ISCTE Business School
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KNOWLEDGE DIFFUSION AT A MAJOR CENTRAL EUROPEAN AUTOMOTIVE SUPPLIER

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Abstract

Diffusion of knowledge is a topic approached by modern economy to reach and sustain competitive advantage. As the environment is more uncertain, it is essential organisations learn to deal with new environmental changes as a consequence of Industry 4.0.

The purpose of this project is to assess the adequacy of valuable knowledge diffusion in organisations during the implementation of Industry 4.0 principles and technologies. This diffusion is implemented in automotive businesses reaching an improvement of communication and production processes and consequently the productivity.

This project establishes a case study, was adopted by an automotive industry Group focusing in promotion of knowledge diffusion and Industry 4.0 implementation among various stakeholders of the same company. The processes were analysed using observation, unstructured interviews and focus groups. The proposed challenge was to study how to apply Industry 4.0 to improve relevant knowledge sharing processes within the company.

Regarding the needs and challenges identified, the best approach was to develop a communication channel which aligns the knowledge between all stakeholders. To link the two departments, recognize the value of an invention and achieve an innovation, some improvements were suggested and a new mean of communication was developed.

The created product have not already been implemented due to time required, stakeholders busy schedule and R&D work dependability. With the proposed solution, the company will overcome the identified communication challenge and reduce the loss of important knowledge to maintain their progress.

Key Words: Knowledge Diffusion, Innovation, Industry 4.0, Alignment

JEL Classification:

O31: Innovation, Research and Development, Technological Change, Intellectual Property Rights - Innovation and Invention: Processes and Incentives

O33: Innovation, Research and Development, Technological Change, Intellectual Property Rights - Technological Change: Choices and Consequences, Diffusion Processes

Resumo

A difusão do conhecimento é um dos tópicos mais abordados pela economia moderna para alcançar e sustentar a vantagem competitiva. Como o ambiente empresarial é mais instável é fundamental que as organizações aprendam a lidar com as novas mudanças ambientais introduzidas pela Indústria 4.0.

O objetivo deste projeto é avaliar no sponsor a adequação da difusão do seu conhecimento mais valioso na implementação dos princípios e tecnologias da Indústria 4.0. Esta difusão é implementada para melhorar os processos de comunicação e produção de forma a melhorar a sua produtividade no setor automóvel.

Este projeto constitui um caso de estudo que foi abordado por um grupo da indústria automóvel para promover a difusão do conhecimento, melhorar processos de partilha de conhecimentos relevantes e a implementação da Indústria 4.0 entre os diversos stakeholders da empresa. Os processos foram analisados e os dados recolhidos por observação, entrevistas não-estruturadas e focus groups.

Em relação aos desafios identificados, a abordagem escolhida foi desenvolver um canal de comunicação para alinhar o conhecimento entre todas as partes interessadas. Para ligar os dois departamentos, reconhecer o valor de uma invenção e para alcançar uma inovação foram sugeridas algumas melhorias e desenvolvido um novo meio de comunicação.

A implementação do produto ainda não foi realizada devido à sua duração, à agenda ocupada dos stakeholders e à dependência do trabalho resultante da P&D. Com a solução proposta, a empresa conseguirá ultrapassar o desafio de comunicação identificado e reduzirá as perdas de conhecimentos importantes para manter a sua evolução.

Palavras-Chave: Difusão de Conhecimento, Inovação, Industria 4.0, Alinhamento

Classificação JEL:

O31: Inovação, Pesquisa e Desenvolvimento, Mudança Tecnológica, Direitos de Propriedade Intelectual – Inovação e Invenção: Processos e Incentivos

O33: Inovação, Pesquisa e Desenvolvimento, Mudança Tecnológica, Direitos de Propriedade Intelectual – Mudança Tecnológica: Escolhas e Consequências, Processos de Difusão

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List of Abbreviations and Acronyms:

AC – Absorptive Capacity

AGV's – Automotive Guided Vehicles

AI – Artificial Intelligence

ASCM S&I - I4.0 – Automotive Supply Chain Management Strategy & Innovation – Industry 4.0

B2B – Business-to-Business

Cobots – Collaborative Robots

CPS – *Cyber-Physical Systems*

et al. – And others

FMS – Flexible Manufacturing Systems

G&G – Geolocation & Geofencing

GDP – Gross Domestic Product

i.e. – That is

I4.0 – Industry 4.0

ICT – Information and Communications Technology

IoT – *Internet of Things*

ISTS – Integrated Storage & Transportation Systems

IT – Information Technology

NASA – National Aeronautics Space Administration

P&D – Pesquisa e Desenvolvimento

R&D – Research & Development

RFID – Radio-Frequency Identification

SCM – Supply Chain Management

TRLs – Technology Readiness Levels

USA – United States of America

1 Introduction

1.1 Technological Context

In the last centuries, there have been three industrial revolutions: the 1st introduced the mechanisation and the use of steam and water, the 2nd brought the electricity and the 3rd defined by the increased automation in manufacturing processes due to the use of IT (Information Technology) (Chen, 2017; Rojko, 2017). All these moments have reshaped the entire world and now we are in the middle of a new industrial revolution entitled as Industry 4.0.

Industry 4.0. has received a lot of attention in recent years due to the ability to produce more efficiently, with bigger quantity and better quality (Chen, 2017). Thus, the modern economy is more directed towards knowledge, and humans have always searched new and improved ways of developing its goods and services with the intention to be more competitive and economically sustainable.

In Fukuyama (2007: 57) opinion *"a major transformation is due to the introduction of a new economic organization"*, to find out the causes and consequences of these changes are required detailed investigations and explanations. The big change this research will focus on, is the fourth industrial revolution.

This strategic initiative began to take form in Germany with the introduction of the term "Industrie 4.0" in 2011 by its government. Germany is a country that is well known for its manufacturing engineering capabilities, being one of the most competitive manufacturing business in the world (Kagermann *et al.*, 2013). To add the fact, Industry comprises 23% of the country's Gross Domestic Product (GDP), it employs over 7 million of people and 52% of the country's GDP is related to exports (Audretsch, 2018; Brettel *et al.*, 2014). And to hold their position as one of the global leaders specialized in the manufacturing sector, as expected, they strive to innovate to keep improving and stay in vanguard of technology.

The benefits of Industry 4.0's implementation, by the year 2025, will contribute as much as 78 billion euros to German GDP (Hermann *et al.*, 2015), once again, it seems understandable why this transition is important nowadays and receives special attention from all organisations.

Over the years, it has grown an interest and research in this topic, becoming a top priority for many authors, research centres and companies. Furthermore, a generic and clear definition of the term *"Industry 4.0"* is so far unclear, creating challenges and difficulties for identification and implementation of Industry 4.0's scenarios (Hermann *et al.,* 2015).

The main idea and goal is to achieve the improvement of manufacturing processes by creating intelligent factories (smart factories) transforming and upgrading the technologies by Cyber-Physical Systems (CPS), cloud computing and Internet of Things (IoT) (Zhong *et al.*, 2017). Everything will be connected through sensors, microcomputers and transceivers bringing not only a physical factory but, in addition a cyber-physical structure obtaining a vast amount of data collection and higher automation of the processes (Hermann *et al.,* 2016).

The implementation of these sensors in each machine creates a big amount of data collected, requiring a lot of computer power to be able to analyse the big data, in order to get as many improvements as possible (Shakerin *et al.,* 2016). This problem can be solved with a tool that allows organisations to use the power of multiple processors over the internet, i.e., *"Cloud Computing"* (Chen, 2017). After this data being analysed in the "cloud", it is transformed into *"Smart Data"* converting the traditional plant into a *"Smart Factory"* (Lasi *et al.,* 2014). These *"Smart Factories"* brings in diverse technological improvements allowing an overall optimization of the company's performance, such as decreasing labour costs, bigger flexibility in the product customisation, reduction of waste and optimization of machines' downtime (Rojko, 2017; Kiel *et al.,* 2017).

1.2 Problem Context

In the world of manufacturing industry, change is a constant and companies need to be able to react and adapt to the new organisational paradigms in order to be as competitive as Industry 4.0 initiative requires. Moreover, organisations need to face many challenges in this era but, one of the main, is being the way of turning the knowledge available into a valuable asset.

Hence, there are three main topics this work will address:

1. the major meanings of Industry 4.0 and the consequences of its implementation.
2. the alignment and the effort companies need to face to learn and adapt in order to follow innovation and avoid losing competitive advantage.
3. the creation of value based in the use of knowledge and its diffusion through all the interested parts.

Altogether, the literature refers to the basic conditions of value creation in the adaptation and distribution of new environmental knowledge as a consequence of "Industry 4.0" principles and its implementation. However, the main challenge is to know how to reach these conditions.

It is, therefore, important to ascertain the impact of the adoption of Industry 4.0 in the particular context/business project in a sponsor of automotive industry as will be done in the next chapters.

1.3 Overriding Objective

The purpose of this study is to assess the adequacy of diffusion of valuable knowledge during the implementation of Industry 4.0 principles in automotive businesses in order to improve overall performance. The main question this study hopes to answer in the context of the automotive industry is:

How to bring these Industry 4.0 (I4.0) technologies into the factories?

Hence, the topic of change management is very important to the development of knowledge' diffusion. Without implementation of these technologies into the factories, all the investment and work developed from R&D becomes useless.

Therefore, this performance will be analysed in terms of organisational culture and structure, strategic alignment, organisational learning, innovation consequences, time, quality, costs, efficiency and effectiveness to obtain and create proposals in order to achieve an improvement in the information sharing, reaching the final destination with quality.

Consequently, to reach this purpose, several partial objectives and its research questions need to be fulfilled:

<u>Partial Objectives</u>

1. Diagnose the current situation of the company.
2. Identify the main needs entailed in current processes of knowledge diffusion.
3. Analyse, create and develop a proposal to solve the requirements identified.

Research Questions

1. **1.** What are the changes brought in to the company by the new industrial revolution "Industry 4.0"?
2. **2.** What were the biggest needs identified in terms of diffusion of knowledge in the company's current processes?
3. **3.** What is the best approach to mitigate the difficulties identified and develop proposals?
4. **4.** What principles were considered important in the creation of value?

1.4 Company Context

The empirical work will be conducted within the Group as one of the biggest German companies worldwide in the automotive industry, focusing on the area of Automotive Supply Chain Management, Strategy & Innovation – Industry 4.0 (ASCM S&I – I4.0). The changes coming from Industry 4.0 will affect everyday's work life and, the main purpose of this department is to identify, implement and adopt these changes. More specifically, the work developed by this department is mainly focused on the strategy perspective of innovation at a management and corporate levels and consists in establishing a "bridge" between the work developed on R&D and the application of this same R&D' work in the factories.

Topics as digitalisation, connectivity, artificial intelligence (AI), globalisation and individualisation are influencing this department and will be one of the most business-critical themes in the future. As the topic of Industry 4.0 is very recent, it has several challenges and questions, which is why it attracts a lot of interest and effort from the comp any because it is a subject with several unknown and innovative topics that worth being investigated.

The department ASCM S&I is operationalised as a central European function that assists in terms of innovation and strategy around 500 plants globally, employing more than 95 000 people worldwide and generating sales of approximately 19 billion Euros in 2018, in the divisions this study will be developed, i.e. the *Automotive unit: Chassis and Safety division and Interior division.* Altogether, as the automotive unit is very big and important, the group intends to grow and follow technological trends and environmental changes required by I4.0. Hence, the department is asked to identify their future needs and challenges in terms of performance and adoption of this new strategic paradigm.

Due to confidentiality issues, and by request of the Group, related to competition, its identification is not revealed and the document will not present any data that could lead to its recognition.

To sum up, the chosen topic about the diffusion and alignment of valuable knowledge regarding Industry 4.0's technologies is very challenging. All the interested Group's automotive plants in Europe will be part of the assignment scope. Process improvements by adopting these technologies to support the developed work are expected in the future.

1.5 Methodology

To achieve the objectives defined above and to respond to the proposed research questions, two methodological strategies will be drawn up.

Firstly, to understand the main topics associated with the value of knowledge in the Industry 4.0 era, a Systematic Literature Review will be carried out. This type of review allows the selection of scientific accepted articles and then, to evaluate, condense and synthesize in a balanced, impartial and comprehensive manner, the best evidence related to a specific topic of interest or research question (Saunders *et al.*, 2007).

Subsequently, a project in a case study will be conducted in a sponsor of the automotive industry, with a special focus to promote knowledge diffusion and industry 4.0 implementation among the various stakeholders of the same company in a scope of a specific industry project. The case study allows the researcher in depth exploration and understanding of a contemporary business situation with important contextual conditions; this has motivated the choice of this research strategy (Yin, 2009).

1.6 Structure

This thesis will be subdivided into six chapters:

- Introduction: consists of general context, problem description, objective and research questions, an initial approach to the methodology and structure.

- Literature Review: with the aim of providing the research foundations this chapter provides a synopsis of the existing literature which is divided into two sections: (i) first, is introduced the concept of Industry 4.0, its fundamental principles, the developed tools, their benefits to companies and their challenges; moreover, the historical background and its importance in the context of automotive organisations; (ii) second, are approached the concepts of innovation, alignment in the value creation process, organisation learning, absorptive capacity, knowledge creation and diffusion processes.

- Methodology: encompasses paradigms, philosophies, epistemology, ontology, research approaches, research design, description of the methods and principles applied to accomplish the overall aims of the study, structured around all several phases of the research.

- Case Study: divided into three sections: a description of studied company and the work area in which the study is carried out, the product creation process that follows the conceptual model developed, the methodology adopted, the process of value creation and definition of future objectives with the product created.

- Analysis & Discussion: covers an analysis and counterweights the results by comparing with the ones obtained in other situations studied.

- Conclusions: encompasses the answers to research questions proposed at the beginning of the study as well as the main contributions of this research. The main limitations of this study are also highlighted and are put forward possible clues for future research.

2 Literature Review

The chapter focuses on two complementary segments: at first, the concept of Industry 4.0 is introduced, then, it aims at providing a common understanding of fundamental principles, developed tools, their benefits, the newest introduced technologies and its distinction from older industries; moreover, the historical background and its importance in the manufacturing companies are described, with a special focus on the automotive industry; at last, the contact with knowledge management philosophy in order to comprehend the key benefits and challenges of the topic. The second section complements the first concepts presented: open innovation, importance of alignment in value creation process, organisation learning, absorptive capacity, variations in technology readiness levels and, at last, process of knowledge creation - with the combination of explicit and tacit knowledge or both concepts separated.

The purpose of this chapter is to gather what organisations need to implement an Industry 4.0 mindset. In fact, they might need to start by adapting their structures and spread valuable knowledge to be well-grounded and more flexible to face the constant changes of the business environment, in order to be able to reach and sustain competitive advantage and better performance.

2.1 Industry: A Historical Background - The Industrial Revolutions

The term of "Industrial Revolution", was first used in Great Britain and the United States of America, in the 1800s, with the advent of the mechanisation and mechanical power generation (Rojko, 2017). In the First Industrial Revolution, Walter's steam engine technology changed the method of production, from manual work to the first mechanical manufacturing processes, mostly in the textile industry (Chen, 2017; Rojko, 2017). Furthermore, a great improvement in productivity was accomplished and significantly improved the quality of life (Chen, 2017; Rojko, 2017).

During the 1900s, Henry Ford introduced the Ford T-Model car with the sentence *"You can have any color as long as it is black"* (Rojko 2017: 79). Thus, this motto clearly shows the introduction of mass production, without the possibility of products' customisation (Rojko 2017). Hence, it was implemented the Second Industrial Revolution, triggered by the electric energy and the arising of the first assembly line which boosted a standard manufacturing practice. Consequently, the productivity was significantly improved obtaining outstanding results and profits (Chen, 2017).

About the Third Industrial Revolution, Oztemel and Gursev state this step as *"the digital revolution"* (Oztemel & Gursev, 2018: 1). In the 1970's was introduced the first programmable control system through Modicon (Drath & Horch, 2014); thus, manufacturing efficiency and productivity was enhanced by the combination of high level of automation in production systems, advanced technologies and information technology, such as Flexible Manufacturing Systems (FMS) and Robotic Technology (Oztemel & Gursev, 2018; Chen, 2017).

2.1.1 Industry 4.0: The Vision and Concept

Nowadays, we are facing the Fourth Industrial Revolution or "Industry 4.0" / "Industrie 4.0", triggered by the Internet and smart devices, which are being used to improve productivity and flexibility of the manufacturing systems (Chen, 2017; Xu *et al.*, 2018). During 2011, the German government implemented this concept of "Industrie 4.0", as a strategic initiative that was adopted as part of the "*High-Tech Strategy 2020 Action Plan"*(Weyer, 2015: 579) to bring *"fundamental improvements to the industrial processes involved in manufacturing, engineering, material usage and supply chain and life cycle management"* (Hermann *et al*, 2016: 3929). In accordance with Lasi *et al.*, (2014), the main idea of this theory is the exploration of the new technologies potential and they found eight fundamental concepts of Industry 4.0, as follows:

1. Progression and transformation of the manufacturing technologies as Cyber-Physical Systems (CPS), the Internet of Things (IoT), Artificial Intelligence and Cloud computing, generating intelligent manufactures (Zhong *et al.*, 2017).

2. *"Digital mapping and virtualization of the real world"* (Rojko, 2017: 80).

3. Concept of "Smart Factories" by using smart technology and a holistically digitalized factory with products and autonomous models (Lasi *et al.*, 2014).

4. Change from conventional production hierarchy to decentralized self-organisation manufacturing systems (Lasi *et al.*, 2014).

5. Increase of individualisation in the connected processes through various channels to create new systems in distribution and procurement. (Lasi *et al.*, 2014).

6. New systems in the development of products and services by individualisation; furthermore, various approaches of product innovation and open innovation will be a big important topic on this matter (Lasi *et al.*, 2014).

7. Following the human requirements and never the opposite, so the focus will be always the human (Lasi *et al.,* 2014).

8. Focus from Corporate Social Responsibility on resource-efficiency and sustainability as essential factors for success products (Lasi *et al.,* 2014).

In short, Hermann *et al.,* (2016) define Industry 4.0 as *"a collective term for technologies and concepts of value chain organization"*, creating a digital transformation in the industrial markets with smart manufacturing, enabling a more comprehensive, interlinked and holistic manufacturing approach. It connects physical with digital, allowing better collaboration across departments, empowering business owners to have a better control and understand every aspect of their company and, at last, it allows them to leverage real data to increase productivity, drive growth and improve the used processes (Xu *et al.,* 2018; Oztemel & Gursev, 2018).

2.1.2 Industry 4.0: Components - Technology Enablers

Intelligent manufacturing requires specific technologies which enable direct communication within production systems, allowing problems to be solved and generate rapid decision making in order to improve productivity (Lee *et al.,* 2014). This way, some of the most important technologies and components are, as follows:

- <u>The Internet of Things (IoT)</u>

According to Kagermann, the fourth industrial revolution started with the integration of The Internet of Things and Services in the manufacturing process, making possible to connect all the elements of a manufacturing system, converting factories into smart factories (Kangermann *et al.,* 2013).

The concept of the Internet of Things consists of a network in which CPS works (Kusiak, 2018; Hermann, 2015). It is an inter-networking world in which various "objects" such as RFID tags, sensors, actuators, mobile phones or others digital devices can interact and cooperate with each other, reaching the purpose of collection and exchange data (Zhong *et al.,* 2017; Gursev & Oztemel, 2018; Hermann, 2015). This way improves the efficiency and quality of data collection, achieving more accurate information and knowledge – attaining an optimistic environment (Chen, 2017; Gursev & Oztemel, 2018).

- Cyber-Physical System

Industry 4.0 is *"often understood as the application of generic concept of CPS to industrial production systems"* (Drath & Horsch, 2014: 56). Rojko states that in Industry 4.0 exists a shift where the physical systems integrate with ICT (Information and Communications Technology) components in order to share information (Rojko, 2017).

Therefore, Chen defines CPS as a *"system of collaborating computational elements and controlling physical entities"* (Chen, 2017: 591), considering this kind of systems the core foundation of Industry 4.0, where a high level of integration and coordination between software and physical components is a requirement (Xu *et al.,* 2018). This coordination and combination can be achieved using an important technical method as an embedded system (Zhong *et al.*, 2017), which can improve significantly the communication efficiency through a compatible network (Chen, 2017; Bauernhansl, 2014).

These devices are independent systems with multiple sensors and computing capabilities that check, control and process their feedback taking their own decisions based on real-time data collection, machine learning algorithms, records of previous performances and analytical results (Kojko, 2017; Oztemel & Gursev, 2018; Bergera *et al.*, 2016).

In accordance with Xu *et al.,* (2018) developments in this system will upgrade the current simple systems and consequently will allow a bundle of positive features, such as capability, adaptability, scalability, resiliency, safety, security and usability.

- Cloud Computing

Chen (2017) states the meaning of Cloud Computing, as a provider of *"an Internet-based computing service, which makes it possible to share software so that a user does not have to install the needed software locally"* (Chen, 2017: 590). The cloud systems are a good source of solutions to handle a big amount of data, information and knowledge, where can be uploaded to a cloud computing center which is stored in private or public cloud servers. It provides some benefits, such as: to support complex decisions making tasks, to reduce costs, to offer high performance, resource sharing, dynamic allocation, eradicates infrastructure complexity, to extend work area, to protect data and, at last, to provide access to information at any time (Zheng *et al.*, 2014; Mitra *et al.*, 2017; Xu *et al.*, 2018; Li *et al.*, 2017).

2.1.3 Principles of Industry 4.0

According to Lu (2017), there are design principles which allow manufacturers to investigate a potential transformation of Industry 4.0 technologies, as follows:

- **Interoperability**

In Industry 4.0, the term of interoperability arises from the connection between organisations, the Internet of Services, humans and communication over the IoT and CPS, as well it represents the capability of exchanging data and sharing information between systems (Shi *et al.,* 2012; Colombo *et al.,* 2015; Kusiak, 2017; Hermann *et al.,* 2015; Lu, 2017). Furthermore, as it will be referred ahead, the core idea of interoperability is integration of multiple distinct systems (Qin *et al.,* 2016).

The Internet of Things (IoT) and CPS technologies are the big impulse of making the integration transparent, wider and deeper with the possibility of process, collect and access large amounts of information, data and knowledge at real time (Chen, 2017). Thus, according to Kagermann *et al.,* (2013), the leading supplier and leading market strategies need to complement each other to achieve Industry´s 4.0 goals. Chen (2017) states that in manufacturing it can be reached three different dimensions of integration:

1. <u>Vertical Integration</u>

Through the manufacturing systems (Qin *et al.,* 2016), this vertical network sets in the factory – smart factories, which means, organise themselves and enable customized production. Moreover, it uses CPS to allow fast reactions through the changes in demand, stock levels and liabilities (Kangermann *et al.,* 2013; Deloitte, 2014). Thus, according to Chen (2017), seamless connectivity over all the elements in the product life cycle within an organisation is a requirement on this dimension, to provide the monitorization of all resources and products anywhere and anytime (Chen, 2017; Kagermann *et al.*, 2013).

Afterwards, all the information and knowledge are shared through the entire organisation *"from manufacturing cells, lines and factories, also integrating the associated value chain activities such as marketing and sales or technology development"* (Stock & Seliger, 2016: 537), delivering efficiency, quality and responsible waste elimination (Chen, 2017; Stock & Seliger, 2016; Deloitte, 2016).

2. Horizontal Integration

This dimension occurs over the value networks (Qin *et al.,* 2016), which means *"when a company is closely integrated with its suppliers and partners"* (Chen, 2017: 590).

Hence, during the value chain of product life, the business models are the digitalisation of value creation. The cooperation between different companies and company-internal intelligence are described across the entire value creation network and there are several topics to be addressed like "sustainability", "know-how protection", "standardisation strategies", "medium to long-term training and staff development initiatives" (Kagermann *et al.,* 2013; Stock & Seliger, 2016).

3. End-to-End Integration

According to Qin, Liu and Grosvenor (2016), this feature occurs across the products chain, which means *"from the raw material acquisition to manufacturing system, product use, and the product end of life"* (Stock & Seliger, 2016: 537). Here, it is feasible to integrate customers' requirements into the manufacturing system as well as the product-to-service integration acquiring customer´s feedback in real time and in an accessible way (Xu *et al.,* 2018). In this way*, "the value chain will be extended to the customer service of the product"* (Chen, 2017: 590).

In the context of a highly dynamic market, the proposal of these features drawn above will allow manufacturing companies to gain some benefits, such as rapid in-time and fault-free production at the market process (Kagermann *et al.,* 2013).

- **Virtualization**

Xu *et al.,* (2018: 2947) state *"Virtualization technology provides cloud computing with resource sharing, dynamic allocation, flexible extension, and numerous other advantages"*. This sentence reports the importance of the use of CPS, therefore this system is able to monitor physical processes – all the sensor data is linked to virtual plant models and simulation models (Hermann *et al.,* 2015).

- **Decentralization**

This principle follows the ability of CPSs to work autonomously, this means, computers enable CPS to make decisions on their own (Hermann *et al.,* 2015). This gives space for customized products and problem solving, creating a more flexible environment in production, improving the overall industrial performance (Lu, 2017). Lu states *"CPS is capable of increasing productivity, fostering growth, modifying the workforce performance, and producing higher-quality goods with lower costs via the collection and analysis of malicious data"* (Lu, 2017: 5)

- **Real-time Capability**

With this capability, in the Smart Factory, the real-time status of a plant is permanently tracked and analysed, in order to make better decisions according to Hermann *et al.*, (2015) and Lu, (2017). Another important aspect is the active reaction to the failure and analysis of malicious data which provides flexibility and optimization of resources improving all systems performance (Lu, 2017).

- **Service Orientation**

Here is where the Internet of Services becomes essential, therefore the production must be based on a service-oriented architecture (Hermann *et al.*, 2015). Weyer *et al.*, (2015: 583) state that *"Service-orientation is a powerful approach to integrate software modules with defined functionality into large and distributed IT systems"*. With the creation of products based on the customer's specifications, people and smart devices must be able to connect efficiently through the Internet of Services to take the maximum advantages of this orientation (Lu, 2017).

- **Modularity**

This principle aims the ability of smart factories to adapt fast to seasonal changes, market trends, new markets and products characteristics, providing flexibility to the system to deal better with unforeseen cases and strengthen the factories/companies (Hermann *et al.*, 2015).

2.1.4 Advantages of the adoption of Industry 4.0

According to the scientific community, Industry 4.0 is a promising solution regarding the current problems and challenges in the manufacturing environment. Thus, the adoption of Industry 4.0 principles will bring benefits as follows:

- Improvement of Productivity and Efficiency

It is possible to manufacture different products at higher speed and quality while allocating resources more economically and efficiently since the factory 4.0 will become more automated (Kiel *et al.,* 2017). Automation will minimize production delays and downtimes created by the optimization of processes based on intelligent control and testing (Herčko *et al.,* 2015; Schuh *et al.,* 2014). Hence, it will achieve positive results as machine availability, robustness in the production process and higher productivity (Kiel *et al.*, 2017).

Furthermore, another consequence of processes automation is the creation of better and faster decisions, solving problems in an effective manner. This way, this fast and accurate answer to problems and needs will increase overall productivity, reducing costs and time wasted, keeping always the quality in the process (Kiel *et al.*, 2017). Rojko also states that Industry 4.0 technologies bring *"More efficient use of natural resources and energy"* (Rojko, 2017: 81).

- Increases Knowledge Sharing and Collaborative Working

According to Rojko (2017), the adoption of Industry 4.0 technologies makes the team stronger, collaborative, flexible and more attractive to the young workforce. This type of technologies allows production lines (machines, conveyors, etc.), business process, the smart products, departments and the cloud to communicate and exchange data interactively over the established network, regardless the location, time zone, platform or any other factor (Kiel *et al.,* 2017; Kamble *et al.,* 2018; Li *et al.,* 2017).

As companies are constantly moving, they need to be better equipped to deal with *"turbulences, uncertainties, inconsistencies, contradictions and paradoxes"* (Takeuchi & Nonaka, 2004: 35). Hence, they require a new management paradigm based on knowledge-creation to face this continuous uncertainty environment and customer needs (Takeuchi & Nonaka, 2004). This paradigm is developed through a dynamic interaction between one company and the employees, creating a group of work and a process of knowledge-creation (Takeuchi & Nonaka, 2004). This interaction solves many problems and creates solutions through dialogue, experience sharing or discussion and creates new points of view (Takeuchi & Nonaka, 2004).

Industry 4.0 brings the introduction of the cloud, which facilitates the transmission of knowledge and smart data from all connected sensors bringing a cyber-physical structure which obtains a vast amount of data collection and a higher processes automation (Lasi *et al.*, 2014). Thus, this automation and connectivity brings diverse technological improvements allowing an overall optimization of the company's performance (Rojko, 2017).

- Increases <u>Flexibility</u> and <u>Agility</u>

With Industry 4.0 technologies, the products can know their own specifications, bringing the possibility to leverage assets to achieve the optimal production requirements from time and scale perspective (Li *et al.*, 2017). This way, all units, machines and technologies in the shop floor might cooperate efficiently to maximize factories' agility and flexibility (Kiel *et al.*, 2017; Kamble *et al.*, 2018).

With these achievements, becomes easier to introduce new products to the production line, to scale production up or down in the "Smart Factory", to create opportunities for one-off manufacturing runs, and much more in the near future (Kamble *et al.*, 2018; Bahrin *et al.*, 2016; Li *et al.*, 2017; Rüßmann *et al.*, 2016; Strange & Zucchella, 2017; Wan *et al.*, 2016; Preuveneers & Ilie-Zudor, 2017).

- Increases <u>Innovation Opportunities</u>

Since Industry 4.0 production lines are made to manufacture broader range and higher volumes, they are ideally suited to new product introduction and experimentation regarding design (Maresova *et al.*, 2018). There are a better combination and interaction between the equipment and the high visibility from IoT, originating intelligent products that enable a deep understanding of what works in both products and the process design (Pereira & Romero, 2017). Therefore, this creates opportunities to innovate giving greater knowledge regarding the manufacturing processes, distribution chains, supply chains, manufactured products and business performances (Kiel *et al.*, 2017).

- Better <u>Customer Experience</u>

According to Kiel, Mueller, Arnold & Voigt (2017), nowadays, consumer behaviour and preferences have changed, influenced by digital tools in a way how human-being work, shop or live. This causes a disruption of the traditional supply chains and increases the need for innovative solutions like the ideas presented here (Kiel *et al.*, 2017).

Consumers increasingly want and demand more possibilities to have direct interaction with the brands, increasing the company's needs regarding fast responsiveness, valuable information availability and fast deliveries (Rojko, 2017). Thus, Industry 4.0 presents opportunities to improve the service itself, delivering better service with more quality to the customers (Rüßmann *et al.*, 2016).

In addition, these technologies will enable an improvement in products' quality, bigger offer to customers, fewer problems with product availability and more innovative products. Additionally, Industry 4.0 technologies can bring to the customers more convenience, power and possibility to have personalized products using mass production which is a big advantage to the companies because let them reduce production costs and increase their profits (Li *et al.*, 2017).

- Reduce <u>Costs</u> and Increase <u>Revenues</u>

Industry 4.0 requires an initial investment but once the intelligence is built into products and processes, the costs of manufacturing will fall as a result of the implementation of Industry 4.0 technologies, i.e. automation, connectivity, digitalisation, systems integration, data management, cloud computing (Rojko, 2017). All in all, this paradigm specifications lead to reduce costs, lead times and enhanced quality (Kiel *et al.*, 2017).

Another important sample of cost reductions potential is regarding factory operation, employees and tooling costs; This is, reducing R&D costs, requiring lower investments into tangible engineering only with the adoption of digital tools (Kiel *et al.*, 2017).

In this sense, cost reduction potential is due to:

- More agile and faster manufacturing;
- Fewer quality problems promoting waste, personnel and overall operating costs reduction;
- Lower machine and line production downtime;
- Better use of resources (Kiel *et al.*, 2017).

In addition to the previously mentioned, Kiel *et al.,* (2017) concepts will increase companies' profit margin through higher revenues with reduced costs with the implementation of Industry 4.0 principles, according all points above.

2.1.5 Challenges of Industry 4.0

With the introduction of Industry 4.0 principles, the companies need to face some challenges:

- New business models - the definition of a new strategy (Pereira & Romero, 2017).
- Rethinking companies' organisation and processes to maximize new outcomes (Kiel *et al.,* 2017).
- Understanding the business cases (Zhou *et al.,* 2015).
- Conducting successful pilots (Luthra & Mangla, 2018).
- Helping the organisation to understand where the action is needed (Zhou *et al.,* 2015).
- Change management, something that is too often overlooked (Luthra & Mangla, 2018).
- Company culture and vision (Pereira & Romero, 2017).
- The genuine interconnection between all departments (Kiel *et al.,* 2017).
- Recruitment and development of new talents (Kiel *et al.,* 2017).
- Information management, as it is, sums up in connecting everything through the "cloud" to have one place with all the suitable knowledge (Kiel *et al.,* 2017). Thus, in a context of relevance, innovation and timely availability it is important for any desired employee and customer goal (Zhong *et al.,* 2016).

2.1.6 Industry 4.0: Impact in German automotive industry

The German manufacturing industry is one of the biggest and most important around the world competing with the USA and Asia. Therefore, this country is the pioneer of the initiative of “Industry 4.0” and most of the German companies are in a race to adopt elements and principles of Industry 4.0 (Rüßmann *et al.*, 2015).

As already mentioned, IoT technology allows the creation of completely new products, services and business models, which nowadays is at the early stages of practical application, being the automotive industry the first to perceive the opportunities of this technology and connectivity among devices (Roblek *et al.,* 2016).

In the future, the process of making a car or components of a car will be managed by automatic job-control systems, where the integration of data will make the manufacturing process change and adapt automatically (Roblek *et al.*, 2016;Rüßmann*et al.*, 2015) . Rüßmann *et al.*, (2015) describe some examples of changes in this industry:

- the production line will be more flexible allowing the production of multiple product models and life cycles;
- the use of small batches makes the production processes more versatile with the help of autonomous robots;
- suppliers will automatically adjust their processes maximizing just in time in logistics, reducing operating and logistics costs;
- employees will have access an augmented-reality glasses, permitting that all manufacturing important information and correct assembly location available through the vision at the exact moment;
- cameras that recognize gestures, with the purpose to assist employees in quality controls checks by automatically recording and storing quality issues, reducing manual paperwork, failure and increasing quality control;
- the creation of virtual models, which can be updated constantly, offering a variety of new services to the customers and create new ideas that can be used to optimise the design of future cars and components.

To better understand the potential impact of this fourth wave of technological advancement, German automotive industry estimates that in the next five to ten years, these changes will generate 25€ billion to 38€ billion in productivity (growth of 10-20%) (Rüßmann *et al.,* 2015). Industry 4.0 will have all chain connected, having a direct impact on producers, employees and its supplier manufacturing systems (Roblek *et al.,* 2016; Rüßmann *et al.,* 2015).

2.1.7 Industry 4.0: Knowledge Management

The processing of Big Data in the Industry 4.0 environment is very important for the implementation and success of one organisation in a competitive market. Knowledge management is one of the advantages that one company should focus on, hence, "*who can get knowledge and applies it faster, they will be more successful on competitive market"* (Shakerian *et al.,* 2016: 176).

The information and knowledge coming from Big Data are a critical component where the information needs to be *"uncovering hidden clusters and correlations so that systematic patterns can be recognized, and a better decision can be made"* (Chen, 2017: 590). Another important aspect from these phenomena is transparency, which means all departments can access and easy-read all the important information, getting more accurate data, eliminating waste, becoming more flexible, agile and aligned (Abreu, 2018; Shakerin *et al.,* 2016).

Shakerian *et al.,* (2016) states that supply chain and knowledge management need to be integrated, hence, this relation nowadays is weak. So, this is what Industry 4.0 brings in order to improve the share of knowledge, documentation and better usage of the information between all interests from all different areas in the supply chain.

Afterwards, it is easy to see the linkage between the knowledge of management and decision making. Within the accurate and organised data, the gap between what decision makers know and what they need to know is eliminated (Shakerin *et al.,* 2016). To implement it, there is a need for strategic decision-making tools to help to define more useful structures in supply chain development. One tool where it can see the integration between knowledge management and cloud services is the use of a "platform". Here, a big amount of data can be accumulated and provided to enterprises services, intelligent design and manufacturing design. Interconnecting all of this will be able to generate advanced and accurate decision making for all chain (Zhong *et al.,* 2017).

In summary, looking at this base for the literature review, it is possible to see the importance of knowledge diffusion in the adoption of Industry 4.0 paradigm. Therefore, with every system interconnected, information digitalized and its automated processing, the factory will acquire a huge amount of data at real time. Hence, to transform it into a valuable company asset, this data needs to be transparent across all employees and departments.

Industry 4.0 brings improvement of knowledge exchange and better information usage, which leads to a faster and better decision making. Other improvements related with this paradigm is: productivity increase, cost reduction, better product quality, work conditions and relationships between employees, smooth and simplified management, bigger information accuracy and quality, improving efficiency in problem-solution and better usage of resources.

To acquire valuable assets, topics as innovation, need to be taken into account to promote value creation and new types of knowledge diffusion. Hence, it is important to recognize possible valuable information, transform it into proper knowledge with easy readiness and comprehension from all the stakeholders, discuss the best method to present it and finally, implementing and use it.

Moreover, there is a lack of research regarding concepts of Industry 4.0 and knowledge management. Nevertheless, the next steps concerning the literature review will consist of specifying knowledge management in detail about the value creation.

2.2 Innovation

2.2.1 Open Innovation

Due to rapid technological progress and changes in the business environment, in the last years, organisations and researches focus on innovation and inter-organisational collaboration to learning how to improve their business and where they should apply their efforts (West & Bogers, 2014). Despite this focus, the rising cost of R&D and the swift advance of technological knowledge make it impossible to maintain internally all the capabilities and knowledge required for value creation (Ferreras-Méndez *et al.,* 2016). Therefore, organisations must collaborate with external agents in order to learn needed knowledge that resides outside their core competencies (Ferreras-Méndez *et al.*, 2016). In accordance with Flor *et al.*, (2018), it is not just a matter of identifying the basic competences of the partner for cooperation, but ensuring that the partner is sufficiently committed to the task in order to build a sustainable and trustful relationship (Flor *et al.*, 2018).

In this sense, the degree of openness of a firm can be explored by two main dimensions:

- <u>Open search knowledge breadth</u>

  It is defined by the number of external sources of knowledge used by the organisation to complement internal efforts. Therefore, a broader number of different sources provides the firm more options for approaching problems from different perspectives and new insights (Terjesen & Patel, 2017). This dimension will require significant costs and a high number of management skills in order to deal with diverse external partners (Flor *et al.*, 2018).

- <u>Open search knowledge depth</u>

  This dimension defines how deeply the organisation accesses external knowledge (Martín-de Castro, 2015). This type of firms with depth search strategy will select a small number of external channels that they consider the most convenient to learn from or offer important knowledge inputs in a continuous basis (Flor *et al.*, 2018). Hence, it is not only about selecting the most adequate channels and establishing the cooperation principles, but also *"about preserving them, which implies being committed in terms of resources and attention"* (Flor *et al.*, 2018: 187).

Open innovation can help organisations reducing the cost of product development and process improvement, speeding up the market entry of new products, improving product quality, allowing a better adaptation to customer needs, sharing the risks in product development, accessing to supplier and customer knowledge, and improving company image and reputation (Wallin & Krogh, 2010).

Altogether, firms should rely on external relationships and networks in order to complement their knowledge domains, and then, develop better and faster innovations (Terjesen & Patel, 2017). To understand knowledge management and innovation processes in industrial markets, it is important the ability to apply new external knowledge to products and services, and this depends on the level of absorptive capacity (Ferreras-Méndez *et al.*, 2016). Ahead more information regarding absorptive capacity will be approached.

Consequently, in the next topic, it is possible to further understand why some organisations are able to take advantage of knowledge from external sources and others not. A conclusion can be drawn analysing the effect of using new external information on the learning processes using search strategies for this type of knowledge.

2.2.2 Integration of Knowledge in Open Innovation

The innovation creation is totally dependent of knowledge and in its essence is a *"process that covers the creation and use of knowledge for the development and introduction of something new and useful"* (Wallin & Krogh, 2010: 145), as it follows with the next three steps:

1. Process of creating relevant knowledge regarding market trends, new technologies and customer needs;
2. Relevant knowledge is transformed by the development of new products, processes and services;
3. Usefulness depends on perspective. To customers, an idea is useful when a product/service solves a problem, whereas, for the company, only is useful when generates a profit.

Hence, the collaboration of people and teams with different knowledge and expertise in various fields and practices, it is vital and challenging. Thus, it is crucial to identify and integrate this different knowledge along the innovation process.

Regarding the study and research from Wallin and Krogh (2010), to think more effectively and organise open innovation projects it is important to identify and follow a process model of how to integrate knowledge (Figure 1). Below it will be explained all five steps:

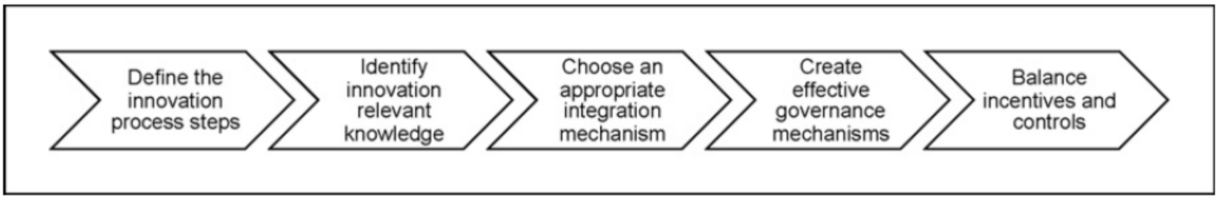


Figure 1: A process model for integrating knowledge in open innovation (Wallin & Krogh, 2010)

1. Innovation process steps definition

Plan a product launch requires tailoring an idea into specific steps through all the innovation process such as: idea generation, concept development, prototype development, market study, demonstrations (pilot manufacturing), full-scale manufacturing, sales and distribution (Wallin & Krogh, 2010). As innovation proceeds, management needs to be aware of which step it is in the moment to specify in detail what types of tasks need to be performed in each sequence.

2. Innovation relevant knowledge identification

It is important to identify a domain and team to work on this process of open innovation. The identification of this domain is challenging because, in an open innovation view, the new knowledge may be captured outside the company through universities, research institutions, suppliers or customers.

3. Choose an appropriate integration mechanism

This step focuses on how people, teams and other external and internal sources, contribute to an effective open innovation through the integration of the identified relevant knowledge. There are four mechanisms as follows:

- *Rules and directives* for integrating knowledge from the exterior. Company may have to rule for instance, before deciding to move a product concept forward into the demonstration phase, if managers must or not deliver data regarding the product's market potential.
- *Sequencing* of tasks. Company may create a timeline to design product components and follow this sequence to trigger the planned tasks.
- *Routines*, as behaviour patterns driven in response to issues, problems or tasks.
- *Group problem solving and decision-making* from outside and with different domain knowledge to solve many tasks, the common problems, the defining steps and processes of open innovation.

4. <u>Create effective governance mechanisms</u>

Since the boundaries of the company are open to the exterior, it raises some questions related to the governance of the process, its results and assets. The purpose of this governance is to facilitate the contribution of external sources and suppliers to provide more knowledge to the company. The designed mechanism should not be too restrictive and unattractive regarding effectiveness.

5. <u>Balance incentives and controls</u>

It is important in this step to find the right equilibrium "*between incentives offered by the firm in open innovation and approaches to control the output and work of outside individuals and institutions*" (Wallin & Krogh, 2010: 152).

2.2.3 Absorptive Capacity

The first time this concept of "Absorptive Capacity" (AC) arise was through Cohen and Levinthal (1990) when both describe the concept of AC, as the ability of an organisation to recognize the value of new external information, assimilate it, and apply it to commercial ends. Hence, it is critical to its innovative capacity, relying and focusing on external knowledge. Afterwards, another very important conceptualization of absorptive capacity is from Zahra and George (2002), where they state and highlight the systems, processes, structure of the organisation and routines that allow firms to identify, assimilate, transform and exploit external knowledge. Additionally, these authors defined absorptive capacity as a dynamic capability that has two general positions:

- Potential AC consists of external knowledge acquisition processes, value and assimilation that can or cannot be used to produce innovations (Ferreras-Méndez *et al.,* 2016; Zahra & George, 2002; Flor *et al.,* 2018);

- Realized AC refers to knowledge leverage that has been internally captivated (Zahra & George, 2002; Ferreras-Méndez *et al.,* 2016).

Regarding Lane *et al.,* (2006), Chiang and Hung (2010), the benefits of a dynamic capability depends on the different modes of organisational learning with the purpose of acquiring new knowledge. Therefore, following this process view based on Lane *et al.,* (2006), the ability of an organisation to use and seize externally knowledge has to pass through three sequential processes namely:

1. <u>Exploration</u>: *"recognizing and understanding potential valuable new knowledge outside the firm through exploratory learning"* (Lane *et al.,* 2006: 856).

   In other words, identification and acquisition of external knowledge (Martín-de Castro, 2015).

2. <u>Transformation</u>: *"combining existing knowledge with externally-acquired knowledge through transformative learning"* (Lane *et al.,* 2006: 856).

   Corresponds to the maintenance of knowledge over time, allowing the assimilation and retention of it, connecting exploratory learning with exploitative learning (Ferreras-Méndez *et al.,* 2016; Garud & Nayyar, 1994; Sun & Anderson, 2010).

   Recent research identifies two stages into transformative learning:

   - *Knowledge maintenance,* when the company captures activities of retaining and storing knowledge, and the way it shares and communicates internally. For example, the creation of a mechanism to review the internally shared catalogue in order to create sustainable, reliable and valuable information is another very important aspect to the organisations (Ferreras-Méndez *et al.,* 2016; Argote *et al.,* 2003).

   - *Knowledge reactivation,* when companies can quickly access accumulated knowledge by relying on it and using its expertise to make changes to internalize the existing knowledge through new experience (Marsh & Stock, 2006).

3. <u>Exploitation</u>: *"using the assimilated knowledge to create new knowledge and commercial outputs through exploitative learning"* (Lane *et al.,* 2006: 856).

   The application of acquired knowledge, it is in this process as well, and corresponds to the concept of realized absorptive capacity.

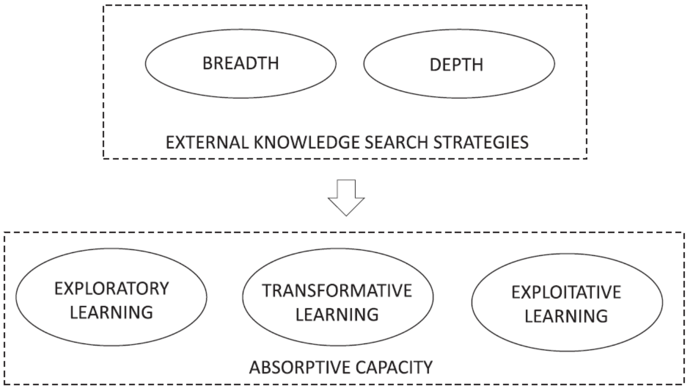


Figure 2: External knowledge search strategies as antecedents of absorptive capacity. Retrieved from (Ferreras-Méndez *et al.,* 2016)

In short, these learning processes are the mechanisms that originate and make possible the development of a dynamic capability inside the organisation as it is illustrated in Figure 2 (Helfat *et al.,* 2009; Ferreras-Méndez *et al.,* 2016). Hence, the gain of sustained competitive advantage through knowledge utilization depends on the company's absorptive capacity (Martín-de Castro, 2015).

2.2.4 Value Creation

According to Möhring (2014), the notion of value has a huge impact and importance to companies nowadays. Hence, the modern industries often hold a strong focus on engineering, technology and product by introducing the notion of value. However, there is a mentality transition in the last decades, suppliers need to dominate the transition from a pure engineering market to a mixed perception of customer-oriented needs.

Given the increased recognition from the customer perspective, these business domains were particularly challenged to incorporate a customer-centric mindset in parallel with the supplier. These two actors need to collaborate in order to generate value as will be analysed and defined ahead. The next Figure 3 highlights the perspectives over value processes, where it will be analysed and oriented in literature review through three distinct areas: supplier perspective, customer perspective and the gap between both, i.e. the interstice.

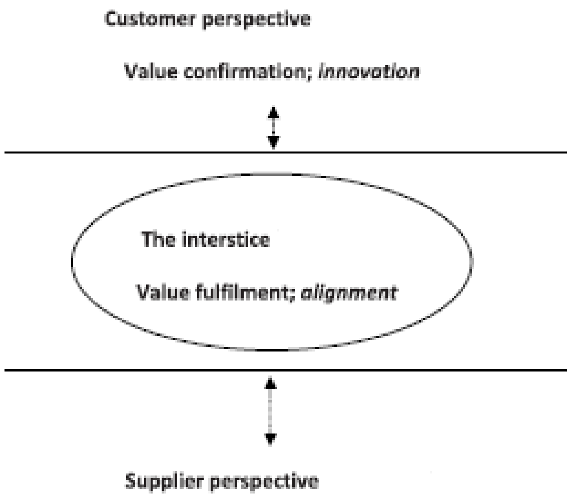


Figure 3: Customer-centric value creation (Möhring, 2014)

- **Supplier**

Value is a subjective variable measured by the customer perception where Baeva (2012: 73) states *"Value is the striving of a human to clarify the meaning and significance of our existence; it is an act of freedom, expression of subjectivity because it is based on our personal experience and preference"*.

<u>Value Proposition</u>

In a consumer perspective, perception is the truth and may not be correct, but it is what he knows. As what he knows is all he needs to know, and it is suggested by value proposition, is stimulated by value proposition to choose and acquire a good product or service to the detriment of a similar one of the competition (Möhring, 2014). Thus, for this value proposition, products and/or services have to fulfil the customer's needs. In order to deliver value to the target organisation, it is important to combine supplier's specialized skills and capabilities in a product and/or service to start an exchange relationship between these two actors (Grönroos & Ravald, 2011).

Products and services acquire quality when the customer realizes that is in better condition with them than without them (Vargo *et al.*, 2008).

Invention

At the beginning of the innovation process, two sides of a supplier-customer combination are considered as potential initiators (Möhring, 2014). The supplier can push an invention into the market, which then reacts with acceptance and exchange (Möhring, 2014). On the other hand, the customer signals the need and seeks the innovation capabilities of an appropriate supplier in a *demand pull* (Harrison & Kjellberg, 2010). This process of "*invention towards innovation*" involves a combination of supplier availability and customer request/need (Harrison & Kjellberg, 2010).

According to Dereli (2015), it is important to understand the difference between these two concepts: invention and innovation. Therefore, an invention is the creation of a new product or introduction of a new process, the means of accomplishment and only needs to be proven as workable (Dereli, 2015; Trott, 2008). To be an innovation, this idea needs to be replicated at an economic cost and needs to satisfy the need of a certain group, making a significant contribution to an already invented product or process (Dereli, 2015; Trott, 2008). This is the reason why only a few inventions can reach innovations since not all of them are economically viable (Dereli, 2015).

Grönroos (2011) also distinguishes between the activity of creating value by the supplier, where can or cannot reach the operational success for the customer, and the real generation of *value-in-use* by the customer, where the supplier maintains its provision of services. This exchange of perspectives and insights requires a major strategic focus, leading both parties to gain a competitive advantage (Grönroos, 2011).

- **The Interstice**

After looking at the supplier's perspective, this chapter moves towards the customer and considers the gap between these two actors, the interstice as depicted in Figure 3.

Alignment

According to Tushman and O'Reilly III (1996), leadership for organisations occurs when they seek the alignment or adjustment between strategy, structure, culture and processes, and simultaneously prepare for the inevitable revolutions required by discontinuous environmental changes. This alignment of technology and structure begins with micro-social processes triggered by new technologies, instigating structural changes (Möhring, 2014). Thus, these transformations involve simultaneous changes in company structure and systems, as well as in their culture and skills (Tushman & O'Reilly III, 2002). So it is this alignment that will convert an invention into a useful tradable entity, i.e. an innovation, where are stabilized within the new or extended environment, becoming effective (Möhring, 2014).

As such, the two active actors (supplier and customer), negotiate and coordinate between them in this interstice, in order to create a connection and cooperation generating a mutual approximation, i.e. alignment (Tushman & O'Reilly III, 2004; Campos, 2006). This process of linking innovation encompasses the organisational gap between the invention of a supplier and its operational application, innovation (Möhring, 2014).

Technology Push – Demand Pull Model

The structure and culture of a company are two organisational contexts that must be adaptable to environmental changes and according to Campos (2006), innovation is analysed by approaches from distinct perspectives that contribute to the success of any innovative enterprise.

These approaches consider alternatively the scientific/technological knowledge and the market demand as determinants in this process of the emergence of technological innovations:

"The science push approach considers that there is a direct link between scientific advances and the technological development of the productive application, culminating in economic well-being. [...] Alternatively, from the late 1960s a number of studies seemed to prove that the driving force of technology would be linked to the needs of demand. This view was synthesized by the demand-pull approach to the study of the relationship between science and technology." (Campos, 2006: 143)

As the last citation defines (Campos, 2016: 143), the dynamics of adaptation to innovation will be composed of a mixture of the two models, i.e. a technological impulse in which the simple availability of new possibilities stimulates demand, and a demand philosophy that serves an already existing purpose, such as the reduction of costs in the target industry (Campos, 2006).

Both models are able to develop activities that require constant searching for new knowledge through Research and Development (R&D) of products, processes or services (*technology push* or *science push*). As well as to choose which of them have already acquired required knowledge and are in the process of production (*demand pull* or *market pull*) (Tushman & O'Reilly III, 2002).

For Rothwell (1994), these models, *technology push* and *demand pull*, are considered as the first and second generation of the innovation process. Consequently, a single focus on only one of the models is destructive: the *technology push* model would generate internal creative processes centred on the pioneering development of technology, based on advances and technological improvements, pushing technology to the market without identifying what the market really needs; a restricted focus on *demand pull* would generate less pioneering of technology by itself, directing it towards meeting the needs of the market that will generate profit in sales (Gibson & Birkinshaw, 2004; Rothwell, 1994).

Cooperation between both models is necessary to improve the development and avoid the questions mentioned above. Since the first generation was the *technology push*, it assumed that an increased internal R&D obtains achievements regards new product development (Gibson & Birkinshaw, 2004; Rothwell, 1994). By all means, the innovation will be pushed by the technology developed internally by the firm (Gibson & Birkinshaw, 2004).

For Rothwell (1994) the *demand pull* approach is the second generation of innovation, represented as a choice among the technical possibilities of the organisation, according to the signals by the market, directing the R&D that had a mere reactive role in the process. The first model can also be characterized as a radical innovation or an innovative learning process, while the second is characterized by adaptation and incremental innovation (Rothwell, 1994). In this same line of conception, the continuous development of new knowledge in searching (*exploration*) and the rapid application of exploitation of this newly created knowledge is fundamental to improving and sustaining competitive advantage, where the balance between them must be maintained as already mentioned previously (March, 1991).

In short, alignment refers to the consistency between all patterns of activities in the business unit as they are working together for the same goals where need to be able to reconfigure and adapt activities in the business unit quickly to meet the demands of the task environment (Gibson & Birkinshaw, 2004).

- **Customer**

After analysing the supplier's perspective on products/services and the alignment placed and created in the interstice area, it is the time to analyse the position of the customer. The customer is the one who confirms the value of the product or service, creating a useful value (Bowman & Ambrosini, 2000). This way, it is possible to confirm and obtain the innovation, the *value-in-use* introduced by the supplier's inventions and the combined alignment (Bowman & Ambrosini, 2000).

Innovation

Nowadays, organisations have to deal with environmental pressures and evolving periods of gradual adaptation interrupted by discontinuities (Tushman & O'Reilly III, 2004). Thus, those organisations that are best prepared to adapt to the market or competitive environment will thrive over time, and this progress ends up being the main ambition of the organisations (Tushman & O'Reilly III, 2002). In this context, to ensure the survival and adaptation in competitive markets, innovation plays a fundamental role in the companies' strategy, including the development of products integrating new technologies (Bowman & Ambrosini, 2000).

However, in high technology scope, with an industrial situation driven by innovation, the activities replace actors and resources in economic importance, making the alignment the most important process (Tushman & O'Reilly III, 1996). Consequently, by the construction or integration of new technology, the identity of a company is reflected within the structure, with new core capabilities being acquired and the existing ones strengthened (Tushman & O'Reilly III, 2002).

Innovation is therefore not simply an exchange by which objects are alienated, marketed, and transferred, but a meaningful interaction based on need and invention (Möhring, 2014). For actual organisations, a successful value generation is seen as a major source of fortune for the business (Möhring, 2014). Therefore, concepts of *value-in-use* and *value-in-exchange* need to be defined in order to comprehend this process.

Value-in-use and Value-in-exchange

According to Bowman and Ambrosini (2000), *value-in-use "refers to the specific qualities of a product perceived by customers in relation to their needs... Thus judgments about use of value are subjective, they belong to the individual consumer. In other words, value-in-*

use is perceived by the customer. " The *value-in-exchange*, *"refers to the price. It is the monetary amount realized at a specific point in time when the exchange of goods is realized"* (Bowman & Ambrosini, 2000: 3).

So, while the *value-in-use* satisfies a need of a person or firm, insofar as it has a specific utility, the *value-in-exchange* is a monetary value, economic, defined by the situational context (Tushman & O'Reilly III, 2002). The first is individual and related to production and qualitative attributes, and the second is economic, contextually measured and have quantitative features involved in the exchanges (Meehan & Wright, 2012).

The customer is "protected" from the supplier by the interstice in which everything is prepared in advance before a customer has the first contact with the new product or service (Meehan & Wright, 2012). The product-service combination polished and adapted by mutual negotiation is the actual result because organisations do not jeopardize to develop a full product without receive customer's feedback (Meehan & Wright, 2012). The more the customer participates in the process of value creation, the more the result will be considered controllable and viable (Tushman & O'Reilly III, 2002).

This process of transformation involves not only a monetary selling price, product or service but also a collaborative or relationship way to learn (Möhring, 2014). By gradually maturing the used processes and/or products, innovation can provide its full potential in a business relationship because of the specific *value-in-use* derived from a customer-centric innovation (Fang *et al.,* 2011).

2.2.5 Organisation Learning

Nowadays we face a highly competitive and constantly changing the business environment where companies must pay close attention to the quality and efficiency of their products and services (Huang, 2014). To face this constant and unpredictable changes, they need to attain "alignment" – i.e. the capacity to react, learn and adapt to fit new circumstances (Beer *et al.*, 2005). Also, in a knowledge-based economy, the key to attain competitive advantage arises from innovation capabilities and the creation of value (Beer *et al.*, 2005).

According to Huang (2014), the concept of alignment consists in *"the integration of strategies related to a business and its contingency variables"* (Huang, 2014: 173) and to enhancing performance and sustain competitive advantage. The various parts such us, organisational structure, environment, strategy, technology, culture and leadership, need to be aligned and work together to pursue common organisation goals (Hung *et al.,* 2010; Beer *et al.,* 2005). As advocated by Benner and Tushman (2003), organisational innovation and adaptation depend on proper structure alignment between process management to accomplish their objectives.

In this economic era, Information Technology (IT) is a primary driver of strategic change and structure reorganisation (Hung, 2006). Hence, it has many benefits but mainly, facilitates the integration of business functions at all levels in a company. This only is possible because IT make corporate-wide information more readily accessible (Hung *et al.,* 2010) helping with its gathering, organisation and storage. Also, the accurate strategic use of IT improves the productivity, profitability, quality and performance of any organisation (Huang, 2014).

Hung, Yang, Lien, McLean and Kuo (2010) suggests that, to support the changes in core process and to ensure better performance, IT alignment is critical to the implementation of organisational process alignment i.e. *"organisational effort required to make processes the platform for organisational structure, strategic planning, and information technology"* (Hung *et al.,* 2007: 1026).

Another very important aspect that Wang, Yang, and McLean (2007) refers, is the concept of an organisational learning culture, which is the result of the combination of organisational learning and learning organisation concepts. Learning organisation defines specific characteristics of an ideal organisation while organisation learning focuses on processes or activities related to organisational change (Hung *et al.,* 2010). The joint of this two concepts summarize the goal of organisation learning culture i.e. *"when an organisation recognized learning as absolutely critical for its business success"* (Hung *et al.,* 2010: 287). In order to improve the core competencies and further sustain competitive advantage, companies must focus on the foundation of learning and competences subjects (Huang, 2014; Beer *et al.,* 2005; Hung *et al.,* 2010).

To summarize, in Figure 4 are illustrated and proposed several relationships between the topics previously described. It shows that the organisation dynamic capability partly intermediates the influence of organisational process alignment and fully intermediates the effect of organisational learning culture on performance.

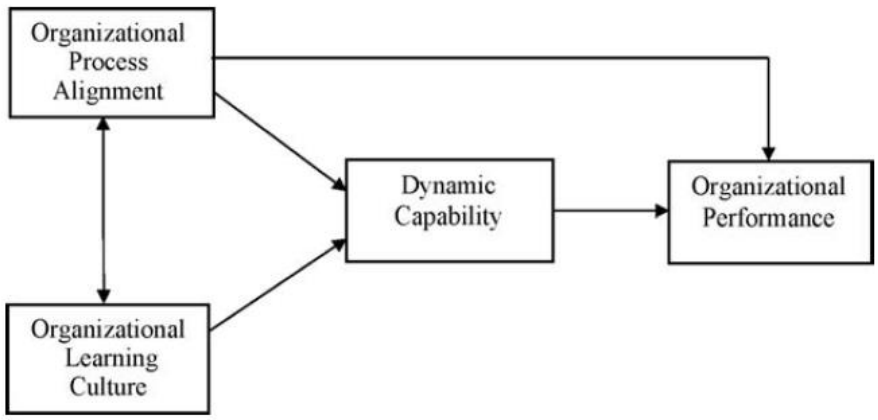


Figure 4: Conceptual framework retrieved from (Hung *et al.,* 2010)

2.2.6 Technology Readiness

In order to detect market and technology trends, an innovative organisation needs to engage in continuous learning opportunities (Flor *et al.,* 2018).

In this sense, the development of new technologies typically depends upon the prior success of advanced technology research and development (R&D) efforts. These developments face inevitably the three major challenges of any project: performance, schedule and budget (Mankins, 2009). To diminish these challenges, managers need to be able to make clear, well-documented assessments of technology readiness and risks, and to do so at key points of program life cycle (Mankins, 2009).

In the middle of 1970s, it was introduced the concept of "Technology Readiness Levels" (TRLs) by the National Aeronautics Space Administration (NASA), which are characterized by a set of specific activities and deliverables (Hallstedt & Pigosso, 2017). These levels are nine and have the objective to assess the maturity of new technology and/or capability towards full economic operation (Straub, 2015). This allows and exploits a highly effective communications and assessment regarding the stage of new technologies among diverse organisations (Mankins, 2009).

According to Straub (2015), Mankins (2009) and Hallstedt and Pigosso (2017), with the enhanced adoption of sustainability in a technology development context, the identification of sustainable-related metrics become increasingly relevant as can be seen in the overview of each technology readiness level presented on the following Table 1.

Table 1: Technology Readiness Levels (adapted from Straub, 2015 and Mankins, 2009)

TRL	Definition	Description
1	Basic principles observed and reported	The lowest level of technology readiness. Scientific research begins to be envisioned as applied research and development. Examples might include paper studies of a technology's basic properties.
2	Technology concept and/or application formulated	Invention begins. Once basic principles are observed, practical applications can be invented. Applications are speculative, and there is no proof or detailed analysis to support the assumptions. Examples are limited to paper studies.
3	Analytical and experimental critical function and/or characteristic proof of concept	At this step in the maturation process, active R&D are initiated. This includes both analytical studies and laboratory studies to physically validate that analytical predictions are correct. These studies and experiments should constitute "proof-of-concept" validation of the applications/concepts formulated at TRL 2.
4	Component and/or breadboard validation in a laboratory environment	Following successful "proof-of-concept" work, basic technological components are integrated to establish that the pieces will work together to achieve concept-enabling levels of performance. This validation must be devised to support the concept that was formulated earlier and should also be consistent with the requirements of potential system applications. The validation is relatively "low fidelity" compared to the eventual system.
5	Component and/or breadboard validation in the relevant environment	Fidelity of the component technology being tested increases significantly. The basic technological components are integrated with reasonably realistic

		supporting elements so they can be tested in a "simulated" environment.
6	System/subsystem model or prototype demonstration in a relevant environment	A major step in the level of fidelity of the technology demonstration follows the completion of TRL 5. At TRL 6, a representative model or prototype system is tested in a relevant environment. Represents a major step up in a technology's readiness. Examples include testing a prototype in a high-fidelity laboratory environment or in a simulated operational environment.
7	System prototype demonstration in an operational environment	Prototype near or at the planned operational system. Represents a major step up from, requiring a demonstration of an actual prototype in an operational environment.
8	Actual system completed and qualified through test and demonstration	Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development for most technology elements. This might include the integration of new technology into an existing system.
9	The actual system has proven through successful mission operations	The actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation.

2.2.7 Types of Knowledge

Regarding the topic of knowledge management, the new knowledge always is originated by the people, thus, when this individual knowledge is converted as an available resource to other people (in the same company), the central activity of the knowledge-creating company is occurring (Nonaka, 1991). This process of transformation occurs continuously at all levels of the organisation (Nonaka & Takeuchi, 2007).

This conversion of knowledge from an individual into more people it will be analysed and explained between two types of knowledge: *tacit* and *explicit* (Baltezarevic & Baltezarevic, 2016).

- *Tacit* knowledge

This type of knowledge is the individual one before to be converted into as an available resource, being very difficult to formalize. Tacit knowledge is very personal because consist in *technical skills* – the know-how captivated from individual experiences – and *cognitive skills* – beliefs, emotions, values and mental models (Baltezarevic & Baltezarevic, 2016; Nonaka & Takeuchi, 2007).

For instance, a worker after years of experience develops a specific expertise gained by doing "at his fingertips", being very difficult to formalize the ability into technical or scientific principles (Nonaka, 1991).

This way, in order to explore the potential of organisations' hidden capital, the companies need to motivate talented individuals to share this potential with all colleagues (Baltezarevic & Baltezarevic, 2016). Therefore, is in this knowledge where the largest competitive power of a company is concentrated (Baltezarevic & Baltezarevic, 2016) so is necessary to apply strategies to use it.

- *Explicit* knowledge

This type of knowledge occurs when the process of diffusion is possible (Nonaka, 1991). This happens, when the company has formulas, product specifications, numbers, manuals or computer programs for all interested company employers use, being a systematic and formal process (Nonaka, 1991; Baltezarevic & Baltezarevic, 2016). Summing up, it is when the know-how is available to all members of the organisation (Baltezarevic & Baltezarevic, 2016) stimulating everyone to share their knowledge and all can take benefits from all company knowledge.

Explicit knowledge can be collected from internal or external sources to improve overall knowledge of the organisation. Additionaly, this type of knowledge improves organisational communication and people's connections to create space to share creative and new ideas (Baltezarevic & Baltezarevic, 2016; Nonaka & Takeuchi, 2007). Consequently, on a daily basis of work, the contact and collective action becomes natural and a routine (Nonaka & Takeuchi, 2007).

All in all, the main objective of the topic “knowledge management” is to identify and motivate an individual to transform and share own hidden knowledge with organisation colleagues. Through the processes of collaboration and social interaction are created an open shape of knowledge available for all organisation’ employees (Baltezarevic & Baltezarevic, 2016), as it will be defined in the next topic.

2.2.8 Knowledge Creation

The creation of knowledge is just possible with a process of interaction between the two types of knowledge already explained: explicit and tacit. Nonaka and Konno (1998) suggests four basic models of knowledge conversion in any organisation. Such models are as follows:

- <u>Socialization</u> - from *tacit* to *tacit* knowledge

This phenomenon occurs when one individual shares tacit knowledge with another individual through direct experience (Nonaka & Takeuchi, 2007; Baltezarevic & Baltezarevic 2016). Is more likely to happen within a group of specific people inside one company where learners absorb the master/teacher’s skills becoming part of their own tacit knowledge base (Baltezarevic & Baltezarevic, 2016; Nonaka & Takeuchi, 2007).

According to Nonaka (1991), socialization is a limited method of knowledge creation, where all organisation can’t access it or leverage it, i.e. never becomes explicit, what difficulties this method implementation, causing more failures because its human dependency.

- <u>Externalization</u>– from *tacit* to *explicit* knowledge

The process model from tacit to explicit knowledge occurs when one individual converts tacit knowledge as a new knowledge, sharing with the other workers from whole organisation (Baltezarevic & Baltezarevic, 2016). So, knowledge creation consists in new formulas or systematic “rules” easy to use and understand to all interested employees (Nonaka & Takeuchi, 2007).

- <u>Internalization</u> – from *explicit* to *tacit* knowledge

This process is the reverse of externalization, as explicit knowledge creates the possibility of new tacit resources development (Baltezarevic & Baltezarevic, 2016). For instance, when an individual employee from a different area begins to internalize the shared explicit knowledge, it will reformulate his/her own tacit knowledge. Gain more knowledge originates new ideas or knowledge that can be complemented with practice and might be used/shared in the future (Baltezarevic & Baltezarevic, 2016; Nonaka, 1991).

- Combination – from *explicit* to *explicit* knowledge

This combination occurs in a process of mature and refine current explicit information creating new knowledge more complex and systematic (Baltezarevic & Baltezarevic, 2016; Nonaka & Takeuchi, 2007).

To conclude, on the interaction of tacit and explicit knowledge, as these four models presented above, communication is stimulated as the main instrument which links the two types of knowledge (Baltezarevic & Baltezarevic, 2016). Consequently, good communication between employees brings new ideas and creativity (Nonaka & Takeuchi, 2007) to help the company evolution. Establishing a good information flow and trust relationships among employees is a determining step to increase the ability to share and learn new/more acquaintances (Baltezarevic & Baltezarevic, 2016).

Summing up

Industry 4.0 brings a new era of environmental changes developing many pressures that organisations have to deal with. Hence, organisations aim to be prepared by adapting its methods to the market or to competitive environment demands to be able to thrive over time. This way, innovation plays a key role in the companies' strategy.

I4.0 pushes (*technology push*) new topics and technologies used by R&D to obtain achievements regarding new product development in order to satisfy the market demand (*demand pull*). Both of these forces need to be aligned to cooperate between them, to do some reconfigurations and adapt activities as quickly as possible to meet the task environment demand. Moreover, these companies need to focus on the processes and activities related to organisational learning to have the capacity to react, learn and adapt to the new circumstances as Industry 4.0 requires.

To develop faster and better innovations, companies should rely on external partners to complement their knowledge domains. Thus, it is crucial promoting the ability to recognize the important value of external information. Assimilate and apply this information (*absorptive* *capacity*) to create a dynamic capability inside the organisations can generates competitive advantage over other companies. Organisations need to adapt progressively to identify, acquire (*exploration*), assimilate and retain the knowledge, transforming it into a readable and systematic form (*transformation*), to use it for commercial purposes (*exploitation*).

With the literature we can notice that all the topics mentioned above are an important theoretical input for the development of this thesis. It stills little researched and have many potential to be extended in future work to search more applications to adopt I4.0 and improve the flow of knowledge within companies. Hence, it is necessary to discuss the methods used to the research allowing readers to evaluate the reliability and validity of this research, as the next section reveals.

3 Methodology

The current chapter comprehends the description of methods and principles applied to fulfil the overall goals of the study, structured around the several phases of the research. Thus, it provides a description of how the study has been planned to follow the approaches of "Engaged Scholarship" and "Participatory Observation". It is then crucial to describe the techniques used and referred to as research tools and consequently play an important role in the execution of this case study. This chapter also describes in detail all phases passed throughout this study.

3.1 Business Research Strategies

3.1.1 Paradigms and Philosophies

For the research, it is necessary to reflect regarding the different beliefs of reality, the philosophies used, and explain the way how the research will be conducted i.e. research strategies.

Since research, in terms of this study, is conducted in cooperation with the Group, both scientific and professional stakeholders are present. This way, to deal properly with all stakeholders' interests and to maximize the benefit of this relationship, one of the frameworks considered is the Engaged Scholarship of Van de Ven (2007).

3.1.2 Epistemology

Epistemology concerns the way how we know the world and what *"constitutes acceptable knowledge in a field of study"* (Saunders *et al.*, 2007: 102; Fisher & Buglear, 2010). In the next points, it will be explained four different types of natural sciences: Positivism, Realism and Interpretivism.

- Positivism is a position that highlights the knowledge of a social phenomenon and is based on what can be observed and recorded rather than subjective understanding (Bryman & Bell, 2015). Hence, once the researcher is independent of the data and has no impact on them, it is objective.
- Realism, according to Saunders, Lewis and Thornhill (2007), essentially advocates that *"objects have an existence independent of the human minds"*, that is, exists a reality separated from our descriptions of it (Saunders *et al.*, 2007: 104).

- At last, Interpretivism, it is based on subjective interpretations and understanding of people regarding the social phenomenon and their actions. It is necessary for the researcher to understand the interpretations of the different human beings as concepts of social matter. The main focus is on the "how" people read the social world and social phenomena, enabling various perspectives to be explored.

For the research, the suitable philosophy that matches with the initial goals of this dissertation is Interpretivism because is the most close with human nature and values the social environment.

3.1.3 Ontology

In this topic, will be referred to two different authors and designations regarding ontology. However, for both authors, they have in common the focus to answer the questions of “How I get knowledge?” and “How do I discover new things?”.

Regarding the work of engaged scholarship developed by Van de Ven (2007), there are four forms of participant observation that can be practised in many different ways. These forms can be used for various purposes depending on the researcher perspective “internal or external participant” and the purpose of the research “to describe or to design”. The next figure (Figure 5), illustrates these four different types of engagement with stakeholders.

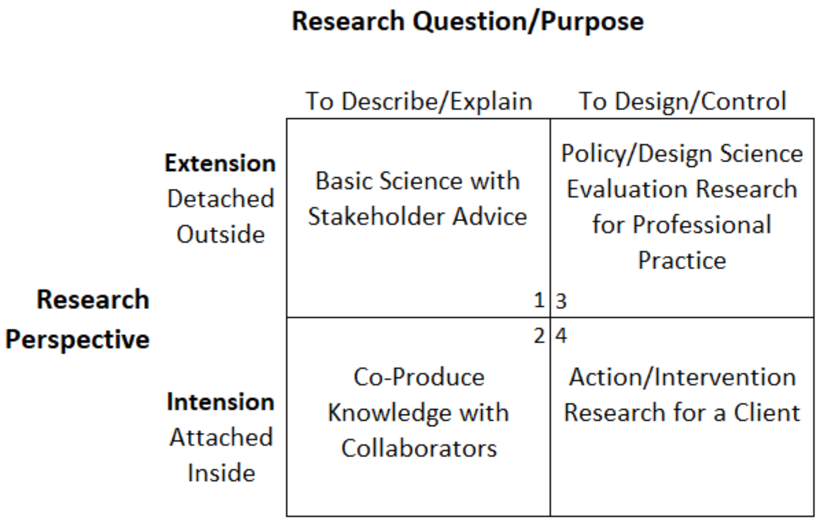


Figure 5: Forms of engaged scholarship (Perspective: Van de Ven, 2007)

As seen in the Figure 5, the combination from the different purposes and perspectives originates:

1. *Informed basic research* is assumed to *"describe, explain or predict a social event"* (Van de Ven, 2007: 27). This type of researcher tries to view the game from an outsider's perspective but solicits advice and feedback from the key stakeholders (Möhring, 2014; Van de Ven, 2007). Other nomenclature used by different authors for this step is *Complete Participation* (Bryman & Bell, 2015) and another is *Observer as a participant* (Bryman & Bell, 2015) used by distinct authors to refer the same step.

2. *Collaborative basic research* demands a better *"sharing of power and activities among researches and stakeholders than informed research"* (Van de Ven, 2007: 27). There is a balance of responsibilities because this type tends to focus on basic questions of mutual interests to the partners (Van de Ven, 2007). All the members of the social environment are aware of the researcher's status as a researcher and have the important job of game's observation i.e. sitting at a table taking notes (Möhring, 2014). Different authors use another nomenclature for this step and call it *Participant as an observer* (Bryman & Bell, 2015).

3. *Design and evaluation research* is assumed to examine normative questions and deal with the design and evaluation of policies or models to solve practical problems (Van de Ven, 2007). It also seeks to obtain evidence-based knowledge and is mandatory to be an outsider to ensure impartial and legitimate results once requires comparisons with another case study stakeholders (Möhring, 2014; Van de Ven, 2007). Other authors named this step as *Complete Observer* (Bryman & Bell, 2015).

4. *Action/intervention research* takes a detailed intervention approach to understand and treat the problem defined (Van de Ven, 2007: 27). Here, the participation of the stakeholder is important and vital in problem-solving using systematic methods of data collection, feedback, reflection and action (Möhring, 2014; Van de Ven, 2007). The researcher assumes a role of technical expert, during the change, once the true identity of the researcher is not known to members (Möhring, 2014). This step can be named *Complete Participation* too when referred by different/distinct authors (Bryman & Bell, 2015).

As explained in detailed Figure 5, the case study approach is predominantly to describe/explain from the perspective of an insider "collaborative basic research". The author of this investigation work as an intern in the department since day one which made him feel one more in the team using always the available data, information and knowledge in order to understand and find an innovative solution. However, the author do not have an autonomous work, focused on basic questions and their biggest tool of research is the observation method. The interaction with the stakeholder assumed as vital to understand and co-create innovative findings was fundamental to conceive the final product described in this work.

Now, following the work from (Saunders *et al.*, 2007) and (Bryman & Bell, 2015) the concepts of objectivism and social constructionism have emphasis regarding ontology.

1. *Objectivism* states the own existence of social world, separated and independent from the actors that belong to it (Saunders *et al.,* 2007).
2. *Social Constructionism* is related with requiring a strong longitudinal interaction and reflection of social actors in industrial networks from people that work together. This way, is possible to create continually revised knowledge and ambiguous innovative projects to motivate employees and involve them in their job (Bryman & Bell, 2015; Möhring, 2014).

According to these ideas, the research can be considered philosophically based on social constructionism since reality is primarily determined by people rather than objective and determined by external factors. In the context of this study, external factors as the characteristics of Industry 4.0 technological push are already present. The actual impact on Business-to-Business (B2B) relationships is, however, based on people's decisions and visions to determine how to use some technology or if the technology matches organisation requirements and goals.

3.1.4 Research Approaches

Following the questions of epistemology and ontology, in this topic the main question to be answered and to focus remains on "How knowledge is discovered and analysed in a systematic way?".

This way, according to Bryman and Bell (2015), the essence of the study is to provide a complete and detailed description of the research, be subjective, deliver the main characteristics of the events and have inductive/emic approach to knowledge discovery. With this brief description, the chosen approach is qualitative research.

There are 3 different approaches regarding the conduct of research:

- Inductive approach, as the opposite of deductive one, it is related with *"building theory"*, based on the collection of data and the development of a theory as a result of the analysis (Saunders *et al.,* 2009). This approach is based on observations where inductive generalizations are never guaranteed to be true since are dependent on the number of observations made (Yin, 2009).
- The deductive approach is related to the development of theory, hypotheses or propositions in order, consequently, to draw a strategy that allows *"testing of theory"* (Bell & Bryman, 2015: 38). The conclusion in this reasoning is guaranteed to be true due to its structure of major premise, minor premise and conclusion (Yin, 2009).

- At last, the abductive approach is *"used to make logical inferences and build theories about the world"* and *"involves the researcher selecting the best explanation from competing explanations or interpretations of the data"* (Saunders *et al.*, 2007: 27). This reasoning usually starts with an incomplete set of observations and goes from there to the likeliest possible explanation and it is used for making and testing a hypothesis with the information available.

This way, to this investigation the chosen approach is the abductive method. The main goal in this thesis is, at first, to collect data, identify the problems, develop the theory as a result of the data analysis and the objectives outlined in the past, and complement it developing solutions to help the organisation and answer to the identified problems.

Summing up, in the next figure (Figure 6), all the concepts are explained and combined. The purpose is to present a simple overview of the strategies and approaches defined above with the special focus for the qualitative research strategy, i.e., the one that identifies with the goals and research purpose.

	Quantitative	***Qualitative***
Epistemology	Positivism	Interpretivism
Ontology	Objectivism	Social Constructionism
Approach	Deductive	Inductive / Abduptive

Figure 6: Overview between different research strategies (Adapted from Saunders *et al.,* 2007)

3.2 Business Research Design

Following the concepts defined in the last chapter, this topic will focus on the process of research design.

3.2.1 Purpose

Research projects have different purposes and can be categorized as:

- Exploratory, where aims to understand and clarify the nature of a problem and *"to seek new insights into phenomena, to ask questions, and to assess the phenomena in a new light"* (Saunders *et al.,* 2007: 133);
- Descriptive, for which should produce an accurate representation of *"persons, events or situations"* (Saunders *et al.,* 2007: 134);
- Explanatory, where there is a focus on studying a problem or situation in order to explain the relationships between the different variables (Saunders *et al.,* 2007).

As a result, regarding the investigation and the principal purpose of understanding the impact and value of innovative knowledge at one automotive multinational, the category that makes more sense to follow is the exploratory.

Thus, the type and method of study in question are essential to define the better suited strategy. There are a number of research strategies that allow to conduct the study in order to meet the research questions and achieve the ideas initially proposed. This way, it is necessary to choose whether the study will be conducted through an experiment, a case study, through the application of a survey, grounded theory or ethnography (Saunders *et al.,* 2007). For the accomplishment of the present dissertation, the Case Study was chosen with special attention to grounded theory and ethnography. All these concepts will be explained underneath in appropriated chapters.

3.2.2 Grounded Theory and Ethnography

Ethnography focus upon describing, exploring and interpreting the influence of culture and the social world, and in this way, the researcher needs to immerse in the culture in order to better comprehend and learn (Saunders *et al.,* 2007). Then, in this research, it is necessary to understand the observed patterns of human activity such as: decisions made in meetings, since the entire research is strongly dependent on human decisions which are based on technological changes.

Grounded Theory is a strategy strongly connected with the inductive approach i.e. theory building, where the theory is developed from the data generated by a series of observations or interviews. It is applied to arise a theory based on the results of the study. This way, regarding the study, this theory enables to develop an inductively resultant theory for the automotive industry based on the results of the Group.

3.2.3 Case Study

To carry out the research in question, the strategy chosen was primarily the case study. This strategy aims to hold the holistic and significant characteristics of real events such as the behaviours of individuals and organisations, or the management and organisational processes (Yin, 2009; Saunders *et al.*, 2007).

Yin (2009) seeks to explore issues not only related to the term of “what”, but also to perceive the “how” and “why” of events in order to provide a detailed explanation of the analysed phenomenon. According to same author, as in this research, a case study identifies more qualitative research too. Moreover, one of the decisions that the researcher has to make, concerning the case study, is regarding its design (Yin, 2009). It is, therefore, essential to determine if a single or a multiple case study method will be used in this research.

Therefore, in one hand, multiple case studies are more robust because they allow an individual and comparative analysis with other cases, permitting the identification of patterns that provide the inputs for the formulation of hypotheses or theories (Yin, 2009; Saunders *et al.*, 2007). On the other hand, a single case study can be useful when it is representative, typical or provides an opportunity to study a specific event, sector or business (Saunders *et al.*, 2007). In the next figure (Figure 7), Yin (2009) demonstrates the various types of design into four groups according to the units of analysis.

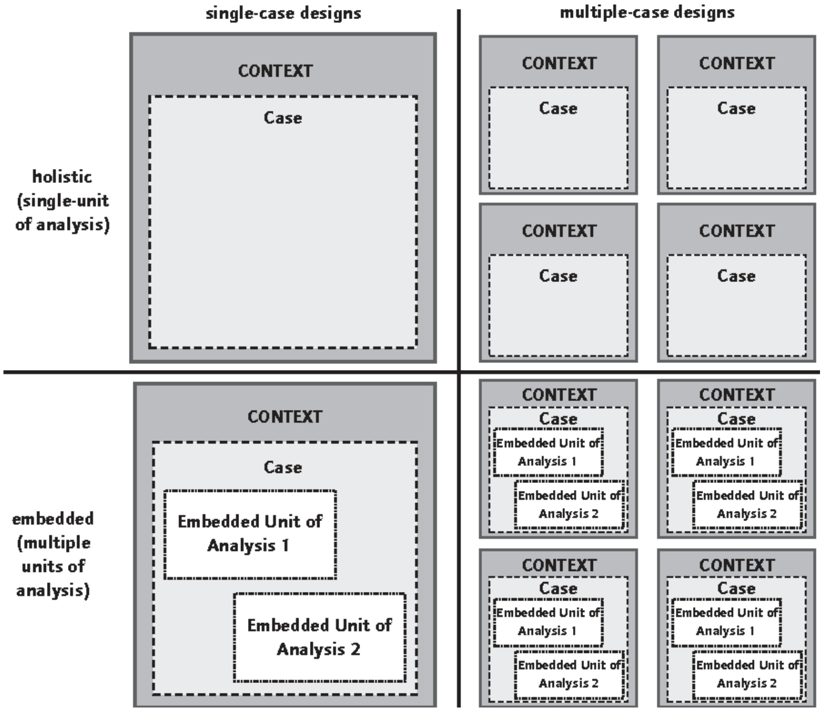


Figure 7: Types of Design for Case Studies (Yin, 2009: 46)

For the current research, the method is a single case study as there is a sponsor and the work will be developed within the company. The decision is on the rational of being an opportunity to study a specific event (Industry 4.0) with a strong component on innovation and entrepreneurship. This is an important factor for the development of this thesis in a very important sector of the global and German industry.

3.2.4 Data collection method

To gather the necessary information to answer the research questions initially formulated it is essential to collect the maximum data available. For this purpose, there are two kinds of data:

- *secondary*, when the use of data for the research problem was originally collected from some other purpose (Saunders *et al.,* 2007);
- *primary,* data collected specifically for the current research (Bell & Bryman, 2015).

For this study, was collected both of the data kinds:

Secondary data was collected from other projects developed in the past and through various tangible sources accessible by the company, such as: "Group Connext" (internal social network), Microsoft SharePoint, Microsoft Teams and network databases (organisations' database). In these sources, where everyone in the department can use it the data for future purposes, is available all the information used, collected and shared by different persons in past projects. The use of this type of data is advantageous because the quality and speed of collection are usually quite high (Saunders *et al.*, 2007).

Primary data was collected through:

- *observation* (mainly used) as already explained above on "Ontology", the authors position is to describe/explain as an insider, i.e., a participant as an observer in terms of observing meetings of the Group management (Bell & Bryman, 2015; Van de Ven, 2007);
- *interviews,* where Yin (2009) argues that is one of the most advantageous techniques for collecting data. Depending on occasion and aim there are several ways of structuring an interview, such as:
    i. *Structured* interviews, where an interrogator physically meets the respondent, reads to them the same set of questions in a predetermined order and records the response, i.e., predetermined and standardized questionnaires (Saunders *et al.*, 2007);
    ii. *Semi-Structured* interviews offer a balance between the focus of a structured questionnaire and the flexibility of an in-depth interview (Bell & Bryman, 2015). The interviewer begins with a set of topics but is prepared to vary the order of the questions that are asked depending on the context of the research condition (Saunders *et al.*, 2007);
    iii. *Unstructured* or *in-depth* interviews are informal, flexible and non-standardized (Saunders *et al.*, 2007);

For Saunders *et al.*, (2007) and Yin (2009) the first type of interview is interconnected to descriptive study, i.e., identify means of reaching generalised paths or a way to obtain statistical data. According to the same authors, semi-structured and unstructured interviews are particularly useful to comprehend the "why" and "how" of the events, where most issues can be open to perceive the nature of events (Saunders *et al.*, 2017; Yin, 2009). The next Table 2 illustrates the different types of interviews interrelated with the perspective of each research category.

Table 2: Types of interviews in the perspective of each research category (Saunders *et al.*, 2007)

	Exploratory	*Descriptive*	*Explanatory*
Structured		* *	*
Semi-structured	*		* *
Unstructure	* *		

** = more frequent, * = less frequent

Thus, for the accomplishment of the present dissertation, are mostly used in-dept (unstructured) interviews and semi-structured method.

- *Focus Groups* is another method used and is described as a group interview that focuses on a specific topic, process, service or product. Covers the need for group interaction encouraging to explore and clarify individual and shared perspectives (Bell & Bryman, 2015).

  To understand stakeholders' opinions about the solutions and definitions of next steps, these research methods techniques (Conference Call Interviews and Focus groups) were used (Table 3).

Table 3: Information about focus groups and interviews during each step (own representation)

Steps		Stakeholder	Date	Time
1	Definition of objectives and needs *(Focus Group)*	1 employee	26th September 2018	90 minutes
2	Creation of an overview framework, structure, and next tasks *(Focus Group)*	2 employees 1 director	2nd October 2018	100 minutes
3	Feedback from strategic area leader of ISTS	1 strategic area leader	16th October 2018	30 minutes
4	Feedback from strategic area leader of G&G	1 strategic area leader	19th October 2018	30 minutes

5	Presentation and discussion of possibles interfaces *(Focus Group)*	2 employees 1 director	1st November	45 minutes
6	Feedback from the team and further steps *(Focus Group)*	2 employees	12th November	45 minutes
7	Feedback from ASCM S&I director and definition of further steps *(Focus Group)*	2 employees 1 director	23rd November 2018	30 minutes
8	Presentation and feedback from Integrated Storage & Transportation System (ISTS) strategic area leader and definition of adjustments *(Focus Group)*	2 employees 1 strategic area leader	8th January 2019	45 minutes
9	Presentation and feedback from Automated Replenishment strategic area leader and definition of adjustments *(Focus Group)*	1 employee 1 strategic area leader	11th January 2019	45 minutes
10	Presentation and feedback from Advanced Robotics strategic area leader and definition of adjustments *(Conference Call Interview)*	1 employee 1 strategic area leader	14th January 2019	45 minutes
11	Presentation and feedback Geolocation and Geofencing strategic area leader and definition of adjustments *(Conference Call Interview)*	1 employee 1 strategic area leader	9th January 2019	45 minutes

12	Presentation and get feedback Human-Machine Interaction strategic area leader and definition of adjustments *(Conference Call Interview)*	1 employee 1 strategic area leader	15th January	45 minutes

Altogether, all primary data will be from different research techniques described below (Table 4):

Table 4: Techniques used in the research (own representation)

Presential meetings
Face to Face interviews
Conference Call interviews
Online interviews
Group Intranet
Focus Groups
Emails

According to Table 2, this type of data collection instrument is more adjusted to exploratory investigations where the final results are qualitative (Saunders *et al.*, 2009; Yin, 2009).

4 Case Study

This chapter presents the case study. Firstly, briefly describes the company's current situation; then, is addressed the subject on demand and, finally, for the same product, the entire value creation process will be analysed, constructed and explained.

During this creation process, the following techniques of data collection will be used: observation, documentation surveying, unstructured interviews and focus groups. They will enable both data and information collection about the "Knowledge diffusion at a major central European automotive supplier" that is the motto of this report. In short, this project consists of adopting "Industry 4.0" in one automotive company. Hence, this work will try to address the following main question:

"How to bring the I4.0 technologies into the factories?"

4.1 Company Description

The empirical work will be conducted within the Group, one of the biggest German suppliers companies in the automotive industry, at the department of Automotive Supply Chain Management, Strategy & Innovation – Industry 4.0 (*ASCM S&I – I4.0*). The main purpose of this department is to implement and adopt the changes coming from Industry 4.0 in employees everyday's work life. It provides a bridge between the I4.0 new technologies and the factories around the world, mostly in Europe.

Topics as digitalisation, connectivity, AI , globalisation and individualisation are influencing this department and it is expected to become one of the most business-critical themes of the future. As the topic of Industry 4.0 is very recent, it has several challenges and questions, which is why it attracts a lot of consideration and investment from the company, being a subject with several unknown topics worth of research and awaiting for more development.

As this company is a large size multinational, employing 250 000 of people, it needs to have a structure and strategy very well designed. To understand the importance of this diffusion and transmission of valuable knowledge, this structure will be explained downwards to ease the comprehension of the motivations beyond this work.

The Group is divided into two big different units: Tires and Automotive. Each unit is totally independent, following different policies, processes, plant designs, and having distinct suppliers, employees and stakeholders. Focusing on the part where the author of this study was immersed and will develop this study, the automotive group, it is subdivided into two production divisions:

- *Chassis and Safety* – active and passive safety technologies and products that support vehicle dynamics providing more safety and comfort. Includes products such as software functions, brakes, dynamics & comfort, advanced driver assistance systems, integrated safety, suspension & anti-vibration, vehicle access and washer systems.
- *Interior* – it develops intelligent solutions and services to connect, control and operate vehicles with drivers and passengers. Includes products such as interior cameras, surface materials, connectivity & telematics, software mobile solutions & services, haptic controls, display systems, comfort & security, control units and innovative infotainment systems.

Around 155 plants globally, employing in both divisions more than 95 000 people, generating in 2018 sales of approximately 19 billion Euros are assisted, in terms of innovation and strategy, by the central European function of *ASCM S&I – I4.0* department. Altogether, as the automotive unit is very big and important, the group intends to grow and follow technological trends and environmental changes as Industry 4.0 requires. For this initiative, it was constructed two model factories (Regensburg and Zvolen), with the purpose to test the new and innovative I4.0 technologies, in order to create structured and sustained solutions and/or opinions for the company' factories.

Hence, the *ASCM S&I – I4.0* department is asked to identify their following needs and challenges in terms of performance and adoption of this new strategic paradigm "Industry 4.0" with the help of several Strategic Areas.

Strategic areas have the purpose to drive the work within the "Industrie 4.0 Automotive" strategy. These areas carry forward the vision of Industry 4.0 with close collaboration between them and the ambition to create a smart work environment. Each Strategic area focuses on research and development of specific products, processes or services to obtain automatization and process performance improvement. For instance, possibilities of these technologies are

Automated Guided Vehicles (AGV) and collaborative robots (Cobots), smart glasses, drones and augmented reality.

Furthermore, the department of *ASCM S&I* is the intermediary between the supplier of the information (Strategic Areas) and the future users of the product (factories), being the one responsible for all I4.0 strategy, internal communication and alignment necessary to reach value and acquire an innovation chain.

4.2 Process of product creation

As a six month intern in the department of *ASCM S&I*, the author of this study carried out a project to create a digital overview about supply chain management (SCM) and Industry 4.0 related technologies, allowing the factories' managers to find the appropriate technology for a certain use case. The elaboration of this project became a need of all strategic area groups regarding how to diffuse the obtained, tested and valid knowledge developed in the model factories to all interested factories around the world.

1st Phase – Preliminary tasks and Framework

For the creation of this project, the team was composed by three people – one intern and two *ASCM S&I* specialists. Initially, it was made a presential meeting (*Focus group meeting 2*), composed by the team and the head of Industry 4.0, with the purpose to create a framework, discuss and determine important matters for the product creation. Hence, it was established in the following main points:

1. <u>Stakeholders</u> *"To whom this information is important?"*

For the elaboration of this product, it was established two *actors*:

- Editors/sources of relevant information: it was defined as the most appropriate groups which carry and develop I4.0 knowledge:

  - Strategic area groups.

  - *ASCM S&I – I4.0* department.

- Users: groups of people for whom this "product" will be useful and used.

  - Managers and Project managers of the factories.

2. Purpose *"What is the goal of this project?"*

The purpose of this technology overview, regarding Industry 4.0 related technologies, is to:

- Deliver to the factories an overview of technology results in a simple and easy to read manner.
- Facilitate rollout and enable self-management of the factories to choose which technology they are looking in order to solve factories' needs, improving their processes employing Industry 4.0 designs and principles.

3. Content "*Which knowledge is important to share to the users?*"

Important topics which are fundamental for the reader to understand each type of used technologies were defined. The most important subjects in this field are:

- General information: specification and explanation of the technology.
- Suppliers: those that were used as a test in the model factories. Each strategic area gained some experience with suppliers and the opinion created generating "*Recommended*" and "*Not Recommended*" results. These earnings will be presented in this overview.
- Use Cases: each technology' experience was tested in a determined factory and specific environment. This information is essential to justify the circumstances of suppliers' opinion.
- Technology Requirements: as a criteria/rating to further analysis. To comprehend in detail how the technology from a supplier matches with the company requirements. These requirements are established by each strategic area to define their objectives and keep the focus on them.

4. Structure *"How to display this information?"*

Some regulations and specifications were defined regarding the outlook of this overview as well as editors' requirements and users' requirements:

- *Editors*: standardized structure for all technologies, easily manageable to edit and update, in the English language.

- *Users*: easy to understand, which implies a tree structure per levels layout, from broad to specific information, the possibility to filter information according to buzzwords (#) and contacts for further information.

Hence, these are important aspects to consider in search for the most suitable interface to manage and pursue the content decided above.

Summing up, the information provided by these four topics must be shared, since all the developed work from the strategic areas will be necessary to bring these I4.0 technologies into the factories in the future. Otherwise, all the research and investment made will become worthless without this transmission of knowledge that instigates the company development.

Next steps:

After this first statement referred above, it was demanded to find the most suitable interface to display all the information defined and start to construct an appropriate layout. It was determined that must be:

- self-explanatory;
- clear;
- easily managed and readable;
- standardized structure;
- easy to find the content using filter information and buzzwords (#).

It was also important to interview two strategic area leaders, stakeholders, to get the opinion about the created framework and understand, in their point of view, if there are any other important requirements which this product must have.

2nd Phase – Interface and layout creation

Regarding this product, for the next meetings, choose the strategic area leaders was a clear decision due to two reasons:

1. According to the technology readiness levels model, both leaders are the most suitable ones. They were in more advanced stages - regarding the technologies chosen, investigated and team results – so they can help the approach to the final decision;
2. The two *ASCM S&I* managers integrated into this team are specialists in the strategic area of *Integrated Storage & Transportation Systems* (*ISTS*). Thus, they have a close opinion and knowledge concerning this area.

For these reasons, the strategic area leaders chosen to phone call interviews (*unstructured interview 3 and 4*) are from *Integrated Storage & Transportation Systems (ISTS)* and *Geolocation & Geofencing (G&G),* where both of the team leaders had positive feedback regarding the content of the framework:

- ISTS leader:

“The requirements are very well oriented and clear. I just need to add the importance in the content to include the IT interface of each technology”

- G&G leader:

“I really like the idea and it will be like a technology’ catalogue to us. Everything is correct in terms of content and I would just add some information regarding the actual status of each technology and some media or website links for further interest”

Therefore, were found three very important informations regarding the structure and the content of the technology overview named as *“catalogue”*:

- IT interface of each technology.
- Actual status of each technology (for instance from demonstration phase until proof of concept phase).
- Available media and/or website links from each technology.

Interface

The next main stage in the creation process was the decision. At first, regarding the interface used and, in second the choosing of the best layout that fits all requirements already mentioned. With this objective in mind, it was searched and analysed the possibility to integrate this product in all present company interfaces, for instance, SharePoint and Connext (collaborative network).

It was chosen the interface of Microsoft OneNote as being one of the interfaces most used by the employees as a tool of work and fits in all the requirements, especially structure and the search function. Thus, it is possible to have all strategic areas divided by sections and, inside of each section, to have several pages divided by technology. This way, it is possible to display in one view all the possible strategic areas and its corresponded technologies. This tool is cost-effective, what is another reason for choosing it, once it is already a company asset and it will not be necessary to purchase new tools as this will lead to high licensing, training and maintenance costs.

Layout

The layout was created based on all the requirements mentioned in the framework and interviews already described. It is divided into four sections, starting for the reader's perspective, from more generic information to a more specific. Thus, it was created a template where the information can be added following the same form (*Appendix 1*). The four sections are:

1. **Generic information**: including corresponding strategic area, contacts, search words (#) and date of the last update.
2. **Technology description**: a description of IT interfaces.
3. **Suppliers**: naming the supplier, divided by two subsections:
    - a summary with the status, experience and its result (Recommended or Not recommended);
    - identification of the use cases with the factory’s location, the use case on which the technology was tested and the available media of each supplier.
4. **Detailed analysis**: criteria of matches/mismatches with supplier according to established requirements by each strategic area.

Altogether, the layout was discussed in a group meeting (*meeting 5 and 6*), composed by four people, to understand the feedback from all participants and the opinion by the leader from the *ASCM S&I* department. Furthermore, the feedback remained positive with the identification of an important topic which should be added, there is the identification of the market coverage by each supplier. For instance, one start-up can only supply in Europe and one multinational company can coverage all factories around the world.

<u>Next steps:</u>

As the official template (*Appendix 1*) was discussed and approved by the leader and all team members, the presentation of the product *"catalogue"* to its editors (Strategic area leaders) must be prepared and fill in with its content, are the identified steps to follow, as it can be noticed in the next phase.

3rd Phase – Presentation to editors and fill in with information

After get through all the steps mentioned, it was made a presentation to several strategic area's leaders. Thus, these leaders were chosen regarding the actual status of progress in terms of technology results, as follows:

- *Integrated Storage & Transportation Systems;*
- *Geolocation & Geofencing;*
- *Advanced Robotics (CoBot & AGV);*
- *Future Work (Human-Machine Interaction / Mobile & Wearable devices);*
- *Automated Replenishment.*

The purpose of this presentation was to explain the product and its objective, as well as detailing the future tasks to each leader, preparing them as the editors of the content and the ones who will be in charge for the management of the displayed information. To better comprehension two entries were defined in the Table 5:

Table 5: Strategic area leaders' entries (own representation)

"What do I do as a Strategic Area Leader?"	
First entry:	"I have found a technology that I am going to investigate further"
Second entry:	"I have a recommended product/supplier to the technology"

Each conference meeting (*Meetings 8-12*) collected positive feedback from all stakeholders, adding in a particular adjustment regarding each technology' requirements (4th section). For instance, the type of requirements can be described as a story with a match as a "Yes" and a mismatch as a "No" or it can be a rating criteria with defined scale. Henceforward, all the small modifications and adaptations are responsibility of each strategic area, as the editors and owners of this knowledge in the future, always maintaining the structure and layout defined.

Concluding, the final product *"Technology overview"* or *"catalogue"* was finished and it is an important piece of the implementation's process of the initiative "Industry 4.0". Otherwise, without this product, all the invested work of each strategic area to find the most suitable technologies and its suppliers will become trivial. Therefore, it will become a valuable product when this information is delivered to the factories and applied in order to improve the overall process with this kind of technology. This process will be analysed ahead.

4.3 Process of value creation of the product – Value framework

"Why this product is important?"/ "Which value would this product bring to the company?"

The product developed arises due to the implementation of principals and mindset of the fourth industrial revolution. Furthermore, the company organised itself creating a new organisational culture, business model and strategy in order to follow innovation and competitiveness (*vide section* 2.2).

In order to adapt and react positively to this new environment as Industry 4.0 demands, it was created a process of value creation, regarding the product created above *(vide section* 4.2*)*, starting as an invention with the aim of accomplishing an innovation.

As it was approached in the literature review, the process of creating value in a product, service or process begins in the phase of cooperation between the supplier of the information and customer. This important information will be used in a request or a need of this certain group, the customers (*vide section* 2.2.4). During the operation, there are several processes to be developed, as the picture below illustrates:

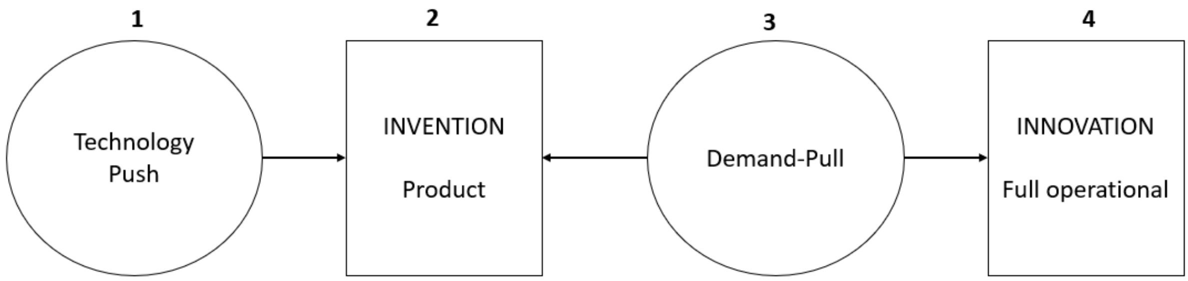


Figure 8: Process of value creation (own representation)

As the Figure 8 demonstrates, and following the *technology push – demand pull model*, the product named as invention is at the intersection point between two different forces – *technology push* and *demand pull* – which in cooperation and aligned among them originates the creation of the product – *"technology overview"* or *"catalogue"*.

Stage 1 – Technology Push

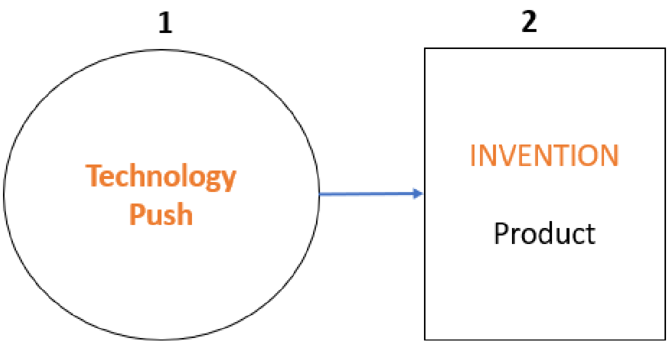


Figure 9: Technology push forces (own representation)

The technological impulse created by Industry 4.0 phenomena has stimulated in the company constant searching for the new knowledge through Research and Development (R&D) and external partners of new technologies, products and processes – *technology push* (*vide section* 2.2.4) (Figure 9). To maintain competitiveness in the German market, the company had to react and fit into this new business environment, depending on its absorptive capacity and learning process. Furthermore, following the different processes of organisational learning (*vide section* 2.2.5), it has been analysed by the strategic areas through *exploratory learning* (*vide section* 2.2.3), new potential technologies and valuable knowledge from external partners. To recognize the value of each new external information and develop a dynamic capability inside the company, this knowledge is tested in the model factories (*vide section* 2.2.3). The Strategic areas are the owners and in charge of this continuous development, as the owners, of new knowledge in searching through innovative learning processes (*vide section* 2.2.5).

Stage 3 – Demand Pull

Skipping the second stage, which will be described later on, this stage is essential to originate an invention. This is an important step since the invention will be transformed into an innovation. Here there are two contradictory forces and consequently two diverse alignments (*vide section* 2.2.4), which in the future complement each other being both essential in the process of value generation (Figure 10):

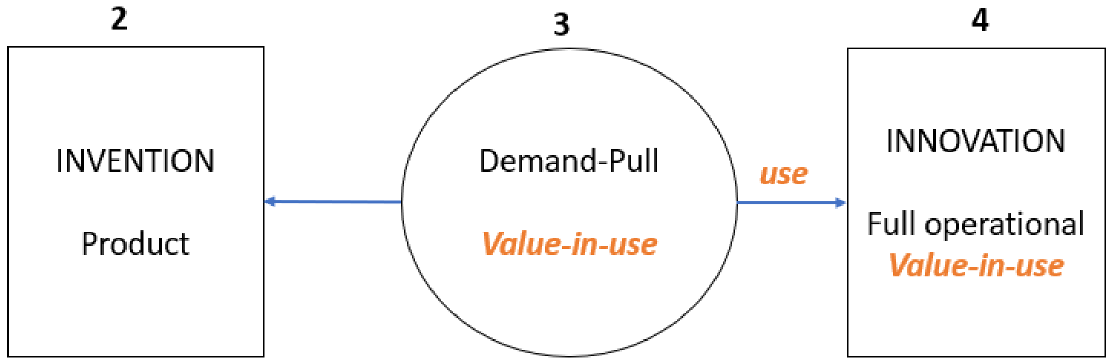


Figure 10: Demand pull forces (own representation)

Towards *<u>Invention</u>* *creation* ***(Stage 2)***

Hence, the technology appeared and was pushed into the market, stimulating demand and forecasting a certain need for the department of *ASCM S&I.* This need was defined as the diffusion of Industry 4.0 knowledge and technologies through all plants. Stating one of the team members of the department:

"How can we communicate these technologies through the plants?"

To answer this question, it was established in the first team meeting *(Focus group – Meeting 1*), that in the future, without the exploitation (*vide section* 2.2.3), the application of I4.0 technologies and potential valuable knowledge through the plants, all investment in R&D and work developed from the strategic areas will be a waste of resources by the company.

As the department forecasted, and to tackling the challenge of change management, was identified a need of communication and transparency between all company. The cooperation between these two models is fundamental to create value, acquire competitive advantages between the two actors and react, reconfigure and adapt quickly the constant changes and demands.

*Towards <u>Innovation</u> creation **(Stage 4)***

From this moment forward, there are no real results but an intention based on predictions and expectations. The reason is principally because there are temporarily more advanced strategic areas than others in terms of R&D and its readiness (*vide section* 2.2.6). Thus, neither all knowledge can be filled in the product nor can be exploited to the actual users of the product (factories).

Here, the transformation of knowledge takes place and the value begins to increase in order to satisfy the identified needs. In order to maintain quality and reliable information, the catalogue will have to be reviewed gradually over time for each strategic area, with the maintenance of knowledge (*vide section* 2.2.2). Another objective identified by the *ASCM S&I* department, with the exploitation of the invented product, communication and internal transparency will be improved following the ideologies of the Industry 4.0. Thus, with the transmission and internal access from all interested employees, temporarily there are steps that will be eliminated, reducing waste and adding value to managerial processes. As the director explained in one group meetings (*Focus Group – meeting 6*) saying:

"This catalogue will eliminate waste, time and resources in our department. In the future, instead of starting to contacting us to ask about technologies and how we can help them to improve the industrial processes, factories will have this product with all the needed information for them to choose which are the best suitable for their needs."

If this forecast is correct, the implementation of this product will have a big impact on the *ASCM S&I* department, reducing the response time and spent resources. This department, just in Europe, was becoming more flexible since there are approximately sixty plants and the department do not have capacity to answer all factories' needs at the same time. Hence, as already mentioned, the department in this process is the intermediary between the supplier of the information (Strategic Areas) and the future users of the product (factories), being the one responsible for all Industry 4.0 strategy, internal communication and alignment necessary to reach value and acquire an innovation chain.

Stage 2 – Invention

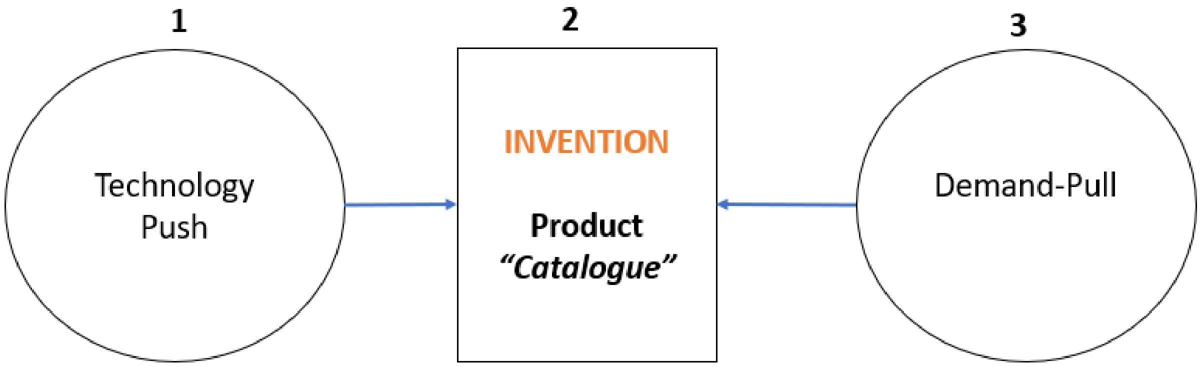


Figure 11: Process of invention creation (own representation)

In this stage, the product described above has been created due to the alignment between the supplier of the potential knowledge and the need of the department to diffuse it, in order to get profit and advantages to the entire company. This invention is an important step in this process, related to organisational change, since can lead the company to future. Thus, the organisational learning depends on the strategy used by the IT and its alignment, to turn this invention into an innovative product (*vide section* 2.2.5) (Figure 11).

From the *technology push* and all work developed in the model factories, there has been an organisational learning alignment to create the product, having a connection and cooperation between both departments – Strategic areas and ASCM S&I (*vide section* 2.2.4). This process decreases the organisational gap between the product and the supplier of valuable information. The product is part of transformative learning in order to maintain the knowledge allowing their assimilation and retention (*vide section* 2.2.2).

This process will create externalization of knowledge, obtaining explicit knowledge (*vide section* 2.2.3) as a final result. In the case studied, the output of this process is the catalogue with its specifications in a systematic and standardized form where the purpose is to exploit available know-how to all interested members of the company. Therefore, this innovative product has both the aim to improve organisational communication and employees' connection, establishing good information flow and trust, being an important aspect used to meet the demand and users need.

This stage is the main purpose of this case study. Nowadays the product is yet recognized as an invention, principally because there are temporarily more advanced strategic areas than others in terms of R&D, so not all information can be filled in the product (*vide section* 2.2.2). Consequently, it has not yet been exploited to the actual users of the product (factories). Therefore, it will be explained and analysed the remaining purposed process of value creation for this product.

Stage 4 - Innovation

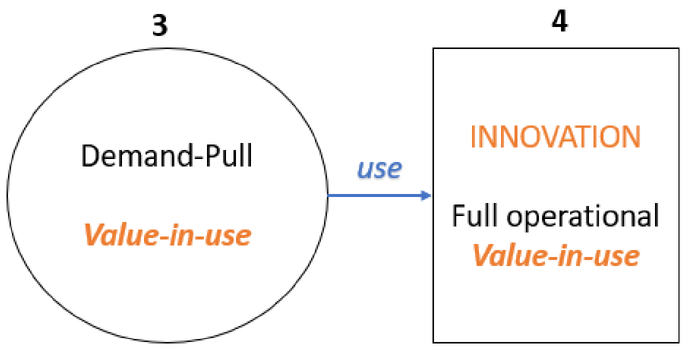


Figure 12: Process of innovation creation (own representation)

This stage is what the created invention intends to achieve. Turning the catalogue into an innovation happens when the users confirms the value of the product, perceiving the qualities and creating a useful value satisfying the need of each factory. Thus, this product is insofar an intention based on expectations and predictions.

Here occurs the exploitation of the product, occurring the application and diffusion through all interested factories and interested stakeholders. To follow innovation and to improve the processes will be achieved *value-in-use*, i.e. factories' managers will have access to this product and start to use it (*vide section* 2.2.4). At this moment, the value of the product increases making the alignment of the most important process, since it is in this moment when happens the real interaction. In other words, the alignment between the invention already created and users' need, creating an innovative product for the company (*vide section* 2.2.4) (Figure 12).

Each strategic area shares an explicit knowledge (*vide section* 2.2.3), which when in contact with the plant managers acquires value and when this knowledge is applied temporarily, it will improve flexibility, agility, productivity, efficiency, collaborative working, knowledge sharing, transparency, reducing errors, costs and consequently, the wasted time (*vide section* 2.2.1).

Summary:

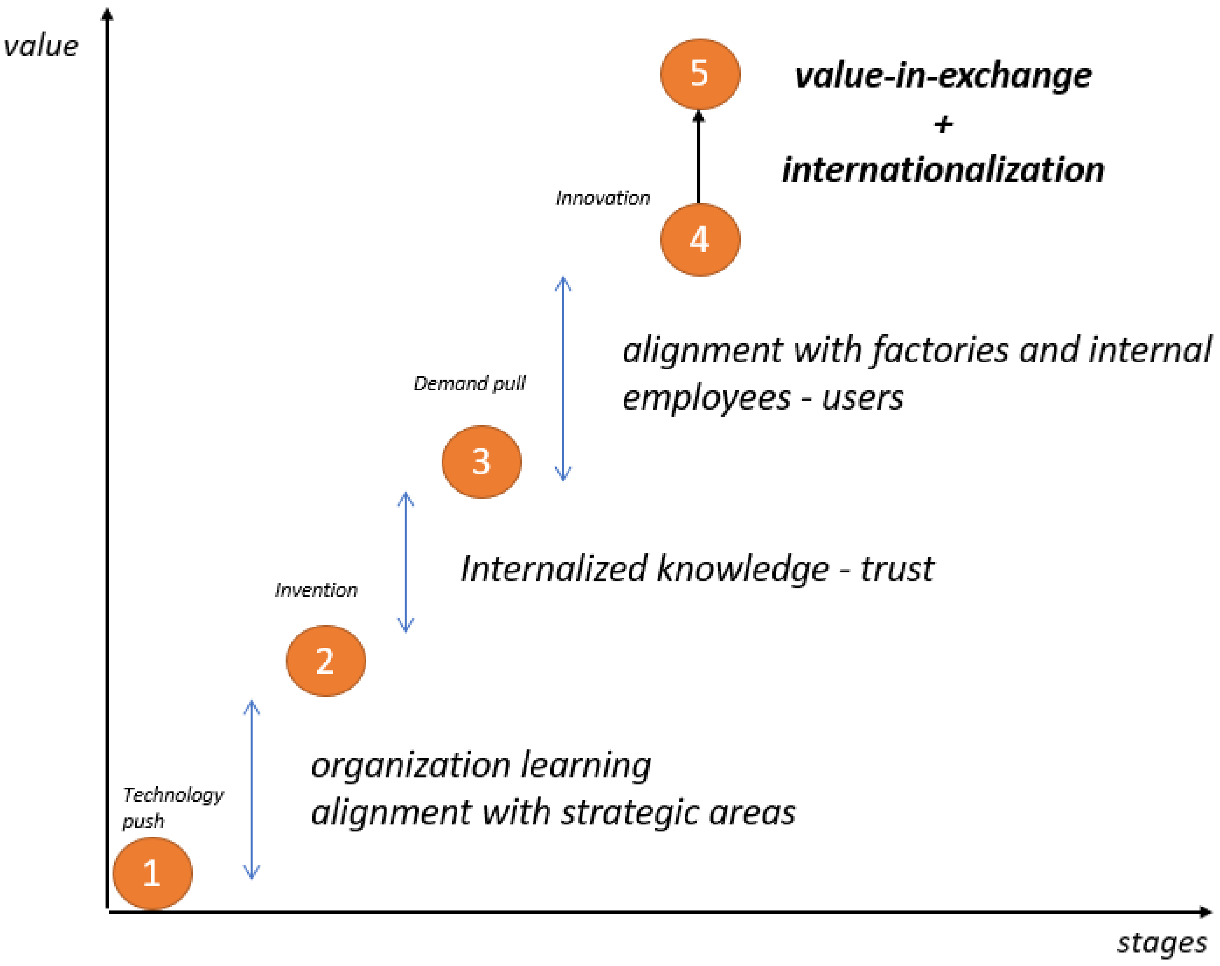


Figure 13: Process of catalogue' value creation (own representation)

In summary, Figure 13 illustrates all the stages described with the respective value increase and specifications the actions between stages.

An important aspect to refer and remark in the analysis of this Figure 13 is the importance of the alignment process to increase the value. It is core to the value creation, in this case study, the focus on the topics as organisational learning since the company needs to adapt and learn continuously new processes to follow innovation. The alignment between the invention, with the knowledge's supplied from the strategic areas, and the needs from the users to acquire useful value (*vide section* 2.2.5). Thus, as the Figure 13 demonstrates, the value improves gradually in order to turn the invention into innovation and as a powerful resource to the company.

Furthermore, from the stage one into the stage two, there is an alignment with the strategic areas to answer the needs of the market and the technological push. Since the company has to learn and adapt the business models, culture and values to face the environmental changes as Industry 4.0 requires it was created the product and it is described as an invention.

From the second stage towards the third one, all the knowledge is internalized with the interested employees and plant managers. Communication and consequently transparency has an important role in this process where the trust from the users according to the information available is seen.

From stage three until stage four is when the application of the diffused knowledge happens. Plant managers or project managers in order to improve processes in the factories, use the information of the product created to choose the most suitable solution for a specific use case at one factory. The product is then transformed into an innovation.

After the application of the new technologies, gradually, the company will perceive real positive results regarding quality in the products, flexibility, efficiency and productivity. It is at this level that originates the fifth stage, when occurs a monetary value, i.e. *value-in-exchange*. The company will acquire economic results, reducing costs and higher the revenues in the production processes. As well, the externalization in the plants around the globe will happen if, after implementation, the results in Europe are as positives as planned.

At this point, the Group will acquire the higher value which this product can bring accomplishing the main purpose of the "catalogue".

5 Analysis and Discussion

Currently, technology and innovation are important sources of competitive advantage and value creation for organisations. Innovation is referred as the process of transforming ideas and knowledge into new processes or products and services. More than just the initial idea involves a set of steps that need to be well managed. These steps are obtained from a process to perform various activities with the specific purpose of generating a particular solution supported by technology. However, the innovation processes do not end with new products development or old products enhancement. The real competitive advantage lies in making this idea accepted in the marketplace. With this purpose, the new developed idea should be effectively disseminated through the stakeholders.

This knowledge diffusion process is accomplished over the time through selected channels used to communicate an innovation within the Group. It is a special kind of communication in which the message purpose is related to gather new ideas, technologies, more company knowledge and potential benefits in order to share and understand the concepts about innovation.

In the case under study, although there is no implementation of the tool for real customers technologically broadcast their knowledge and communicate within the company, there is a creation process carried out in the described work environment. To understand the process of social change due to the impact of technological advances, such as Industry 4.0 and automation, it is important to lean over the process of technological diffusion of knowledge. Without the correct understanding of the diffusion mechanisms, the process of technological innovation will have little social and economic impact within the organisation because it does not reach its purpose and the knowledge will not be available where it is needed.

Analysing the process described, mainly by observation methods, focus groups and following the value creation model, in a network between different entities (*vide section* 2.2.3), the product created, i.e. the “catalogue”, and consequently the information it contains, reaches a state of “invention”, i.e., technological innovations developed by the strategic areas (R&D). Therefore, the notions of technology push and market pull are identified as the occurrence of a new industrial revolution focused on the topics of digitization, connectivity and AI where it requires research and development activities (technology push). The factories need new technologies to reduce waste and errors in order to improve the quality and efficiency of their industrial processes (market pull).

The network between knowledge suppliers and interested parties needs to be aligned to enrich information exchange and create self-sustaining and valuable communication. Once this communication and interaction occurs, the value begins to be created, transforming an invention into an innovation. To encourage this communication, was developed the catalogue described previously. Analysing this creation process, it is possible to conclude that consumer opinions were not taken into account, requested or analysed throughout all this process to further develop a product based on the user's needs. At this point, users are unaware of this product creation and information contained within, so the market pull is defined by assumptions from a corporate department and not from actual data obtained by market analysis. Thus, it does not follow the model proposed by Mohring (*vide section* 2.2.3), increasing the risk of users do not understand the content value added what might limit the adoption of the technological innovations.

An eventual failure in the implementation need to be refrained because will lead to substantial company losses and a non-return investment regarding the high initial investment that could compromise the company growth. Clearly, the use of this design is limited to cases where the parameters are the same or very homogeneous. Thereby, this assumption will only hold in a very small amount of real cases. The reliance to make all decisions about this product without gather feedback from users can be explained by the huge experience of the persons selected for this project. All stakeholders understand the entire process within a factory and are very well aware of their. This demonstrates trust, very powerful talent pool, big focus on company training and organisational learning regarding the entire chain. Overall, on the one hand this decision can be very risky and in the future can cause some loss and waste, but on the other hand can demonstrate a good outcome and manifest strength and trust in entire company, namely, a powerful and valuable intellectual property and knowledge management.

Additionally, Rogers (2010) identified important key characteristics of different "adopter categories – adoption curve" which divides and classify consumers into segments, within a social system, based on their willingness to try out a new innovation or product. The model, is part of the Diffusion of Innovations Theory from the same author (Rogers, 2010), that seeks to explain how new technological tools and innovative practices spread throughout societies and cultures. This model gives an important addition to this study once it would be possible to analyse adopters, which are the factory final users, and predict its characteristics in order to be more conscious of the user’s needs and their future actions. Altogether, it might be a good method to analyse the users behaviour and conduct. Consequently, this method lets to anticipate and respond to any unforeseen events by reducing the risk of non-adoption.

For future handling of historical data collected about this method, all the results and analysis should be documented. Based in this readiness model, to try new products, and adapting to this study on research, the type of consumers are individuals with some degree of knowledge and influence regarding the automotive industry and the company itself, which mostly will be the factory managers. Hence, analysing his behaviour and job demand, they are high educated, leaders and more connected with their communities which, in this case, are the factories. Briefly, according to all these characteristics, the stage where the users are incorporated is the “Early Adopters”. Furthermore, future research should analyse and lean over the consumers profile and behaviour with more accuracy.

For instance, regarding the high-technology products in telecommunication industry, also developed in a big multinational company, Truong *et al.*, 2017 analyses in two studies, one in an experimental site and the other in a field site, the adopting strategy and the consumer perceived risk on a high-technology products and compare it with a prior work regarding the fast moving of consumer goods. One of the limitations, perceived by the authors, is the lack of a direct measure of the consumer innovativeness, based on leadership opinions. Therefore, this is recognized in this case as well and it would be important to perceive how the idea should be spread through the factories allowing to choose the most reliable option.

This review will shed some light about this matter and illustrate potential uses for technology applications. Future researchers may conceptualize, distinguish and comprehend the underlying technology models and theories that may affect the previous, current and future application of technology adoption.

Furthermore, Rogers (2010) in his book, *Diffusion of Innovation*, proposes that companies pay attention to the five key elements of an innovation diffusion process to determine their strategies and boost the company's innovation performance: innovation, adopters, communication channels, time and social system. As well, in this work he defined that diffusion occurs through a five-step decision making process or adoption process. The work under study did not focus this topic regarding the process of decision making and documenting.

Hence, to better comprehend the creation process of the communication channels, the five stages will be analysed below in this chapter:

- Knowledge

  This is the initial step of the first contact to an innovation but lacks the information about how it was obtained, when each strategic area (R&D) is investigated and searched for the most suitable technologies to be adopted in the future.

- Persuasion

  This step, as well, was actively studied from each R&D department (strategic areas) that was planned an attitude toward each innovation.

- Decision

  Here is one of the most important steps that each strategic area need to pass through. The company makes an important decision whether adopts or rejects the innovation on which acquires empirical evidence based on the tests and information previously collected. In this study, it is possible to realize that depends on the development grade of each strategic area to obtain this final result. To be possible to diffuse through the most interested parties, each area should decide where it will be implemented in the future, namely the factories.

- Implementation & Confirmation

  Both these stages ahead, it could not be perceived in the work developed under this study. It will occur when the target group employs the innovation.

To conclude, between these different stages, there are communication channels behaving as a development indicator regarding each technological innovation. Thoroughly, these communication points connect each step aligning them to make progress in diffusion process development. The catalogue links the elements of Decision and Implementation as a communication channel, as the persons in contact with the information are different. It is here, where this study focuses that the alignment between these stages occurs.

As there are no case studies regarding diffusion of innovation in Industry 4.0 this analysis were focused studies on similar fields. This is chosen because the IT is the common point between this thesis and the works are already published in this area of knowledge diffusion. Therefore, Cujliak (2006) analysed the diffusion of innovation theory in medical technologies which concluded that the technologies can be used to transmit the knowledge to interest stakeholders. The most challenging stages, where emerge more problems, as can be seen in this study (Cujliak, 2006) are the implementation of communication channels. According to this article, the adoption and acceptance of technologies confirms the predicted technological trends but it is important to not forget that the topic belongs to a different field of technology and have distinct consumers, comparing with the current thesis.

Subsequently, the "Invention" was created following the topics defined as essential for a technological diffusion towards a large network. As the case study requires, are:

A- Technology description:

Identification, description and required interfaces.

B- Suppliers:

Identification of tested suppliers and results obtained subsequently after testing at model factories.

Description of each case study, location, and more technological information for each supplier.

C- Detailed analysis:

Requirements description offered by each supplier that is available after R&D review.

According to the organisational learning model, in order to acquire new knowledge and the ability to use and seize external knowledge, it is recommended to follow the sequential process and the proposed model (*vide section 2.2.2*). The exploration phase is reached by the strategic areas (R&D) identifying and acquiring external knowledge. The transformative learning is the phase where this work ended and is where the study in question focuses on transforming acquired knowledge into shared, communicated, organised and easily understood information, i.e, value. It is the bridge between exploratory and exploitative learning, represented by the digital catalogue for the purpose of innovative technological diffusion.

6 Conclusion

This chapter will present the main conclusions to be drawn from this research, taking into account the Literature Review made, the analysis and discussion of the results found in the previous chapters. The answers to the Research Questions identified in Chapter 1 will be outlined and discussed, as well as the contributions of this investigation. Furthermore, the main limitations associated with this research, as well as some suggestions for future work related to the topic under study were put forward.

6.1 Addressing the Research Questions

The answers to the research questions initially proposed will be presented in this section, some inherent curiosities of the research and steps to help company to overcome their challenges and objectives set out in Section 1.3. The answer to these questions will continue to be focused on the automotive industry.

Research Question 1:

"What are the changes brought in to the company by the new industrial revolution "Industry 4.0"?"

In this case, given the literature review (*vide section* 2.1), it is concluded that I4.0 is an opportunity to explore and investigate new approaches to deal with major company challenges. It turns an old fashioned factory into a smart factory bringing changes in terms of connectivity and automation, which allows a more effective communication and collaboration between the departments. To keep competitive, the Group had to quickly adapt to this new organisational paradigm and encourage its adoption by all employees.

As the scope of the study is limited to the communication between strategic areas and factories, the information processing is one of the topics where this transformation had impact within the Group. Thus, with the implementation of I4.0 technologies, it is possible to enable all assets, departments and cloud to communicate and have an interactive flow of data at real time over the entire network, turning all the knowledge available into a valuable asset. The entire chain is connected with an high level of integration and coordination between the digital and physical components.

Communication was one of the major noticeable changes, improving the relationship between workers and the proximity among departments. Consequently, their productivity was relatively improved by sharing their knowledge and promoting mutual help. Other important point was its aid in the integration of new employees, simplifying the access to information and knowledge, with the purpose of fast learning and incorporation decreasing the loss of intellectual property when a person is dismissed by the Group. Also, reduced productivity losses due to ignorance because demystified human errors and infractions motivated by ignorance or lack of preparation providing an easy access to the most important information. It motivates compliance with laws, standards, rules and safety indications which improves quality, reduces losses and future additional expenses. Additionally, reduced bureaucracy, form usage, and the amount of printed and accumulated paper only by encouraging the use of digital information. Another contribution to overcome the new company challenges is facilitating the barriers for everyone adopt new technologies and allows marketing to make a strategic change in their campaign within the Group.

Using the knowledge base available throughout the Group is possible to reallocate resources to more important issues than less-priority such as: information storage, research and organisation tasks.

Actually, it is possible to store large amounts of data at the Cloud and make the processes more automated bringing many improvements mainly in the processes and, as well, in the company technology, performance, flexibility, optimization, agility and productivity.

<u>Research Question 2:</u>

"What were the biggest needs identified in terms of diffusion of knowledge in the company's current processes?"

To the changes that the Industry 4.0 paradigm brings to the company, the main identified needs are:

- to have a valuable diffusion of knowledge between departments with the strong use of technological communication tools; the tools should let the information is available to interested parts in order to improve their processes in factories. In short, how to align the information between strategic areas and factories. Thus, it is important to make available an organised and perceptible knowledge base regarding I4.0 technologies.

This knowledge was previously researched by the strategic areas in order to be read by the stakeholders at the factories and consequently to be applied in the future.

- by the department, ASCM S&I, was to eliminate internal resources by responding, in the future, to all factories with an interest in improving their internal processes. They predicted that in the future, when the information will arrive to the factories will exist new technologies that can improve processes and reduce their costs. Consequently, the number of stakeholders interested in this information will grow exponentially and the department will not have the resources available to meet the demand. Thus, a solution must be found to prevent this probable performance issues.

<u>Research Question 3:</u>

"What is the best approach to mitigate the challenges identified and develop proposals?"

Regarding the needs and challenges identified in the previous research question, the objective was to develop a communication channel that aligns the knowledge regarding I4.0 technologies between strategic areas and the ones interested within the factories around Europe. In short, the bridge between R&D and technologies application in the factories.

However, the best approach to follow was decided through focus groups of the team responsible for this project. This approach started with the identification of stakeholders, purpose, content, structure, interface and layout.

In this sector, with a big company in terms of dimension, the transfer of knowledge is an essential component which the company must have to generate value, keep improving their knowledge base, create innovative ideas and improve the processes. Thus, to this knowledge diffusion reach its objective was identified that the technology' catalogue must be attractive to draw the attention of the users and stakeholders, i.e. customer engagement. After all, it must be self-explanatory, transparent, easily managed and readable with a standardized and pleasant structure.

In this sector, the interface designed in Microsoft OneNote was the elected for including all the requirements mentioned. This choice was made for being one of the tools most used by the employees in entirely company and does not exist the need to acquire new tools which would demand additional budget and time resources for licensing, training and maintenance.

Research Question 4:

“What principles were considered important in the creation of value?”

The created project aims to spread the knowledge obtained and generated by the strategic areas (R&D) in the company under study. This transmitted knowledge has very innovative potential but, to be applied, has to reach the employees in factories. This is, information only begins to generate value, value-in-use, when it is used in factories.

According to the model of value creation (*vide section* 2.2.3), the essential principles for value generation are: alignment, value-in-use and value-in-exchange. Alignment is the most important concept because knowledge can create value for the company when is aligned among all stakeholders.

Despite all the investment from the beginning needed to acquire the catalogue’ technologies, time and resources from R&D to gather all the knowledge, at long term, the value-in-exchange created, by implementing these same technologies into the factories, is projected to be higher than any initial cost, producing the value expected. This value, according to the company under study, is:

- Improving the quality of the information, as there are fewer intermediaries on the way, consequently, reaches the final destination with higher quality. Therefore, obtains a reduction of dependency, so fewer resources and maintenance will be needed to maintain the quality of the shared information.

- Increasing employees’ productivity in the factory and in ASCM S&I department. Consequently, fewer department resources are in charge of replying to the sudden needs of the factories and can be allocated to more important matters, achieving one of the defined objectives.

- Improving logistic and production processes, with the application of more advanced technologies, to follow the principles of the new revolution “*Industry 4.0*”. This, subsequently can provoke factories to generate less waste, increasing their productivity and flexibility.

However, the alignment and value-in-exchange could not be perceived because the knowledge gathered, in a digital catalogue form, has not been yet diffused to the factories, which are the most interested company unit.

6.2 Contributions

The concept brought by this study, the treatment of knowledge to be useful within the organisation in I4.0, was not explored in literature yet. This is a very important analysis topic, because the decision to move on and try something as revolutionary as Industry 4.0 needs to come from company management. Despite an high initial investment in acquisition and R&D, the benefits advocated by this method will outweigh the value production for the company. Information has an essential role in the company growing as a whole because knowledge has to be shared quickly, in an accurate form, in order that all departments and sectors of a company have access and the power to apply it. Thus, the entire supply chain is interconnected through innovation and knowledge diffusion.

This concept is the reason why, with knowledge, we can manage the resources of the organisation in order to create value from them, leading to a sustainable competitive advantage. Therefore, knowledge and information are one of the most important assets of a company because they can increase its productivity.

It has been shown that the correct diffusion of knowledge can help to enhance the application of developed and investigated technologies focusing on the Industry 4.0 principles. The participation of R&D department in the study and selection of the most suitable technology suppliers, in order to improve production processes, can create a unique and very valuable knowledge for the whole company that can be used to increase profits.

The model used to prepare the company for Industry 4.0 is an important contribution to the practice, as it represents a relevant communication and management tool to evaluate the adoption of new technologies. Taking into account company’s organisational structure and technological infrastructure, enables to construct a personalized form to adopt this methodology and prepare to the future, as it is described in this document. Based on the developed model, the strategic areas into the factories establish and exchange knowledge for organisational change processes. This task can be done with an objective to adopt new typologies and technologies through different forms of sharing collaborative information supported by digital updates of technological platforms.

According to the study mentioned in research, the contribution made was mainly the creative part, tests, plan tasks between focus groups, organisation, construction and finally presentation of the final product created. In this study are also introduced many of the technologies that are in vogue today, which can provide and leverage the improvement of internal processes, exploiting the potential of computerized products and procedures.

6.3 Study Limitations

The main limitation of this work is related to the fact that it is not possible to obtain real results with the product use. Currently, the product has not been made available to the actual planned users and the results are based on expectations. Thus, despite the conclusions and discoveries in the literary, it is necessary to strengthen and complete the study in the company in order to assess the real results.

As this is a business project, only a case study was used which consists in an intrinsic limitation. According to Yin (2009), the use of multiple case studies allows a closer approximation of the global reality of the market. Thus, despite the findings and the conclusions obtained, it is necessary to strengthen the study in automobile industry, understanding its implication in other businesses. Focusing on academic work, multiple case studies could add more consistency to the results.

To finish, the big structure and size of the company and its distribution of departments around the world made difficult to observe the development of the organisation and the work in progress by the strategic areas.

6.4 Suggestions for future research

Through the realization of this research, some points of interest of a future study were discovered, not only in the specific automotive sector, but also in general, regarding the topic of the knowledge transmission in a big multinational company.

In the scope of an academic dissertation it will be interesting to expand this dissemination project to other sponsors, in order to obtain results that contribute with more value to scientific investigation.

6.5 Recommendations

Thus, each Strategic Area should study the role of Mediator as a potential administrator or responsible for information management and administration.

For this specific sector, although it was not valued during this study, is recommended some research on the importance of standards. There must be some kind of more independent and stable link between the members and the product to be supported by a more formal and automated technology platform.

Investigation of the application of AI or Data Mining mechanisms is an important investment to monetize the maximum profits from the data gathered by this tool.

Some research about adding intelligent suggestions to check the documentation should be done with the objective of suggest improvements to meet the standards and styles of documents helping users to create good documentation quickly.

To prevent early abandonment of the tool is recommended to do research about peak use and stabilization analysis.

In order to create a consumer engagement that allows users to form an attachment with the company it is recommended to research the application for a space to register user comments, questions, and concerns. Additionally, this space might allow users to feel like they have voice and are able to provide feedback in a positive and meaningful way. To the company can be a way of identifying errors and realizing what information or tools users need the most.

To widespread information can be developed a multimedia sharing system for non-confidential information to be used by all factory employees to foster the sharing of all workers in order to share knowledge (with tutorials and videos of their practical tasks).

Finally, it is recommended to study the formalization of this project so that it is possible to obtain real results and subsequent analysis within these results.

References

Argote, L., McEvily, B., & Reagans, R. (2003). Managing knowledge in organisations: An integrative framework and review of emerging themes. *Management Science*, *49*(4), 571-582.

Audretsch, D. B. (2018). Why is Germany so Strong in Manufacturing? *Manufacturing Policy Initiative*, (4), 1–5. Retrieved from https://manufacturingpolicy.indiana.edu/doc/insight/Insight March 2018.pdf

Baeva, L. (2012). Existential axiology. *Cultura*, *9*(1), 73-83.

Bahrin, M. A. K., Othman, M. F., Azli, N. N., & Talib, M. F. (2016). Industry 4.0: A review on industrial automation and robotic. *JurnalTeknologi*, *78*(6-13), 137-143.

Baltezarevic, V., & Baltezarevic, R. (2016). Knowledge sharing in virtual organisations. *Transfer*, 128.

Bauernhansl, T. (2014). Die vierteIndustrylle Revolution. *Der Weg in ein wertschaffendes Produktionsparadigma*, *4*, 3–35.

Beer, M., Voelpel, S. C., Leibold, M., & Tekie, E. B. (2005). Strategic management as organisational learning: Developing fit and alignment through a disciplined process. *Long Range Planning*, *38*(5), 445-465.

Bell, E. & Bryman, A. (2015). *Business research methods*. Oxford University Press.

Benner, M. J., & Tushman, M. L. (2003). Exploitation, exploration, and process management: The productivity dilemma revisited. The *Academy of Management Review*, *28*(2), 238-256.

Bergera, C., Heesa, A., Braunreuthera, S., &Reinharta, G. (2016). Characterization of cyber-physical sensor systems. *Manufacturing System*, *41*, 638–643.

Bowman, C., & Ambrosini, V. (2000). Value creation versus value capture: Towards a coherent definition of value in strategy. *British Journal of Management*, *11*(1), 1-15.

Brettel, M., Friederichsen, N., Keller, M., & Rosenberg, M. (2014). How virtualization, decentralization and network building change the manufacturing landscape: An industry 4.0 perspective. *International Journal of Mechanical, Industrial Science and Engineering*, *8*(1), 37-44.

Campos, A. D. (2006). Ciência, tecnologia e economia. *Economia da inovação tecnológica. São Paulo: Hucitec*.

Chen, Y. (2017). Integrated and intelligent manufacturing: Perspectives and enablers. *Engineering*, *3*(5), 588-595.

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly*, *35*(1), 128-152.

Colombo, A. W., Schleuter, D., & Kircher, M. (2015). An approach to qualify human resources supporting the migration of SMEs into an Industrie4.0-compliant company infrastructure. In

IECON 2015 - 41st Annual Conference of the IEEE Industrial Electronics Society (pp. 003761–003766). Yokohama: IEEE. https://doi.org/10.1109/IECON.2015.7392687

Culjak, G. (2006). Diffusion of innovation theory in medical technology applications. *International Business Information Management*, 405-411

de Abreu, P. H. C. (2018). Perspectivas para a gestão do conhecimento no contexto da indústria 4.0. *South American Development Society Journal*, *4*(10), 126-145.

Deloitte (2014). Industry 4.0 - Challenges and solutions for the digital transformation and use of exponential technologies. [*http: //www.industrie2025.ch/fileadmin/user_upload/ch-en-delloite-ndustry-4-0-24102014.pdf*]. Accessed 16 October 2018

Dereli, D. D. (2015). Innovation management in global competition and competitive advantage. *Procedia-Social and Behavioral Sciences*, *195*, 1365-1370.

Drath, R., &Horch, A. (2014). Industrie 4.0: Hit or hype? [Industry Forum]. I*EEE Industrial Electronics Magazine*, *8*(2), 56-58.

Fang, S. R., Fang, S. C., Chou, C. H., Yang, S. M., & Tsai, F. S. (2011). Relationship learning and innovation: The role of relationship-specific memory. *Industrial Marketing Management*, *40*(5), 743-753.

Ferreras-Méndez, J. L., Fernández-Mesa, A., & Alegre, J. (2016). The relationship between knowledge search strategies and absorptive capacity: A deeper look. *Technovation*, *54*, 48-61.

Fisher, C., & Buglear, J. (2010). *Researching and writing a dissertation: An essential guide for business students*. Pearson Education.

Flor, M. L., Cooper, S. Y., & Oltra, M. J. (2018). External knowledge search, absorptive capacity and radical innovation in high-technology firms. *European Management Journal*, *36*(2), 183-194.

Garud, R., & Nayyar, P. R. (1994). Transformative capacity: Continual structuring by intertemporal technology transfer. *Strategic Management Journal*, *15*(5), 365-385.

Gibson, C. B., & Birkinshaw, J. (2004). The antecedents, consequences, and mediating role of organisational ambidexterity. *Academy of Management Journal*, *47*(2), 209-226.

Grönroos, C., & Ravald, A. (2011). Service as business logic: Implications for value creation and marketing. *Journal of Service Management*, *22(1)*, *5*-22.

Hallstedt, S. I., & Pigosso, D. C. (2017). Sustainability integration in a technology readiness assessment framework. In *ICED17: 21st International Conference on Engineering Design* (pp. 229-238). Design Society.

Harrison, D., & Kjellberg, H. (2010). Segmenting a market in the making: Industrial market segmentation as construction. *Industrial Marketing Management*, *39*(5), 784-792.

Helfat, C. E., Finkelstein, S., Mitchell, W., Peteraf, M., Singh, H., Teece, D., & Winter, S. G. (2009). *Dynamic capabilities: Understanding strategic change in organisations*. John Wiley & Sons.

Hercko, J., Slamkova, E., & Hnat, J. (2015). Industry 4.0 as a factor of productivity increase. In *Transcom 2015*, (pp. 1–5). https://doi.org/10.1007/s00426-005-0020-8

Hermann, M., Pentek, T., & Otto, B. (2015). Design Principles for Industrie 4.0 Scenarios: A Literature Review. *Technische Universitat Dortmund*. https://doi.org/10.1109/HICSS.2016.488

Hermann, M., Pentek, T., & Otto, B. (2016). Design Principles for Industrie 4.0 Scenarios. *2016 49th Hawaii International Conference on System Sciences (HICSS)*. doi: 10.1109/hicss.2016.488

Huang, H. L. (2014). Performance effects of aligning service innovation and the strategic use of information technology. *Service Business, 8*(2), 171-195.

Hung, R. Y. Y. (2006). Business process management as competitive advantage: A review and empirical study. *Total Quality Management & Business Excellence*, *17*(1), 21-40.

Hung, R. Y. Y., Yang, B., Lien, B. Y. H., McLean, G. N., & Kuo, Y. M. (2010). Dynamic capability: Impact of process alignment and organisational learning culture on performance. *Journal of World Business, 45*(3), 285-294.

Kagermann, H., Wahlster, W., & Helbig, J. (2013). Securing the future of German manufacturing industry: Recommendations for implementing the strategic initiative INDUSTRIE 4.0. *Final Report of the Industrie 4.0 Working Group*.

Kamble, S. S., Gunasekaran, A., &Gawankar, S. A. (2018). Sustainable Industry 4.0 framework: A systematic literature review identifying the current trends and future perspectives. *Process Safety and Environmental Protection*, *117*, 408-425.

Kiel, D., Müller, J. M., Arnold, C., & Voigt, K. I. (2017). Sustainable industrial value creation: Benefits and challenges of Industry 4.0. *International Journal of Innovation Management, 21(*08*)*, 1740015. doi: 10.1142/s1363919617400151

Kusiak, A. (2018). Smart manufacturing, *International Journal of Production Research, 56: 1-2,* 508-517.

Lane, P. J., Koka, B. R., & Pathak, S. (2006). The reification of absorptive capacity: A critical review and rejuvenation of the construct. *Academy of Management Review*, *31*(4), 833-863.

Lasi, H., Fettke, P., Kemper, H., Feld, T. & Hoffmann, M. (2014). Industry 4.0. *Business & Information Systems Engineering*, *6*(4), 239-242.

Lee, J., Kao, H. & Yang, S. (2014). Service innovation and smart analytics for Industry 4.0 and big data environment. *Procedia CIRP, 16,* 3-8.

Li, D., Tang, H., Wang, S., & Liu, C. (2017). A big data enabled load-balancing control for smart manufacturing of Industry 4.0. *Cluster Computing*, *20*(2), 1855-1864.

Li, Z., Shen, H., Li, H., Xia, G., Gamba, P. & Zhang, L. (2017). Multi-feature combined cloud and cloud shadow detection in GaoFen-1 wide field of view imagery. *Remote Sensing of Environment*, *191*, 342-358.

Lu, Y. (2017). Industry 4.0: A survey on technologies, applications and open research issues. *Journal of Industrial Information Integration, 6,* 1-10.

Luthra, S., & Mangla, S. K. (2018). Evaluating challenges to Industry 4.0 initiatives for supply chain sustainability in emerging economies. *Process Safety and Environmental Protection*, *117*, 168-179.

Mankins, J. C. (2009). Technology readiness assessments: A retrospective. *Acta Astronautica*, *65*(9-10), 1216-1223.

March, J. G. (1991). Exploration and exploitation in organisational learning. *Organisation Science*, *2*(1), 71-87.

Maresova, P., Soukal, I., Svobodova, L., Hedvicakova, M., Javanmardi, E., Selamat, A., & Krejcar, O. (2018). Consequences of Industry 4.0 in business and economics. *Economies, 6*(3), 46.

Marsh, S. J., & Stock, G. N. (2006). Creating dynamic capability: The role of intertemporal integration, knowledge retention, and interpretation. *Journal of Product Innovation Management*, *23*(5), 422-436.

Martín-de Castro, G. (2015). Knowledge management and innovation in knowledge-based and high-tech industrial markets: The role of openness and absorptive capacity. *Industrial Marketing Management*, *47*, 143-146.

Meehan, J., & Wright, G. H. (2012). The origins of power in buyer–seller relationships. *Industrial Marketing Management*, *41*(4), 669-679.

Mitra, A., Kundu, A., Chattopadhyay, M. & Chattopadhyay, S. (2017). A cost-efficient one time password-based authentication in cloud environment using equal length cellular automata. *Journal of Industrial Information Integration, 5*, 17-25.

Möhring, M. M. (2014). *Innovation in a high technology B2B context: Exploring supply networks, processes and management*. Springer Science & Business.

Nagy, J., Oláh, J., Erdei, E., Máté, D., & Popp, J. (2018). The role and impact of Industry 4.0 and the Internet of Things on the business strategy of the value chain - The case of hungary. *Sustainability*, *10*(10), 3491.

NONAKA, I. (1991). A empresa criadora de conhecimento. *Gestão do Conhecimento/Harvard Business Review*, *11*.

Nonaka, I., & Takeuchi, H. (2007). The knowledge-creating company. *Harvard business review*, *85*(7/8), 162.

O’Reilly, C. A., & Tushman, M. L. (2002). Winning through innovation: A practical guide to leading organisational change and renewal. *Boston, MA, Harvard Business School Publishing*.

O'Reilly 3rd, C. A., & Tushman, M. L. (2004). The ambidextrous organisation. *Harvard Business Review*, *82*(4), 74.

Oztemel, E., &Gursev, S. (2018). Literature review of Industry 4.0 and related technologies. *Journal Of Intelligent Manufacturing*.

Pereira, A. C., & Romero, F. (2017). A review of the meanings and the implications of the Industry 4.0 concept. *Procedia Manufacturing*, *13*, 1206-1214.

Preuveneers, D., &Ilie-Zudor, E. (2017). The intelligent industry of the future: A survey on emerging trends, research challenges and opportunities in Industry 4.0. *Journal of Ambient Intelligence and Smart Environments*, *9*(3), 287-298.

Qin, J., Liu, Y. & Grosvenor, R. (2016). A categorical framework of manufacturing for Industry 4.0 and beyond. *Procedia CIRP*, *52*, 173-178.

Roblek, V., Meško, M., &Krapež, A. (2016). A complex view of Industry 4.0. *Sage Open*, *6*(2), 2158244016653987.

Rogers, E. M. (2010). *Diffusion of innovations*. Simon and Schuster.

Rojko, A. (2017). Industry 4.0 concept: Background and overview. *International Journal of Interactive Mobile Technologies*, *11*(5), 77.

Rothwell, R. (1994). Towards the fifth-generation innovation process. *International Marketing Review*, *11*(1), 7-31.

Rüßmann, M., Lorenz, M., Gerbert, P., Waldner, M., Justus, J., Engel, P., & Harnisch, M. (2015). Industry 4.0: The future of productivity and growth in manufacturing industries. *Boston Consulting Group*, *9*.

Saunders, M., Lewis, P., & Thornhill, A. (2007). *Research methods for business students.* Pearson Education.

Schuh, G., Potente, T., Wesch-Potente, C., Weber, A. R., & Prote, J. P. (2014). Collaboration mechanisms to increase productivity in the context of Industrie 4.0. *Procedia CIRP*, *19*, 51-56.

Shakerian, H., Dehnavi, H., &Shateri, F. (2016). A framework for the implementation of knowledge management in supply chain management. *Procedia - Social And Behavioral Sciences*, *230*, 176-183.

Shi, X., Li, L. X., Yang, L., Li, Z., & Choi, J. Y. (2012). Information flow in reverse logistics: An industrial information integration study. *Information Technology and Management*, *13*(4), 217-232.

Stock, T. &Seliger, G. (2016). Opportunities of sustainable manufacturing in Industry 4.0. *Procedia CIRP*, *40*, 536-541.

Strange, R., &Zucchella, A. (2017). Industry 4.0, global value chains and international business. *Multinational Business Review*, *25*(3), 174-184.

Straub, J. (2015). In search of technology readiness level (TRL) 10. *Aerospace Science and Technology*, *46*, 312-320.

Sun, P. Y., & Anderson, M. H. (2010). An examination of the relationship between absorptive capacity and organisational learning, and a proposed integration. *International Journal of Management Reviews*, *12*(2), 130-150.

Takeuchi, H., & Nonaka, I. (2004). Knowledge creation and dialectics. *Hitotsubashi On Knowledge Management*, 1-27.

Terjesen, S., & Patel, P. C. (2017). In search of process innovations: The role of search depth, search breadth, and the industry environment. *Journal of Management*, *43*(5), 1421-1446.

Trott, P. (2008). *Innovation management and new product development*. Pearson Education.

Truong, Y., Klink, R. R., Simmons, G., Grinstein, A., & Palmer, M. (2017). Branding strategies for high-technology products: The effects of consumer and product innovativeness. *Journal of Business Research*, *70*, 85-91.

Tushman, M. L., & O'Reilly III, C. A. (1996). Ambidextrous organisations: Managing evolutionary and revolutionary change. *California Management Review*, *38*(4), 8-29.

Van de Ven, A. H. (2007). *Engaged scholarship: A guide for organisational and social research*. Oxford University Press on Demand.

Vargo, S. L., Maglio, P. P., & Akaka, M. A. (2008). On value and value co-creation: A service systems and service logic perspective. *European Management Journal*, *26*(3), 145-152.

Wallin, M. W., & Krogh, G. V. (2010). Organizing for open innovation: Focus on the integration of knowledge. *Organisational Dynamics*, *39*(2), 145-154.

Wan, J., Yi, M., Li, D., Zhang, C., Wang, S., & Zhou, K. (2016). Mobile services for customization manufacturing systems: An example of industry 4.0. *IEEE Access*, *4*, 8977-8986.

Wang, X., Yang, B., & McLean, G. N. (2007). Influence of demographic factors and ownership type upon organisational learning culture in Chinese enterprises. *International Journal of Training and Development*, *11*(3), 154–165.

West, J., & Bogers, M. (2014). Leveraging external sources of innovation: A review of research on open innovation. *Journal of Product Innovation Management*, *31*(4), 814-831.

Weyer, S., Schmitt, M., Ohmer, M. &Gorecky, D. (2015). Towards Industry 4.0 - Standardization as the crucial challenge for highly modular, multi-vendor production systems. *IFAC-PapersOnLine*, *48*(3), 579-584.

Xu, L. D., Xu, E. L., & Li, L. (2018). Industry 4.0: State of the art and future trends. *International Journal of Production Research*, *56*(8), 2941-2962.

Yin, R. K. (2017). *Case study research and applications: Design and methods*. Sage Publications.

Yu-Yuan Hung, R., Chung, T., & Ya-Hui Lien, B. (2007). Organisational process alignment and dynamic capabilities in high-tech industry. *Total Quality Management*, *18*(9), 1023-1034.

Zahra, S. A., & George, G. (2002). Absorptive capacity: A review, reconceptualization, and extension. *Academy of Management Review*, *27*(2), 185-203.

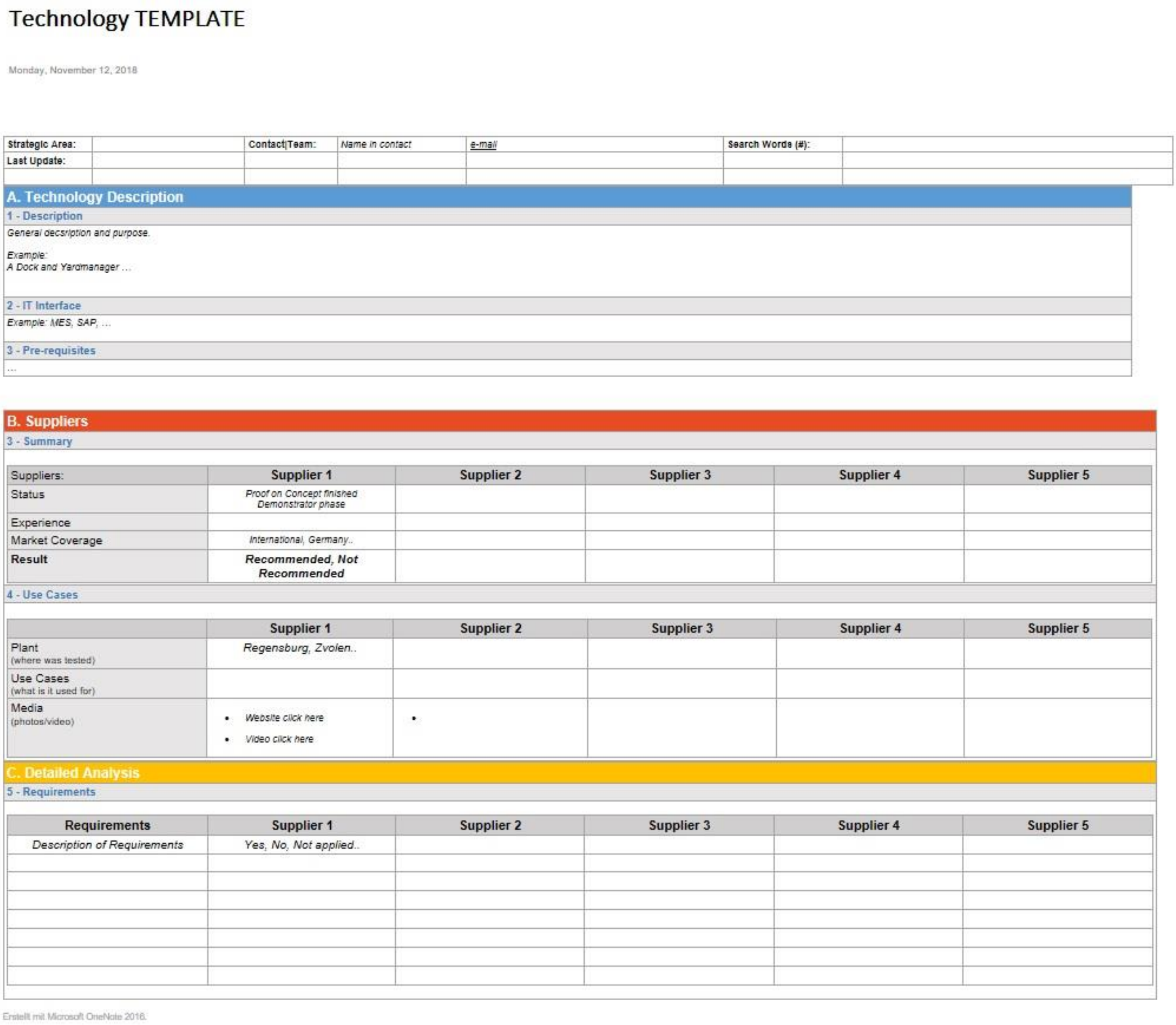
Zheng, X., Martin, P., Brohman, K. & Xu, L. D. (2014). Cloud service negotiation in Internet of Things environment: A mixed approach. *IEEE Transactions on Industrial Informatics, 10*(2), 1506-1515.

Zhong, R. Y., Xu, X., Klotz, E., & Newman, S. T. (2017). Intelligent manufacturing in the context of Industry 4.0: A review. *Engineering*, *3*(5), 616-630.

Zhou, K., Liu, T., & Zhou, L. (2016). Industry 4.0: Towards future industrial opportunities and challenges. In *2015 12th International Conference on Fuzzy Systems and Knowledge Discovery, FSKD 2015* (pp. 2147–2152). Institute of Electrical and Electronics Engineers Inc. https://doi.org/10.1109/FSKD.2015.7382284

Appendices:

Appendix 1:



Technology TEMPLATE

Monday, November 12, 2018

Strategic Area:		Contact|Team:	*Name in contact*	*e-mail*	Search Words (#):	
Last Update:						

A. Technology Description

1 - Description

General description and purpose.

Example:
A Dock and Yardmanager ...

2 - IT Interface

Example: MES, SAP, ...

3 - Pre-requisites

...

B. Suppliers

3 - Summary

Suppliers:	Supplier 1	Supplier 2	Supplier 3	Supplier 4	Supplier 5
Status	*Proof on Concept finished Demonstrator phase*				
Experience					
Market Coverage	*International, Germany..*				
Result	***Recommended, Not Recommended***				

4 - Use Cases

	Supplier 1	Supplier 2	Supplier 3	Supplier 4	Supplier 5
Plant (where was tested)	*Regensburg, Zvolen..*				
Use Cases (what is it used for)					
Media (photos/video)	• *Website click here* • *Video click here*	•			

C. Detailed Analysis

5 - Requirements

Requirements	Supplier 1	Supplier 2	Supplier 3	Supplier 4	Supplier 5
Description of Requirements	*Yes, No, Not applied..*				

Erstellt mit Microsoft OneNote 2016.

Figure 14: Catalogue template (own representation)