inc. and Oxford University researchers predict that automation will eliminate a third of all jobs within the next decade (Galluzzo, 2015).

In the 3PL industry, automation has the potential to have a significant impact, given that only 8% of warehouses currently use robots for picking and packing (Chung, 2016). Picking, packing, and sorting can now be done by Automated Guided Vehicles (AGV) thanks to recent advances in robotics technology (DHL, 2016c). Robots are capable of moving goods to human pickers, picking and packing at stations, and moving to storage areas to pick up goods (Chung, 2016). Flexibility is also enhanced by their ability to cover seasonal peak periods, move between warehouses, and carry out replenishment and cleaning activities at night (Chung, 2016). Unloading robots for trailers and containers can help workers who are doing physically demanding work. There are now robotic arms that can locate and analyse the volumetric characteristics of a single parcel, as well as deciding on the most efficient unloading sequence (DHL, 2016c).

Robots will also be used for last-mile delivery. Pre-sorting packages inside delivery units and autonomous parcel delivery are all possibilities, according to some researchers, in addition to moving heavy objects (DHL, 2016c). Robots that can drive on sidewalks and deliver packages to customers' homes are being developed by start-up companies. A thirty-minute delivery time goal is the goal, and customers will be able to choose from a variety of slots, track the robot's location in real time, and unlock the cargo with their phones when the robot arrives. In order to ensure the operation's safety, human operators will monitor the robot while it drives autonomously and intervene if necessary (DHL, 2016c).

There are also many ways in which a hospital delivery robot and a nurse can help each other out (DHL, 2016c). Prosthetics and "exoskeletons" can also benefit from robotics' wide range of capabilities, helping amputees and the elderly regain mobility (DHL, 2016c). Elderly people may also benefit from exoskeletons, allowing them to be more physically productive at work and at home (DHL, 2016c).

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3.3.2 Challenges of Robotics implementation

Robotics implementation presents a number of safety concerns (Galluzzo, 2015). Workers can't see traditional industrial robots, so they're enclosed in cages and programmed to shut down as soon as they arrive, making them inefficient (Galluzzo, 2015; DHL, 2015). Robot-human collaboration is also a major concern because of legal restrictions (DHL, 2016c). When it comes to liability, as robots learn and become more autonomous, they can be considered less under the control of human operators. When a legal entity is held liable for such an impact, this raises questions about current liability laws (European Commission, 2016b). Additionally, there will be legal and ethical issues to contend with. With the rise of robots capable of performing manual and repetitive tasks, governments, unions, and the general public will have to decide how much automation is appropriate and how much human workers can be replaced (DHL, 2015). While workers adjust to working alongside robots and creating a culture of human-robot interaction, cooperation, and collaboration, management faces significant risk (DHL, 2015). Additionally, a talent shortage risk may arise as more white-collar jobs are created to collaborate with robots, but the available talent pool lacks the necessary skills and expertise to programme them (World Economic Forum, 2016). The possibility of a loss of capital should also be considered (DHL, 2016c). Investment costs for industrial robots are too high for small and medium-sized businesses to justify (DHL, 2016a). However, new low-cost collaborative arms are entering the market that can alleviate this predicament (DHL, 2016c).

3.4.1 Drones /UAVs

The use of unmanned aerial vehicles (UAVs) in logistics is in its infancy. Technical limitations (such as poor weather stability) and regulations (such as the need for case-by-by-case approval) as well as public concerns about its use in densely populated areas are among the reasons given by DHL for this situation (DHL, 2016a). JLL (2016) supports this view, stating that air space regulations, security concerns, and commercial viability issues, when compared to current logistics models, impede mass delivery of packages to homes in consumer markets (JLL, 2016). As a result, DHL claims that commercial drone use will take longer than five years (DHL, 2016a). A long-term industrial application is expected, with low development levels in the next five to ten years, according to JLL's predictions (JLL, 2016). Drones will enable logistics companies to reach out to rural areas that are otherwise inaccessible (DHL, 2016a). Consequently, service quality can be improved without the need for human intervention (DHL, 2016a). Using unmanned aerial vehicles (UAVs) to deliver goods to distribution centres, retail outlets, or designated drop-off points can reduce the cost of individual shipments in urban networks (DHL, 2016a). This will alleviate traffic congestion in densely populated areas while also increasing the operational speed and flexibility of logistics networks in the first and last mile (DHL, 2016a). Monitoring sites and inventory with drones can help to prevent theft and report suspected damage or maintenance requirements (DHL, 2016a).

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Commercial drone trials have been successful, and regulatory bodies are expected to ease restrictions on drone deliveries in the coming years (DHL, 2016a). However, there are also a variety of views in the industry about how drones will affect logistics. Europe will see a minimal impact from drones in the next decade, but they could have a significant impact on low-cost product delivery for nations with less air space regulations and a lack of logistics infrastructure (JLL, 2016). (JLL, 2016). DHL, on the other hand, sees UAVs as primarily being used in high traffic areas and remote locations, but not as a replacement for ground-based transportation (DHL, 2016a). Drone delivery of small packages is expected to be commonplace by 2025, according to other industry experts (Trends Magazine, 2016).

Figure: 3.1

(Unmanned Grounded Delivery Vehicle)

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Figure: 3.2

(UAV- Unmanned Aerial Vehicle)

Drones can help the pharmaceutical industry gain greater global access. Increased reach and potential to save lives can be achieved by providing emergency delivery services to remote or underdeveloped areas (such as in Africa) (DHL, 2014a).

3.4.2 Challenges of Drones implementation

Drones pose a security risk because they are vulnerable to hacking (DHL, 2016a: Trends Magazine, 2016;). There is a potential risk of unauthorised interceptions or hacking because of the wireless connection to the operations centre (Kuila & Patki, 2022). In addition, commercial adoption is hindered by public concerns about security and privacy. Companies that monitor their employees and non-employees, whether on purpose or not, run the risk of being held liable for their actions (DHL, 2014a). People's concerns about the possibility of a ubiquitous unmanned aerial vehicle (UAV) spying on them are echoed by civil liberties organisations such as Privacy International (DHL, 2014a).

It is important to note that when using drones in densely populated areas, there are inherent safety risks, such as the risk of a UAV falling from the sky due to engine failure or navigation loss (DHL, 2014a; DHL, 2016a). To ensure that drones can be used safely, proper safety measures and operational procedures must be established to ensure that regulators are satisfied with the current state of granting approval on a case-by-case basis (DHL, 2014a; 2016a). The lack of a policy framework for commercial development means that investments in the technology currently carry a financial risk (Patki & Kuila, 2022).

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3.5.1 Blockchain

Sharing a digital record is made possible by an open infrastructure known as blockchain (Underwood, 2016; SMMT, 2017a). Using a distributed ledger that is not owned by a single entity, the technology is able to function (Underwood, 2016). Other computers on the network use cryptographic algorithms to encrypt and verify transaction data before it can be entered into the ledger. New data will be added to the chain and made available to the network if many computers believe that the transaction is valid. (Underwood, 2016). To keep transactions safe and secure, it is nearly impossible to alter any single record without detection (Underwood, 2016; SMMT 2017a). It is possible to have public or private blockchain networks. In contrast to public blockchains, which allow anyone to contribute, private blockchains are permissioned, limiting participation to a small group. It is possible that the latter is for a specific industry or chain of supply (Underwood, 2016). It is therefore possible to exchange verifiable information between supply chain partners while maintaining digital trust using a blockchain (European Commission, 2016; SMMT, 2017a).
As high-speed broadband networks and devices become more widely available in developed economies, blockchain technology can spread more quickly (Ernst and Young, 2016a). Furthermore, thanks to significant advancements in cybersecurity and blockchain technology, businesses can now store mission-critical data in the cloud with confidence (SMMT, 2017a). Supply networks that are more open and distributed may be possible because this information was previously held by external entities (Underwood, 2016; SMMT, 2017a). As the foundational technologies for blockchain, such as Big Data and cloud computing, are spreading, the impact of blockchain is expected to be realised sooner than expected and with greater levels of disruption than the current mobile-social-cloud-Big Data transformation, which is already underway (Ernst and Young, 2016a).

3.5.2 Challenges of Blockchain implementation

To gain more accurate and useful data in a shared blockchain, companies will have to accept the trade-off of competitors knowing their procurement details and the configuration of their supply chain channels (Ernst and Young, 2016c). Because many companies lack the level of trust necessary to justify increased data sharing practises, this competitive risk may not be worth foregoing (SMMT, 2017a).
There are also regulatory risks (European Commission, 2016a). No matter how much businesses, customers, or governments value blockchain, it will take time for the industry to come together to develop standards and regulations that govern how the technology can be used (European Commission, 2016a). Blockchain start-ups face an uncertain regulatory environment, which has a negative impact on their growth and capacity because it restricts their ability to take action (European Commission, 2016a).

The blockchain public ledger requires a common language with stated rules for interaction, which can only be achieved through standardised processes." The

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technology, however, may be hindered by lobbying pressure from established organisations (European Commission, 2016a). Banks will be the primary source of rebuttal because the transfer of economic benefits from goods and services has traditionally been the domain of banking institutions (European Commission, 2016a). A lack of investment in advanced analytics could leave businesses vulnerable to the next wave of data growth, including IoT and blockchain, if they don't invest in these technologies now (SMMT, 2017a). Maintaining competitiveness requires investment in the cloud, mobile, and Big Data, as many developed economies have already implemented the cloud and high-speed broadband networks to support the next wave of IoT and blockchain (Ernst and Young, 2016c).

4 Conclusion

From this research, it's time to draw any necessary conclusions. Following is a breakdown of the chapter's structure. Using the research aims and objectives from Section 0, the first section summarises the key findings from the literature review. It is important to note that these findings have managerial implications. Further analysis of these findings will identify their limitations and examine how they relate to other broader issues that have been studied in this study. As a result of this research approach, the chapter will conclude with a list of opportunities for further research, such as

i) This paper would help academicians and industrial partners to get an initial sketch of the industry 4.0 research.
ii) Discussed challenges and barriers of industry 4.0 would help organisations to map the current challenges they are facing.
iii) In a brooder extent, this research can be taken forward to understand the aspects of industry 4.0 in different sectors, such as retail, telecom and other government sectors.

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