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Industry 4.0 and the Food Manufacturing Industry: A Conceptual Framework

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Abstract

Background: The manufacturing industry is diverting away from the one-size-fits-all mass manufacture towards more customized processes. With increasingly individualized consumer preferences and an intense competitive environment, food manufacturers are required to meet specific consumer demands with similar efficiency to those produced massively. Such market requirements are feasible with the technological advancements envisioned by Industry 4.0. The consequences of such are increased flexibility and mass customization in manufacturing which forces the food manufacturer towards its realization. The integration process, however, involves a comprehensive transformation that affects every aspect of the organization. This consequently imposes significant challenges upon the food manufacturing company.

Purpose: The study aims to investigate the transformation process ensued by the food manufacturer for Industry 4.0. Consequently, a conceptual framework is developed detailing the application of Industry 4.0 in the food manufacturing industry.

Method: An inductive qualitative approach, in combination with a multiple-case study, is pursued to address the formulated questions of research. Based on such, semi-structured interviews were conducted with individuals representing three multinational food manufacturers. Further, a thematic analytical technique was adopted as means to identify similarities and patterns within the obtained data. The collected data was analyzed using thematic analysis through which the researchers came up with the conceptual framework.

Conclusion: The results of the research reveal internal and external factors such as labor policies and IT infrastructure to influence the transformation process for Industry 4.0. In due to this, the implementation of the phenomenon occurs phase-wise, globally coordinated and regionally concentrated. This enables the organization to overcome the obstacles faced and, subsequently, ensure the successful deployment of Industry 4.0.

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Muhammad Soban Adil & Sedin Mekanic

Abbreviations

I4.0	*Industry 4.0*
IoT	*Internet of Things*
IIoT	*Industrial Internet of Things*
ICT	*Information and Communications Technology*
CPS	*Cyber-Physical Systems*
MNE	*Multinational Enterprises*
IoS	*Internet of Services*
ERP	*Enterprise Resource Planning*
MES	*Manufacturing Engineering Systems*
SME	*Small & Medium sized Enterprises*
MNC	*Multinational Corporation*
JIT	*Just in Time*

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1. Introduction

This chapter aims to give a short introduction to Industry 4.0 and the implications on the food manufacturing sector. Further, the problem description, purpose and objectives, and research questions are presented. The chapter concludes with an outline of the study.

1.1. Background

The manufacturing industry is subject to a continual process of evolution. First, came the realization of new energy sources such as the application of the steam engine. Then, came the shift towards mass manufacture, initiated by standardizing production processes. Next, came the adoption of Information and Communications technology (ICT) into the manufacturing industry, gradually mitigating the barriers between the digital, physical, and biological spheres. Today, the manufacturing industry, once again, stands at the cusp of an industrial revolution. It is widely regarded that the manufacturing industry is diverting away from the one-size-fits-all mass manufacture. Increasingly individualized consumer preferences, changing market dynamics, have amplified the need for profitable mass customization. Such production aims to meet specific consumer demands with similar efficiency to those produced massively (Calegari & Fettermann, 2018), necessitating a flexible and agile supply chain. These requirements have induced the desire for new fabrication techniques. As such, changing market conditions and dynamics are forcing the organization towards continuous adaptation and proactive change, as means to create and capture value. This is where digital transformation becomes relevant.

A consequence of the precedent gradual fusion of technologies, the emerging revolutionary phase originated in Germany in 2011 and is commonly referred to as "Industry 4.0". It involves a radical digital transformation of key business operations wherein advanced technology is integrated into every aspect of the organization. The paradigm of Industry 4.0 envisions the creation of an intelligent, self-regulating, and interconnected industrial value chain (Liao et al., 2017). In this context, manufacturing

technologies are upgraded and transformed by cyber-physical systems (CPS) and the Internet of Things (IoT), these being the kernel of Industry 4.0 (Davies et al., 2017; Zhong et al., 2017). Such convergence of digital technologies enables the creation of a virtual replication of the physical system in a sandbox environment. This introduces the possibility for predictive analytics through simulation (Ezell, 2018; Lu, 2017). In other words, manufacturing systems are able to interact and conduct intelligent real-time data analysis to forecast failure, configure themselves, and align to changes. Accordingly, a "smart factory is established. The consequences of such are increased flexibility in manufacturing, improved productivity, and more importantly, mass customization (Wang et al., 2016; Zhong et al., 2017). This enables the organization to efficiently produce increasingly individualized products with high quality and short-lead time to market. It thus enables the organization to cope with the current challenges imposed by the shift in consumer demand. Evidently, the realization of the phenomena becomes lucrative industry wide. Especially within the food manufacturing industry.

This sector of the economy is maculated with changing consumer preferences and an increased demand for a wider variety of unique goods (Luque et al., 2017; Hasnan and Yusoff, 2018). To this then, existing practices such as lean seem unable to fully address the shift to customization in a profitable manner (Sanders et al., 2016; Kolberg & Zühlke, 2015). As a consequence, food manufacturers are increasingly attentive to the paradigm proposed by Industry 4.0. The technological advancements of the phenomenon are envisioned as to enhance the responsiveness, flexibility, and productivity of manufacturing systems (Hasnan & Yusoff, 2018; Luque et al., 2017; Sanders et al., 2016; Erol et al., 2016). This directly addresses the issues that currently entail the food manufacturer, facilitating profitable mass manufacture. At the same time, however, such digital transformation imposes substantial challenges upon the organization. More so to the food manufacturer. This industry has, in general, exhibited an incapability to fully utilize digitalization. In that sense, it has lagged behind other sectors such as automotive. Albeit the need to continuously upgrade technology may differ between sectors, the opportunities presented by Industry 4.0 are too lucrative to ignore. Increased demand for individualized products, strict requirements for food safety, along with the increased awareness on quality, is forcing the food manufacturer towards Industry 4.0 technologies.

The emerging revolutionary phase, thus, encompasses the digitalization of modern manufacturing.

1.2. Statement of Research Problem

It is clear that Industry 4.0 technologies are presented as an essential factor to address the obstacles facing food manufacturers today. As with most technological advancements, however, to introduce such technology bestows significant pressure on the organization. More so to the food manufacturer as this sector fails to fully utilize digitalization which has consequently constrained the transformation of Industry 4.0 into industrial practice. Nevertheless, an increasing number of food manufacturers, mainly multinational enterprises, direct their attention and resources towards Industry 4.0 adoption (IW Consult/FIR 2015: 26). To, however, fully implement the I4.0 model signifies a radical digital transformation which is a significant challenge for even the largest of firms. For that matter, it is imperative for research to investigate these factors that obstruct the digital transformation process to Industry 4.0. More importantly, the measures and actions undertaken by the food manufacturer to overcome these. So far, however, it has not attracted much research attention. It is apparent that the fourth industrial revolution has undoubtedly become one of the more important research topics in the realm of manufacturing. The many studies conducted have primarily focused on the potential of the respective digital technologies and application areas in the organization (Liao et al., 2017). Hence, less attention has been directed towards how the digital transformation process unfolds especially within the food manufacturing industry. To advance general understanding of the digital transformation process for Industry 4.0 adoption, the study aims to investigate the required actions and measures implemented by the food manufacturer to ensure its successful deployment.

1.3. Purpose and Objectives

The aspiration of the proposed research is to develop a conceptual framework that addresses the application of Industry 4.0 in the food manufacturing industry. For that, the following research questions are proposed:

i. What are the challenges faced by the food manufacturer for the adoption of Industry 4.0 - related technologies?
ii. How are these identified challenges managed by the manufacturer to ensure the successful digital transformation to Industry 4.0?

1.4. Disposition

This section of the study provides a brief overview of the structure encompassing this paper. **The opening chapter** of the dissertation addresses the topic and purpose of study. This section provides the reader with clarity on the research subject, as well as the objectives targeted by the researchers.

The second chapter, then, regards the frame of reference and attempts to contribute sufficient background knowledge concerning the topic of study. In a more detailed manner, the phenomena of Industry 4.0 and the related technologies is profoundly described and related to the food manufacturing industry.

In the following chapter, emphasis is directed towards the scientific approach of research conducted. This methodological section includes research philosophy, research approach, research design, data collection, and data analysis. The closing segment of the chapter addresses and ensures the quality and ethics of the research conducted.

The empirical findings are presented in the **fourth chapter.** Here, the subjects of research, i.e., participating firms, are introduced and thoroughly described. This lays the groundwork for the subsequent analysis of data.

Thereafter, in the **fifth chapter** of the study, the systematic analysis of the empirical findings is addressed. In a more detailed manner, the transcribed material retrieved from interviews is assessed in accordance to the categorization technique applied. Further, the study delves deeper into the examined cases in an attempt to later address the formulated research questions.

The sixth and final chapter of the study presents the concluded findings of conducted research. Herein, the set research questions are further addressed and fulfilled. Moreover, the contribution of the research conducted is presented. This is followed by the respective limitations of the study and suggestions for future research concerning Industry 4.0.

2. Frame of Reference

This chapter provides an assessment of literature that addresses the topic of research. First, an overview of Industry 4.0 is provided, and second, the comprising technologies are examined in detail. Last, the applicability of the presented phenomena is analyzed in relation to the food manufacturing industry.

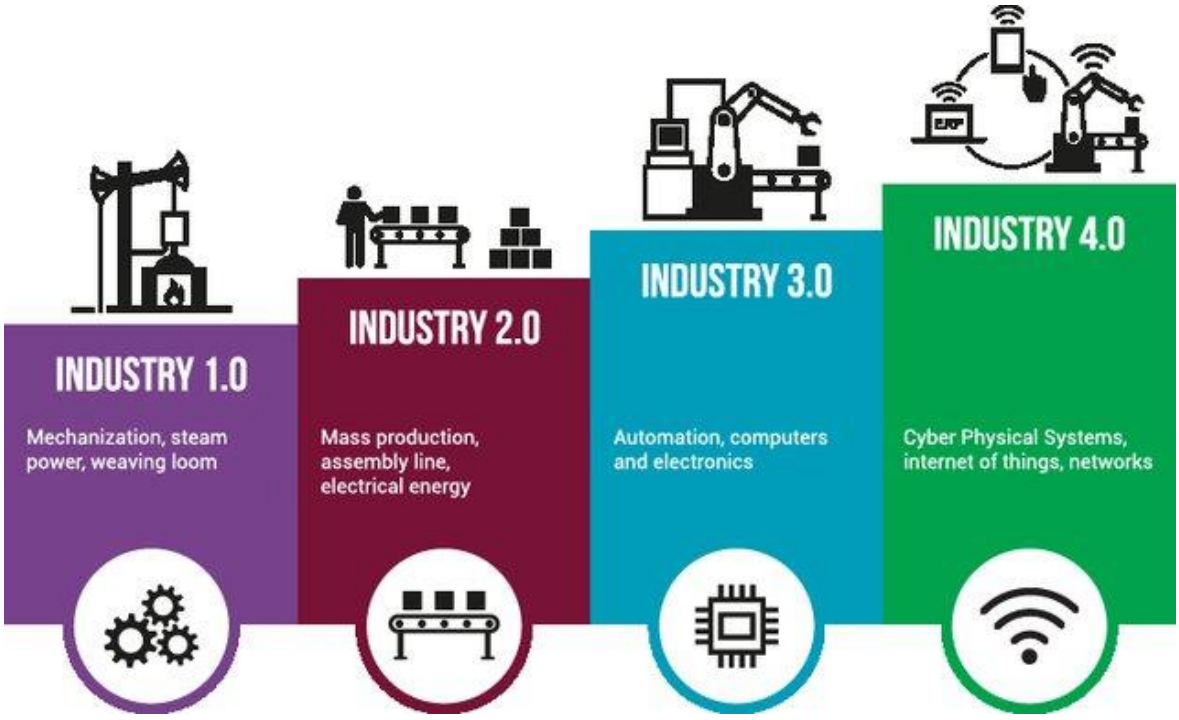
2.1. The phenomena of Industry 4.0

Product quality, sustainability and just-in-time production are currently one of the biggest concerns of organizations. Lean practices have been utilized to overcome these issues and it is important to implement them with consistency and awareness for the organizations to succeed (Sanders et al., 2016). Some firms have succeeded in implementing most of the lean practices. However, the organizations are still lagging in gaining its fruit to the fullest. This is where industry 4.0 comes-in, it is a new concept, also known as the fourth industrial revolution (Tortorella & Fettermann, 2017).

Three previous industrial revolutions had an immense effect on the manufacturing industry. They allowed the productivity and efficiency of the industrial sector to extensively grow. The first industrial revolution took place in mid-18th century, followed by the second in 19th century and the third in 20th century. Industry 4.0 is represented as the fourth industrial revolution. I4.0 uses advanced technologies extensively, it has been discussed and researched extensively among the researchers (Pereira & Romero, 2017; Zhou et al., 2015). However, few authors think that there is substantial room for more research on its impacts within different manufacturing industries. Industry 4.0 is a concept that embodies the upcoming industrial model with the implementation of various things. These include the implementation of Cyber-Physical System (CPS), Internet of services (IOS), Internet of things (IOT), big data, cloud manufacturing, augmented reality and robotics (Pereira & Romero, 2017). The perception of industry 4.0 was introduced

in Germany in 2011, where it was not given much attention. However, during a conference in 2013 in Germany it was talked about again and this got the attention of the German Government. After which the German government introduced it as one of its strategic initiatives (Rojko, 2017).

Figure 1. Industrial Revolutions



(Kucera et al., 2018)

Industry 4.0 has been envisioned as a smart factory with the application of future-oriented machinery and a state-of-the-art communication and information system (Sanders et al., 2016). This revolution will transform the industry into producing more efficiently and effectively, while keeping the communication a vital part of it (Luque et al., 2017). However, as mentioned by Sanders et al. (2016), the whole process of implementing I4.0 and making it operational is a cost-intensive process. As was the case with previous revolutions, the countries and companies will take some time to adopt to the new revolution. However, few countries have already introduced policies for the implementation of industry 4.0 within their manufacturing industries. Germany is at the forefront of its application followed by Brazil and Spain (Sanders et al., 2016; Luque et al., 2017; Tortorella & Fettermann, 2017).

Nowadays, the manufacturing industry is changing at a considerable rate. This change is directed by the dynamic customer demands and market trends. Furthermore, the

manufacturing is moving towards individualization. This requires the firms to adapt to these changes swiftly (Zhou et al., 2015; Bartodziej, 2017). The researches carried out on industry 4.0 show it as an encouraging solution to these issues. As I4.0 works by amalgamation of all the manufacturing processes of the organization (Sanders et al., 2016; Zhou et al., 2015). It is important to understand how execution of industry 4.0 is done? It is based upon the cyber physical system (CPS) building blocks. Which are ingrained with advanced connectedness and decentralized controls. These blocks can communicate with each other in real time and transfer important information without human influence. However, comprehensive software support is still required to gather these blocks on the same platform. This is done with the usage of enterprise resource planning (ERP) or manufacturing engineering systems (MES) (Pereira & Romero, 2017). Introduction of these technologies affect the productivity and efficiency of an organization. As they minimize the human contact and information sharing is not just done from the machine to the operator but also to other machines. This tremendously affects the production time of an organization (Jazdi, 2014; Bartodziej, 2017).

Industry 4.0 is a new concept, which the scholars are still trying to study and research on. Further, looking for mechanisms to implement it in different industries. At the same time, some researches also show that it is too early to talk about its implementation and it will take ten or more years to fully understand this phenomenon. Moreover, the authors mention that this concept is far from being realizes as there are many challenges which come with this revolution and have not been figured out yet. These challenges include political issues, technological issues, social issues, economic challenges and scientific challenges (Luthra & Mangla, 2018; Zhou et al., 2015). Furthermore, Zhou et al. (2015), in their research mention that it is important to investigate these challenges and sort them out. As I4.0 is a “smart factory” concept, it will remove the human interaction and the process will be working completely with the artificial intelligence. Whereas, different manufacturing industries require different types of processes. Thus, proper processes are required to be constructed according to needs of the manufacturing industry utilizing I4.0.

As mentioned in the beginning, lean practices were being implemented by firms to overcome the changing demands of the customers. Furthermore, Industry 4.0 was introduced to overcome the areas which the firms were lagging even with implementing lean practices (Sanders et al., 2016). The scientific material available differs with the

concept of relation between lean practices and Industry 4.0. As few scholars are of the opinion that for the implementation of industry 4.0 in an organization, lean practices should already be practiced there. Whereas, few scholars suggest that there is no evidence of relation between the both and implementation of lean practices is not a requirement for introducing Industry 4.0 (Sanders et al., 2016; Pereira & Romero, 2017; Bartodziej, 2017). Moreover, Mayr et al. (2018), have based their research on the inspecting the effects of lean practices on the implementation of I4.0 within the manufacturing industry. The scholars mention Bill Gates within their research, who said that lean practices are a prerequisite for the implementation of I4.0. As lean practices are utilized to make the manufacturing process more efficient whereas, I4.0 automates that process. So, if the existing process is not efficient and industry 4.0 is implemented, the organization will face high level of disruptions leading up to inefficiency.

2.2. Industry 4.0 and the related technologies

Industry 4.0 is a complicated yet adjustable system, that is based on different technologies. It is important to understand that these technologies are digital based technologies. Furthermore, the system automates the whole manufacturing process and gathers real time data, which can be utilized by the management for analysis and make well informed decisions (Zhou et al., 2015). The base of industry 4.0 is made by nine technologies, even though they are already in use by different manufacturing companies. However, with industry 4.0 these technologies are unified for the manufacturing process. In addition, this unification enhances and automates the production process (Rüßmann et al., 2015). The table 1.0 provides an insight to the technologies of industry 4.0.

Table 1.Technological pillars of industry 4.0

S.No.	Pillar	Description
1	Big Data and analytics	Analytic technology that is used to determine the threat, solution, prevention, control and to forecast the new issues based on large data sets recorded from many different sources.
2	Autonomous robots	Industrial robots that can complete tasks intelligently, with the focus on safety, flexibility, versatility, and collaboration.
3	Simulation	The simulation software is used to leverage the real-time data and model the physical manufacturing system. This allows an engineer to test, analyze and optimize the setting virtually before any actual changeover is conducted.
4	Augmented reality	A real-time view of a physical real-world environment that has been enhanced or augmented by superimposing virtual computer-generated information to it. The main components of AR technology are displays, input devices, tracking, and computers.
5	Horizontal and vertical integration	The establishment of a universal and standardized data network system enables different companies, departments and functions to be integrated and linked, whereby a seamless cooperation and an automated value chain is made feasible
6	Cybersecurity	The provision of reliable communications, sophisticated identity and access control for systems to address the issue of cybersecurity threats.
7	Industrial Internet of Things (IIoT)	The inter-networking of the different objects which are embedded with sensors, actuators or other digital devices for data (information) collection and exchange. This enables the devices to communicate and interact with one another and with a more centralized controller, as necessary. It also decentralizes analytics and decision making, allowing real-time responses.
8	The Cloud	The cloud computing allows data sharing across the connected devices to the same cloud within milliseconds or faster. This implies that the cyber-physical systems operating in the manufacturing system can be intelligently linked with the help of cloud systems in real time. The cloud computing enables the delivery of computing services such as servers, storage, databases, networking, software, analytics and more applications through visualized and scalable resources over the Internet.
9	Additive manufacturing	Additive manufacturing made use of a virtual model e.g. a complex 3D CAD model data, to produce a product in a fully automated process through 3D printing or use of similar technologies.

(Hasnan & Yusoff, 2018)

2.2.1. Big Data and Analytics

Big data means the collection of real time data being provided by the sensors in any process. Whereas, analytics is where the said data is analyzed, and conclusions are drawn. However, in industry 4.0 big data is a collection of data sets that are used to draw conclusions with the use of analytics, about the products being produced. This process greatly helps in reducing the decision time, optimizing production, increasing product quality and giving a heads up for machine repairing/service (Chen et al., 2018; Rüßmann et al., 2015).

As mentioned before, the data collection is done through sensors, which are placed at different points within the process. These points include manufacturing machines, manufacturing process, company management systems and customer management systems (Rüßmann et al., 2015). For a smart factory to work continuously and provide quality products, intelligent machinery is a requirement. Furthermore, the maintenance of the machinery is also an important aspect. With the help of the data being provided by the sensors, the failure of the machinery and maintenance requirement can be predicted (Chen et al., 2018). Prediction of failure and routine maintenance can greatly reduce the breakdowns. Thus, increasing the production productivity. Moreover, big data and analytics greatly helps in product design optimization. As data mining is utilized in mining different data and modeling it to come up with desirable results (Chen et al., 2018; Frank et al., 2019).

2.2.2. Autonomous Robots

Robots have been long used in the manufacturing industry around the world. The main reason for their usage is the precision with which they can work. Furthermore, they can perform complex tasks in less time as compared to humans. As the world is changing, so are the robots. Nowadays, more advanced robots are being developed, that are autonomous with least amount of human interaction. Furthermore, these robots are capable to communicate with one another and in a safer environment (Frank et al., 2019; Rüßmann et al., 2015).

Industry 4.0 encourages more autonomous processes. Therefore, autonomous robots are an important aspect of implementing I4.0 in the manufacturing industry. Robots have been categorized in two types by few scholars. These include collaborative robots and

autonomous robots. Furthermore, autonomous robots are used for a manufacturing process and is a part of the smart factory. Whereas, the collaborative robots collaborate with humans and help them with their work. This makes the employees more agile and improves their performance (Romero et al., 2016; Frank et al., 2019). The main idea behind collaborative robots is to make the employee more available for more complex tasks that require the precision of the human eye in the manufacturing process (Frank et al., 2019). Moreover, the employees pass through extensive training programs which provide them with extensive knowledge that is beneficial to the whole production process (Zhou et al., 2015). However, the introduction of autonomous robots will highly increase the quality and productivity of the process. In addition to making the whole process more sustainable (Romero et al., 2016). Moreover, there are still certain scholars that consider it as a vision and label it as irreplaceable. According to them, the current manufacturing processes are required to be well-designed and according to the industry its being applied in (Maly et al., 2016).

2.2.3. Simulation

In any organization, it is important to understand the workings of a new process or product that must be introduced. Simulation is a method of using a model of that process or product to study and understand it better. In recent times, simulation has become an important tool for organizations. As it provides them an opportunity to see the workings of their project before its implementation. However, this concept has been there since the 1960s, but was not widely used. Simulation was mostly used in the engineering side of the manufacturing process and included 3D mapping for the processes, products and equipment (Rodič, 2017).

With the implementation of Industry 4.0, simulation is used at multiple places within the process. Additionally, it gives a benefit to the employees to have a prior knowledge of how the process will work. Furthermore, the real-time data collected through the sensors can be used to make a simulation and reflect the physical situation. Another word used by different scholars for this practice is a “digital twin”. With the help of the simulation the employees can analyze the process and revamp it according to their requirement. Moreover, this exceedingly increases the product quality and highly reduces the setup time for the machines (Rodič, 2017; Rüßmann et al., 2015).

2.2.4. End-to-End, Horizontal, & Vertical System Integration

Computers have been used in the manufacturing process for some time now. They help the employees with the production and record the data for further research. According to Rüßmann et al. (2015), companies are not completely integrated. Which includes the different departments of the organizations as well as the customers. Zhou et al. (2015) mention in their research that there are three types of integration that a firm can achieve, horizontal, vertical and end-to-end integration. Where, horizontal integration is between the information provider and the production machines. This provides a seamless connection for the information to flow and improve productivity. Furthermore, vertical integration is between the departments of the organization. This form of integration increases the flow of information between the departments as well as reduces the time for approvals. Thus, greatly improves the productivity of the whole process (Pereira & Romero, 2017). Whereas, end-to-end integration means, integrating all the systems across the whole process chain. This includes the departments, production line, warehousing, supply chain and logistics (Zhou et al., 2015).

Pereira & Romero, (2017), mention in their research that the above mentioned three dimensions of integration are Industry 4.0s main part. The main purpose of industry 4.0 is to achieve seamless processing that can ultimately reduce productivity and increase quality of the products (Luthra & Mangla, 2018). Moreover, with the integration the departments of organizations will become more connected and over-time as it is implemented slowly, the true objective of a smart factory can be achieved.

2.2.5. The Industrial Internet of things

Ever since internet became a reality, the interconnections of computers have also become a certainty. It has changed the way people used to get around their daily lives, has made communication among the people easy, as well as gives a perception of reduced distances. Similarly, the internet has also reconditioned the industrial world in its workings. Nowadays, there are smart devices which are capable of doing all the tasks imaginable, yet they are hand-held devices. The focus of the manufacturing industry is to utilize these devices to their fullest and develop an intelligent network within organizations (Zhou et al., 2015). Moreover, according to Zhou et al. (2015), it has been observed that Industry 4.0 will be making more use of the internet and internet of things. According to the

scholars, this will help in communications of humans and machines, which will in turn make machines more intelligent while manufacturing products (Rüßmann et al., 2015).

Industry internet of things (IIoT) is a concept which is used in Industry 4.0 for connectivity of the organization, within as well as with its stakeholders. The main function of IoT is gathering data that it collects through different networks and sensors placed throughout the manufacturing process. It does that with the usage of different technologies, these include sensing devices like RFID, infrared sensors, positioning sensors, laser sensors and many other technological devices which are connectable to the internet (Frank et al., 2019).

Nowadays, many organizations use sensors and computers in their processes but the majority of them have not integrated them. Which insinuates that the components do not communicate with each other. Whereas, with IoT the devices are interconnected and communicate with each other over a secure wireless connection. It makes it easier to control the devices through a centralized setup. However, the data collection is performed in a decentralized manner, as per the specified process. This helps in fast decision making on the basis of singular processes. Furthermore, it allows to take decisions in real time, hence making the process more seamless (Rüßmann et al., 2015; Frank et al., 2019; Zhou et al., 2015).

2.2.6. Cyber Security

Cyber security is an important part of any organization, as data safety is its utmost priority. Currently, the companies work within a close network, without the possibility of outside sharing from within the network. Furthermore, most of the firms have advanced firewalls to protect themselves from hackers. However, sometimes these protective measures are also not enough, and the firm can suffer major damage (Rüßmann et al., 2015).

With the introduction of I4.0, this is a bigger challenge as industry 4.0 requires the integration of all the processes as well as connections with the stakeholders involved in its process. Which means, the network will no longer be closed and will be more susceptible to outside attacks. Since, many production processes are interconnected, and data is being shared. Thus, proper preventive measures are required to be applied. As few scholars have also indicated that a thorough sophisticated cyber security system needs to

be in-place according to the requirement of the manufacturing industry to tackle this problem. As firms are also responsible for the data of their supply chain partners and not only for their own data (Luque et al., 2017; Luthra & Mangla, 2018; Zhou et al., 2015; Rüßmann et al., 2015).

2.2.7. The Cloud

The cloud was a new concept introduced a few years ago. It is believed to reform the existing computing industry. The essential function of the cloud is to save the data away from the source and at a location which is accessible from around the world. It is currently being utilized by different companies to save their data as it makes it more secure and in an event of an unforeseen disaster, the data is not lost (Dillon et al., 2010).

As the main purpose of implementing Industry 4.0 is to achieve complete integration. Cloud plays a major role in it. As in the manufacturing process, the sensors are sending real-time data and the machines are communicating with each other. It is essential that the data being sent and received is saved at a secure place. This is where the Cloud comes-in, as the data can be saved on it and will remain there unless otherwise instructed. Furthermore, I4.0 also includes big data, which is huge chunks of data, cloud is useful in storing it in small quantity (Li et al., 2017). Moreover, another requirement of organizations implementing I4.0 is to share data with its subsidiaries and outside the company bounds. This data sharing can be regarding the production process or machine data or data for suppliers. This will be made more effective with the cloud as the data can be accessed by others in matters of seconds. Further, this can increase the overall process effectiveness, as the data can be accessed and supervised remotely (Rüßmann et al., 2015; Jazdi, 2014).

2.2.8. Additive Manufacturing

As industry 4.0 is the 4^{th} industrial revolution, thus, it brings with itself new ways to manufacture products. Additive manufacturing is one of the physical parts of I4.0. With the current manufacturing practices of firms, their capability is limited when it comes to customization and currently, the world is rapidly moving towards customization. Therefore, additive manufacturing will be a vital part of an organization implementing industry 4.0 (Dilberoglu et al., 2017).

Additive manufacturing is a completely new concept and companies are starting to utilize this. Aerospace companies are at the forefront of using this technology. This form of manufacturing mainly utilizes 3D printing, applying different prototypes and manufacturing individual units. As mentioned before, the customers are demanding more customized products, this technology will greatly help organizations in making a small bunch of those products (Rüßmann et al., 2015). Furthermore, the organizations can focus on making lighter products for their machines while maintaining or repairing. This will help the firms in reducing the costs of transport for those parts as well as save time (Dilberoglu et al., 2017).

2.2.9. Augmented Reality

Augmented reality itself is a concept that is starting to appear in the world. It is an explicit or ambiguous image of the real word that has been virtually upgraded with the usage of different software's (Carmigniani et al., 2010). It was initially developed to be used in mobile phones and smart glasses. In recent times, it has been introduced as one of the technologies that is used for the implementation of Industry 4.0 in the manufacturing industry (Maly et al., 2016).

Augmented reality can be used in various ways with the implementation of industry 4.0. It can be used for the benefit for the workers. As with augmented reality, the workers can be provided with real-time data. This will help them in making better decisions while working. Furthermore, if a worker is maintaining a production machine, the designs or method to carry out that process can be displayed in their line of sight. This practice will reduce the chances of a mistake immensely (Rüßmann et al., 2015). In addition, the mentioned technology can greatly help with autonomous robots. It can be used for the visualization of the robots using 3D technology. Even though this is a concept and the scholars mention that further research is required on this concept. However, within their research the authors mention that usage of 3D technology is greatly effective as it helps the robot in judging the movements of the employee and does what it is required to do (Maly et al., 2016).

2.3. Food Manufacturing Industry

Manufacturing industries around the world are dominated with large players. Be it automobile, aerospace or pharmaceutical industry, all these industries tend to have one large manufacturing facility that caters to several regions. However, that is not the case with the food manufacturing industry. The food manufacturing industry is made-up of small and medium enterprises (SMEs) and multinational corporations (MNCs). Furthermore, these companies tend to place small manufacturing units close to their consumers unlike other industries (Bolling & Gehlhar, 2005).

The food manufacturing industry comprises of diverse products, which differ is every aspect from its production time to delivery time or is it a perishable item or not. The production process of these products differs based on their characteristics. Furthermore, the supply of these products also varies due to their attributes (Dora et al., 2015). Moreover, legislation is another issue faced by the food manufacturing industry, as these vary from area to area. It is important to understand that the food manufacturing industry starts from the farmer and ends at the final consumer (Lawrence & Friel, 2020).

Food manufacturing industry produces a wide variety of products and every product has a different production process and supply chain requirements. This insinuates that different products have different expiry dates and distinct manufacturing processes. Furthermore, the product line also depends upon the market it is produced for. Similarly, the marketing practices also vary according to the product and market it is to be sold in (Bolling & Gehlhar, 2005). Additionally, the food manufacturing industry produces products that are affordable, convenient and durable. These products include foods that are nominally processed and can be used in the daily lives of people. The said industry can mass-produce the food items that can also be cooked at home. The distinction between them are the characteristics, which the food manufacturing firms instill, to acquire their targets. These characteristics include shelf life, durability, intensified flavors and low cost (Lawrence & Friel, 2020).

As the food industry is made up of SMEs and MNEs, it is important to understand the difference between these both and how they differ. SMEs are small and medium sized companies whose focus is a limited region in which they produce and sell the products (Dora et al., 2015). Within SMEs, small enterprises are bases on a local level and medium

enterprises are based on national level. Furthermore, SMEs have some advantages over MNCs which include the involvement of the top management, smaller team sizes, informal culture and structure. These advantages help these companies is making decisions more efficiently (Lawrence & Friel, 2020; Dora et al., 2015). Moreover, MNCs are large companies that are spread across borders and continents. These companies include big names like Unilever, Nestle, Mondelez, Kraft etc. These large companies own most of the share of the food manufacturing industry. These firms work in a different way then to any SMEs as they have the required stability, capability and funds. They expand by acquiring local companies in their desired region (Bolling & Gehlhar, 2005; Lawrence & Friel, 2020). Moreover, as these companies are based in most of the countries, they operate through regional offices. Which means, they have divided their market area in different regions and those regions have country offices underneath them. However, most of these companies have manufacturing plants in most of the countries and produce the products according to the market demand (Bolling & Gehlhar, 2005; Demartini et al., 2018).

2.4. Industry 4.0 and Food Manufacturing Industry

The food manufacturing industry has immense competition within and for the survival of organizations, they need to produce products that are distinct from one another. This exercise forces companies to come-up with new products or purchase a small or medium enterprise in a certain region. Furthermore, for companies to achieve the competitive advantage, they also need to alter their processes which range from production to their supply chain (Lawrence & Friel, 2020). This requires the organization to digitize their processes as well as apply lean practices within their processes. These practices are already being utilized by large scale firms as it provides them with better productivity, increased product quality and enhanced supply chains. Moreover, the focus of this industry towards digitization only increased in the year 2016 (Demartini et al., 2018). However, before that the focus was towards the adaption of lean practices to make the manufacturing processes seamless. These practices are applied throughout the manufacturing process and the supply chain (Dora et al., 2015). Moreover, it is important to understand that the food manufacturing industry has different types of supply chains, depending upon the product it is for. There is a general supply chain and then there is a cold supply chain, all the products that are not temperature sensitive can utilize the normal

supply chain. Whereas, for temperature sensitive products, cold supply chain is necessary to keep the product from deteriorating before it reaches the consumer. Furthermore, another reason for the organizations to utilize lean practices was to make their processes and supply chains more sustainable due to the ongoing global warming (Pilinkienė et al., 2017). However, the scientific material studied has shown that complete implementation of lean practices can not be achieved. Moreover, for SMEs it was a bigger challenge due to lack of funds and resources. Thus, MNCs have implemented lean practices but they still lack the goals they want to achieve. Even though with its implementation, most of the processes are digitized and production is done seamlessly. However, due to ever changing customer demands and increase in customization of products, the firms are lagging (Pilinkienė et al., 2017; Dora et al., 2015; Buer et al., 2018).

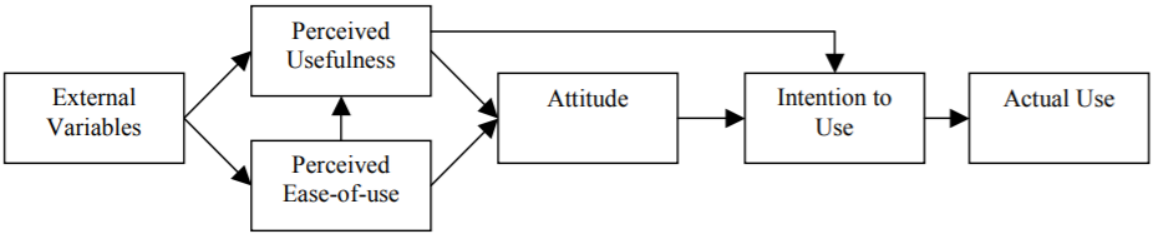
As mentioned previously, few scholars are of the opinion that implementation of lean practices is a prerequisite for implementation of Industry 4.0 (Mayr et al., 2018). Moreover, the focus of Industry 4.0 is to digitize and integrate the whole process of food manufacturing organizations. The organizations already have a lot of technologies implemented within their process, but they are not integrated at desired level. The focus of the firms nowadays in the food manufacturing industry is to implement JIT, this will immensely help in reducing waste and making their processes sustainable. This can be done with the integration of inventory levels, manufacturing process and supply chain. Furthermore, with the implementation of industry 4.0 the digital appliances will be able to exchange information over a wireless network. This practice will make the whole process more productive and seamless. Moreover, with the implementation of the mentioned technologies, the main objective of a “smart factory” can be achieved as well as overcome the issues being faced while practicing lean (Buer et al., 2018).

2.5. Technology Adoption Models

2.5.1. Technology Acceptance Model

Acceptance of a new technology by the user is one of the major hurdles in introducing a new technology. During 1970s, a lot of new technologies were being introduced but failed during its implementation phase. Multiple studies were conducted to overcome the failure rate but were unsuccessful (Chuttur, 2009). However, in 1985 Fred Davis in his doctoral thesis suggested a technology acceptance model. Moreover, this model was achieved with the help of previous work done by Fishbean & Ajzen (1975), on Theory of Reasoned Action (Lee et al., 2003; Chuttur, 2009).

Figure 2. Technology Acceptance Model



(Röcker, 2010)

In his model, Davis (1985) provides three factors that affect the willingness of users. These include attitude toward usage, perceived ease of use and perceived usefulness. According to the hypothesis, the user attitude towards the technology being introduced matters greatly, it is considered a crucial step. Moreover, this step is affected by the two previous factors which display the technologies capabilities in respect to how useful the new technology is and how it is to use.

Overtime, as new developments were being made, the technology acceptance model was also refined by Davis (1985) by adding more variables. Furthermore, modifying the existing relationships within the model. Moreover, other researchers also contributed to the research and modified the model. Technology acceptance model is now considered as a leading model by organizations implementing new technologies.

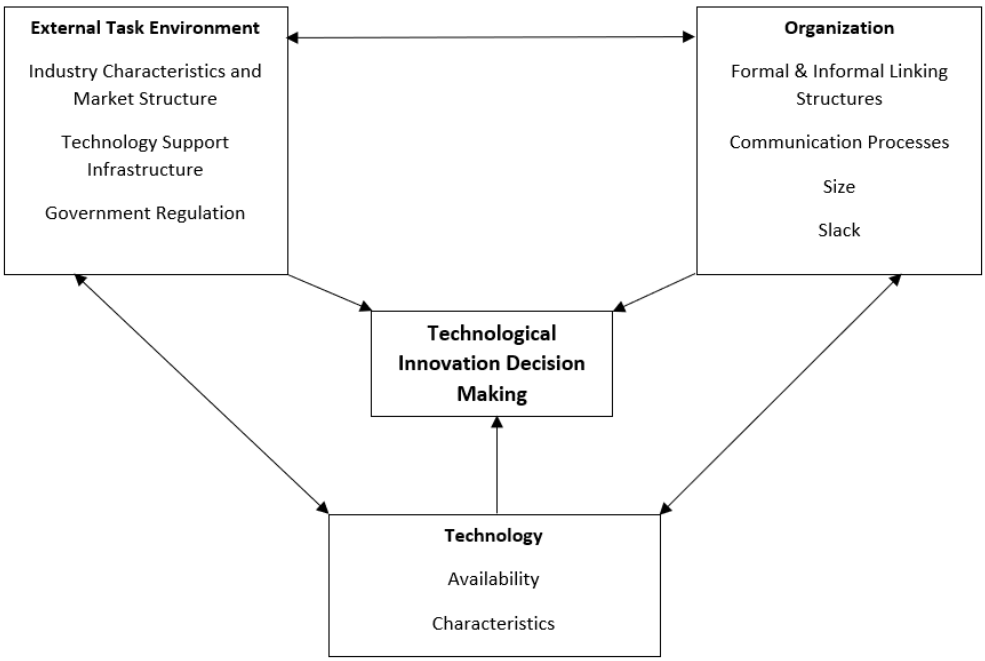
Furthermore, over the period of the last two decades, researches were conducted on the utilization of technology acceptance model. Different technologies like internet banking, email and so on were utilised during the testing phase. The obtained results showed that

the model in question cannot be utilized with the future technologies adoption (Röcker, 2010; Burton-Jones & Hubona, 2005). According to Röcker, (2010), the technologies being adopted were more towards a personal level, like the computer or a software application. However, according to the author that is not the case now, the technologies being introduced now will constantly support the user, along with enhanced capabilities.

2.5.2. Technological Innovation Decision Making Framework

Technology innovation decision making process can be utilized by the organizations which is adapting new technologies. It is based on three factors which are external task environment, organization and technology. This can be backed up by the research by Tornatzky and Fleischer (1990), where they recommend the organizations to make use of the model in question for adoption of a technology while keeping the existing technology as a scale towards implementation.

Figure 3. Technology Innovation Decision Making Framework



(Baker, 2011)

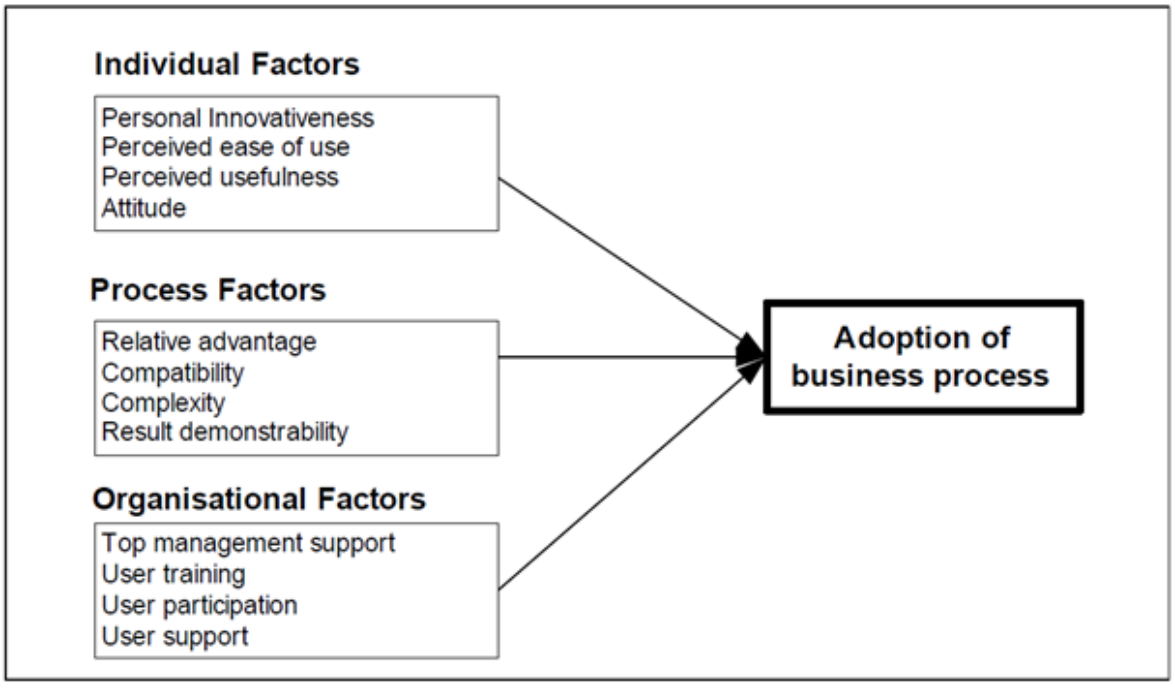
The model considers multiple things within the above-mentioned factors. Few of them include the type of industry, regulations of the government, size of the organization and so on. After carefully going through the model, the researchers for this paper came up with the conclusion that this model is not feasible for the study being conducted.

According to the authors, the model does not include the points that this study aims to identify. This claim can be backed-up by the study conducted by Wang et al. (2010), according to them the model in question does not possess the capability to pinpoint the specific variables for an organization. The authors further state that the variables being utilized in the model have been changing in different studies.

2.5.3. Business Process Adoption Model

Business processes are an important part of any organization and in current world its importance is increasing even more. Currently, the organizations are moving towards customization and that requires a constant change in their business processes. However, for a successful implementation of a business process, it is pertinent to understand the changes within the process and its overall impact. To apprehend the changes, business process adoption model is utilized.

Figure 4. Business Process Adoption Model



(Luzipo et al., 2015)

Business processes are the operations that are being conducted within the organization. These operations are considered an important resource of an organization and all of its workings are based on these (Luzipo et al., 2015). According to (Strnadl, 2006), business processes are well thought out sets of activities that provide value to the consumers or

complete the strategic goals of an organization. Business process adoption model consists of three factors, these include individual factors, process factors and organisational factors (Luzipo et al., 2015).

However, business process adoption model cannot be utilized for the study being conducted. Bowers et al. (1995), mention in their study that the changing of the business process of an organization or introducing a new one is a time taking task. They further explain in their study, as a new process is introduced thus, a lot of testing is required making it very expensive for the organization. According to Stoitsev & Scheidl, (2008), the introduction of a new business process within an organization requires a radical change, which is not in the best interest of any organization or its employees. Thus, the researchers of this paper do not feel that this model is appropriate for the study being conducted.

3. Methodology

The methodological section of the study regards the scientific approach to the research conducted. This chapter binds all elements of the research process together to yield a more rational study. The segments addressed are research philosophy, research approach, research design, data collection, data analysis, research quality and ethics.

3.1. Research Philosophy

The research philosophy of a study constitutes the beliefs and assumptions facilitating the creation of a coherent research process. The extant literature identifies the underlying philosophical assumptions of the researcher as ontology and epistemology (Easterby-Smith et al., 2015; Saunders et al., 2009).

Ontology refers to an individual's assumptions of the nature of reality or being. In this context, Easterby-Smith et al. (2015) recognize four ontological stances that differ in their interpretation of reality. These are realism, internal realism, relativism, and nominalism (Easterby-Smith et al., 2015). The ontological position underlying this study is that of relativism. According to the extant literature, relativism perceives the concept of "truth" as a construct of multiple realities. Herein, the comprehension of a phenomenon is dependent on the observer's perspective, thus, dismissing the belief of one universal truth (Easterby-Smith et al., 2015). This complements the purpose of the study, i.e. to develop a conceptual framework. For one, the research process consists of qualitative, semi-structured, interviews to acquire data. Within this the multiple realities of the participants, as well as the two researchers, construct the concluded result, i.e. conceptual framework. It is thus apparent that the "truths" of the study are the outcome of interaction between the researchers and the subjects of research.

Epistemology, on the other hand, refers to an individual's assumptions of what constitutes as valid and legitimate knowledge. In simpler terms, it is the relationship the researcher has with research. The examined literature identifies two positions of epistemology. These are positivism and social constructionism (Easterby-Smith et al., 2015; Saunders et al., 2009). The philosophical stance of the study resonates with the characteristics of social constructionism. According to Saunders et al. (2009), social constructionism regards the belief that reality is constructed by the individual based on social interactions.

In this context, reality is interpreted in coordination with other individuals which resonates to the relativist ontological stance. The focus of the study is to construct a conceptual framework addressing Industry 4.0 adoption. This requires a comprehensive and detailed assessment of multiple perspectives relevant to the topic of research. As this is done through social interaction, i.e. semi-structured interviews, the research process correlates to the emphasized philosophical stances.

3.2. Research Approach

For any scientific study, it is vital to discuss the research approach pursued. This regards the plan and procedure of conducting the study and, thus, influences the reasoning of the research process.

The extant literature identifies two different research approaches that can be undertaken by a research paper. These are a deductive research approach and an inductive research approach (Easterby-Smith et al., 2015; Saunders et al., 2009). To distinguish between them, deductive reasoning is primarily applied to develop a premeditated hypothesis and, consequently, test the constructed theory. The inductive approach, on the other hand, develops theory on the basis of the data collected (Jebreen, 2012; Saunders et al., 2009). This paper aims to develop a conceptual framework that addresses the application of Industry 4.0 for the food manufacturer. In this context, the research process is data driven. Hence, the study is not based on any predetermined theory or hypotheses which indicates inductive reasoning (Saunders et al., 2009). For that matter, data is collected and subsequently analyzed to produce a theoretical explanation of the phenomenon. Succinctly, inductive reasoning is pursued by the study which complements the creation of theory.

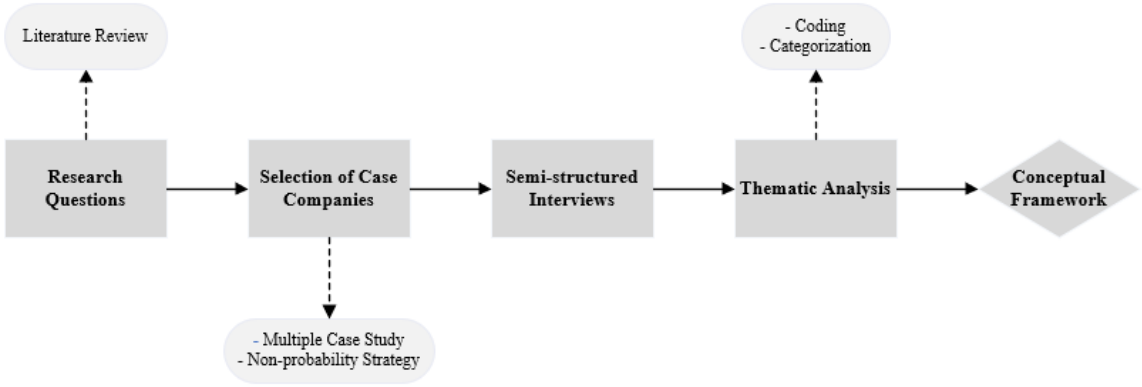
To conduct a scientific study the researcher/s apply, primarily, one of two research methods. This being either a quantitative research method or a qualitative research method (Easterby-Smith et al., 2015; Saunders et al., 2009). In turn, these differ in the types of data that is collected, as well as for what reason. A quantitative study regards the collection of numerical data that is employed to, for one, test a premeditated hypothesis (Nayak, 2015). Evidently then, it is less compatible with an inductive research approach. A study of the qualitative nature, on the other hand, collects non-numerical data on the basis of observation and interaction (Creswell & Poth, 2017). This, contrary to theory

testing, offers the opportunity for a more flexible and open-ended interpretation of the findings. These characteristics that encompass qualitative research are feasible to fulfill the purpose of this study. The attentiveness of qualitative research towards the individual perspective attributes to the belief of reality being a social construct. Therefore, the emphasized method of research resonates to the philosophical stance of the study. In addition to this, Saunders et al. (2009) states that theory development that is based on qualitative data is induced by the collection of multiple perspectives. This correlates to the ontological position assumed.

3.3. Research Design

This section of the methodology encompasses the set of logical procedures that are followed by the study to adequately address the research problem. Accordingly, it constitutes the blueprint for the collection, measurement, and analysis of data. The following figure presents such in a summary type manner.

Figure 5. Research Design Process



3.3.1. Case Study

In accordance to the qualitative nature of this study, there are five primary approaches to conduct research. These are narrative, phenomenological, grounded theory, ethnographic, and case study (Creswell & Poth, 2017), and the more feasible approach is dependent on the set purpose of research. For this paper, the study strives to construct a conceptual framework to address the implementation process of Industry 4.0 for the food manufacturer. In that sense, the appropriate method of research is that which facilitates the recognition of similarities and contradictions amongst the selected sample. This resonates with the characteristics of case study research (Creswell & Poth, 2017; Yin,

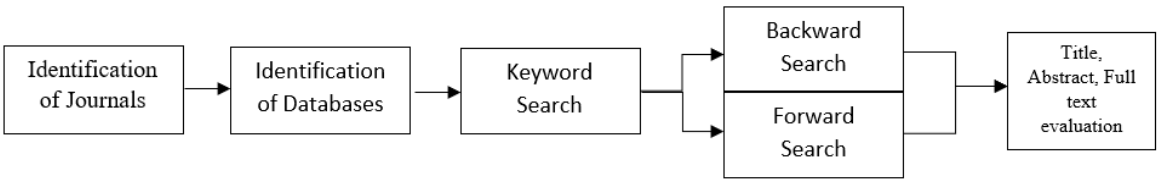
2009). In their study, Easterby-Smith et al. (2015) refer to case study as an in-depth examination of a contextualized phenomenon, e.g. organization. Accordingly, this paper employs a multiple-case study as means to profoundly explore Industry 4.0 adoption in its real-life context. A limitation of such, however, is the restricted generalizability of the concluded results (Yin, 2009).

Multiple-case research regards the "empirical investigation of a particular contemporary phenomenon within its real-life context, using multiple sources of evidence." (Robson & McCartan, 2016, p. 150). The use of various subjects of research allows for a wider exploration of the research questions constructed as data is collected from multiple sources of information (Creswell & Poth, 2017; Robson & McCartan, 2016). Such triangulation of data enables the researchers to identify differences and similarities across the multiple cases (Yin, 2009). This consequently enhances the reliability of the constructed theory (Eisenhardt, 1989). The feasibility of multiple-case research to fulfill the purpose of research is evident. It allows the researchers to identify similarities and patterns concerning the measures and practices undertaken by food manufacturers for realizing Industry 4.0. This then encourages the creation of theory and its reliability.

3.3.2. Literature Search

The aim of this section is to enhance the credibility of the literature review and promote the (re)use of the results in subsequent studies. In the current work, a systematic approach was selected to review existing literature. To provide a comprehensive overview of the targeted research area, the literature search followed the structure set out by Brocke et al. (2009). This is presented in figure 5.

Figure 6. Literature Search Process



(Brocke et al., 2009)

In respect to relevance and quality, the assessment of journals took into consideration the subjective input of the Chartered ABS Academic Journal Guide (ABS). This contributes

significantly to the reliability of the study. However, the isolated application of ABS is insufficient to properly evaluate journals. For that matter, most of the academic databases used inhabit the feature for selecting peer-reviewed articles. These being 'Web of Science' and 'Primo'. Consequently, an additional 'metric' is constructed to ensure the importance and quality of secondary data. Also, the study utilized the platform 'Google Scholar'. The next phase regarded the literal search for data which was based on a variety of keywords. Before such, a screening process is set that narrowed down the literature to articles published between the years of 2011-2020. In their study Brocke et al. (2009), it is stated that a literature review first addresses the broad topic of the paper. Accordingly, the subsequent search for literature regarded more broader terms (e.g. digital transformation, Industry 4.0, food manufacturing) as well as synonyms of these terms such as intelligent technologies and the Internet of Things. This was followed by a forward and backward reference search to review additional relevant articles.

Table 2. Keywords used to obtain literature research

Area of Study	Used Keywords
Industry 4.0	"*Industry 4.0", "Food Manufacturing 4.0", "Smart Factories", "Intelligent Manufacturing", "Cyber-Physical systems", "Internet of Things"*
Digital Transformation	*"Digital Transformation", "Technology adoption", "Food Manufacturing Industry"*

3.3.3. Data Collection

An essential stage in conducting research regards the collection of data, or more comprehensively, what data to collect and why. In relation to the nature of this study, qualitative interviews are the primary technique adopted to gather data. This corresponds to the philosophical stance of the study to which multiple 'truths' are realized. Moreover, the interactive approach pursued contributes to obtaining more detailed information and knowledge concerning the researched topic (Easterby-Smith et al., 2015). The extant literature identifies various forms of interviews, which mainly differ in whether the conversation style strictly adheres to an interview protocol (Easterby-Smith et al., 2015; Tracy, 2012). For this study a semi-structured approach is deemed as the more appropriate type of interview.

The semi-structured interview technique implies the use of an interview protocol that guides the researcher through the interview process. However, albeit the conversation is somewhat guided, the researcher is provided with the ability to probe for additional insight (Easterby-Smith et al., 2015). As the researcher is not fully tied to the predetermined protocol, a room for flexibility is offered. This encourages more comprehensive discussions that diverge from the predetermined question. The consequence of such is the occurrence of information-rich explanations (Saunders et al., 2009) which contributes to the inductive approach to research pursued.

In relation to the emphasized interview technique, the accompanying flexibility of the semi-structured interview promotes the occurrence of researcher bias. It is very likely that the discussions are dictated by the researcher's personal opinions which may be based on their own bias. This, to an extent, corrupts the data acquired (Easterby-Smith et al., 2015). To control for such, the predetermined questions are formulated in a neutral manner without preconceived opinions. Moreover, a set of general questions regarding the organization and the participant, i.e., firm size, work experience, education, constitute the first phase of the interview. In addition to primary data, secondary data such as company reports, and other related documents are reviewed prior to the interview process. This enforces the competence of the interviewer during the engagement in discussion (Easterby-Smith et al., 2015).

3.3.3.1. Sampling Strategy

Albeit the recognition of the sampling strategy is less emphasized in qualitative research (Creswell & Poth, 2017; Neuman, 2009), this study addresses in detail the sampling procedures. The sampling strategy, whether it be a quantitative or qualitative research approach, determines the selected subjects of research and, thus, the quality of findings. Concomitantly, the study adopts a non-probability sampling strategy for the selection of cases. An extensive literature review revealed a positive relation between company size and Industry 4.0. This implied that the larger organization is more likely to have initiated the digital transformation process for Industry 4.0 compared to their smaller counterparts. Based on such, the first predetermined criterion was set to filter food manufacturing companies in relation to the number of employees inhabited. To assure the larger manufacturer was selected, those organizations with more than 50.000

employees were emphasized. The second criterion regarded the focus of the respective companies towards digital solutions and transformation. This involved a review of secondary data such as company reports and statements as means to identify the more innovative subjects. These were regarded as more experienced and knowledgeable on digital transformation and Industry 4.0. As the relevant cases were identified, the participants of research primarily inhabit a medium - to high managerial position such as plant manager. This was emphasized due to the fact that these roles often work on a strategic level and are closely associated with digital technologies and future innovation. A consequence of such criteria, however, is that a limited number of interviews were conducted at first. Accordingly, a snowball sampling strategy, or chain referral, was pursued (Neuman, 2009). The participants were politely asked if they may refer us to any colleagues that are knowledgeable of the research topic for potential interviews. This consequently attributed to the number of interviews and the comprehensiveness of the findings.

3.3.3.2. Interview Process

The interviews were conducted through WhatsApp calls. Both the researchers were present during the interviews. Initially, half of the conducted interviews were planned to be done in person. For which, the researchers planned to travel to the United Kingdom. Due to a pandemic, however, the researchers could not travel, thus, shifting all the interviews to the online platform. All the interviews were conducted in English language. Furthermore, the interviewees were sent a consent form before the interviews regarding recording the interviews. The consent form can be found in Appendix B, however, due to anonymity the signed forms cannot be presented. Once all the interviews were conducted, the recording were transcribed manually and through an online software "Trint". From here on the researchers proceeded towards conducting a content analysis. In total seven interviews were conducted from the case companies. Further, the time for each interview varies, however, total time for all the interviews was approximately 9 hours.

3.3.4. Data Analysis

A consequence of applying interviews as the primary technique for data gathering is that the received data is largely unstructured. In order to make sense of it, the collected data is assessed through thematic analysis. The characteristics of thematic analysis corresponds well to studies that attempt to identify patterns or similarities in a replicable and systematic manner (Easterby-Smith, 2015; Prior, 2014; Braun & Clark, 2006). Therefore, it correlates well to the inductive and multiple-case study research approach pursued. For this study, the thematic analysis process as outlined by Braun & Clark (2006) is followed. Accordingly, the thematic analysis encompasses the initial reading and assessment of transcript material, followed by a coding procedure and the subsequent categorization of data, and lastly the concluded interpretation and findings. In a more detailed manner, the collected data sourced from several interviews is transcribed and thoroughly assessed by both researchers. This implies familiarization with the data (Braun & Clark, 2006). The data is then classified into codes and 'themes' that are relevant to the research questions. This procedure separates valuable information from the excess non-valued data (Easterby-Smith, 2015). Subsequently, a process of categorization is initiated in an attempt to segment the observed phenomena into meaningful units or clusters. This process allows the study to establish linkages and similarities within the data and between the examined subjects of research (Braun & Clark 2006). Furthermore, as a safety precaution, an additional revision and read through of the analysis process and the transcribed material is conducted. This is done by both researchers, implying congruence regarding the accuracy and relevancy of data and the concluded interpretation (Lincoln & Guba, 1985; Polit & Beck, 2012). As a consequence, potential bias is mitigated, and the quality of data enhanced.

3.4. Quality Insurance

To assess the rigor of the qualitative study, this paper conforms to the stringent criteria introduced by Lincoln and Guba (1985). These regard credibility, dependability, confirmability, and transferability. By fulfilling the identified criteria, a degree of trustworthiness, i.e., quality, of research is established (Easterby-Smith et al., 2015; Lincoln and Guba, 1985).

The purpose of the first criterion, credibility, is to establish confidence that the concluded findings are true, credible, and believable (Lincoln and Guba, 1985). To do so, the study maintained constant communication throughout the research procedure between the case companies, the interview participants, and the respective researchers. Further, in correspondence to the triangulation technique, data is gathered from several sources such as interviews and company reports. This strengthens the credibility of the study (Easterby-Smith et al., 2015).

The dependability criterion regards the repeatability of the research study, i.e., the consistency of the concluded findings in other contexts (Lincoln and Guba, 1985). To ensure a higher degree of dependability, this study has, first, provided a rich description of the study methods and, second, a detailed audit trail (Lincoln and Guba, 1985). The theoretical content of the study is clearly stated and sourced and detailed information regarding the research design, research subjects, and sample strategy is provided. Additionally, a detailed track record, i.e., audit trail, of the data collection process is comprehensively documented. Evidently then, the dependability criterion is well established within the study and as a consequence subsequent studies may arrive at similar interpretations and conclusions.

Transferability, on the other hand, regards the degree to which the concluded findings can be generalized or transferred to any other contexts (Lincoln and Guba, 1985). This study provides an extensive and intricate description of the research context, stated through a comprehensive problem statement, research purpose, and question. Moreover, multiple sampling techniques were applied and documented in a detailed manner. This indicates a higher degree of transferability (Easterby-Smith et al., 2015; Lincoln and Guba, 1985). However, it is well documented that multiple-case research limits the generalizability of the study (Yin, 2009). As such, the generalizability of the concluded results is largely restricted to the multinational enterprise.

The fourth criterion, conformability, refers to the objectivity of during data collection and subsequent analysis. To minimize potential biases due to the narrative of the individual the research process and the steps taken are documented in a detailed manner. As this dissertation is conducted by two researchers it is implied that there is congruence between the individuals regarding the accuracy and relevancy of the data (Polit & Beck,

2012). Moreover, triangulation techniques were applied to ensure a higher degree of conformability. This is clearly portrayed within the data collection process where a triangulation of sources was utilized, e.g., interviews and company reports. As a consequence, conformability is established.

In conclusion, the study has carefully established methodological rigor based on the above-mentioned criteria. This ensures the robustness and comprehensiveness of the paper, as well as the development and maintenance of trustworthiness, as envisioned by Lincoln and Guba (1985).

3.5. Research Ethics

To ensure the research adheres to the ethical standard, this study emphasizes the ten principles of ethics as identified by Easterby-Smith et al. (2015). These are presented in table 2.

Table 3. Principles of Ethics

Ethical Principles	Research Adherence
Ensuring that **no harm** comes to participants	To minimize the risk of such encouraged the researchers to take several precautions. These include the obtainment of informed consent, assurance of anonymity and confidentiality, and the right for the participant to withdraw at any time. Moreover, the participant selected the medium/platform desired for conducting the interview.
Respecting the **dignity** of research participants	The individual autonomy of the respective participants was maintained throughout the research process. In a detailed manner, the participant's desire for postponement of interviews, withdrawal from research, anonymity, and data confidentiality was rigorously upheld.
Ensuring a fully **informed consen**t of research participants	Prior to the informed consent, the respective participants were informed through email of how the data acquired will be processed, shared and made public (seminars and DiVa), disposed of, as well as the possible outcome of research. Accordingly, an Ethics Consent Form was obtained that asserts the purpose of the study, as well as the rationality and complete autonomy of the participant over their data. Moreover, the participants were informed that they have the right to withdraw themselves and their data from the research whenever.
Avoiding deception about the nature or aims of the research	
Honesty and **transparency** in communicating about the research	
Avoidance of any **misleading** or false reporting of research findings	

Protecting the **anonymity** of individuals or organizations. Ensuring the **confidentiality** of research data	The respective participants and case organizations are kept completely anonymous throughout the research process. Accordingly, the researchers are the only individuals aware of the complete sample. Further, the data obtained was stored and protected securely through restricted access. The audio and transcribed material was deleted shortly after the research study concluded.
Protecting the **privacy** of research participants	
Declaration affiliations, funding sources and **conflicts** of interests	None identified.

(Easterby-Smith et al., 2015)

4. Empirical Findings

The empirical section of the study is essential to any scientific process as it regards the data acquired. Succinctly, this chapter, first, encompasses a brief introduction to the respective case companies and interviews. Second, a summary of the empirical data gathered through the interview process is presented for each respective subject of research.

4.1. Case Company A

The respective subject of research produces a wide array of products, inhabiting a portfolio in excess of 2000 brands. As a multinational food manufacturer, production of the enterprise is relatively capital intensive and concentrated on high volume manufacture. Correspondingly, it maintains a continuous directive towards the optimization of automated production and has, in that sense, introduced innovation processes to sustain such development. This exemplifies the innovative nature of the organization and its consequent devotion to digital transformation and strategy.

In accordance, the interviewees representing case company A are individuals in managerial positions that operative within the supply chain department. These are further displayed and referenced in table 4.

Table 4. Interviewees of Case Company A

Company	Department	Job Position	Duration	Reference
A	Supply Planning	Category Supply Manager	1 Hr 36 Mins	A-01
A	Demand Planning	Category Demand Manager	42 Mins	A-02
A	Production	Production Manager	56 Mins	A-03

The interviews conducted portray a familiarity between the three individuals and the phenomena that is Industry 4.0. For them, it is envisioned as a fully automated and self-monitored system that diminishes the need for the individual within the organization (A-01; A-02; A-03). Its necessity for the food manufacturer, however, is continuously reaffirmed throughout the respective interviews. When asked regarding the relevance of Industry 4.0 for the organization, it is collectively stated that the case company possesses a high degree of automation. These technologies are primarily confined to food processing and packaging, in which it is stated by A-01 that these sections are close to

contactless in many facilities within the developed market. It is asserted by the interviewee that automation is key to maintain a strict hygiene and quality standard. For now, the organization is concentrated on further advancing their automated technology and the development of advanced AI as means to cater to increasingly complex consumer demands.

The interviewee further states that the business potential of the specific technology is highly dependent on the customized ratio that is required by the consumer. To exemplify, the respondent emphasized the production of premium products. It is stated that these goods demand a higher degree of customization within the production process compared to the common commodity, e.g. milk. In this regard, the interviewee highlights the Internet of Things, Big Data analytics, and end-of-line automation as the specific Industry 4.0 technologies that are emphasized by the case company. These are expected to enhance efficiency, minimize downtime, and better cater to customized demands. It also stated by A-01 that, specific to the food manufacturing sector, any potential for innovation is mainly located within packaging. The following question regarded the perceived timeframe for implementing Industry 4.0 within the organization. The respondents state that the case company is slowly progressing towards its realization and that digital initiative such as pilot programs have already been initiated. To implement the phenomenon as a whole, however, is not currently relevant for the organization.

Whereas, respondent, A-01, mentions that a radical approach to digital transformation will lead to a supply chain disruption. For a food manufacturer, the consequences of such are magnified. The respondent states that compared to other manufacturing sectors such as automotive, customers are willing to wait the whole year for the next edition of a car. In the food sector, on the other hand, the product is easily substituted by the consumer if it is not available on the shelf. This according to A-01 has influenced the strategy of the organization towards Industry 4.0 adoption. Next, the respective interviewees were specifically asked regarding the digital strategy adopted by the case company. It is collectively stated that a global team has been established to direct the digitalization process. A-02 expands further and explains that these individuals are tasked with identifying the business potential of the respective technologies and to implement the necessary projects. It is mentioned that such deployment of resources and equipment is regionally concentrated and largely attentive towards the developed market. This is

reasoned by the respondent in relation to the cost of labor and competitive advantage. The interviewee A-02 states that automation, for one, is more preferable in the developed market compared to its counterpart. It is perceived to present a greater competitive advantage in the developed market due to the higher costs of labor.

Moreover, similar reasoning process is exhibited by A-01 and A-03. The first interviewee, A-01, mentions that it is "easier" to implement newer technologies in the developed market as it inhabits a larger pool of skilled labor, necessary for such realization. A-03, on the other hand, affirmed that the incentive for pursuing technological advancements is relative to the specific environment. Herein, the interviewee emphasized government regulations and local labor policies, presenting these as a nuisance for the multinational enterprise and digital transformation. Automation was brought forward as a potential disturbance to the regulations as such technology is perceived by the respondent as a replacement for the individual and, consequently, loss of jobs. The conclusive segment of the respective interviews specifically targeted the potential challenges or obstacles to Industry 4.0 adoption, as perceived by the subjects of research. In the first interview conducted, the respondent emphasized labor in general as a determinant factor for realizing technology. It was mentioned that human resources needed for the realization of Industry 4.0 is different from the human resources currently available within the case company. The respondent regards that data scientists are more sought after rather than individuals with AI knowledge or automation engineers. Presenting it as an obstacle, A-01 highlights the extensive investments required to develop the necessary digital knowledge of employees directly affected by the technologies. Further asserting the human factor, the interviewee states that "half the job is done if the mindset is properly exhibited and captured". A-02, the second interviewee, emphasized the current infrastructure of the organization, stating that it is currently too dependent on the individual for even the minutest of tasks. The respondent affirms that the case company possesses excellent change management abilities and a visionary mindset. To, however, effectively realize the phenomena, A-02 necessitates a refinement of the current organizational structure to complement the technological advancements of Industry 4.0. A similar reasoning process is presented by A-03. The interviewee identifies agile processes and the ability to configure modular designs at plant level as imperative to successfully realize Industry 4.0.

4.2. Case Company B

This multinational company within the food manufacturing industry is present in more than 200 countries around the world with a workforce of more than 250,000. Furthermore, the company's portfolio consists of thousands of products which it sells around the world through its different divisions. The products produced by the company include recreational food as well as things of daily use. Moreover, they are also in the business of producing sports drinks and nutrition food. The case company focuses on developing products according to the taste of the region the products are sold in. Company B is moving towards digitization at a fast rate and in 2019 were also awarded the "corporate innovation award". These efforts are being led by the company CTO at the global level and supported by regional teams.

The data used for analysis on the given topic, interviews were conducted. The interviews were conducted from two people in the managerial section of case company B. References for the interviewees are provided in table 5.

Table 5. Interviewees of Case Company B

Company	Department	Job Position	Duration	Reference
B	Planning & Logistics	Planning and Logistics Head	1 Hr 23 Mins	B-01
B	Production	Manufacturing Manager	1 Hr 8 Mins	B-02

The interviews of the concerned individuals were conducted separately. The interviews started with general questions regarding the individuals to gather better knowledge about their background and work experience. At the beginning of the interviews, the participants were asked about their knowledge about Industry 4.0 and their concept of "smart factory". Respondent B-01, responded with acknowledgement regarding the industry 4.0 knowledge, he apprised us that he knows about the concept and have read on it. B-01, further elaborated that for him a "smart factory" is a place with the least amount of human interaction, automated and smart machinery. Whereas, participant B-02 responded by informing us that she is quite familiar with the concept of industry 4.0. She describes it as "evolution of applications over time with respect to the industry and customer requirements". She further explained the concept of a "smart factory" as a place that is smart enough to run its operations on its own without any human interaction, unless necessary and that too to a bare minimum.

Subsequently, the participants were asked about the industry 4.0 technologies which they feel are more relevant to their industry. The participants had similar responses to the question, they mentioned big data and analytics, automation, and the internet of things. According to B-01 and B-02, all these technologies largely contribute towards the revolution of the food manufacturing industry. Furthermore, the interviewees were asked about the industry 4.0 technologies that are currently being used by the organization. Participants B-01 and B-02 respond collectively by enlightening us that the organization is already running fully automated warehouses around the world. According to them, they have implemented ASRS systems (automated storage and retrieval system) and FIFO sequencing in their warehouses. In addition, the organization is utilizing big data & analytics, automation and cloud systems. However participant B-01 adds to it by explaining, the complete implementation of industry 4.0 technologies is a lengthy process and according to him, the implementation can be done over a period of five to ten years. The interviewees further informed us regarding a global team overlooking this process and all their plants around the world have a post of automation and control engineer. Where, his job is to oversee its implementation at that specific plant.

Towards the later part of the interview, the participants were asked regarding the benefits of industry 4.0 technologies. Including what they personally think after the experience with the existing technologies. Respondents B-01 and B-02 answered by enlightening us about the benefits which included real time data output and analytics, enhanced quality of products, decreasing lead time, safer and hygienic production environment, reduced labor cost, reduced energy cost and less errors. Furthermore, the participants were asked about actions to be taken while moving towards industry 4.0. The respondents replied with very similar answers, according to them, it is important that the leadership of this organization must be fully cognizant of its application and the benefits it can yield. Moreover, participant B-01 and B-02 informed us that other requirements like a strong digital and networking infrastructure, a specialized and dedicated team and a long implementation plan are also required. Towards the end of the interview, we asked the participants regarding the challenges they will or are facing due to the implementation of industry 4.0 technologies. In response to this, B-02 said that one of the top challenges is the lack of knowledge regarding industry 4.0 technologies and lack of skill. Another challenge she mentioned was “lack of flexibility”, according to her automation comes

with its own set of rules which cannot be altered. As per B-01, the challenges for a multinational like this organization are different. According to him, the challenges range from regional level to a global level and for every regional level there are different labor policies and governmental regulations. Whereas, at the global level the company needs to come up with a collective strategy for its implementation and implement the technologies in a step-by-step manner. The step-by-step implementation will itself be a challenge for the company at a global level, he explains, as few of the regions will be more advanced than the others and global decisions cannot be implemented to all the regions.

4.3. Case Company C

The respective multinational food manufacturing company is based in more than 190 countries. Whereas, its portfolio contains more than 400 brands that are being used worldwide. The said company manufactures its products in different regions, tailoring them to the local taste. Furthermore, the case company focuses on having its manufacturing within the country, it sells its products in. The said company has more than 100,000 employees globally and prides itself in being future makers, pioneers and innovative since the last few decades. During this age of digitization, the case company is also actively moving towards it. This is worth mentioning, as it is being led from the top. The case company's current CEO has pledged to make digital transformation a priority and is ambitious to make the company fleet-footed and a digital giant.

To gather in-detail and in-depth data about the implementation of industry 4.0 is case company C, interviews were conducted. Two people belonging to the managerial positions of the company were interviewed. Their job positions and references are provided in table 6.

Table 6. Interviewees of Case Company C

Company	Department	Job Position	Duration	Reference
C	Supply Chain (Audit)	Global Corporate Audit Manager	1 Hr 52 Mins	C-01
C	Supply Chain (Manufacturing)	Factory Manager	1 Hr 19 Mins	C-02

The conducted interviews started with the question of familiarity with industry 4.0 concept. The participants responded by not knowing about the term and informed us that the terms “smart factory” and “smart machines” are used instead of “industry 4.0”. Where, the respondent C-01 explained the smart factory is a facility where all the KPIs are interlinked with a real-time display and the data collection helps the management in an effective decision-making process. Whereas, the respondent C-02 explained it as a “human less” factory or what he calls a “dark factory”, as the robots do not need light to conduct their operations. Whereas, for the importance of industry 4.0 technologies in the food manufacturing industry, the respondents responded by highlighting different issues within the industry. The first respondent mentioned the importance of industry 4.0 implementation in the food industry, which would help in cutting down their losses. On the other hand, the second respondent mentioned the Internet of Things (IoT) and automation as more relevant to their industry. As according to C-02, these technologies help smoother the production process and are easy to implement within the food industry.

Furthermore, the participants were asked regarding the state of their organization with the implementation of industry 4.0, for which they had similar responses. According to C-01 and C-02, their organization is already in the process of implementing industry 4.0 and for this purpose, a global team is leading the initiative followed by regional level teams. As reported by the respondents, this effort is being sponsored by the CEO of the company and the COO of the organization is responsible officer for it. The respondents were asked the question related to the current state of Industry 4.0 technologies in their organization. Against which the respondents replied by informing us that their multiple factories around the world have already been automated. Furthermore, C-01 and C-02 apprised us that few of their warehouses have also been automated, and currently they are utilizing technologies like Internet of things, cloud computing, big data and analytics, automation and autonomous robots. Moreover, the participants informed us of the benefits the organization gained after the implementation of the above-mentioned technologies. C-01 and C-02 mentioned lower operating costs, higher quality, lower carbon footprint, just-in-time, improved workplace and process safety, improved efficiency, less breakdown as some of the benefits. Further, the respondents focused on the improved decision-making process due to availability of reliable and real time data.

Furthermore, the interviewees were asked about the challenges in implementing the industry 4.0 technologies are what are the implications of implementing it. According to participants C-01 and C-02, training for the employees and getting skilled labor is one of the major challenges. Followed by, cultural change within the factories and to maintain the organizational commitment. The participant C-01 describes the implementation of industry 4.0 as “It’s a journey not the destination”. The respondent C-02, identified the requirement of less labor as another challenge. According to him, a lot of people will be laid off and that will cause an issue depending upon the labor policies of those countries. Further, both the participants mentioned the limitation of industry 4.0 in the food manufacturing industry. According to them, industry 4.0 technologies cannot be implemented completely within the industry, rather there will be some parts which will need to have human connection. The participants also mention the challenges faced as a multinational company. As they have factories based in different countries and every country has different governmental regulations and labor laws. The participants were also asked a question regarding the requirements/prerequisites for the implementation of industry 4.0 technologies. To which respondents responded by explaining that few of the mentioned technologies already exist in the organization. However, to achieve full integration, the initiative should be taken by the leadership, which should be visionary.

The interviewees further mention that proper research on return of investment is required as the whole process is quite expensive. They also mention the requirement of a dedicated global team to work towards the objective. Moreover, they also mention the need of having regional teams as every region has different challenges to work through. Towards the end of the interview, the interviewees were asked a question regarding the current pandemic and how it has affected them. To which they responded that as they already have industry 4.0 in some of their factories, they have not faced a lot of issues as there is least human interaction involved. They also agreed that without these new technologies, managing the food supply chain in this pandemic would have been much more difficult.

5. Analysis

In this chapter we examine our empirical findings in relation to previous literature. On the basis of such, the study develops a conceptual framework. The process underlying the creation of the model is located in the employed methodology.

5.1. The challenges for Industry 4.0 adoption

Industry 4.0 provides an opportunity for companies to move towards and adapt new technologies. Implementation of industry 4.0 means completely digitalizing organization processes. Which increases the organization's productivity and quality of products being produced (Sanders et al., 2016). It is apparent that the application of new technology in an organization creates barriers for its success. However, it is important for the organization to overcome them, as without it, the complete implementation will not be possible (Zhou et al., 2015; Bartodziej, 2017). Similarly, the mentioned case companies also face challenges with the implementation of industry 4.0 technologies.

5.1.1. Case Company A

Through the collected data of case company, A, it has been observed by the researchers that while implementing the technologies of industry 4.0, it is facing some hurdles. These hurdles have been better explained by the individuals interviewed. According to them, an initial issue for the organization is lack of skilled workers, which makes it difficult to operate the new technology to its full capacity. Furthermore, according to the respondents, case company A faces a challenge of its infrastructure. Which, according to them cannot support the full implementation of industry 4.0 technologies at its current state. Moreover, they mention the investment as a challenge also, as its implementation is a costly matter along with a long road map for its implementation. This sort of investment is also a challenge for a multinational organization. Another challenge the participants mentioned was related to the implementation in developed countries and developing countries. According to them, the implementation in developed countries is uncomplicated as compared to the developing countries. As the availability of resources for its implementation are scarce and expensive as compared to developed countries. For case company A, phasing out legacy systems is another challenge. Which, according to

the participants is required to be done at regional levels and global level for better acceptance of the new technologies.

5.1.2. Case Company B

After going the interviews of representatives of case company B, the researchers observed different challenges being faced by the organization. These challenges were both hindering the implementation of new technologies and obstructing the effort for moving towards the new technologies. The respondents mention the limitation of knowledge about the industry 4.0 concept among the employees, which in their opinion create a level of distrust. Moreover, they mention the shortage of skilled labor for operating the new technologies, which are part of the new revolution. Investment is another challenge that is required to be addressed by the organization. According to the interviewees, this is an expensive and long-term investment as is the implementation of industry 4.0. The representatives call it "not a basic case of investment". Furthermore, one of the participants during the interview mentions "lack of flexibility" as one of the challenges being faced by the organizations. According to her, the new systems come with their own set of rules which cannot be corrected. However, according to multiple researches, as a result of implementing I4.0 technologies, it increases the manufacturing flexibility and improve productivity (Liao et al., 2017; Wang et al., 2016). The researchers established through the data, case company B is still largely dependent on old ways of working, as the organization is not integrated at the desired level. Furthermore, the respondents talk about implementation of industry 4.0 technologies in the developing countries. Where, according to them a major drawback is the labor cost. Which is much lower as compared to developed countries, thus, the products produced by the labor force remain cheaper as compared to being produced at a facility with I4.0 technologies.

5.1.3. Case Company C

Industry 4.0 technologies implementation process is being conducted. Where, the organization is also facing few barriers in their implementation process, as identified by the researchers. The researchers concluded from the interviews that the barriers faced by case company C are somewhat similar to the previously mentioned case companies. According to the participants, untrained personnel is a leading challenge. These include both the workers and IT staff, as I4.0 technologies are new, and the employees need to be

trained to operate the machines. Furthermore, the respondents mention organizational commitment as an important challenge. Since without the support of the whole organization, complete implementation cannot be successful. This is in line with the finding of different researchers, according to them organizational commitment is an important aspect of technology implementation. Furthermore, low commitment can lead to failure in implementing the new technologies (Müller, 2019; Türkeș et al., 2019). Moreover, the respondents also mention cultural change as a challenge. According to them, the existing culture is more human friendly, and employees feel at ease with the usage of the current system. As mentioned by Müller (2019), employee acceptance is an important step in technology acceptance for the organization. This requires the organization to change its culture by educating them on their concerns and questions.

5.2. Cross-Case Synthesis

In the following section we present the identified challenges faced by the food manufacturer for the digital transformation to Industry 4.0 adoption. These dimensions are exhibited within the interviews conducted and subsequently identified in the empirical findings. A categorization of the challenges is given in the table 7.

Table 7. Identified Challenges

S. No	Challenges Identified	Sub-Categories
1	External Environment	- Government regulations & labor policies - Industry characteristics
2	Human Resource	- Talent development & acquisition - Employee resistance
3	IT Infrastructure	- Compatibility - Standardization
4	Technology	- Complexity - Availability

5.2.1. The External Environment

A crucial role is played by the environmental factors in an organization during the adoption of new technology (Huang et al., 2019). These environmental factors range from social factors to political factors, social factors include communication, conflicts and so on. Whereas, political conflicts depend upon the location of the organization, as well as the political situation and governmental regulations (Huang et al., 2019; Aripin et al.,

2019). To gather a better understanding of how the external factors are affecting the multinational companies in the food manufacturing sectors, the conducted interviews were used. During the interviews, it was noticed that all the participants mentioned some external factors which hinder their progress for adopting a new technology. These factors were present due to various reasons, the significant being the region its operating in. The most common challenges observed in the interviews were governmental regulations and labor laws, and industry characteristics.

5.2.1.1. Government Regulation and Labor Policies

Multinational companies are based around the world, with their manufacturing plants in different countries. Thus, they must follow regulations of the countries they are based in, moreover, follow the labor policies of those countries. As with the introduction of industry 4.0 technologies, a lot of people will lose their jobs or will have to obtain a new skill set to be placed in another line of work (Rajnai & Kocsis, 2017). Furthermore, for multinationals it is a challenge to follow the governmental regulations for the countries they are based in. Moreover, in this current age, different countries have different regulations for implementation of industry 4.0 technologies. Some developed countries have already introduced regulations for companies, promoting the usage of industry 4.0 technologies (Kergroach, 2017; Sanders et al., 2016). Whereas, this is not the case in the developing countries, they will eventually move into the same direction as the developed countries, but it will take some time (Kergroach, 2017). These challenges were visibly presented in the interviews conducted with the representatives of the case companies. During the interviews, respondent A-01 mentions the governmental regulations as one of the leading challenges for the organization as it directly corresponds to people losing jobs. Which, in some countries is against the labor laws. Similarly, according to C-02 for multinationals it is important to follow the labor policies of the region they operate in. Moreover, he mentions that it is possible for MNEs to introduce new training programs for employees who do not fit the criteria. These programs will help in introducing more skilled labor and help in reducing the number of people who would lose their jobs. Similar dilemma has been mentioned by the participant from case company B, according to her the food manufacturing industry must follow the governmental regulations with respect to the products being produced. Along with the digital policy of the country, the production is happening in. Further, B-02 mentioned in her interview that the labor policy

for the countries vary and it is a challenge for the organization to overcome these policies without a clear guideline from the government. These findings are in line with the already existing literature, as mentioned in the beginning of the paragraph.

5.2.1.2. Industry Characteristic

The advent of industry 4.0 brought an opportunity for different industries to gain a competitive advantage over their competitors. However, different industries took a different approach towards the revolution, few took it head-on. Whereas, few started its implementation, and few have not taken it up till now. These patterns were observed in the already existing literature, the researchers principally focused on the automobile and aerospace industry. According to the literature, implementing industry 4.0 technologies is straightforward in few industries whereas it is rather difficult in the others (Aripin et al., 2019). It has been realized after going through the extensive literature, the food manufacturing industry lags in digitalization. The industry still observes old practices and technology in their manufacturing processes (Huang et al., 2019). - Implications for implementing Industry 4.0.

Moreover, these findings from the literature can be backed-up by the conducted interviews. Participants A-01 and A-02 talk about the usage of legacy systems in their organization, they further elaborate that new systems are already in place, but the employees are more inclined towards the old ones. Other respondents further explained, the food manufacturing industry is quite different to other industries who are taking up industry 4.0 technologies. According to them, the products in other industries change after a certain period. Whereas, in the food manufacturing industry, products can change in an instant, especially the packaging of the product. Respondent C-01, talks about end of line automation which is primarily focused on packaging. Similarly, interviewee B-02 talked about packaging of products with respect to the marketing strategy, which can change according to the market. Further, participant A-01 also mentions packaging on demand of the customers, which according to him can be made more effective after the introduction of new technologies.

5.2.2. Internal Resources

The availability of necessary resources for companies facing the digital transformation to Industry 4.0 is critical. In this context, the essential resources identified are the availability and compliance of talent and the appropriateness of the existing IT infrastructure.

5.2.2.1. Talent development and acquisition

As researchers conclude, the realization of Industry 4.0 indicates a radical change in the working environment (Erol et al., 2016; Simons et al., 2017). It is apparent that by inheriting the capability to independently interact and align to changes, the intelligent machine is destined to assume an increased range of responsibility. Repetitive work, for example, is today performed by the individual but will tomorrow be employed to the intelligent system. In their study, Davies et al. (2017) report that the role of the current employee will be elevated to the status of a 'knowledge worker'. The addition of advanced robotics, artificial intelligence and machine learning is therefore reshaping the role of the individual. Increased intelligence of products, however, indicates an increase in the complexity of processes (Davies et al., 2017; Frank et al., 2019). It is argued by Erol et al. (2016) that to meet the growing complexity of the production facility, requires an upskilling of staff and sourcing of new qualified employees. This is addressed in our interviews and emphasized as a major issue facing the digital transformation to Industry 4.0. It is generally stated by the case companies that the required human resources are not fully present within the organization. This is further expanded upon by interviewee C-01 who argues that untrained workers pose a significant risk to the sustainable adoption of Industry 4.0. A similar reasoning process is exhibited by Brödner (2015), stating that it is the know-how and adaptive capacities of workers that, paired with the intelligent system, enable Industry 4.0 to unfold its full potential. Therefore, the reallocation of tasks and responsibilities – a consequence of the smart factory – needs to be underpinned by the appropriate training measures. In this scenario, management support is crucial as it consequently facilitates organizational learning (Agostini & Filippini., 2019; Kagermann et al., 2013). A similar reasoning process is exhibited in the interviews in which the role of management is emphasized to cultivate people with the necessary digital knowledge. The respective case companies are primarily attentive towards developing the technical skills (e.g. troubleshooting) and IT knowledge of employees. Such

interdisciplinary skill development is emphasized by Simons et al. (2017) as an essential competence to possess in order to cope with the demands of the smart factory.

5.2.2.2. Organizational resistance

It is apparent that the deployment of Industry 4.0 involves a significant restructure of processes at all levels of the organization. In this scenario, the application of intelligent technologies is expected to lead to more transparent, and decentralized workflows (Horváth & Szabó, 2019). At the same time, the production facility becomes more complex to operate (Frank et al., 2019). In the study by Schröder (2016), the author states that the increased transparency and complexity of work promotes employee anxiety and stress. This stimulates uncertainty within the organization and potential resistance against innovation. The interviewees emphasize such as a significant hindrance to Industry 4.0 adoption. It is recognized by an interviewee that the increased workflow transparency may impose an increased pressure on the employee to perform well. This risk of data transparency that is imposed on the employee is largely overlooked in the extant literature. Data transparency, as envisioned by Industry 4.0, enables the employer to excessively monitor employee performance. As a consequence, it incentivizes potential resistance against intelligent technology. A similar incentive is exhibited by the interviewees in relation to the growing complexity of processes. The dominant variable for employee resistance, however, is identified by the interviewees as the fear of losing one's job. Intelligent technologies evidently indicate the inclusion of more automation and robots.

5.2.2.3. IT infrastructure

Industry 4.0 adoption indicates the creation of a highly modular and scalable automated production line (Weyer et al., 2015). Accordingly, to accommodate the needs of the production model requires an equally flexible and scalable infrastructure. This often leaves the implementing organization with two alternatives, either to adapt the existing IT infrastructure systems or to install completely new systems. This is expressed in our interviews as a challenge faced by the respective case organizations. It is collectively stated that the current IT Infrastructure is not fully capable to support the complete digital transformation to Industry 4.0. The interviewees argue for the difficulty to successfully harmonize and network the existing IT systems to the required degree of flexibility and

scalability. A-02, for example, mentions that the current system is too human-friendly and independent. In a detailed manner, the interviewee states that the employed automation to processing and filling is significantly dependent on the human operator. Similarly, big data analytics is reported as underutilized by the interviewee. A similar issue is exhibited by case organization B, interviewee B-02 states that current processes are dependent on the individual for the minutest of tasks. The computation of data, for example, is done manually in some facilities. Based on such, the corporate IT infrastructure assumes more of an executional type of role within the respective case organizations as opposed to a strategic and innovative one. This consequently inhibits IT system scalability and standardization (Berghaus & Back, 2016). As stated by Weyer et al. (2015), the creation of a connected and integrated network, as demanded by Industry 4.0, requires the standardization of the corporate IT infrastructure. It is thus apparent that the IT infrastructure of the respective organizations are at an early stage of the digital transformation process. Accordingly, interviewee A-02 and A-03 necessitate the need to develop more agile processes as well as to strengthen cross-department collaboration within the case company. This involves for example business-capabilities within IT (Berghaus & Back, 2016). For case company B, on the other hand, the organization is moving towards employing a cloud-based application in the facilities that are yet confined to the manual registration of data. At the same time, the case company inhabits an advanced degree of automation and robotics. Interviewee B-01 mentions that the organization has constructed a fully automated robotic storage and retrieval system (AS/RS) warehouse facility. This demonstrates the varying degree of the firm's IT infrastructure. Case company C, on the other hand, has largely modified its entire operations, particularly end-of-line automation. The interviewee C-02 states that most of its plants have transitioned to a fully digital factory. In this context, cloud-based systems are employed across the organization to monitor the different plants in real-time. Based on such, it is mentioned by the interviewee C-01 that the case company was increasingly able to automate its repetitive processes. It is apparent that the IT infrastructure of the organization is at a later stage of digital transformation in comparison to the precedent case companies.

5.2.3. Technology

Current world structure demands the use of technology in its daily life. However, the usage of industry 4.0 technologies depends upon the size of the organization. As different researches show that multinational organizations are more likely to benefit the most from these technologies and achieve more advanced efficiency (Dalenogare et al., 2018; Horváth & Szabó, 2019). Furthermore, for the implementation of these technologies there are multiple factors to consider. As according to the data gathered from the interviews, the factors include complexity of systems, availability of technology and the relative advantage.

5.2.3.1. Complexity

The technologies involved for achieving industry 4.0 are in possession of a separate identity and can communicate with each other on what is required within the production process (Valdeza et al., 2015). As per the interviews conducted, it was seen that all the participants believed the technologies involved are quite complex. Moreover, the respondents enlightened us about the stages of technology implementation. However, it was observed that all three companies are at a different stage of implementation of these technologies. The respondent C-02, also mentions during his interview about the end of line automation that he has achieved in his factory. He mentioned the requirement of the right skillset in people to operate it effectively. C-02 further mentions, even if more the organization is successful in implementation of other technologies, it will become a challenge for the organization to run and sustain them. As the whole concept of implementation and the technologies itself is rather complex. Whereas, participant B-01 explained during his interview that the whole process of industry 4.0 implementation is a sophisticated task, thus its implementation will be a lengthy process. The information provided by B-01 can be complimented with a quote said by participant C-02, “It is a journey, not a destination”. Moreover, respondents from case company A also informed us during the interviews that the whole process of industry 4.0 is complex. According to them, industry 4.0 technologies implementation is focused towards the end of line production. These findings from the interviews are in line with the extant few researchers have already concluded. According to Davies et al. (2017) and Frank et al. (2019), the organizations implementing industry 4.0 technologies face a big challenge as these technologies make the manufacturing process more sophisticated.

5.2.3.2. Availability

Through the conducted interviews, it was seen that representatives from all three case companies agreed on availability of industry 4.0 technologies as a challenge. The interviewees were responding in the context of a multinational company, as according to them the technologies are not completely available in some regions. As according to respondent C-02, the availability of technology is a challenge in the developing countries due to non-availability of support services. Similarly, participant A-01 enlightened us with the fact that the technology is available through Europe and China. Where, the technology from Europe is quite expensive as compared to the technology available in China. However, he explains, the technology available from China is not trustworthy and does not fulfill the company's quality standards. The participant from the third case company, being case company B, also stressed on the importance of easy access of technology in all the regions. According to B-02, if support services for industry 4.0 technologies are not present and the technologies themselves are substandard. These can become obstacles in achieving industry 4.0 implementation within the organization. Few researchers also show the difference between the technology availability in developing and developed countries. According to Hansen et al. (2018), the developing countries lag in getting the proper infrastructure for new technologies as compared to developed countries. Hansen et al. (2018), research can be backed up by the research of Bogoviz et al. (2018), they state that the concept of Industry 4.0 emerged in Europe and it has been recently introduced in the developing nations. Thus, the availability of industry 4.0 technologies is easier in developed nations. The mentioned expanded literature backs-up the views expressed by the interviewees.

5.3. Analysis discussion

The barriers to Industry 4.0 adoption are thoroughly addressed in the above section of the analysis. As per the interviews, there are numerous factors - internal and external - that influence the ensued digitalization process of the case organizations. It is collectively stated that the complete application of Industry 4.0 is hindered by the identified impediment factors. Consequently, the case organizations portray a pattern of implementation that resembles a phase-by-phase approach.

Phase-by-phase approach according to the interviewees is by implementing technologies in stages rather than implementing them instantly. This helps the organization plan and prioritize the regions and areas of usefulness. Furthermore, according to the participants, areas like end of line automation and warehouses are the first places to implement the necessary technologies. However, the case companies are multinational, thus, the participants also shed light on the aspect of regional implementation. They further explained, industry 4.0 technologies are available in the developed countries. Whereas, in the developing countries it is not conveniently available and is quite expensive as compared to the labor cost. Thus, the organizations prefer labor force to do the work, rather with the usage of new technology. Moreover, it has also been observed through the interviews, implementation of industry 4.0 technologies should be prioritized according to areas producing products with more margins.

Considering the data gathered from the three case companies, the researchers determined three critical success factors. These being Global-level team, Region-wise concentration, and selective training. According to the participants, these factors are currently being utilized by the organizations to manage their challenges, which have been discussed in the previous section.

5.3.1. Global-level Team

Global-level coordination team is one of the critical success factors that the researchers have identified. According to the interviews conducted, the participants from all the case companies mentioned “global level teams” working towards the implementation. According to them, the global team should be led by a member of senior management, as is the case in one of the case companies. The researchers observed that the global team has an indirect role in the external environmental factor. As the external factor is different for all the regions, it largely depends upon the local governmental regulations, labor policies and the industry characteristics. Thus, the regional team takes the lead in this factor, while staying in coordination with the global level team for necessary support. However, as the researcher identified, the global team is directly involved with other identified challenges. These include IT infrastructure, human resource and technology since these factors affect the global level implementation of industry 4.0 integration. The authors further focus on the fact that the global team needs to prioritize the implementation of I4.0 with respect to different regions. This can be done by determining the most important areas with the consultation of the regional teams. Moreover, the global level team is required to oversee the implementation in different regions and provide the necessary resources.

5.3.2. Regional Concentration

The identified challenges from the data collected are directly related to the regionally concentrated team. Regionally concentrated teams are another critical success factor identified by the researchers. According to the researchers, the regional teams are responsible to handle the external environmental factors being faced by the organization. As these factors vary from region to region and vary in different countries. Furthermore, these teams also need to focus on the internal factors of the organization, which includes human resource and IT infrastructure. According to the researchers, the regional teams can make a better assessment of the current IT infrastructure and what is required to be replaced for I4.0 technologies implementation. Furthermore, the same teams are required to identify the human resources issues being faced and generate a plan to overcome this. Lastly, the teams also need to concentrate on the technologies to be utilised in the specific sectors. Focus on the complexity and availability of the required technologies in their region. It is important to mention that the regional teams need to prioritise the

implementation according to the region they are responsible for. Furthermore, as per the researcher, the regional concentration teams need to be in coordination with the global level team to coordinate for the necessary resources required.

5.3.3. Selective Training

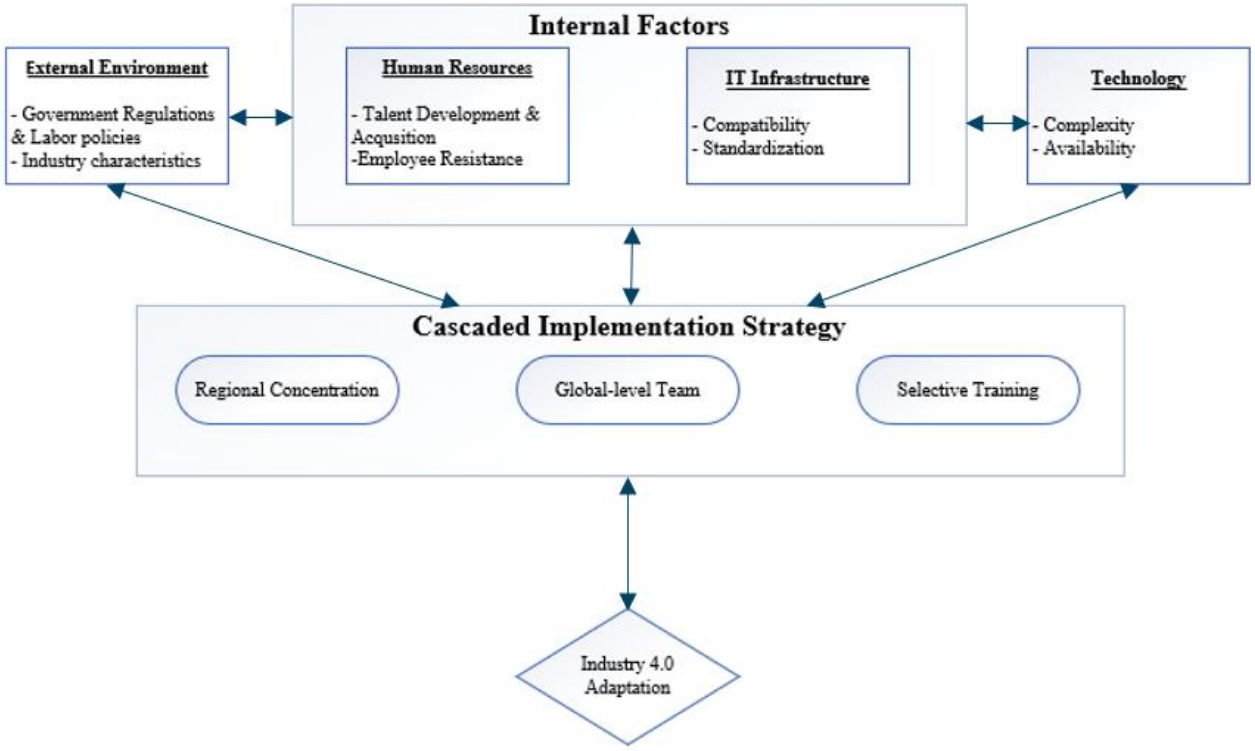
It is apparent that the potential of Industry 4.0 – related technologies is dependent on the practical knowledge and adaptability of employees. This necessitates the need for an effective change management program that proactively manages, communicates, and involves employees in the transformation process. Internal factors of the organization are impacted by the identified critical success factor. According to the authors, the human resources are responsible to identify the employees requiring the selective training. Moreover, the human resource should also be responsible with planning a timeframe for the training of the selective groups. Furthermore, the researchers focus on the relation between the IT infrastructure and selective training. According to them, the selective training must be designed according to the level of complexity of the IT infrastructure, that is to be introduced. Furthermore, training programs are also required on the existing infrastructure, if it is to be updated/upgraded. Selective training is also linked to technology, an identified challenge faced by the organizations. According to the researchers, it is important to prioritize the technologies that are to be implemented. This is done through coordination with the regional and global level teams. Selective training programs must follow the similar structure and introduce programs for the technologies being introduced first. Followed by the programs for technologies to be introduced at a later stage.

5.3.4. Conceptual Framework

On the basis of the conducted cross-case synthesis within the analysis phase, the researchers developed a model. The developed model provides a clarity on which challenges food manufacturers are most likely to face during the implementation of industry 4.0 technologies. Further, the model goes into different critical success factors, which have been identified by the researchers. These factors, according to the participants, are useful in overcoming the challenges. However, each challenge is dealt with the utilization of one or more than one theme. This can be observed through the arrows in figure 6. Furthermore, while following the critical success factors mentioned

in the diagram, an organization can achieve implementation of Industry 4.0 technologies through cascaded implementation.

Figure 7. Conceptual Framework



6. Conclusion

With increasingly individualized consumer preferences and an intense competitive environment, manufacturers are required to meet specific consumer demands with similar efficiency to those produced massively. This has imposed several challenges upon the manufacturer to efficiently create and capture value. Accordingly, such requirements are feasible and efficiently addressed by the technological advancement envisioned by Industry 4.0. In this context, manufacturing technologies are upgraded and transformed by Cyber-Physical Systems and the Internet of Things which creates an intelligent, self-regulating, and interconnected production process. This involves a comprehensive digital transformation of key business operations that affects every aspect of the organization. Accordingly, the study set out to investigate the required actions and measures undertaken by the organization to ensure the successful transformation to Industry 4.0, in the context of the multinational food manufacturer.

The conducted study applies multiple-case research consisting of three multinational food manufacturers. The findings identify numerous challenges, both internal and external, that obstruct the adoption of I4.0. These inhibiting factors significantly influence the transformation process that is ensued by the food manufacturer. It is concluded that the appropriate strategy insinuates a phase-wise implementation that emphasizes the specific region and the deployment of knowledge to specific individuals. Accordingly, a framework is developed that conceptualizes the appropriate measures and actions undertaken by the food manufacturer within the digital transformation process for Industry 4.0.

6.1. Research Contribution

This research encompasses a comprehensive investigation of digital transformation in the context of Industry 4.0. The findings of the study contribute to organizations and researchers alike, by inductively designing a theoretical framework which may guide the transformation process of the entity. In contrast to other approaches, the developed model identifies and subsequently addresses the more prominent challenges that arise within this process, resulting in a more comprehensive framework. Last, the study emphasizes areas in need of future research.

6.2. Recommendations

During the course of this research, the researchers identified different challenges faced by the food manufacturing industry during implementation of Industry 4.0 technologies. Furthermore, the researchers came-up with recommendations for the food manufacturers.

i. The researchers suggest the organization pursues the phase-by-phase implementation strategy. As the manufacturer should prioritize the areas of implementation, including the technologies and the regions.
ii. The technology implementation should involve all the employees, from the beginning till the end of implementation. Regarding, training as well as keeping them informed.
iii. The technological implementation is recommended to be human centric, as means to develop user friendly solutions. The consequence of such, it eases the implementation process towards industry 4.0.

6.3. Limitations & Future Research

During the course of the written paper, the world was hit by a global pandemic referred to as Covid-19. This forced people to confine themselves to the safety of their homes which influenced the data collection process. The interviews that were supposed to be conducted in person were moved to an online platform. Moreover, due to the pandemic the supply chain around the world was stressed, due to which it was difficult to get hold of people to be interviewed. These barriers may have suppressed some information that could have a significant impact on the deduced results. The study is confined to the multinational enterprise as means to investigate Industry 4.0. This limits the generalizability of the concluded findings to smaller sized food manufacturers. Hence, further research is suggested to target the SME and Industry 4.0 adoption in the food manufacturing sector. In addition to this, another area for future research attention is data transparency and excessive monitoring.

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8. Appendices

8.1. Appendix A

Questionnaire

Part 1 - General Questions

1. Which position are you working at within the organization?
2. What is your role and responsibilities at this position?
3. Which areas of the organization fall under your supervision?
4. Since when have you been at this role?

Part 2 - Industry 4.0 and the organization

1. How comfortable are you with the idea of Industry 4.0?
    a. What do you understand by the word “Smart” Factory?
    b. Which Industry 4.0 technologies are you familiar with?
2. How relevant is Industry 4.0 for your organization?
    a. What do you think will be the time period required for the complete implementation of Industry 4.0 concept?
    b. Are any of the technologies available being utilized within your organization?
3. What is your opinion regarding the use of I4.0 technologies within food manufacturing?
    a. Do you think all technologies are relevant to food manufacturing industry?
4. Is your organization planning on completely shifting to I4.0 technologies?
    a. Which actions are necessary to undertake for continuous implementation?
    b. How do you propose, an implementation like this can be achieved?
    c. Which resources you deem necessary for its implementation?

5. As your organization is already implementing I4.0.
    a. Is there a designated person overseeing the project?
    b. In your opinion, a multinational like in your case can work with the same team responsible for all the regions.
    c. How can these issues be resolved?
6. Which are the key factors that you think are important to look into during the implementation phase?
7. Which issues do you face during the implementation of different technologies?
    a. Issues that you face with respect to your employees.
    b. Issues with respect to the region the organization is based in.
    c. In your opinion, the issues faced by the organization after the realization of Industry 4.0.
8. With digitalization/Industry 4.0 technologies, which are the biggest improvements that the food manufacturing industry can achieve?
    a. Can these advancements be helpful in the current scenario? (The Pandemic).
    b. How do you think these advancements will change the current work environment? (With respect to the employees working in the factories).
9. How do you think the issues that arise from this can be best addressed?

8.2. Appendix B

Consent Form:

I volunteer to participate in a research project conducted by Muhammad Soban Adil and Sedin Mekanic from Jönköping International Business School. I understand that the project is designed to gather information about implementation of Industry 4.0 technologies in your organization.

1. My participation in this project is voluntary. I understand that I will not be paid for my participation. I may withdraw and discontinue participation at any time without penalty.

2. I understand that most interviewees will find the discussion interesting and thought-provoking. If, however, I feel uncomfortable in any way during the interview session, I have the right to decline to answer any question or to end the interview.

3. Participation involves being interviewed by researchers from Jönköping International Business School. The interview will last approximately 90-120 minutes. Notes will be written during the interview. An audio tape of the interview and subsequent dialogue will take place for researchers to not miss details said in the interview.

4. I understand that the researcher will not identify me by name in any reports using information obtained from this interview, and that my confidentiality as a participant in this study will remain secure. Subsequent uses of records and data will be subject to standard data use policies which protect the anonymity of individuals and institutions.

5. It is only the researchers that will have access to raw notes or transcripts. This precaution will prevent my individual comments from having any negative repercussions.

6. I understand that this research study has been reviewed and approved by JIBS.

7. I have read and understand the explanation provided to me. I have had all my questions answered to my satisfaction, and I voluntarily agree to participate in this study.

8. I have been given a copy of this consent form.

_____	_____
Signature Date	Signature Date
Muhammad Soban Adil	Sedin Mekanic

For further information, please contact:

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