Securing the future for the Manufacturing Industry:

Towards the adoption of the Smart Industry

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Acknowledgements

Hereby I am presenting you the last piece of a long-lasting, but completed puzzle. This thesis fulfills the last part to graduate as a Master of Science in Business Administration. However, the latter indicates also the end of being a student. The period of being a student at the University of Twente brought me valuable friendships, extension of knowledge and prepared me for the labor market. Despite the end of one of the most memorable periods in life, I am excited to start with a new adventure.

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Management Summary

Introduction: Currently around the world, the traditional manufacturing industry is in the throes of a digital transformation, also called "Smart Industry" or the "Fourth Industrial Revolution". The vision is a smart connected and data driven factory accelerated by exponentially growing technologies such as Internet-of-Things, Cloud Computing and Big Data analytics.

The transition towards Smart Industry is a hot topic among practitioners and scholars. However, due to the novelty of the topic there is little to no research on the adoption and acceptance of the new information technology.

Purpose: The purpose of the study is twofold. First, the study explores the current intention of manufacturers to implement Internet-of-Things in their products or production processes. Second, the author expects on forehand a high Behavioral Intention in combination with a low Perceived Ease Of Use indicating the expected challenges organizations face for Smart Industry adoption. Therefore, the second part aims to develop a method that contributes to the adoption of Smart Industry.

Main research questions: The first part of the study is guided by the following research question: *"What is the current intention of Dutch manufacturing companies to implement the Internet-of-Things technology into their products or production processes"?*

The second part of the research is guided by the question: *"How to achieve a business innovation towards Smart Industry for manufacturing organizations?"*

Research Methods: To fulfill the aim of this research and to answer both research questions a multi-method approach is used. First, exploratory research is performed to collect opinions and to measure the behavioral intention of manufacturing organizations to implement the Smart Industry following the Technology Acceptance Model. Data is collected by means of an online questionnaire among 43 manufacturing organizations. Second, an Action Design Science study is performed to develop a method that contributes to the adoption of Smart Industry. Data is collected via semi-structured interviews within two cases. Both cases are manufacturing organizations which are both in a different implementation phase towards Smart Industry.

Conclusions: Looking at the results of the first research question, the aforementioned assumptions are confirmed. The Behavioral Intention to adopt Smart Industry is high among the manufacturers. However, the majority is still in the research phase due to challenges and the low Perceived Ease of Use. The constructed method derived from business innovation and Smart Industry literature suggests the following steps to successful adoption: Initiation, Smart Ideation, Smart Idea Conversion and Implementation whereby each phase is guided by frameworks and feedback loops. The main challenges identified are the necessary new skills as data analytics and online security.

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Chapter 1: Introduction

This study is conducted for Innovadis, a technology based company that helps clients to realize commercial objectives into a multi-channel commerce strategy with the help of innovative IT solutions in the field of webshops, portals and interfaces.

Currently, Innovadis aims to change their sales strategy from conventional solution selling into “insight selling”. This change in strategy is required due to the fact that nowadays customers have considerably more transactional power than in the past. This movement in power can primarily be explained as a consequence of the ubiquity of information and increasing marketplace transparency. Therefore, the sales approach requires an enhanced and deepened understanding of customers’ needs prior to the sales call (Rapp, Bachrach, Panagopoulos, & Ogilvie, 2014).

The conventional solution-selling method, prevailed since the 1980s, trained salespeople to align a solution with an acknowledged customer need and had to demonstrate why this solution is better than solutions from competitors (Rapp et al., 2014). Nowadays, solution selling not only involves understanding and defining expressed needs (Adamson, Dixon & Toman, 2012), but also includes recognizing customers’ latent and even emerging needs (Blocker, Cannon, Panagopoulos & Sager, 2012).

Therefore, the salespeople of Innovadis will be acting as knowledge brokers whose job is to acquire knowledge about their products and customers’ industries and have a conversation with their customers to discover their expressed and unexpressed needs (Homburg, Wieseke, & Bornemann in Rapp et al., 2014) and solve the customers’ problems through their own products (Blocker et al. 2012; Verbeke, Dietz, & Verwaal, 2011). In addition to that, sales interactions simply cannot start with questioning ‘tell me about your business’. The job of a salesperson is to be the expert while focusing on customers markets as well as on ways to accrue value for customers (Thull, in Rapp et al., 2014).

In order to fulfill the insight selling approach it is essential to know your customers market, which is in this case the **manufacturing industry**. Knowing the developments within this industry including the future possibilities and challenges is of major importance for Innovadis product development. The obtained insights form input for possible solutions they will create to help manufacturing organizations to stay competitive in the market.

This chapter will introduce the topic and describes the problem statement, the research questions, the practical and academic relevance of the subject, and ends with the further outline of this thesis.

1.1 Problem statement

Currently around the world, the traditional manufacturing industry is in the throes of a digital transformation. The digital transformation is accelerated by exponentially growing technologies, such as the Internet of Things, intelligent robots, Cloud Computing and Big Data Analytics. These aforementioned technologies are used to digitize the complete value chain. In doing so, products and services can be better personalized and production, provisioning and supply chain processes become more efficient, adaptive and flexible. This digital transformation accelerated by the aforementioned technologies is often referred to as either the “Industrial Internet” , “Smart Industry” or the “Fourth Industrial Revolution” (Kagermann, Wahlster, & Helbig, 2013; Schlaepfer & Koch ,2015). The vision is a smart, connected and analytics or data-driven factory (Gröger et al., 2016) which combines a high degree of automatization with many application possibilities of data-derived insights (Kassner et al., 2017). The Smart Industry concept holds among others the promise of increased flexibility in manufacturing, mass customization, increased speed, better quality and improved productivity (Davies, 2015). However to capture these benefits, to keep up with the global economic trends and to sustain its competitive advantage, requires action by the industry. This is confirmed by Schlaepfer and Koch (2015); ‘companies and their industrial processes need to adapt to this rapid change if they do not wish to be left behind by developments in their sector and by competitors’.

The transition towards the Smart Industry is a hot topic among practitioners and scholars. However, due to the novelty of the topic there is little to no research on the adoption and acceptance of the new information technology. For new information technology to be adopted successfully, sufficient user acceptance is necessary (Wu & Wang, 2005). It is therefore valuable to know whether potential users have the intention to use the Internet-of-Things technology, which is the core technology under the Smart Industry. Next to that, the author expects that organizations have the intention to adopt the Smart Industry[1], but struggle how to innovate their business towards Smart Industry. Therefore, the aim of this research is twofold. First, the study aims to identify whether manufacturing organizations intent to implement the Internet-of-Things technology in their products or production processes. The widely applied Technology Acceptance Model (TAM) serves as a basis for this study. Second, the research contributes to the adoption of the Smart Industry by providing a method that facilitates the process of innovation towards Smart Industry whereby opportunities and challenges can easily be identified, which in turn determines the first steps towards implementation.

[1] Noteworthy is that Smart Industry and Internet-of-Things are interchangeably used throughout the whole paper.

1.2 Research questions

The current study consist of two parts that complement each other. First, the behavioral intention of manufacturing organizations to implement the Internet-of-Things will be identified following TAM. Therefore the first research question is:

- “What is the current intention of Dutch manufacturing companies to implement the Internet-of-Things technology into their products or production processes”?

Second, the author expects that manufacturing companies have a positive attitude towards the Smart Industry resulting in a high behavioral intention to implement. However, the author expects organizations to face difficulties during the innovation process resulting in a low perceived ease of use. Therefore, part two contributes to the adoption of Smart Industry by providing a method for the transformation towards Smart Industry, whereby opportunities and challenges can easily be identified, which in turn helps to determine the first steps towards implementation. The second part is guided by the following research question:

- “How to achieve a business innovation towards Smart Industry for manufacturing organizations?”

1.3 Practical and academic relevance and contribution of the research

The fourth industrial revolution or Smart Industry has reached the industry and is a hot topic among researchers and practitioners, especially for those who are interested in a transformation towards a Smart Factory. Therefore the relevance of the topic is not expected to diminish anytime soon.

This study contributes in several ways to the Smart Industry literature. Most of the literature about the industrial revolution is written in a technical perspective, while this paper will contribute to the business perspective. Furthermore, most of the papers assume that manufacturing organizations have a positive attitude and intention to implement Internet-of-Things in their products or processes. However, to the best of the authors knowledge, none tested the actual intention of the industry. Next to that, this study provides a method that contributes to the adoption of the Smart Industry and gives insight in the current challenges organizations face when converting their innovative ideas in tangible smart products, processes or services. Therefore, the research yields valuable information for manufacturing managers and consultants of Innovadis as the results of the TAM study might influence the current focus for product development at Innovadis and the method can be used to help Innovadis’ clients to implement Smart Industry.

1.4 Outline for Thesis

The current paper will be structured in seven chapters. *Chapter 1* gives an introduction into the report and describes the problem statement, relevance and research questions. *Chapter 2* describes the used methodology for research question one and two. *Chapter 3* discusses current literature about the Smart Industry and elaborates on the constructs used in the research model for research question one, including the hypothesis development. *Chapter four* presents the results of the survey and answers research question one. *Chapter 5* discusses relevant literature concerning research question two and introduces the initial design of the method. *Chapter 6* presents the results of the case studies and demonstrates the use of the developed method. Lastly, *Chapter 7* concludes the main findings of the study and presents the limitations and implications for further research.

Chapter 2: Methodology

To fulfill the aim of this research and to answer both research questions a multi-method approach is used. First, exploratory research is performed to collect opinions and to measure the behavioral intention of manufacturing organizations to implement the Smart Industry following the Technology Acceptance Model. Second an Action Design Science study is performed to develop a method contributing to the Smart Industry adoption. For both methods desk research is performed in order to understand the context of the Smart Industry, to elaborate on the Technology Acceptance model, including the hypothesis development and to provide the basis for the design of the method. The main advantage of desk research or secondary data is to take the body of accessible knowledge with multiple perspectives into account at manageable efforts (Saunders et al., 2009, p.268). The desk research focuses on publicly available data sources with high-credibility by reputable institutions, associations or individuals published within the last three years in Dutch or English. Due to the high degree of topicality of the research goal and the practice orientation, the desk research is not limited to academic publications.

Research Question 1: "What is the current intention of Dutch manufacturing companies to implement the Internet-of-Things technology into their products or production processes"?

A quantitative cross-sectional research approach is performed to answer the first research question. As the goal of this question is to discover the intention of implementing Internet-of-Things in the manufacturing industry. Empirical data will be gathered via an online survey.

2.1 Sampling RQ1

This study focuses on manufacturing organizations. Only those people who are in a managerial position with knowledge of Internet-of-Things are asked to participate in the study. These leaders have a stable knowledge background and are aware of the future business plans of the organization. This is done with the intention to reduce the probability that individuals lack interpretations of terminology and concepts used in the survey (Dew, 2009). This sample technique is called purposive sampling, which is “a type of non-probability sampling in which the units to be observed are selected on the basis of the researchers judgment about which ones will be the most useful or representative’ (Babbie, 2010, p. 193). In order to contact people in a managerial position at manufacturing organizations, a professional business network is necessary. Therefore, the customer database of Innovadis, Inextenzo and Novel-T is used. These organizations have all customers within the manufacturing industry. Furthermore, suitable respondents were pro-active approached via Linkedin in order to increase the amount of respondents. In total 130 companies were invited to participate in the survey. In order to stimulate participants in partaking in the online survey, two free tickets were provided for the Smart Industry seminar in June 2017 when they completed the survey.

2.2 Data collection and analysis RQ1

Data is collected by means of a self-administered online questionnaire designed with LimeSurvey. The self-administered questionnaire consists of three parts. The first part is designed to acquire background information about the company under study such as: company size, annual revenue, amount of employees, sector and region of operating. Next to that, the participant needs to fill in their position at the company and if they are familiar with the Smart Industry and Internet-of-Things. This in order to control for the right target group filling in the survey and to get reliable results. The second part of the questionnaire consists of statements regarding the constructs PU, PEOU, A and finally BI. The third part includes some questions about the perceived challenges, the implementation stage of the company and measures the interest for the Smart Industry event organized by Innovadis. The questions and statements in the questionnaire are presented in Dutch and English. A five-point scale based on the Likert-scale is used to determine the extent to which a participant strongly disagrees (1); somewhat disagrees to a certain extent (2); nor agrees nor disagrees (neutral) (3); somewhat agrees to a certain extent (4) or strongly agrees (5) with a given statement. The collected data is analyzed with SPSS. The first and third part of the questionnaire are analyzed by means of descriptive statistics. The second part of the questionnaire is analyzed for reliability (Cronbach’s alpha) and validity by means of a confirmatory factor analysis. Furthermore, the research model is tested by means of simple regression to find the strength and direction of the relationship between the constructs.

2.3 Action Design Science Research RQ2:

As the author expects that the Behavioral Intention of manufacturing organizations is high to implement the Smart Industry, although in combination with a low Perceived Ease of Use, indicating the difficulties organizations face during the adoption, the second part focuses on a method that contributes to the adoption and implementation proces of the Smart Industry guided by the question: “How to achieve a business innovation towards Smart Industry for manufacturing organizations?”

The current study uses earlier published scientific research to ensure rigor and designs a method that is helpful in practice. These aspects relate to the description of a design and action theory (Gregor, 2006). ADR is a relatively new research method in the field of Information Systems (IS) research and combines Design Research (DR) with Action Research (Sein, Henfridsson, Purao, Rossi, & Lindgren, 2011). The ADR method focuses on case research with an iterative and agile approach of doing research. The current study has a topic which is fairly new in literature, which means that methods might change along the way. Therefore, the iterative and agile approach of doing case research suits this study well (Sein et al., 2011).

Figure 1 presents the ADR method consisting of four different stages. The first stage, called the problem formulation stage, specifies and conceptualizes the practice inspired research goal and introduces with the help of a literature review the initial or alpha version of the designed method. Subsequently, during the building, intervention and evaluation (BIE) stage the initial design will be implemented and evaluated. The feedback will be

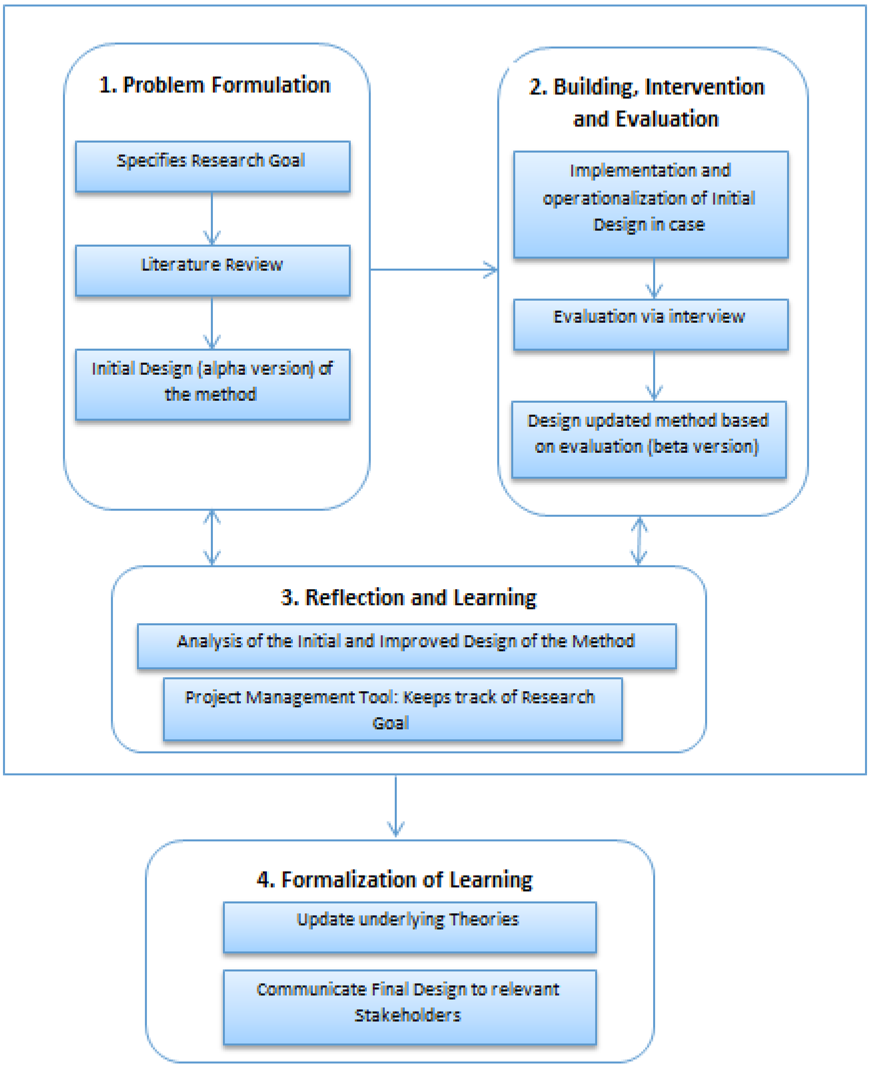


Figure 1: ADR stages and process steps

used to design the beta version of the method. The reflection and learning stage analyses the evolution of the initial and improved method and acts as a project management tool that keeps track of the research goals and notice when it is necessary to change or adjust tracks. The formalization of learning stage updates the underlying theories, generalizes the results and communicates it to the relevant stakeholders in the form of a presentation, paper or thesis.

2.4 Data collection RQ2

The building, intervention and evaluation (BIE) stage implements, improves and designs a method through the so called BIE cycle. The initial design derived from literature will be implemented in two different cases in order to test the utility and completeness of the method. Based on the feedback and observations during the interviews the initial design will be improved, resulting in the beta version of the method. The two cases are selected based on the current implementation phase towards Smart Industry determined by the survey used for research question one. Two manufacturing organizations are selected, whereby the first organization is already in the early implementation phase and the second organization is still at the beginning, called the research phase, wherein the organization is exploring how Smart Industry can be used in their products, processes or services. In this way the utility of the method is tested and demonstrated in two different situations whereby valuable information, best practices and experienced challenges from both points of view are collected.

The BIE cycle

Sein et al. identify two types of BIE cycles. The IT dominant approach and the organizational dominant approach. In practice, the main difference between the IT dominant and organizational dominant approach “is the level of involvement of the practitioners and end users during the design process” (Rothengatter, 2012, p.36). In this case the practitioners as well as the end users are involved simultaneously during the design process. Therefore the organization dominant approach seems the best fit for this research.

The ADR team

The research team consists of the researcher, practitioners and end-users of the method. The researcher in this case is the author of the thesis. The practitioners and end-users cooperated simultaneously during the case studies. The practitioners are the initiators for the transition towards Smart Industry and the end-users are the stakeholders that are to be working with the developed method.

Interview Framework

During the case studies a semi-structured interview approach is used whereby structured topics make it possible to analyze and compare cases with each other by asking open questions. The main questions of the interview aim to execute the defined steps towards Smart Industry innovation whereby business objectives will be linked to smart possibilities, which in turn will be assessed and converted via the Smart Technology architecture. Hereby, necessary changes towards implementation are identified. The outcome of these steps will help strengthen innovation proposals and stimulates the adoption and implementation. Follow-up questions are used to specify answers when they are not immediately clear (Rubin & Rubin, 2012). See Table 1 for the interview outline.

Subject	**Estimated Time**
Introduction of the research	5 min
Definition Smart Industry **1.** *What is Smart Industry in your opinion?* **2.** *What is Internet-of-Things in your opinion?*	5 min
Initiation phase: Identify the Business Objectives and Drivers for change **3.** *To what extent is your organization considering or taking steps towards Smart Industry?* ***4.*** *What are the drivers for this innovation?* ***5.*** *Which business objectives do you hope to achieve with Smart Industry?*	10 min
Smart Ideation: guided by the opportunity framework **6.** Which core product, service or process do you see of added value to become Smart? - Generate smart ideas that contribute to the stated objective	10 min
Smart Idea Conversion: Assessing the impact and convert the idea via the Smart Technology architecture of Porter & Heppelmann. Introduce the key areas of the framework of Porter & Heppelmann and explain the function to identify the existing elements to convert the idea in a tangible product, process or service and the challenges the organization foresees per area. **7.** - *What is the impact of the idea on each area?* - *Are some of the smart requirements already available in the organization?* - *Is the required knowledge or expertise per area present in the organization?* - *Which challenges do you foresee when transforming the idea in a tangible product/service or process?*	20 min
Evaluation **8.** *Are steps, areas or requirements missed by the interview approach?* ***9.*** *Do you consider this approach as useful during the transformation to Smart Industry?* **10**. *Was it possible to give estimations of e.g. challenges close to the truth?* **11.** *Would you like to add something to the interview?*	5 min

Table 1: Interview Guide

Chapter 3: Theoretical Framework RQ1

In this section, several basic concepts will be explained to understand the context of the Smart Industry. Moreover, this section elaborates on the constructs used in the research model for research question one, including the hypothesis development.

3.1 The Smart Industry

3.1.1 The Smart Industry and the main drivers

Essentially, the term Industry 4.0 (used in Germany) or Smart Industry (used in the Netherlands) is a result of several historical stages of industrial revolution which are visualized in Figure 2 .

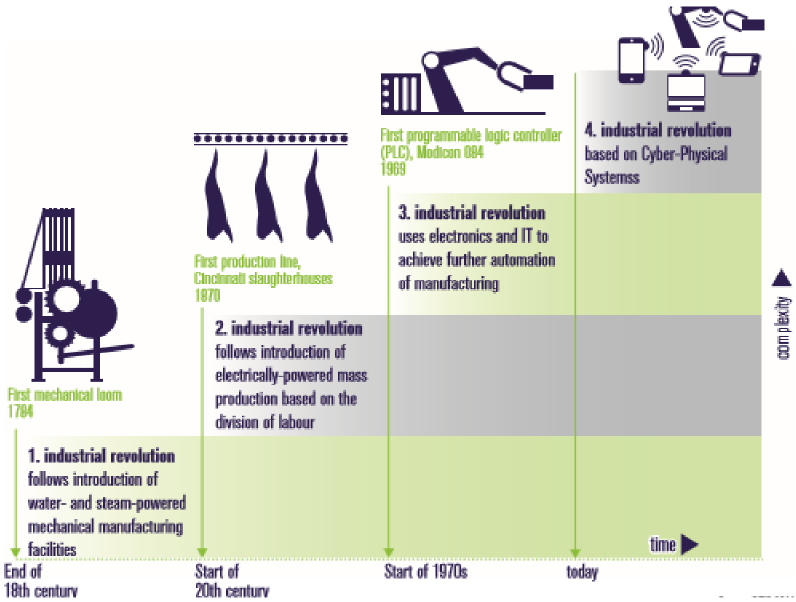


Figure 2: The four stages of the Industrial Revolution (Kagermann et al., 2013)

Starting with the first revolution at the end of the 18th century where the introduction of mechanical manufacturing equipment and machines revolutionized the way goods were made. The change towards mechanical production methods caused a shift from an agrarian, handicraft-based economy towards an industry led by machine manufacturing. The second revolution at the turn of the 20th century created electrically-powered mass production, based on assembly lines and the division of labor. The third revolution at the end of the 20th century came with the deployment of electronics and Information Technology (IT) to achieve increased automation of manufacturing processes by automating and optimizing production lines with machines taking over manual work such as complex and repetitive human tasks or brainwork (Kagermann et al., 2013)

Nowadays, we are at the start of the fourth industrial revolution which is driven by a few global developments. First of all, the European industry lost a third of its industrial base over the past 40 years (Davis, 2015). This de-industrialization, a process which is present in most of the developed economies, is caused by the relocation of labor-intensive work to countries with lower labor costs and global supply chains with suppliers located outside the EU (Davies, 2015).

Second, the international price competition, the fast changing demand of customers and the fast commoditization of products requires the industry to adapt to flexible, just-in-time and cheap production processes via modular designed machines in order to achieve the required production paradox: standardized customization (Smit, Peters, Kemps, Vos, & Sterk, 2016). Next to that, the trend of servitization, whereby services become the main revenue driver instead of the traditional production process, will disrupt the current industry and business models (Smit et al., 2016; Vargo & Lusch, 2008)

Lastly, the development of exponential technologies such as sensor technology, Industrial-Internet-of-Things, artificial intelligence, robots and cyber physical systems enables individualized solutions, flexibility and cost savings in industrial processes (Schlaepfer & Koch, 2015). These technologies are the key in creating a future industry that can withstand the changing economic playfield, deal with the changing market demands , and address social challenges in such a way that the Dutch industry can still compete with the fast growing international competitors (Smart Industry Workgroup, 2014). The aforementioned technologies and trends are not to be compared with a greater level of production automation, which is the case in the third industrial revolution. In the fourth industrial revolution technologies are paving the way for disruptive approaches to development, production and the entire logistics or value chain (Schlaepfer & Koch, 2015).

While having defined the origin of the Smart Industry and its main drivers, the definition of the Smart Industry remains unclear and is not consistent among scholars and practitioners (Brettel, Friederichsen, & Keller, 2014). According to the Smart Industry workgroup (2014): Smart Industries are *"industries that have a high degree of flexibility in production, in terms of product needs (specifications, quality, design), volume (what is needed), timing (when it is needed), resource efficiency and cost (what is required), being able to (fine)tune to customer needs and make use of the entire supply chain for value creation. It is enabled by a network-centric approach, making use of the value of information, driven by ICT and the latest available proven manufacturing techniques" (p.17)* Similarly, *"Industry 4.0 focuses on the establishment of intelligent products and production processes"* (Brettel, Friederichsen, & Keller, 2014, p.38). Other authors argue that Industry 4.0 is *"(…) often understood as the application of the generic concept of cyber physical systems (CPS) and Internet-of-Things"* (Drath & Horch, 2014, p.56).

A recent study of Schlaepfer and Koch (2015) reveals that Industry 4.0 could be defined as merging the real and virtual world, which reflects the interpretation of Cyber-Physical-Systems and the Internet of Things. A general definition should therefore include the function of Cyber-Physical-Systems and the Internet of Things which combined tends to merge the real and the virtual world. Therefore the following definition will be used as a general guideline to interpret the Smart Industry: The Smart Industry could be defined as a smart way of combing the real and virtual world by implementing Cyber-Physical-Systems and the Internet of Things within the products and industrial processes in order to establish a flexible and selfmanaging network between humans, machines, products, buyers and suppliers.

3.1.2 The Industrial Internet-of-Things and Cyber-Physical-Systems

The Smart Industry tends to merge the real and virtual world by digitizing the entire value chain with implementing amongst others Cyber-Physical-Systems (CPS) and the Industrial Internet-of-Things (IIoT). But what are these two main techniques?

The phrase "Internet of Things" or the "Industrial Internet of Things" reflects the growing number of smart, connected objects (e.g. products or machines) and highlight the new opportunities they can represent (Porter & Heppelmann, 2014). As Porter and Heppelmann (2014) explains: "The internet, whether involving people or things, is simply a mechanism for transmitting information" (p.1). The internet is therefore not the attribute what makes smart connected objects fundamentally different. The changing nature of the "things", the expanded capabilities and the data generation possibilities are the unique characteristics which leads to a new era of competition (Porter & Heppelmann, 2014)

In the fourth industrial revolution, IT is becoming an integral part of the product or machine itself. In effect, computers are being put inside the products or machines with the help of embedded sensors, processors, software, and connectivity which are coupled with the cloud. Within the product cloud machine data is stored and analyzed, which drives improvements in product functionality and performance (Porter & Heppelmann, 2014)

In order to create such smart connected objects Porter and Heppelmann (2015) describe three core elements which are:

(I) *Physical components*, such as mechanical and electrical parts;

(II) *smart components*, such as sensors, microprocessors, data storage, software and a digital user interface;

(III) *connectivity components,* such as ports, antennae, protocols and networks that enable communication between product and the cloud.

An example of the Industrial Internet of Things:

A typical industrial machine processes raw materials or semi-finished products and converts this into new semi-finished or finished products. Within the machine, sensors, actuators and software regulate the monitoring, execution and control of the production process. An actuator is a device that puts something in motion, such as a pump or motor. Many machines are already able to adjust their actuators on the basis of observations of the sensors. If these applications are connected to all the machines in a production chain or even with the machines from the buyer or supplier, the Industrial Internet of Things will be created. The extended network of sensors, actuators and industrial software which communicate and interact with each other, makes it easier for producers to respond to the changing demand of customers (Smit et al., 2016). For example when customers suddenly prefer spelled bread instead of wheat, a small adjustment in the system is enough to change the whole production process.

Mymuesli.com did the same and allows users to configure an individual muesli mix. The muesli package is moving through the factory and the 'smart package' communicates to each of the machines how much of each of the ingredients should be filled. So within the industry, machines will not be standing on its own anymore. Linear production processes will be replaced by a network centric approach with intelligent and flexible network approaches and spells the end of the traditional 'value chain' and announces the birth of the 'value network' (Smart Industry Workgroup, 2014)

On the other hand, the definition of Cyber-Physical Systems is ambiguous and is often intertwined with IIoT. The difference stems from the fact that both techniques belong to different research communities, therefore the emphasis differs. CPS has roots in control, computer science, real time systems and sensor networks. While IIoT has roots in communication networks and wireless communication.

Cyber-Physical-Systems can be defined as intelligent machines monitored and controlled by computer algorithms and or humans (Sol, 2016). The IIoT forms the network between the Cyber-Physical-Systems for information transfer. Simple hardware does not have the capability to connect, therefore the hardware needs to be transformed into software(CPS). Therefore, CPS forms the first level of vertical digital integration and IIoT forms the second.

3.1.3 Advantages of Smart Industry for manufacturers

Many advantages are determined for manufacturers when Smart Industry is implemented. These advantages can be related to the identified main application areas of Smart Industry, which are: 1. Smart Products, 2. Smart Services and 3. Smart Production Processes as summarized in Figure 3. Below each advantage will be explained in more detail.

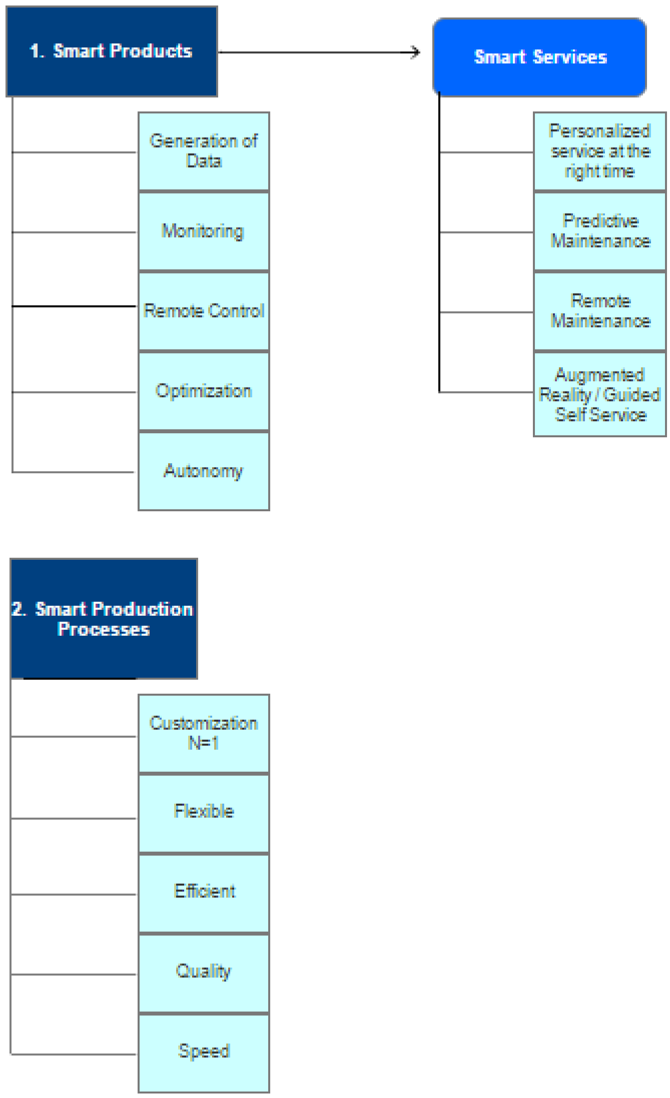


Figure 3: Overview of the advantages of Smart Industry (own depiction)

1. Smart Products

New product capabilities (Porter & Heppelmann, 2014)

With the introduction of smart connected products new product capabilities emerge which can be grouped into four areas: monitoring, control, optimization, and autonomy (See Figure 4). Whereby each capability is built upon the preceding one. The first capability of the smart connected products is monitoring, whereby the generated data allows the manufacturers to track a products' operating characteristics, history and use pattern. Subsequently, the data can be used to alter the design, improve the market segmentation, offer appropriate after-sale service and can indicate new sales opportunities. The second capability, control enables manufacturers to control the product remotely via algorithms built in the product or cloud via rules, for example: "if pressure gets too high, shut off the valve" or "when traffic in a parking garage reaches a certain level, turn off the overhead lighting" (Porter & Heppelmann, 2014). Control through software allows for customization. The third capability optimization, build upon the monitored data coupled with control allows companies to optimize the products performance, output, utilization, efficiency and service. Combing all aforementioned capabilities, smart connected products can achieve a certain level of autonomy. For example, autonomous product operation like the vacuum cleaner that uses sensors and software to scan and clean floors in different sized rooms. As Porter and Heppelmann (2014) states: "autonomous products are able to learn about their environment, self-diagnose their own service needs, adapt to users preferences and communicates with other products or systems". Therefore, autonomous products reduce the needs for operators, improve the safety in dangerous environments and facilitates operation in remote locations.

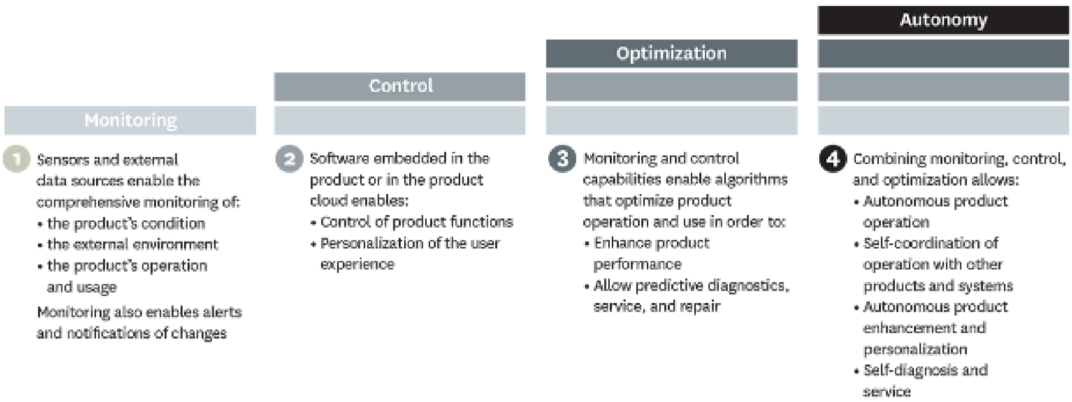


Figure 4: The new product capabilities (Porter & Heppelmann, 2014)

2. Smart Services

New Services (Porter & Heppelmann, 2014; Bosch, 2014)

Smart connected products and machines creates opportunities for new services such as: after sales or services, remote maintenance and predictive maintenance.

Sales and marketing units can monitor sales, usage, and consumption over a long period of time and are able to offer the right service at the right time. Observing real time critical data points in a device or machine allows for rule-based prediction and proactive recognition of failures and notification of service teams to avoid outages for customers what leads to a new service as predictive maintenance. Hereby a new degree of automation and efficiency is possible – e.g. new parts are automatically ordered on time before replacement and service staff is directly allocated when necessary.

3. Smart Production Processes

Implementing the Smart Industry whereby machines and raw materials communicate with each other and cooperatively manage production processes (Siemens, 2016) offer many advantages in the production process in terms of:

Efficiency (Davies, 2015; Schlaepfer & Koch, 2015; Brettel et al., 2014; KvK, 2015).

Digitization of the products and their production processes becomes much more efficient due to the intercommunication of machines, raw materials and products *which allows for better coordination and communication, resulting in higher efficiency and optimizing throughput times, and capacity utilization* (Schlaepfer and Koch, 2015, p.4). Next to that, Schlaepfer and Koch (2015) argue that digitization will ensure the efficient use of energy resources and a reduction might be obtained through reduced lead times and new forms of marketing and distribution channels due to for example e-commerce.

Flexibility (Siemens, 2016; Rüßmann et al., 2015; Davies, 2015; Schlaepfer & Koch, 2015; KvK, 2015).

One of the core features of the Smart Industry is the high degree of digitization and automation. By means of flexible networks formed by CPS and IoT, the production processes and machines becomes more efficient and flexible, since the machines are able to monitor the operations automatically. These machines and systems allow for real-time responses towards the need for raw materials, the fast changing market demand or to detect failures which optimizes the production process (MacDougall, 2014). Next to that, small batches or even single outputs becomes interesting due to the flexible production process.

Speed (Davies, 2015). Digitizing the entire production process, the speed with which a product can be produced will also improve. Digital designs and the virtual modeling of manufacturing process can reduce the time between the design of a product and its delivery. Data-driven supply chains can speed up the manufacturing process by an estimated 120% in terms of time needed to deliver orders and by 70% in time to get products to market (Davies, 2015)

Quality (Rüßmann et al., 2016; Schlaepfer & Koch, 2015; Brettel et al., 2014; KvK, 2015). The autonomous exchange of information between machines allows for major quality improvements by analyzing the data of the smart connected machines across multiple systems. Tracking relevant data can reduce errors, downtime and costs by providing high quality in the products and production process with zero defects or waste. In addition, data analytics enables companies to identify faults in third-party supplied parts faster and helps to understand the relationship between problems and specific parts. Therefore, problematic production outputs can be identified early and unhappy customers or expensive recall processes can be avoided (Bosch, 2014). So, the Smart Industry transforms random machines into sophisticated smart machines, which share continuously information on, errors and faults, current stock levels, and changes in orders or demand levels which all contributes towards quality improvements (Schlaepfer & Koch, 2015, p. 4).

As an example, the Siemens plant in Germany has successfully implemented the digitization in their production processes and reduced the defects from 500 per million in 1989 to 12 defects per million in 2015, with a reliability rate of 99% (Davies, 2015). Bottom line, quality plays an important role in the process of cost reduction. According to Davies (2015) the top 100 European manufactures could save €160 billion if they are able to reduce all defects down to zero.

Customization (Davies, 2015; Schlaepfer & Koch, 2015; Brettel et al., 2014; KvK, 2015; Porter & Heppelmann,2015)
Variability used to be costly and time consuming due to the required variation in physical parts. Adapting flexible and modular production processes can reduce these costs. Next to that, the software in smart connected products or machines allows for cheaper variability as well. For example John Deere used to manufacture multiple versions of engines, each with a different level of horsepower. Integrating software in their machines enables them to alter the horsepower of standard engines. Similarly, digital user interfaces makes it easy and less expensive to modify a product via e.g. changing the control options. Therefore, meeting the customers' needs for variability through software becomes a critical new design discipline (Porter & Heppelmann, 2015).

3.1.4 Challenges for implementing the Smart Industry

A number of benefits exist, however, there are still great technical and economic challenges companies has to deal with if they decide to transform their operations towards Smart Industry guidelines. Recent literature provides evidence that the following challenges are most frequently mentioned:

Lack of financial resources (KvK, 2014; Rüßmann et al., 2016; Davies, 2015)

In order to realize the Smart Industry concept, large amounts of funds and investment needs to be raised in order to drive the process of digitalization. Many companies fear the risk of the digital transformation, due to the long investment cycles and the inability to access the future value of the investment (Davies, 2015; McKinsey Digital, 2015). According to Davies (2015) an investment for the German industry is projected at €40 billion annually until 2020. PwC state that the investment in the digital transformation will reach approximately 5% of the annual revenues. Hereby the advantage is that the estimated return will already be generated within two years (Geissbauer, Koch, Kuge, & Schrauf, 2014). The exact amount of the initial investment relies on the type of businesses and the products the manufacturer produces. For instance industries with high production volumes will agree on a larger initial investment to implement Smart Industry processes (Schlaepfer & Koch, 2015). However, it is not recommended to increase the volumes to justify the large initial investment without sufficient demand for the products. There are many different predictions and forecasts about the required investment and return of the Smart Industry, however in any case the transformation at zero costs is not possible.

Lack of knowledge and skills mismatches of labor force (KvK, 2014; Davies, 2015)

In order to prepare and implement the digital transformation a basic requirement is to have skilled workers with expertise on information and communication. Since the Smart Industry brings a tremendous change from traditional manufacturing work with mainly manual labors towards coding and controlling real-time sophisticated machines (Davies, 2015). The Smart Industry requires a labor force with skills as ICT-expertise, big data management, data analysts, network management, mathematics and information technology. Organizations who do not employ staff with the required skills need to retrain existing staff, gather additional workers with the required skills or replace them. However, employees with the required skills become scarce, Davies (2015) predicts a shortage of 825.000 ICT professionals in the European labor market by the end of 2020. Having the right skilled employees is seen as a major obstacle towards the digital transformation as concluded in the survey of PwC (2015).

Having a well-defined IT-infrastructure and technology stack (Schlaepfer & Koch, 2015; Porter & Heppelmann, 2015; Kagermann et al., 2013; Davies, 2015).
Having the right technology stack and IT infrastructure has a positive influence on the success of the Smart Industry concept (Kagermann et al., 2013; Schlaepfer & Koch, 2015). According to Davies (2015) the digital infrastructure and its connectivity with the Internet is one of the core values under Smart Industry. This perception is reinforced with the results of PwC, who surveyed 235 manufacturing companies from five different industries. 90% of the organizations believe that the IT-infrastructure and the ability to analyze the data exchange is key for the success of the digital transformation towards Smart Industry (Geissbauer, et al, 2014). However, more than half of the companies surveyed by Schlaepfer and Koch indicated their infrastructure as not fully suitable for Smart Industry.

Increased cyber risk through digitization and the need for security (Porter & Heppelmann, 2015; Mckinsey Digital, 2015; Davies, 2015)
Until recently, IT departments in manufacturing companies used to be responsible for safeguarding the firms' data centers, business systems, computers and networks. However, with the introduction of the Smart Industry whereby products and machines becomes smart and part of a digital network where data is shared via internet applications, the game changes dramatically. All smart connected devices or machines may be a point of network access and form a source of cyber risk (Porter & Heppelmann, 2015). Cyber risk can be defined as: "a multitude of different sources of risk affecting the information and technology assets of a firm" (Biener, Eling, & Wirfs, 2015). The identified sources of risk can be grouped in hacker attacks, virus transmissions, data breach and cyber extortion. Hackers can among others take over the control of a product (e.g. car or aircraft), change specifications of products or tap sensitive data that moves between the manufacturer and customer. The increased risk of cyber-attacks drives companies to develop contingency plans to mitigate their exposure. Important is to have up-to-date machines and IT-infrastructure, since outdated software increase the risk of cyber-attacks. Furthermore, key assets and core processes should be prioritized and protected accordingly and regular trainings and simulations should be given in order to facilitate short-term reactions to cyber-attacks (McKinsey Digital, 2015). Next to that, in order to guarantee data privacy for customers, data policies must reflect government regulations and transparently define the type of data collected and how it will be used internally and by third parties (Porter & Heppelmann, 2015).

3.2 Technology Acceptance Model

Knowing the main possibilities and challenges of the digital transformation towards Smart Industry, the question rise: “What is the current intention of Dutch manufacturing companies to implement the Internet-of-Things technology into their products or production processes”? In order to measure user acceptance and usage of new technologies, the widely applied Technology Acceptance Model (TAM) is used. The Technology Acceptance model, as displayed in figure 5, is proposed by Davis in 1986 and designed to model user acceptance of information systems (Davis, Bagozzi, & Warshaw, 1989). The model is grounded on the theory of reasoned action (TRA) proposed by Fishbein and Ajzen (1975). TRA states that a specific behavior is determined by behavioral intent, whereby Behavioral Intent is determined by a person’s attitude and Subjective Norms towards that specific behavior (Fishbein and Ajzen in Davis et al. 1989). The Technology Acceptance Model uses the TRA model as a baseline and test whether causal relationships exist between perceived usefulness (PU), perceived ease of use (PEOU), the attitude of potential users, the intentions, and in the end the actual adoption behavior of computer usage (Davis et al., 1989).

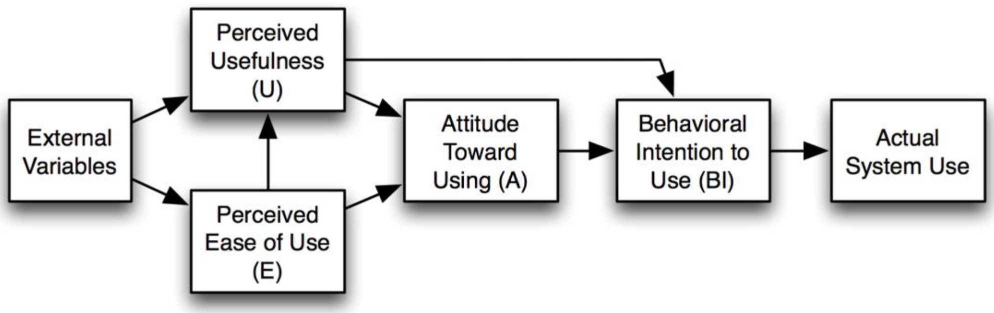


Figure 5: Technology Acceptance Model (Davis et al., 1989)

The Technology Acceptance model suggests that the actual system usage depends on the users' intention to do so, whereby the behavioral intention is determined by the attitude towards the system, which in turn is influenced by the 'perceived usefulness' and 'perceived ease of use' of the system. In addition to that, the model includes a direct effect of Perceived Ease Of Use on Perceived Usefulness and suggests that Perceived Usefulness has a direct effect on the Behavioral Intention. The model is tested and verified in different studies wherefrom the results show that primarily Perceived Usefulness and secondarily Perceived Ease Of Use are good determinants for user intentions to use computers. Furthermore, the Technology Acceptance Model is critically reviewed and analyzed by Legris, Ingham, & Collerette, (2003) in 22 articles published between 1980 and 2001. In their analysis is concluded that the model is proven to be of quality and provides statistically reliable results. However, they stated as a point of critic that the model should include more or other components such as human and social change processes to explain more than 40% of the actual system use. Moreover, their critical review showed mixed results for the relationship between Attitude and Behavioral Intention. Only seven out of 22 studies found a significant and positive relation and four did not find a relation between the constructs (Legris et al., 2003). The remaining eleven papers did not measure the relation between Attitude and Behavioral Intention. Over the years, various researchers complemented the original TAM model in various ways, for example Chen, Gillenson and Sherrell (2002) added the construct compatibility of the Innovation Diffusion Theory of Rogers (1983) to assess consumer behavior in a virtual store. The constructs of the Innovation Diffusion Theory (IDT) are comparable to TAM as relative advantage is comparable to perceived usefulness and complexity to perceived ease of use. So, as concluded by Wu and Wang, (2005) and Chen et al., (2002) TAM and IDT complement one another. Furthermore, Davis and Venkatesh (2000) created TAM2 by extending the original TAM with social influence processes and cognitive instrumental processes. Other researchers, Venkatesh, Morris, Davis, & Davis, (2003) formulated a unified theory of Acceptance and Use of Technology (UTAUT) derived from the review of eight different user acceptance models.

Looking at the aforementioned TAM studies, most of the studies found support for the relationship between PU, PEOU and BI. However, the majority have not included attitude in their research models. Instead, a direct link is proposed between the constructs PU, PEOU and BI. Due to the immature stage of the Smart Industry and Internet-of-Things, attitude is perceived as a valuable variable and is therefore implemented in the research model. Therefore, the following hypotheses are developed:

H1. There is a positive relation between **perceived usefulness** and the organizations' **attitude** towards implementing the Internet-of-Things in its products and production processes.

H2. There is a positive relation between **perceived ease of use** and the organizations' **attitude** towards implementing the Internet-of-Things in products and production processes

H3. There is a positive relation between **attitude** towards implementing Internet of Things and **behavioral intent**

H4: there is a positive relation between **perceived usefulness** and **behavioral intent** to implement Internet-of-Things

Model, constructs and measures

The model consists of two factors who are assumed to influence the Attitude towards Internet-of-Things which in turn influences BI. The two constructs are perceived usefulness (PU) and perceived ease of use (PEOU). The original variable definitions are modified to fit the Smart Industry context of this research (see Table 2).

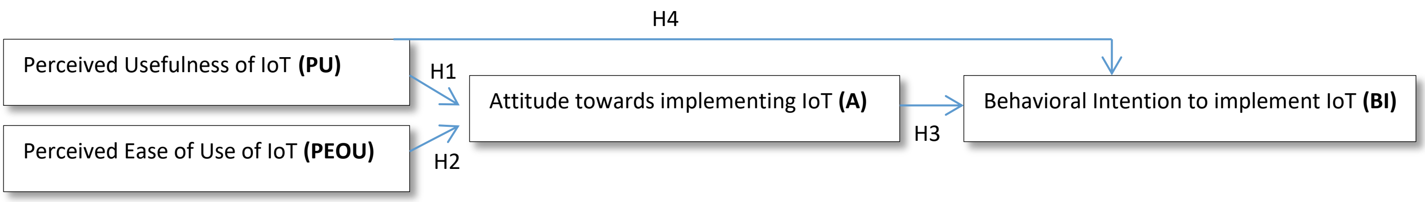


Figure 6: Research Model RQ1

Different publications, frameworks and models were reviewed to determine the measures as displayed in appendix 1. For PU and PEOU, measures are adapted from the previous studies using the Technology Acceptance Model (e.g. Davies et al., 1989; Chen, et al., 2002; Wu and Wang, 2005;) and modified to fit the Smart Industry context. The measure for behavioral intent (BI) is adopted from Venkatesh et al (2003). For attitude towards implementing Internet-of-Things the measures are adopted from Venkatesh et al. (2003) and Davies et al. (1989)

Table 2: Construct definitions

Construct	Definition	Reference
Perceived Usefulness (PU)	The degree to which an organization believes that implementing the Internet of Things technology into their products and production processes will increase their performance.(Modified)	Davis (1989)
Perceived Ease Of Use (PEOU)	The degree to which the organization beliefs that Internet-of-Things technology is easy to use and implement (modified)	Davis (1989)
Attitude (A)	An organizations positive or negative feelings about implementing the Internet-of-Things into their products or production processes (Modified)	Davis et al. (1989)
Behavioral Intent (BI)	An organizations subjective probability that they will implement the Internet-of-Things technology into their products or production processes (Modified)	Ajzen & Fishbein (1975)

Chapter 4: Data analysis and Results RQ1

4.1 Descriptive statistics

In total 130 companies are invited to partake in the survey. 60 respondents started the online survey of which 17 responses are excluded due to incomplete information or non-managerial position. Subsequently, the response rate of the completed surveys is: 43/130 x 100% = 33% . Due to the fact that the target group – people in a managerial position at manufacturing organizations – is quite complex, it is surprising that 43 leaders from different organizations completed the questionnaire. The remaining respondents are classified based on their function, whereby 5 categories are formed. The first category is named 'CEO' and represent participants with the function title: CEO, DGA, Company Director, Managing Director, Owner and Deputy Director. The second category is named 'Marketing and Sales' and includes functions as: Marketing Manager, Sales Manager, Commercial Director, E-Business and Digital Communications Director; The third category is named 'ICT and Technology' and includes functions as ICT Manager, CTO and Technical Director. The fourth category is named 'Operations' and includes functions as Supply Chain Manager, Product and Production Manager and Engineering Manager. The last category is named 'Other' and represents functions as project manager, manager and innovation manager. Table 3 identifies that most of the respondents have the position Marketing / Sales (40%) or CEO (24%). Next to that, most of the leaders (60,5%) who completed the questionnaire work for SMEs (1-250 employees). Looking at the revenue of the organizations it is interesting that, despite the fact most of the organizations are SMEs (1-250 employees) still most of the organizations (37,2%) have an annual revenue in the second highest category (€50 million - €1 billion).

Table 3: Descriptive statistics of the Questionnaire (1)

	Frequency	Percentage (%)	Cumulative (%)
Function			
CEO	10	24%	24%
Marketing/Sales	17	40%	64%
ICT/Technology	6	14%	78%
Operations	4	10%	88%
Other	5	12%	100%
Size by employees			
SME: 1-250	26	60,5%	60,5%
Large: 250-20.000	16	37,2%	97,7%
Extra Large: 20.000 or more	1	2,3%	100%
Size by revenue			
€1-€1 million	1	2,3%	2,3%
€1.1 million - €10 million	12	27,9%	30,2%
€10.1 million-€50 million	13	30,2%	60,5%
€50.1 million- €1 billion	16	37,2%	97,7%
€1 billion or more	1	2,3%	100%

Table 4: Descriptive statistics of the Questionnaire(2)

	Frequency	Percentage (%)	Cumulative (%)
Implementation phase			
1. Non-existent: Not yet begun to consider, or decided not to proceed.	6	14%	14%
2. In research	23	53,5%	67,4%
3. In planning for pilot (completed research)	3	7%	74,4%
4. Early implementation	9	20,9%	95,3%
5. Extensive implementation	2	4,7%	100%
Budget allocated for investments in the Smart Industry (IoT)			
Yes	19	44,2%	44,2%
No	11	25,6%	69,8%
Not yet, we are planning to do so	13	30,2%	100%
Obstacles or challenges (more options allowed)			
Lack of employees skills and knowledge	32		
High investment costs in technology	18		
Increased cyber risk and data protection	17		
Connect machines or products	13		
Uncertain what the return on investment will be	15		
Don’t know where to start	8		
Other	3		

Looking at Table 4 most of the organizations (53,5%) are in the research phase towards the Smart Industry. Which means that they are researching how the Smart Industry (IoT) can be utilized in their products, machines or services. Next to that, it is surprising that 20.9% of the organizations are already in the early implementation phase, which means that they have begun to introduce products, machines or services utilizing Internet-of-Things technology. 44,2% of the organizations already allocated budget for investments in the Smart Industry and 30,2% are planning to do so in the near future. Looking at the perceived or expected challenges, most of the organizations consider lack of employees skills and knowledge, high investment costs and increased cyber risk to the main challenges. A few respondents added some challenges such as: lack of clear support policy from local government; Missing the urgency and awareness through the whole organization; and, integration issues from their product in a greater system.

4.2 Measurement model

In this section, the measurement model is analyzed and results will be discussed. The research model consists of two independent variables (PU and PEOU), two dependent variables (A and BI) and 15 items. First, all items were analyzed using confirmatory factor analysis and checked for item reliability.

Dependent variables:

Looking at the items of the dependent variable Behavioral Intention the statistic of Kaiser-Meyer-Olkin (KMO) is 0.5 (see appendix 2, Table 10) This indicator is used as an index to examine the appropriateness of factor analysis. Malhotra and Birks (2007) noted that high values (0,5-1.0) indicate that factor analysis is appropriate. Table 11 in appendix 2 shows that component 1 has an Eigenvalue of 1,900 The other components have an Eigenvalue less than 1.0, which means that they are no better than a single variable. Both items load high on the same component which means that these two items are reliable to measure BI. Another test to ensure the appropriateness of the questionnaire is Cronbach's alpha which measures the internal consistency reliability. The coefficients are between 0-1 and different researchers argue that a value ranging from 0.65-0.95 generally indicates satisfactory internal consistency reliability (Nunnally & Bernstein, 1994; DeVellis, 2003). The Cronbach's alpha of the behavioral intention scale is 0.936 which indicates an excellent internal consistency reliability.

The second dependent variable is Attitude, the items of attitude score a KMO statistic of 0,682 (See Appendix 2, Table 10). Attitude is an one dimensional construct with an eigenvalue of 2,441 for component 1 (See Appendix 2, Table 11). The other components are below 1 which means they are no better than a single variable. The internal consistency reliability measured by the Cronbach's alpha is 0,883.

Independent variables:

The confirmatory principal component factor analysis using varimax rotation showed a Kaiser-Meyer-Olkin value of 0.664 which indicates that the data is suitable for factor analysis.

Table 5: Rotated Component Matrix Independent Variables

Component	1	2
PU1	**.854**	.061
PU2	**.724**	-.204
PU3	**.735**	.229
PU4	**.742**	.023
PU5	**.863**	.018
PU6	**.716**	.123
PEOU1	.145	**.870**
PEOU2	.062	**.928**
PEOU3	-.035	**.491**

Extraction Method: Principal Component Analysis
Rotation Method: Varimax with Kaiser Normalization
a. Rotation converge in 3 iterations.

As Table 5 indicates, all items of Perceived Usefulness can be taken together as one factor, since all the items load high on the same component. The same applies to Perceived Ease of Use. Furthermore, the items of Perceived Usefulness show a Cronbach's alpha of 0.861. The items of Perceived Ease of Use have a Cronbach's alpha of 0.685 as summarized in table 6 below.

Table 6 below gives an overview of the mean scores, standard deviations and reliability of the research variables. It is remarkable that the mean score of Behavioral Intention is 4.13 which means somewhat agree despite the newness of the technology. The Perceived Usefulness has a mean of 4.30 which is in the middle of somewhat to total agree which indicates that the respondents perceive or expect the IoT technology to be useful. The Perceived Ease of Use has a mean of 2.43 which is close to the middle of somewhat disagree and neutral and indicates that respondents do not perceive Internet of Things to be easy in use or implementation. Lastly the attitude has a mean of 4.3 which indicates somewhat agree and can be interpreted as positive towards IoT.

Table 6: Means, Standard Deviation and Reliability of Research Variables

Variables	Number of items	Mean	S.D.	Alpha
Perceived Usefulness	6	4.30	.649	0.861
Perceived Ease of Use	3	2.43	.827	0.685
Attitude	3	4.30	.709	0.883
Behavioral Intention	2	4.13	.964	0.936

Regression analysis

The four hypotheses were tested using a multiple regression analyses. The results of this regression analyses are shown in Table 7 and Table 8 below. First, the dependent variable Attitude is tested by the independent predictors Perceived Usefulness and Perceived Ease of Use. Looking at the R-square value of 0.646, there could be stated that 64.6% of the variation in Attitude can be explained by PU and PEOU. The results of the model show that the direct effect of PU on Attitude has a positive and significant effect with a coefficient of .856. Therefore the first hypothesis: "*H1: There is a positive relation between PU and A towards implementing Internet-of-Things*" can be accepted. The direct effect of PEOU on Attitude has a weak positive coefficient of .081, however this effect is not significant (.299). Therefore the second hypothesis: "*H2: there is a positive relation between PEOU and A towards implementing Internet-of-Things*" cannot be accepted.

Looking at the relationship between Attitude and Behavioral Intention, there can be concluded that 40.9% of the variation in BI can be explained by Attitude (R-square of .409). Attitude has a positive and significant direct effect on BI with a coefficient of .869. Therefore the third hypothesis: *"H3: There is a positive relation between attitude towards Internet-of-Things and BI*" can be accepted.

Lastly, a positive direct effect of PU on BI is expected which can be confirmed looking at the table below. 31,8% of the variation in BI can be explained by PU. PU has a positive and significant effect on BI (B=.837). Therefore the fourth hypothesis: "*H4: there is a positive relation between PU and BI regarding Internet-of-Things"* can be accepted.

Table 7: Total Variance Explained in the Research Model

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate	R Square Change	F Change	Df1	Df2	Sig. F Change
1	.804[a]	.646	.628	.433	.646	36.462	2	40	.000
2	.639[b]	.409	.394	.750					
3	.564[c]	.318	.301	.806					

a. Model 1: PU + PEOU → A
b. Model 2: A → BI
c. Model 3: PU → BI

Table 8: Hypothesis testing: Unstandardized Coefficients

Hypothesis	Path	B	t-value	P	
H1	PU → A	.856	8.257	<0.01	Accepted
H2	PEOU → A	.086	1.053	>0.01	Rejected
H3	A → BI	.869	5.326	<0.01	Accepted
H4	PU → BI	.837	4.371	<0.01	Accepted

4.3 Concluding Remarks

As this part explores the Behavioral Intention of manufacturers to implement Internet-of-Things in their products or production processes there can be concluded that the intention is high with a mean score of 4.13 on a scale of 1-5. The intention is formed by the positive attitude of manufacturers towards Internet-of-Things with a mean score of 4.30. The attitude is in turn influenced by the Perceived Usefulness (4.30) and Perceived Ease of Use (2.43). The result on PEOU confirms the on forehand expected struggle of organizations towards the use and implementation of Internet-of-Things. The descriptive statistics confirm the high behavioral intention since 44% already allocated budget for investments and 30% are planning to do so within 1 year. Furthermore, most of the organizations are still in the research phase towards the Smart Industry which means that they are researching what the Smart Industry and Internet-of-Things can bring them and how it can be utilized in their products or production processes. The major challenge towards implementation is considered to be the lack of employee skills and knowledge in combination with high investments.

Chapter 5: Theoretical Framework RQ2

As expected, the results of the TAM study (see Figure 7) show a positive attitude and a high behavioral intention of manufacturers to implement Internet-of-Things in their products or production processes. However, despite the high behavioral intention, only a small amount started with the implementation. The majority is still in the research phase due to lack of knowledge and skills, high investment costs and not knowing where to start, which combined leads to the low perceived ease of use.

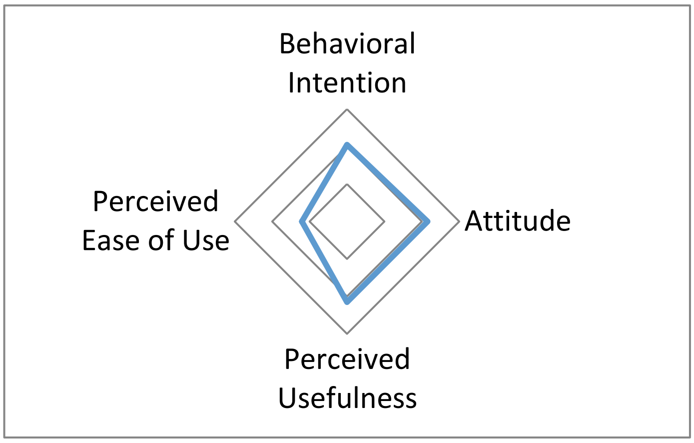


Figure 7: Overview outcome TAM study

Therefore, the goal of the second research question is to develop a method that guides the process of innovation towards Smart Industry.

As the necessity of innovation towards Smart Industry becomes clear among manufacturers, the question rises how to achieve a Smart Industry business innovation? Different approaches for innovation processes are proposed by different researchers. For example, Wheeler (2002) developed the Net-Enablement Business Innovation Cycle (NEBIC) model. The NEBIC model focuses on the process of IT innovations in large organizations by focusing on the required capabilities and their interactions to proactively realize customer value "in an age of unending IT change" (Wheeler, 2002, p.6). The theory describes four capabilities that are central to successful net-enablement: 1. Choosing emerging/enabling technologies. The choosing capability includes routines to create insights on emerging and enabling technologies that could support the value creation for customers; 2. Matching proposed technologies with economic opportunities. The matching capability combines insights of the previous step with business and strategy; 3. Executing business innovation for growth. The executing capability includes routines that (re)configure resources to develop e.g. innovative products or services which in turn contributes to the business growth; and 4. Assessing customer value. The assessing capability includes routines that produce market data via evaluations of the delivered value and measuring customer preferences. The obtained market data strengthens and guides all the aforementioned capabilities .

A variant of the NEBIC model is the App-enabled Business Innovation Cycle (ABIC) developed by Ehrenhard, Wijnhoven, van den Broek and Zinck Stagno (2017). The ABIC model differs from the NEBIC model at the following aspects: the ABIC model focuses on app-enablement routines in the context of start-ups instead of large organizations. It proposes an iterative or scrum-like method of innovation with frequent and smaller feedback loops during the innovation process. Furthermore, the assessing capability is placed at the beginning of the cycle as well, which indicates a market driven and early customer focus. Lastly, at the outcome level, the ABIC uses 'business value' (value realization during the whole innovation process) instead of 'customer value' (value realization after value proposition is delivered to the market) indicating a broader outcome measure.

Besides looking at capabilities for innovation processes , De Reuver, Bouwman, & Haaker, (2013) propose a business modeling roadmap tool derived from the integration of road mapping and business model literature. Four steps are proposed in this method to achieve business innovation: the first step is to find the desired business model change, second, the impact on the rest of the business model need to be determined, third, the findings need to be translated into activities and fourth, a change plan needs to be devised. A second approach on business innovation comes from Meertens, Starreveld, Iacob, & Nieuwenhuis, (2013) who use business case literature for framework development. Their method results in the following steps: 1. Business drivers, 2. Business Objectives, 3. Alternatives, 4. Effects, 5. Risks, 6.Costs, 7. Selection of alternatives and 8. Adoption plan development (Meertens et al., 2013). Lastly, Frankenberger, Weiblen, & Csik, (2013) look at innovation process literature instead of road mapping or business case literature. Four steps are suggested to find and implement an innovation. First, the reasons for change are identified called the initiation phase. Second, these results are used to create and generate innovative ideas which is named the ideation phase. Third, the effect of the innovative ideas on the business model are assessed which is named the integration phase and fourth, the implementation phase, which is usually executed with pilots, experimentation and trial and error.

As can be seen several approaches from different perspectives are developed to achieve a business innovation. However, at heart, the models feature a set of common characteristics as Eveleens, (2010) concludes, most of the steps in the models can be classified into four 'phases, stages, components or main activities'. The first being the reason and objective for change, the second the process of generating innovative ideas that contribute to the determined objectives, the third phase takes up one of the promising possibilities and focuses on its elaboration and development, or as Eveleens (2010) states: "to turn the (selected) idea into some tangible product, process or service." The fourth phase of the innovation process is the one in which the innovation is implemented and brought to the market. These four phases will be used and transformed in a Smart Industry context resulting in – Initiation, Smart Ideation, Smart Idea Conversion and Implementation. The aforementioned phases will be used as the basis of the constructed method (see Figure 8).

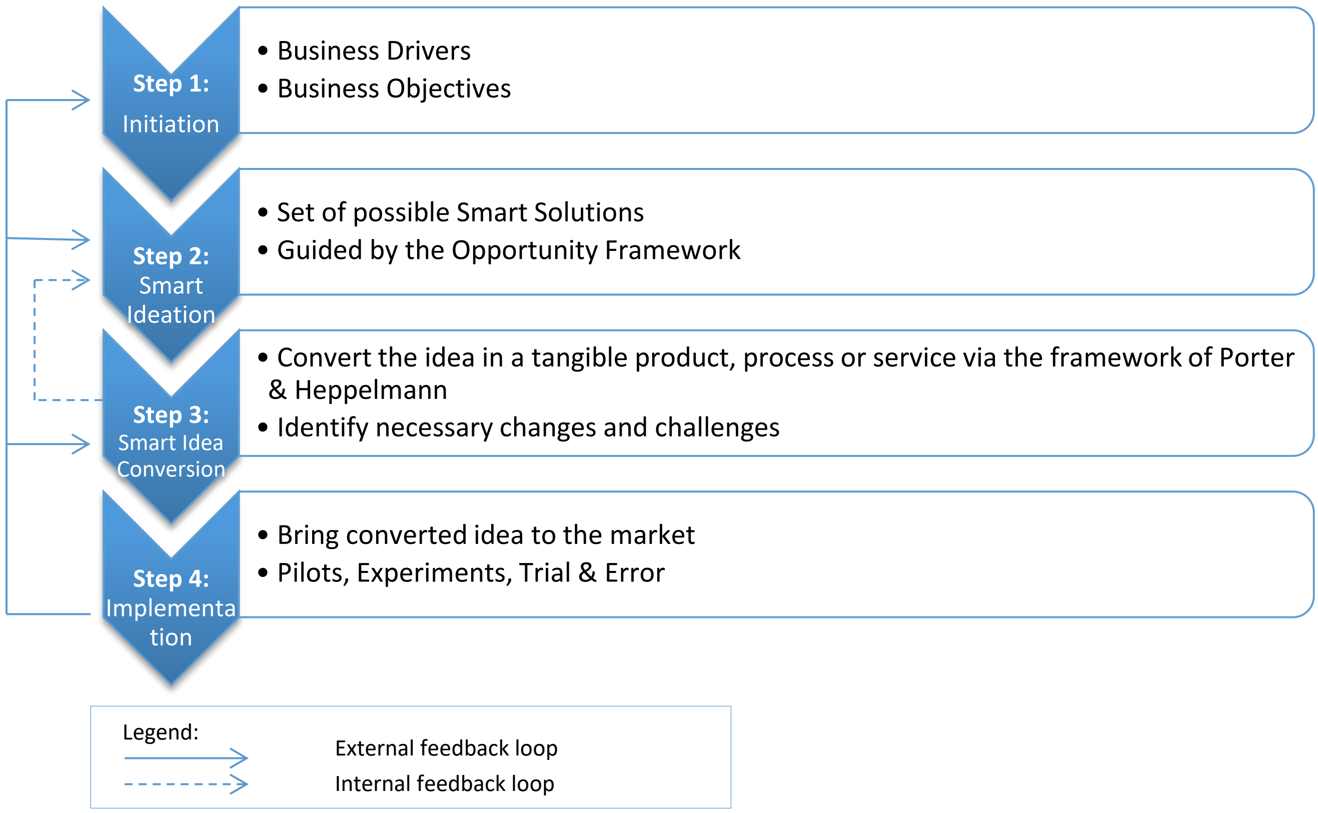


Figure 8: Proposed Method RQ2

5.1 Step 1: Initiation

In this method the initiation phase can be identified as the discovery of the need for innovation and will be determined via the business objectives and drivers as Meertens et al., (2013) suggests. The business objectives can be defined as the goals of the innovation (Meertens et al., 2013). They state which business drivers are addressed and how these are hoped to be achieved with the proposed innovation. The objectives can be derived from specific aspects of the strategy; one or more of the business model elements that need improvement; or a current experienced problem whereby products or processes need to become more efficient or better address the needs of customers

5.2 Step 2: Smart Ideation

During the second phase, Smart Ideation, a set of 'smart' innovative ideas will be generated that contributes to the determined business objectives. Smart can be defined as doing things smarter than you are used to, by taking actions based on many detailed information (data) generated from e.g. sensors and to automate tasks. The opportunity framework will be used to guide the Smart Ideation phase whereby first the focus of innovation will be determined (product, process or service). Thereafter possible solutions will be identified and aligned with the determined business objectives.

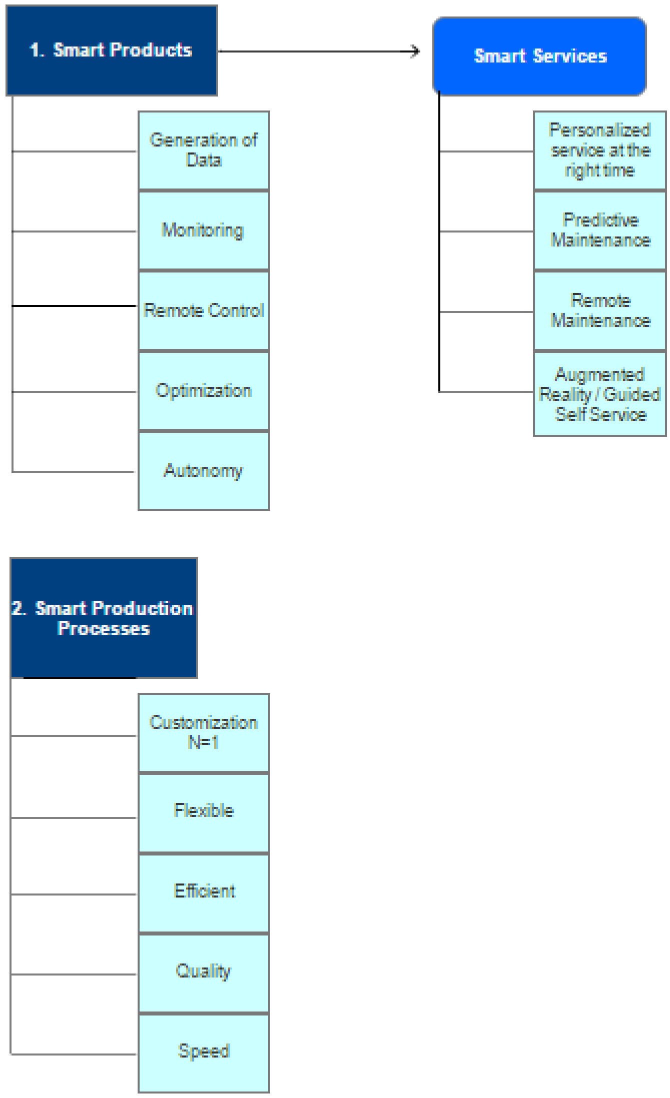


Figure 9: Opportunity Framework Smart Industry

5.3 Step 3: Smart Idea Conversion

Smart Idea Conversion will assess the impact and convert the idea via the framework of Porter and Heppelmann (2015). The framework clearly explains the core technology elements of a smart solution. It occurs that organizations already possess elements or technology to create a smart environment, but do not capitalize on this opportunity. Via this framework companies can easily determine the already existing elements and identify necessary changes or challenges. In this way an usable overview will be created of 'what do we want' and 'what do we have or need', resulting in the most appropriate Smart Industry investment.

The technology required to implement Smart Industry successfully, consist of several core elements. Porter & Heppelmann (2015) visualized these elements in their technology architecture of the Smart Industry published in the Harvard Business Review (See Figure 10).

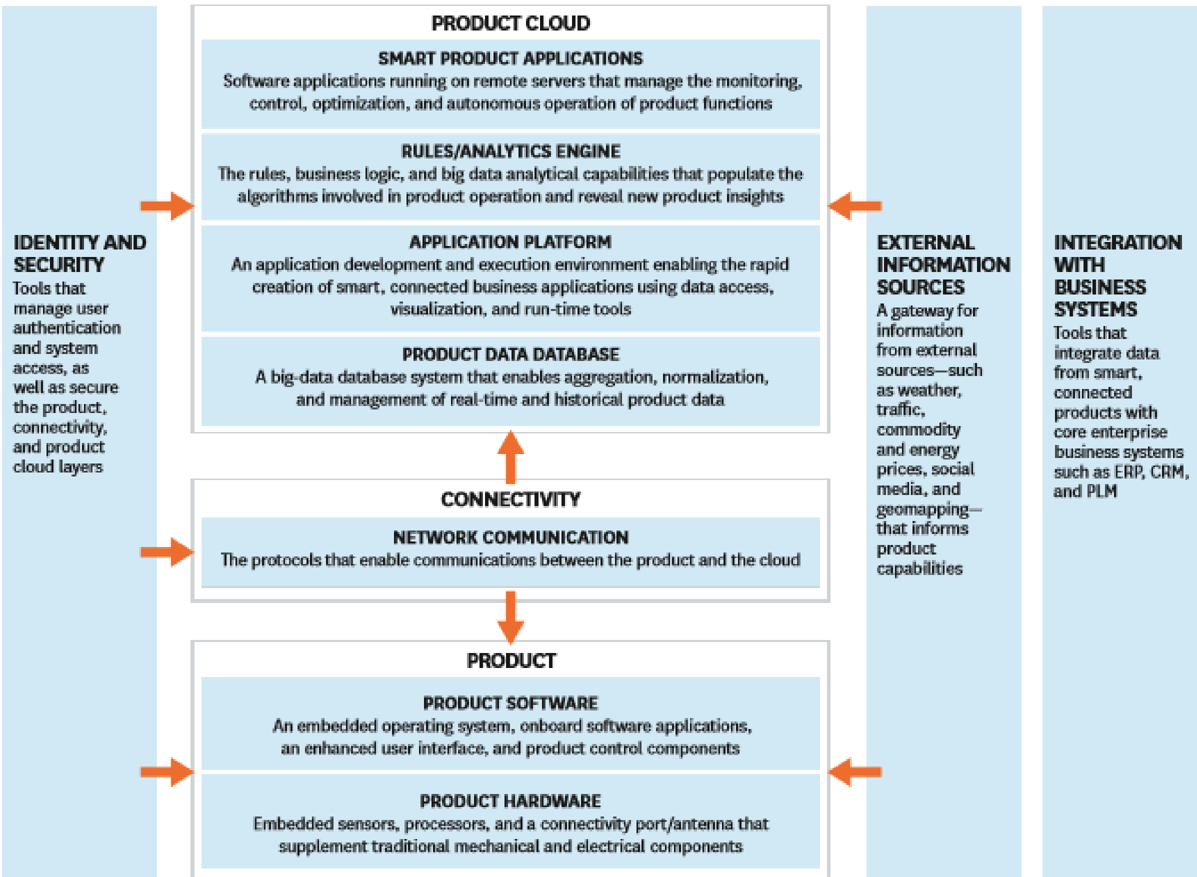


Figure 10: Smart Technology Architecture - Porter & Heppelmann (2015)

The framework starts at the product level, which consist of hardware and software. Porter and Heppelmann state that the hardware should be complemented with embedded sensors, processors and a connectivity port. Thereafter, the software should be added in the form of an embedded operating system, onboard applications, an enhanced user interface and device control components. This level is the foundation of intelligent products. However, Porter and Heppelmann focus only on smart connected products, while smart connected products are only one example of the identified smart possibilities. Therefore the framework will not be limited to smart connected products and includes smart connected machines to optimize production processes as well. The second level of the framework covers the connectivity that enables communication between the product or machine and the cloud which enables a network of collaborating objects. The third level is the cloud. In the cloud data will be stored in a big-data database that enables aggregation, normalization and management of real time and historical product data. Furthermore, rules and analytics also called the business logic needs to be created in order to process and act on the generated data in a meaningful way. Next to the three layers, several other components need to be taken into consideration, such as the identity and security of data, the external information sources that can be coupled with data about the product or machine, such as information about the weather, traffic, energy prices, social media or geomapping and lastly integrating the data into the core business systems such as ERP, CRM and PLM. Due to its adequacy, simplicity and clear overview of the smart core elements and requirements, it is chosen to serve as a basis for the Smart Idea Conversion phase.

5.4 Step 4: Implementation

The last phase of the method is the implementation phase. The implementation phase brings the converted idea to the market by executing the pre-determined steps by means of pilots, experimentation and trial and error.

Besides the proposed steps towards Smart Industry innovation, the method includes several feedback loops as suggested in the research of Wheeler, (2002) and Ehrenhard et al. (2017). The feedback loops will strengthen the entrepreneurial learning, which allows for adaptive sense-making resulting in higher customer or business value (Bogner & Barr, 2000; Ehrenhard et al., 2017).

The internal feedback loop from Smart Idea Conversion towards Smart Ideation might contain insights from mistakes due to wrong or obsolete choices that appear later on in the process and execution. The three external feedback loops from Implementation to Smart Idea Conversion, Smart Ideation and Initiation contains user preferences and evaluations of the delivered value which in turn contributes to the learning process and helps adjusting the innovation to a more favorable path.

Chapter 6: Results Case Studies RQ2

6.1 Case 1

The first case study is conducted at an international tyre manufacturer with production sites in Europe and Asia. The plant in Enschede produces three different types of tyres: passenger car tyres (6,400,000 per year) agricultural tyres (543,000 per year) and bicycle tyres. Currently, the organization is in the early implementation phase towards Smart Industry. The ICT Manager participated in the study.

Definitions

Smart Industry according to the international tyre manufacturer:

"Doing things smarter than you are used to, by taking actions based on many detailed information (data) and to automate tasks. At the moment humans have the overview and perform tasks based on observations. Within Smart Industry this process will be automated whereby the machine will take action when something e.g. moves." (ICT Manager, personal communication, April 2017)

Internet-of-Things: According to the ICT Manager "the enabler for Smart Industry is Internet-of-Things. Internet-of-Things are sensors that are connected with each other via a network and communicate with a server" (personal communication, April 2017). This network can be the internet or for example a LoRa network which is used to bridge greater distances between objects.

Initiation phase: Business Drivers and Objectives

It is the ambition of the international tyre manufacturer to grow into the global top ten tyre manufacturers. In order to achieve this position, the delivering of tyres to car manufacturers is mandatory (OE-deliveries). To become an OE supplier will only happen after an intensive OE-certification program, whereby high product quality is from utmost importance. Therefore the ability to track and trace the total manufacturing process is one part of the requirements during the certification process.

The OE readiness became the trigger for the organization to have a look at the possibilities of Smart Manufacturing. Apart from getting the OE-certification, the organization aimed for solutions that are beneficial for them as well such as: improvement in quality, more efficient production process and planning.

Smart Ideation phase:

To become OE-ready a track and trace system through the whole production process needs to be implemented, whereby each batch of output can be traced to its input. The implementation of the aforementioned track and trace system is complicated due to the complex production process involving different machines to create tyres. See below the simplified version of the production process of a tyre in the organization.

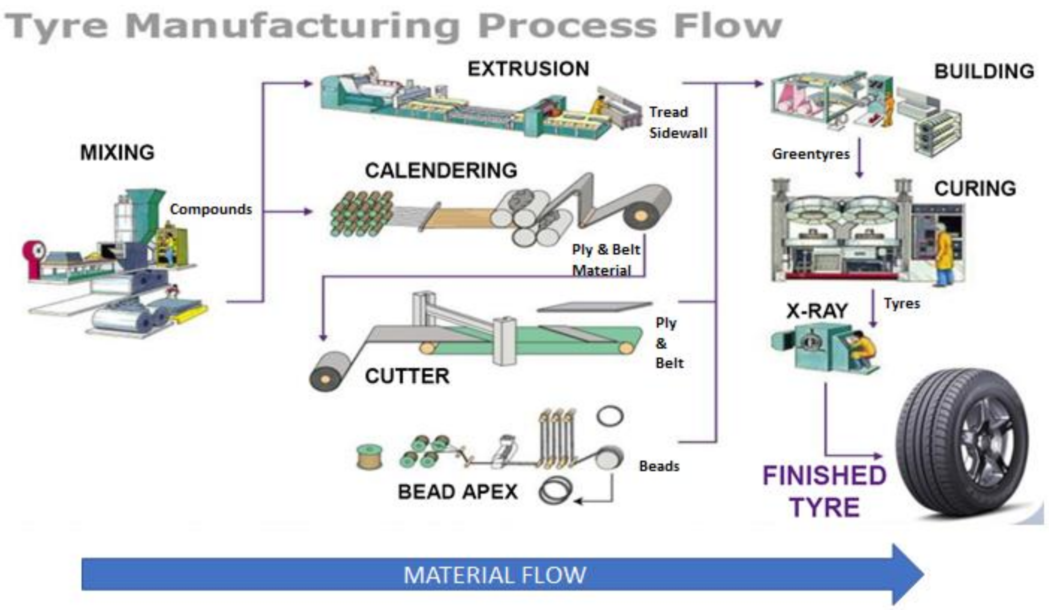


Figure 11: Tyre production process at the case study organization.

Smart Industry can be of help by adding a barcode or RFID chip to each pallet with input and output. The machine is able to read the barcode and decides if the ingredients on the pallet can be added to the mix in the machine. If not, the machine closes the valve and rings an alarm. The output of the machine is placed on a new pallet provided with a charger ID and moves to the next machine, in this way a genealogy of all processing steps will be created. Whereby every output can be traced to its input. Furthermore, it becomes interesting to combine the data to the temperature, pressure, speed or other relevant production parameters, whereby a process analyst can analyse the data and explain the variation in the process. Identifying relationships between a specific parameter and the uniformity of the product can improve the product quality by controlling for the most important parameters.

Furthermore, the ICT manager sees great potential in smart tyres. Adding a RFID chip to tyres enables the organization to remotely read tyres. The collected data can be used for improvements in the product itself or to add services for the customers. Combing the data to car specific data will be ideal (such as, mileage, speed, traffic or weather conditions). In this way information can be obtained about the performance of the tyre under specific circumstances.

Smart Idea Conversion: Assessing the impact on the model of Porter & Heppelmann

Looking at the dimensions of the framework of Porter & Heppelmann in order to create a smart product or production process, some challenges are identified. Looking at the smart tyre, the main challenge according to the tyre manufacturer, is to attach the chip in such a way to the tyre that it sticks. The chip need to resist pressure and heat in the production process but need to remain in the same position as well when the driver drives more than 100 kilometers per hour. Furthermore, combining RFID chips with embedded sensors becomes a challenge, whereby external expertise of a chip supplier is required. The connectivity need to be stable and able to bridge the distance to the board computer. Looking at security, the chip may not affect the quality or safety of the tyre. Furthermore, different data collection and privacy laws affect this innovation since the tyres are distributed all over the world and especially when the aim is to couple the data to car specific information, the question rises ‘who is the owner of the data?’ Therefore the impact in this area is expected to be high. Looking at the smart production process, the impact in the different areas of the framework are quite neutral since many requirements are already present. The machines already contain sensors that measure important parameters, however until now the data is never used or coupled for product or service improvements. Furthermore, a stable communication network is available through the plant that can transmit the generated data towards the cloud. Here, databases are already present to collect and manage the data. However, the biggest challenge for this innovation becomes the data analysis in order to find the critical process parameters that explain the variation in the uniformity of the product. Again, this area requires external expertise, since the required knowledge and skills are not available in the organization. Looking at the integration with the core business systems, the ICT manager foresees a necessary change in the current ERP system. The ERP system is a transaction driven system that needs to be changed into an event driven system, whereby every scan of a barcode triggers an action based on predetermined logic.

Overall, the main challenges for the organization are in the product, identity and security and cloud area. These challenges are in terms of data analysis, data protection laws and creating sensors or chips that sticks to the rubber under all circumstances. These challenges requires external expertise, since the knowledge and skills are not available in the organization. Furthermore, a distinction can be made between product and process innovations, whereby process innovations for the organization are less challenging than the product innovation.

Evaluation

The steps are considered as useful and adequate during the innovation process towards Smart Industry. However, according to the ICT Manager the connectivity is a very generic construct in the framework. “It would be useful to consider the availability, quality and the ability to bridge great distances, since our plants are located at remote sites over the world as well” (personal communication, April 2017). Furthermore, standardization in several elements is important to consider to improve the viability of the innovation. Lastly, privacy and data collection laws are missing at the identity and security area, especially for international organizations this aspect becomes important.

6.2 Case 2

The second case study is performed at an international hose pump manufacturer that produces hose pumps for different industries all over the world. The Managing Director and Manager Engineering participated in the interview. The organization is in the research phase towards the Smart Industry, whereby Smart Industry opportunities are investigated which could contribute to their organizational performance. However, the innovation process is complicated by the fact that the different offices have no direct contact with the customers. A sales office in America is responsible for the client-facing activities. Therefore, the current office lacks information about their customers’ needs which in turn complicates their product innovation activities.

Definitions

Smart Industry:

According to the Director: ‘Smart Industry means Smart Manufacturing whereby products and processes are made smart with new digitalization techniques and data driven actions’ (personal communication, May, 2017).

Internet-of-Things:

‘IoT is for us the technology that enables the connection of products and machines via the internet, whereby data can be send and received from the object’. ‘In our organization Internet-of-Things is seen as the facilitator of becoming smart’. (Manager Engineering, personal communication, May 2017).

Initiation phase: Business Drivers and Objectives

Currently, the organization is one of the leading companies over the world regarding Hose Pumps. However, within two years their patent expires, which probably result in more competition. In order to stay relevant and to sustain their position as a leading manufacturer of Hose Pumps, smart industry became a factor of interest. The objective became to increase product reliability and to reduce the cost of ownership for clients in order to differentiate from the competition.

Smart Ideation phase

Creating a smart pump that enables predictive maintenance service became the end result of the Smart Ideation brainstorm. Offering predictive maintenance gives the manufacturer the opportunity to look beyond selling hardware only, and to add value-services that guarantee recurring revenue. This will transform their business model from product-oriented towards service oriented. Furthermore, it will contribute to the long term existence as 'smart products' with built-in sensors and data capture functionality are expected to become the standard in the future. The smart pump will eliminate unnecessary maintenance tasks, reduces unplanned downtime and extend the pumps life cycle resulting in an increase in the customers' overall productivity and profitability. Offering predictive maintenance as a service enables the organization to offer their product with an uptime guarantee and provides them with real-time usage information that can lead to more product or service innovations. So, looking at the opportunities framework, the initial focus will be on the product which is in this case the pump. The pump will be designed in such a way that it will achieve the third level of smart product capabilities: optimization. Thereafter, the smart product becomes the enabler for creating the smart service: predictive maintenance.

Smart Idea Conversion: Assessing the impact on the model of Porter & Heppelmann

In order to convert the idea into a tangible service several steps need to be taken. The impact on the product level is considered to be high since the pump needs to be equipped with embedded sensors that measure relevant parameters such as temperature, speed and pressure. The main concern of the organization is the reliability of the sensors since the pump is part of a greater process or machine in the clients production line. Furthermore, the reliability can be affected due to grease on fingers that touch the sensors or when the pump is switched on and off. The interviewees expect the need to form a partnership with a sensor supplier since the required knowledge and skills are not available within the organization. Looking at the impact on the connectivity level, the organization foresees some issues with clients on remote locations, where no communication network is available or with limited quality. Looking at the product cloud where the data can be stored, managed and

analyzed, the impact will be high since the current organization is not organized for centralized data collection. At the moment data is generated, but both interviewees indicated to have no idea where the data is stored and if action is taken. External expertise is required to facilitate this process. The impact on identity and security is expected to be high, since capturing real time usage information of the pump can create the risk for clients to lose their warranty. This can affect the willingness to share information or to use the service at all.
Looking at the external information sources, the pump interacts with other machines in the production process of the client, however getting access to the data of those machines is complicated but relevant, since it can influence the performance of the pump.

Overall, there can be said that implementing the smart idea of predictive maintenance in the pumps requires the expertise and skills of partners in several steps of the framework. Furthermore, several practical concerns are highlighted such as the need for reliable measurements and data, the privacy concerns of customers in terms of warranty, the availability and quality of the network communication at the customers site and the interaction of the pump with other machines at the customers site. These identified main challenges need to be overcome for successful implementation.

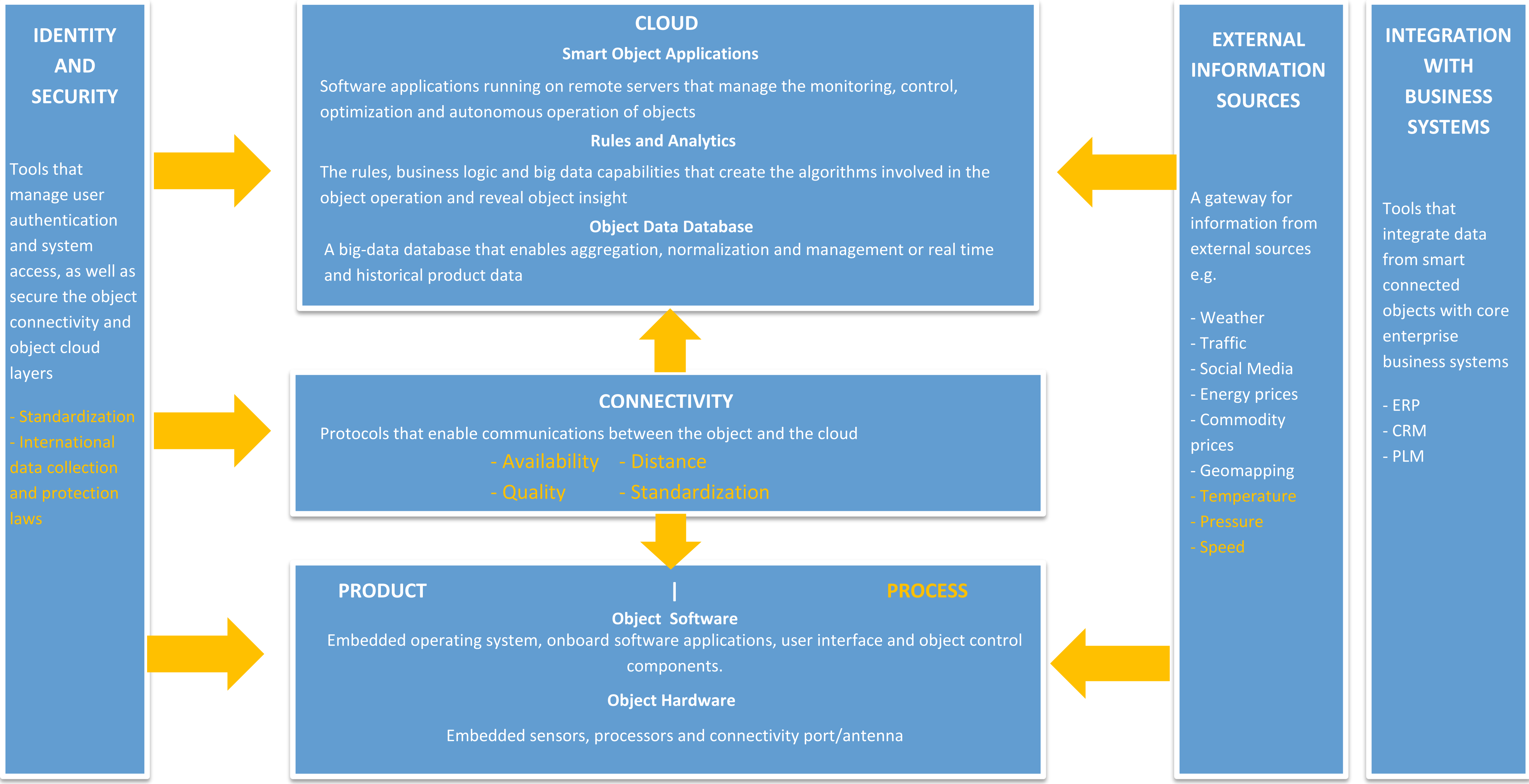
Evaluation

The steps are considered as helpful since the manufacturer is currently in the research phase towards Smart Industry. 'Mapping our ideas in a systematic way via every angle involved, helped us to identify necessary changes and to make our ideas concrete'.
However during the analysis it became clear that in almost each area external expertise is required. 'For us it would be helpful to select one partner who in turn offers a complete value proposition including (other) relevant partners specialized in one of the other main areas'.

Innovation steps / Case	Initiation phase		Smart Ideation	Smart Idea Conversion				
	Business Drivers	**Business Objectives**	**Opportunity framework** - smart product - smart process - smart service	**Object (product or machine)**	**Connectivity**	**Cloud**	**Identity & Security**	**External Information Sources & Integration**
Case 1	- Become in top 10 tyre manufacturers - Increase sales market	- OE-ready - Improve product quality and efficiency in production process	**- Smart process:** Track & Trace system in production process **- Smart product:** Smart Tyres	- Add RFID chips with embedded sensors and connectivity port to the object in such a way that it remains in same position. → requires external expertise.	- Evaluate existing standardization, availability, quality and ability to bridge distances.	- Find the critical process parameters → external expertise - Create business logic to develop an algorithm that adjust the parameters when necessary - Create genealogy of all process steps	- Evaluate Standardized protection methods - Examine if international data collection laws affect solution - Determine the owner of the data	- Adjust ERP system from transaction driven to event driven - Connect the smart tyre to car specific information (speed, mileage or weather conditions)
Case 2	- Expiration of patent - Stay no. 1	- Increase product reliability - Reduce cost of ownership	**Smart product resulting in Smart service:** - Smart pump with Predictive Maintenance Service	- Add embedded sensors to measure critical performance indicators - Ensure data reliability	- Evaluate existing standardization, availability, quality and ability to bridge distances.	- Create algorithms that involve the business logic when maintenance is required.	- Find out the willingness of customers to share the real time usage data	- Connect the data of the pump to interconnected machines in the production line of the client

Table 9: Overview executed method in two cases

Figure 12: Extended Framework Porter & Heppelmann, (extensions in orange)



Chapter 7: Conclusion and Discussion

The current study is about the adoption of Smart Industry and is divided in two parts that complement each other. This section presents both conclusions.

The first part explores the Smart Industry concept with Internet-of-Things as the core technology and studies how Perceived Usefulness, Perceived Ease of Use, Attitude and Behavioral intention are correlated and capable of predicting the manufacturers' attitude, which in turn predicts behavioral intention to implement Internet-of-Things in their products or production processes. The descriptive statistics show that most of the organizations are still in the research phase towards the Smart Industry which means that they are researching what the Smart Industry and Internet-of-Things can bring them and how it can be utilized in their products or production processes. The majority already allocated budget for investments towards the Smart Industry (44,2%). Others are planning to do so in the near future (30,2%) and the minority did not allocate budget and is not planning to in the near future (25,6%). Furthermore, most organizations see the lack of employee skills and knowledge about the Smart Industry as the major challenge towards implementing the concept.

The central research question in this part was defined as follows: "What is the current intention of Dutch manufacturing companies to implement the Internet-of-Things technology into their products or production processes?" The scores on attitude and behavioral intention show a mean score of 4.30 and 4.13 respectively on a scale of 1 to 5 which is considered as positive. The latter indicates that companies have a positive attitude and intention to implement Internet-of-Things. As the Smart Industry and the possibilities of Internet-of-Things are still in its embryotic phase, future research may conclude differently.

The results of the TAM study confirmed the expected high behavioral intention and low perceived ease of use, indicating the difficulties organizations face for Smart Industry adoption. Therefore, by means of an Action-Design-Science study a method is derived from business innovation literature, which answers research question 2: "How to achieve a business innovation towards Smart Industry for manufacturing organizations?" The method represents the necessary steps manufacturers need to take for Smart Industry adoption, resulting in: Initiation, Smart Ideation, Smart Idea Conversion and Implementation. The steps are guided by feedback loops and frameworks such as the opportunity framework, and the extended framework of Porter and Heppelmann to transform the idea in a tangible product, process or service. Moreover, the current method creates the possibility to align business objectives with smart technical requirements, whereby challenges can easily be mapped and first steps towards implementation can be identified. The two case studies demonstrated the use of the method and identified challenges that are supported in literature. For example, during the idea conversion phase the need of new skills such as software development, data analytics and online security expertise were the main challenge to convert the idea in a tangible product, process or service. A similar conclusion is found by Porter and Heppelmann (2015).

7.1 Limitations and Future Research

The first part of the study made an effort to explore the concept of the Smart Industry and the acceptance of Internet-of-Things as the core technology. Due to its explorative nature and the newness of the topic, the model is limited to the original constructs of the TAM model which is suitable for the purpose of this part. Extending the research model with additional constructs on data privacy, compatibility or trust might provide a more comprehensive research model. Moreover, the relatively small sample size has limitations with regards to external validity as results cannot be generalized to different populations. Next to that, the small sample size has its limitations for performing a factor analysis, however since the original model and constructs were used which are tested and confirmed by several researchers in longitudinal studies, the analysis is performed with the small sample size and no deviating results were found. Furthermore, when testing user acceptance in an early stage of the development process, it is a challenge to realistically express what the proposed system will look like (Davis et al., 1989, p. 1000). As the Smart Industry and the Internet-of-Things are still in its embryotic phase, different perceptions and understandings exist among the organizations. Moreover, Internet-of-Things technology can be used for many purposes. Therefore a very generic definition is given that can apply for all organizations. However, the latter may cause different results when a specific application of Internet-of-Things is evaluated.

Looking at the second part of the research, the subjectivity of the interviewee in the case study is a limitation which is caused by the methodology. The current research limits itself to one interview at a manufacturing company, which can cause a biased view of the identified solutions and challenges, due to knowledge and expertise. The results would become more accurate and complete when they are validated with more employees from different departments of the same company. Furthermore, a limitation to the external validity of the sample used need to be taken into consideration when interpreting the results. The sample size of 2 different cases, each in a different phase towards the implementation of Smart Industry is too less to generalize the results for all manufacturing organizations in all phases determined towards the adoption. Future work can test if the method holds in different settings, and can even be further developed with best practices of organizations that already fully implemented Smart Industry.

Lastly, the second part applied Action Design Research to analyze the problem and to develop a solution. This research method is relatively new which became mainstream with the publication of Sein et al. (2011). However, until today the amount of scientific papers in which ADR has been applied is limited. ADR is a blend of design science and action research. ADR differs from design science by the approach to conduct the problem analysis, solution design, implementation and evaluation synchronous and operationalized at the same time. The main advantage of ADR is the iterative and agile way of doing research and the close similarity to the engineering process, which is ill-structured, but an effective approach to develop solutions to problems. However, the ill-structuredness is also the downside of the ADR approach, which makes it hard to document and repeat in other situations. Furthermore, within the ADR approach the researcher is both the observer and the person who implements the change, which might cause a researcher bias.

7.2 Practical Implications

Results of this study provide insights for IoT solution developers, consultants, researchers and organizations interested in the transition towards Smart Industry. The extensive literature review described the concept of Smart Industry with its drivers, opportunities and challenges which is valuable information for Innovadis to get insight in their customers market. The information can be used for the required change in the current sales approach. Furthermore, the TAM study identified the actual intention of the manufacturing industry to adopt Internet-of-Things in their products or production processes, which can form input or determine the focus for Innovadis' product development. Moreover, this research provides as one of the first a method to implement Smart Industry which can be used by Innovadis to help clients during the transformation. Furthermore, it is recommended during the transformation to form a cross functional team that is involved in the whole initiative to avoid loss of knowledge and speed as Smart Industry digitizes the whole value chain. In line with the previous recommendation, Smart Industry solutions require different specializations which are often not fully embedded in the organization, therefore partnerships or better called a 'value network' is necessary to create Smart Industry. It is recommended for Innovadis, as a solution provider, to form partnerships with organizations specialized in one of the required knowledge fields in order to offer one integrated value proposition for Smart Industry to manufacturers.

7.3 Theoretical Implications

Besides the aforementioned practical implications, these findings have important theoretical implications. Looking at the research model of the TAM study, all hypothesis, except H2 are supported. So, the proposed research model is partially supported. Results of the present study indicate that only PU is a significant predictor to measure the attitude towards implementing Internet-of-Things. PU alone explains 63.6% of the variance in Attitude which is 1% less when PEOU is included (see table 14, appendix 2). PEOU has no significant effect on attitude, a similar conclusion is also recognized by Vijayasarathy (2004) in a TAM-study on online shopping. So, in a Smart Industry (IoT) context, the construct PEOU is not a significant predictor for attitude. Furthermore, by combining Smart Industry literature with Business Innovation literature a method for Smart Industry adoption is constructed. The proposed framework of Porter and Heppelmann (2015), which guides the Smart Idea conversion phase, is extended with empirical insights from the current study. The main focus of the original framework is on smart connected products. However, Smart Industry affects more than only products. Machines are a crucial component in the daily operation of manufacturers and have high potential to become smart. Therefore the extended framework has a broader focus which includes products and machines. Furthermore, the connectivity level is a very generic construct in the original framework, assessing the connectivity in terms of availability, quality, distance and standardization makes the connectivity level more specific and relevant for users. Moreover, machine specific data is added to the External Information Sources to make the framework more suitable in a manufacturing context, and lastly as both case study organizations operate internationally the identity and security construct needs to include international data collection and protection laws. However, the framework remains a subject to change as Smart Industry is still in the embryotic phase. Future research can develop the method even further when more information comes available or when the method is operationalized in different settings.

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Appendices

Appendix 1: Variables and measures of the survey

Variable	Measure	
Perceived usefulness (PU)	Implementing IoT would make it easier to collect customer or production data	PU1
	Implementing IoT enables us to deliver and optimize personalized services	PU2
	Implementing IoT will optimize the production process in terms of efficiency and flexibility	PU3
	Implementing IoT would improve the quality of our product	PU4
	Implementing IoT helps to optimize our business performance	PU5
	Companies who integrate IoT have a stronger competitive advantage than companies that don't	PU6
Perceived Ease of Use (PEOU)	Our organization has the capabilities and knowledge to succesfully implement IoT	PEOU1
	Managing structuring and analyzing the generated data will be easy for us	PEOU2
	It is impossible to implement IoT without expert help	PEOU3
Attitude (A)	All things considered implementing IoT is a good idea	A1
	Implementing IoT is a smart idea	A2
	Implementing IoT is of added value to our organization	A3
Behavioral Intention (BI)	My organization intent to have implemented IoT in the near future	BI1
	My interest in IoT will increase in the future	BI2

Appendix 2: SPSS Output

Table 10: KMO and Barlett's Test of BI, A, PU and PEOU

Scale	KMO	Barlett's Test sign at
Behavioral Intention	0,500	0,000
Attitude	0,682	0,000
PU and PEOU	0,664	0,000

Table 11: Eigenvalues Dependent Variables

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
BI			
1	**1,900**	**95,013**	95,013
2	,100	4,987	100,000
A			
1	**2,441**	**81,373**	81,373
2	,402	13,383	94,756
3	,157	5,244	100,000

Extraction method: Principal Component Analysis

Table 12: Component Matrix Dependent Variables

Scale	Component 1	Component 2
BI1	,975	
BI2	,975	
A1		,901
A2		,858
A3		,945

Table 13: Eigenvalues Independent Variables

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
PU + PEOU			
1	**3,703**	**41,147**	41,147
2	**1,899**	**21,104**	62,250
3	,969	10,771	73,021
4	,799	8,879	81,900
5	,620	6,885	88,786
6	,438	4,866	93,651
7	,248	2,758	96,409
8	,209	2,318	89,727
9	,115	1,273	100,000

Extraction method: Principal Component Analysis

Table 14: Regression total variance explained PU --> A

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,797[a]	,636	,627	,43343

a. Predictors: (Constant), PU