Rotterdam School of Management
Erasmus University

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Stunted Innovation: How large incumbent companies fail in the era of supply chain digitalization

RSM - a force for positive change

STUNTED INNOVATION:

HOW LARGE INCUMBENT COMPANIES FAIL

IN THE ERA OF SUPPLY CHAIN DIGITALIZATION.

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STAGNERENDE INNOVATIE:

HOE GROTE GEVESTIGDE BEDRIJVEN FALEN

IN HET TIJDPERK VAN TOELEVERINGSKETEN DIGITALISERING.

Thesis

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To my family.

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List of Abbreviations

AI	Artificial Intelligence
API	Application Programming Interface
ERP	Enterprise Resource Planning
I4.0	Industry 4.0
IIoT	Industrial Internet of Things
IoT	Internet of Things
IT	Information Technology
MRP	Materials Requirements Planning
MRPII	Manufacturing Resource Planning
SC	Supply Chain
SCM	Supply Chain Management
RPA	Robotic Process Automation

STUNTED INNOVATION: HOW LARGE INCUMBENT COMPANIES FAIL IN THE ERA OF DIGITALIZATION.

"I do not believe in process. The problem is that at a lot of big companies, process becomes a substitute for thinking. You're encouraged to behave like a little gear in a complex machine. Frankly, it allows you to keep people who are not that smart, who are not creative".

-Elon Musk

1. Introduction

How do large companies implement new technologies? How do intra-company organizations absorb digital innovations? What role do management, employees, processes, and infrastructure play in the success of developing and implementing digital technologies to make operations more efficient? This dissertation aims to shed light on what happens behind the curtains of large incumbent organizations along the process of implementing new digital technologies and provides insights into the effects of inter- and intracompany digitalization based on empirical evidence from supply chain operations in industrial and corporate settings.

The research work included in this dissertation has contributed to fill a gap in the supply chain integration literature concerning the intra- and inter-organizational effects of digital technologies on supply chains at large Tier 1 corporations. This dissertation provides an insightful initial structuring of the key challenges for the implementation of industrial digitalization solutions in supply chain management. It makes contributions to advance our understanding of absorptive capacity and technology adoption theories in one area that provides further exploration possibilities in varied contexts.

Although some recent work has studied the potential use of new digital technologies in operations management, they have largely addressed only OEM companies and none of them have used empirical data nor have studied inter-and intra-company effects of new digital technologies.

1.1 Research motivation

After completing my master's degree in Industrial Systems, Manufacture and Management at the University of Cambridge with a dissertation about inter-company open innovation between Porsche AG and BMW GmbH, I spent 10 years working for large transnational manufacturing companies in diverse locations. As an entry-level employee and later as Senior Manager I constantly experienced the implementation of new policies, processes, technologies, and major organizational restructures. These events were sometimes successful, other times a large-scale failure but they always had a deep impact on the company worldwide; internally, and externally.

Therefore, my intellectual curiosity deepened in the direction of analyzing and understanding how companies can successfully implement new technologies into its diverse internal organizations and with external partners. I got particularly driven to explore cases of failed implementations to detect the factors that contributed to unsuccessful results or undesired effects.

"This is something I got wrong. I thought it was all about technology. I thought if we hired a couple thousand technology people, if we upgraded our software, things like that, that was it. I was wrong. Product managers have to be different; salespeople have to be different; on-site

support has to be different. And I just think it's infecting everything we do. It's infecting our own IT. It's infecting our own manufacturing plants. It's infected everything we're doing, I think in a positive way."[1] *(GE's Jeff Immelt on digitizing in the industrial space, McKinsey & Co., 2015).*

1.2 Background

The world keeps on evolving every day, technology changes every single aspect of our lives at a staggering speed. Industries and companies have therefore to find pathways to respond to new market needs and more challenging customer's demands. Many industries like the automotive industry are facing important technological, environmental, and demographic challenges up to the extent that some long-established companies have started to make great investments in digital alternatives to ease the burden on their operations.

On the other hand, production systems are changing at the same increasing speeds, especially in the automotive business where leading manufacturers are promptly converting their plants to Industry 4.0 enabled production floors. Machines are being integrated into digital virtual production systems where operations are facing much more automation than ever before. Production systems are progressively making use of new interfaces which enable them to tell machines what to produce every hour according to the requirements of the customer, an Original Equipment Manufacturer (OEM) final assembler. Quality defects, machine failures and production requirements need to be monitored on the spot to make the immediate appropriate adjustments to the production plan, it is the era of automation, bots, and artificial intelligence.

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[1] **Jeff Immelt, GE CEO, 15-03-2017.** https://www.mckinsey.com/business-functions/people-and-organizational-performance/our-insights/ges-jeff-immelt-on-digitizing-in-the-industrial-space

1.2.1 Supply Chain Management

As defined by (Simchi-Levi, Kaminsky, & Simchi-Levi, 1999) and cited by Gunasekaran & Ngai (2004): “Supply Chain Management (SCM) is a set of approaches utilized to effectively integrate suppliers, manufacturers, warehouses, and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize systemwide cost while satisfying service level requirements”.

The origins of supply chains can be dated back to ancient civilizations like the Mayan and Roman Empires which built roads to move goods and trade; they also established systems to manage crucial activities like agriculture, labor and armies. Along the centuries, the mass production and transport of parts for weaponry contributed to set the foundations of today’s supply chains. In the 20^{th} century the rapid growth of the automotive industry and the global trade demanded improvements in procurement, production and shipping. In 1908 the serial production of Henry Ford´s T-model officially commenced the continuous evolution of supply chain management in the automotive industry which was later greatly influenced by the creation of Toyota’s production systems since the 1950’s.

Supply chain management is a key factor for effectiveness, competitiveness and profitability, previous research work has developed frameworks for measuring SCM’s strategic Key high Performance Indicators (KPIs) covering each phase of SCM: Planning, Sourcing, Production, Delivery and Customer Service (Gunasekaran, Patel, & Tirtiroglu, 2001).

Barcoding, which was originally patented in the 50’s but commercially used since the 70’s, helped to enable the monitoring of global supply chains for the first time. Barcoding and now RFID have provided visibility to inventory and production management, however, they imply risks in relation to data security vulnerabilities (Tu, Zhou, & Piramuthu, 2021).

MRP (Material Requirements Planning) was developed in the 60`s in partnership with IBM as an evolution to previous versions of computerized systems for manufacturing and inventory control; MRP has enabled the planning and scheduling of materials (Robert Jacobs & “Ted” Weston, 2007). In the early 80`s, the integration of information systems grew as a result of developments in computers with higher storage capabilities; MRPII (Manufacturing Resource Planning) offered new capabilities like enhanced shop floor management, resource management, forecasting, and detailed cost reporting focusing on greater process control and overhead cost reduction (Robert Jacobs & “Ted” Weston, 2007).

In the 90’s ERP (Enterprise resource planning) offered major improvements in software and architecture enabling integration within and across different functional areas (Robert Jacobs & “Ted” Weston, 2007). The data centralization and sharing capabilities provided by ERP systems has contributed to companies’ never-ending optimization efforts. With the wide adoption of ERP systems, the integration and communication within and among supply chain partners became a reality. Collaborative communication and control over supplier’s implementation of best practices contributes to continuous supplier performance improvement (Joshi, 2009).

The role of IT in supply chain management has become increasingly important after shifting from a management enabler to the monitoring of every activity to facilitate decision making processes (Gunasekaran et al., 2001). IT infrastructures integrated into Supply Chains can significantly increase productivity, performance, and revenue due to greater information share among the Supply Chain partners which enable improved demand planning and a more precise materials management (Patnayakuni & Seth, 2016).

The progress made on global supply chains, enabled the possibility of outsourcing and offshoring components and subassemblies, however, the profitability of internationalizing manufacturing to low-cost-locations (LCL) could be affected by the costs of coordinating the supply chain from abroad (Casson, 2018). Global manufacturing networks in the automotive industry have originated different arrays of supply chains where materials and components can flow from plant to plant across different countries, regions and continents (Erfurth & Bendul, 2018). However, if complex and critical components are outsourced to unsuitable or unexperienced suppliers, costs could increase for the company whereas profits and knowledge would go to its suppliers (Denning, 2013). In complex supply chains like in the automotive industry, sourcing key interdependent components to different suppliers, can critically affect the quality of the final product (Agrawal, Muthulingam, & Rajapakshe, 2017).

Data is power; the analysis of data obtained through internet-enabled supply chains can contribute to achieve higher levels of efficiency and quality at the time of supporting supply chain integration and innovation (MacCarthy, Blome, Olhager, Srai, & Zhao, 2016). IT has a great influence on SCM effectiveness, however, successful strategic IT systems are hard to implement in SCM as they span to internal and external operations including other partners; therefore, metrics are needed to measure performance (Gunasekaran et al., 2001).

In environments where customer needs changes rapidly, a higher supply chain performance would have a direct positive effect on overall firm performance. But the success factors for IT-enabled supply chains do not entirely rely on the mother company, it is also imperative that the supplier base's capabilities and infrastructure are compatible with the new technologies being implemented (Roh, Kunnathur, & Tarafdar, 2009).

As supply chains become more complex, the importance of effective IT management systems that support a company's supply chain strategy becomes more critical (Qrunfleh & Tarafdar, 2014). In today's supply chains, data analytics and new technologies like blockchain, big data analysis, and IoT-based real-time monitoring systems are becoming the hotspot for achieving optimization and higher performance; however their real long-term effectiveness is yet to be investigated (Miller, Ganster, & Griffis, 2018; C. G. Schmidt & Wagner, 2019). Digitally enabled supply chains have become a firm's critical area where IT-enablement can directly improve performance in global operations. On the other hand, intangible resources such as managerial skills are key drivers of performance improvement in digitally enabled supply chains (Dong, Xu, & Zhu, 2009).

Supply chains keep on evolving, these evolutions are triggered by different factors including product innovation (Gunasekaran & Ngai, 2005) and changes in the global economy (Casson, 2018). It is up to each company to decide how to cope with the new challenges and industry demands, nonetheless, companies have found in digital technologies a promising hope.

1.2.2 Supply Chain integration

Supply Chain integration has attracted the attention of both the industry and researchers in the last years. There is a constant increasing need for improving operational performance, risk and cost reduction and technology-based optimization of Supply Chain Operations. As defined by Flynn & Zhao (2010): "Supply Chain Integration can be defined as the degree to which a manufacturer strategically collaborates with its supply chain partners and manages intra- and inter- organizational processes to achieve effective and efficient flows of products and services, information, decision and transactions in order to maximize value to the customer".

Supply chain integration has proven to provide positive effects on performance improvement within the organization and along the whole chain. In initial studies, the integration had been focused on external integration which includes the interaction between the firm, suppliers and customers (Frohlich & Westbrook, 2001). Furthermore, internal integration is a strong contributor of customer and supplier integration creating a positive effect on financial performance (Yu, Jacobs, Salisbury, & Enns, 2013).

It is not a surprise that Supply Chain Integration has been studied during the last years as a means to know and understand its effects and possible benefits for diverse industries. Integration induces new challenges within the firms which involve major cultural changes in sensitive areas including trust, collaboration an partnerships (Braunscheidel & Suresh, 2009). In some big widely networked industries like the automotive, an assembling firm depends on hundreds of suppliers, strict customer requirements, tight timings and complex supply chains. Therefore due to the high interdependence of all supply chain actors and the complexity of production components and sub-assemblies, it's impossible to survive without some kind of integration or deep collaboration as no member of the network have the knowledge or expertise to produce a complex product by itself (Lockström, Schadel, Harrison, Moser, & Malhotra, 2010). Close and intense collaboration is needed to overcome market's and industry's challenges. When dealing with a global network of suppliers, understanding its cultural norms and values will help to increase trust and build stronger and more successful relationships and improve the performance of the supply chain (Cannon, Doney, Mullen, & Petersen, 2010).

Since the 1980's, with the emergence of personal computers, there have been different paths by which Supply Chain Integration has been targeted. A common practice amongst different manufacturing industries have been EDI (Electronic Data Interchange) systems whose properties are to enable the electronic transfer of documents between two partners (e.g. purchase orders), however, there is a greater need to support the information flow with faster and more efficient technologies where process data can be shared in real-time. EDI, although efficient, is unsuitable as communication technology for the new challenges of data flow (Premkumar, Ramamurthy, & Saunders, 2005)(Premkumar et al., 2005).

It is hard to attain a successful supply chain by not having the support of IT as firms constantly move into global scenarios and multi-region environments (Gunasekaran & Ngai, 2004). It has been proven that IT infrastructures enable firms to develop Supply Chain Integration capabilities and this integration derives into substantial and continuous improvement of company's operational performance and increase of revenue (Patnayakuni & Seth, 2016). IT-enabled integration allows the transfer of data on a real-time basis which allows firms to effectively manage risks and make critical decisions on time. Operational costs can be reduced by improving efficiency, enabling real-time communication, and avoiding delays, planning failures and errors (Tridas Mukhopadhyay & Kekre, 2002).

Studies suggest that IT systems influence the effectiveness and success of an integrated supply chain (Gunasekaran & Ngai, 2004; Lockström et al., 2010), there is also evidence about the benefits of Supply Chain Integration (Droge, Jayaram, & Vickery, 2004; Yu et al., 2013), however, previous studies have been based on older IT platforms which still require constant human input such as ERP and EDI (Gunasekaran & Ngai, 2004).

Although it has been found that this integration, supported by IT enablers, positively contributes to operational excellence, revenue growth and overall performance could be further extended by sharing product ideas, trainings and technical knowledge through internet-bases systems (Frohlich & Westbrook, 2001; Patnayakuni & Seth, 2016); Industry 4.0, artificial intelligence, cognitive technologies, blockchain and overall IoT systems are providing new business models and complex settings under which Supply Chain Integration is taking place. These digital innovations are challenging the way we used to understand Supply Chains and are, in parallel, bringing new variables, environments and effects that were not regarded before.

1.2.3 Industry 4.0

Industry 4.0 or I4.0, the so-called 4th Industrial Revolution, aims to fuse the production's physical world with the virtual world of internet and information technology. The introduction of Industry 4.0 in the supply chain will open the doors to develop new business models by meeting new business needs; it will substantially increase the exchange of data at intra- and intercompany environments. Organization will have to be reconfigured to meet the new digital requirements; capabilities, processes and tools will change with the use of greater amounts of data (Geissbauer, Weissbarth, & Wetzstein, 2016).

The term Industry 4.0 was coined to describe the 4th revolution in manufacturing industry considering the use of steam-powered machinery as the first revolution, the second comprised electricity-powered serial production and assembly lines, and the third integrated computers and automation to production systems.[2] Industry 4.0 creates digitally enabled productive systems through sensors, data analysis, machine learning, predictive analysis and the digital networking of physical machines and production lines. The collected data can be further analyzed and shared with internal departments and external partners with the purpose of optimizing operations.

In the digitalization era, as extensive data exchange occurs among members of the supply chain, intercompany data protection and confidentiality becomes a critical aspect to consider. Communication among companies is a two-way road which must be tailored to suit each situation. Previous research has found that successful relationships are based on factors including: "a high level of mutual trust, early supplier involvement, extensive cooperation and a high level of information exchange "(Bensaou, 1999). However, it has also been found that

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[2] What's Industry 4.0?, Bernard Marr, Forbes, September 2018, https://www.forbes.com/sites/bernardmarr/2018/09/02/what-is-Industry-4-0-heres-a-super-easy-explanation-for-anyone/?sh=7c3617729788

trust can require reorientation and recalibration in order to remain in an optimal level (Stevens, MacDuffie, & Helper, 2015).

Industry 4.0 is laying a foundation stone for new unexpected developments in diverse business areas. This is causing a generalized drive at top management levels to move towards implementing digitalization and IoT initiatives as fast as possible. Moreover companies are under great pressure as the first movers are expected to reap significant benefits from their more advanced digital capabilities (Reinhard, Jesper, & Stefan, 2016). However, as the real benefits of these initiatives and effects within organizations are largely unknown, this represents a research gap that needs to be addressed.

One of the main business areas of concern in this change is Supply Chain. Over the last two decades, it has been widely discussed how supply chain optimization and supplier integration bring substantial benefits to the companies involved specially in performance (Frohlich & Westbrook, 2001) . However, after some time, this integration can reach a level of stagnation where no more benefits are tangible. In the last decades, Supply Chain integration has been attained by means of IT platforms such as ERP and EDI, however, supply chains are continuously evolving into more complex systems and so is the availability of IT solutions becoming increasingly wide and more technologically advanced (Qrunfleh & Tarafdar, 2014). Whether digitalization can contribute to supply chain integration, is also an effect that needs to be studied.

1.2.4 IoT and Digitalization in the Supply Chain

The introduction of more technology enabled products is likewise pushing the development of new operation technologies which, in turn, are impacting entire production systems including Supply Chains. Operations management is turning towards IoT to find ways for becoming more agile, efficient, and risk-reduced by means of IoT applications. Internet of things (IoT) is a newly adopted term in industry and business which refers to machines and electronic devices enabled by sensor technology connecting them through the internet for real-time data transfer.

Tools such as ERP, MRPII and JIT are not sufficient for digitizing supply chains as they do not provide real-time communication with production lines and machines. A whole re-arrangement of internal and external operations is required by means of a holistic Information System integrating IT resources, infrastructure, data, and human capabilities (E. A. Williamson, Harrison, & Jordan, 2004). However, no single integration technology can address all challenges, therefore multiple technologies have to be used according to different requirements, constraints and information systems infrastructures (Themistocleous, Irani, & Love, 2004).

Along the last 10 years these ideas have evolved into today's Supply Chain Digitalization, a holistic internet-based environment under which all Supply Chain systems, functions and players are fully connected and whose generated data is analyzed in real-time to enable quick decision-making, support risk mitigation and provide immediate reaction to disruptions, and contingencies that could endanger customer value creation. However, there is scarce availability of data based on empirical research regarding the advantages that digitalization has for Supply Chain Risk Management (Schlüter, 2017).

The Internet can provide real-time access to analyze big volumes of data which could possibly help to build stronger strategic partnerships and make better decisions. Recent research has recognized the importance of IT alignment amongst partners of the supply chain as a factor for firm's value creation. "Strategic importance of supply chain partners is a significant motivational force to drive for creating IT alignment, inter-firm integration and strategic collaboration amongst them which sets the ground for customer value creation" (Kim, Cavusgil, & Cavusgil, 2013).

Digitalization by means of IT Tools, IoT and Artificial Intelligence platforms is regarded as a possible future of Supply Chains, moreover new challenges will arise; its benefits are until now hypothetical, uncertain, and unknown. Just like IT is essential to enable Information Management in Supply Chains and contributes to alleviate supply chain issues, it may also become a new source of vulnerability and instability (Pereira, 2009). As the amount of information shared increases, selecting the right information for making decisions becomes a challenge; on the other hand, a leak of confidential strategic information and an IT system failure are critical risks to consider (Pereira, 2009). Although well planned IT integration into SCM systems will bring improved performance (Gunasekaran & Ngai, 2004), as supply chains intensify their complexity, IT applications will become more sophisticated and a fit must exist between firm's and supplier's IT capabilities and sophistication (Qrunfleh & Tarafdar, 2014).

1.3 Dissertation outline

1.3.1 Preface

The dissertation is organized in three articles that look at the digitalization and automation aspects of Operations Management from different perspectives and are analyzed through empirical work in contrasting settings by using diverse theoretical backgrounds. The main objective behind developing three articles was to study the digitalization phenomena from three contrasting but complementary angles. Firstly, an external perspective looking at how large companies can contribute to the digitalization of its suppliers and external partners. Secondly, an internal perspective describing how these large companies digitalize their internal operations. Lastly, the attention turns towards a business model perspective analyzing the exploitation and commercialization of digital technologies developed by the large company. Thereby Chapter 2 depicts the implementation of IoT technologies into a supplier's production plants by means of tools developed by its customer; the authors study this phenomenon through the Supplier Integration and Technology Acceptance lenses.

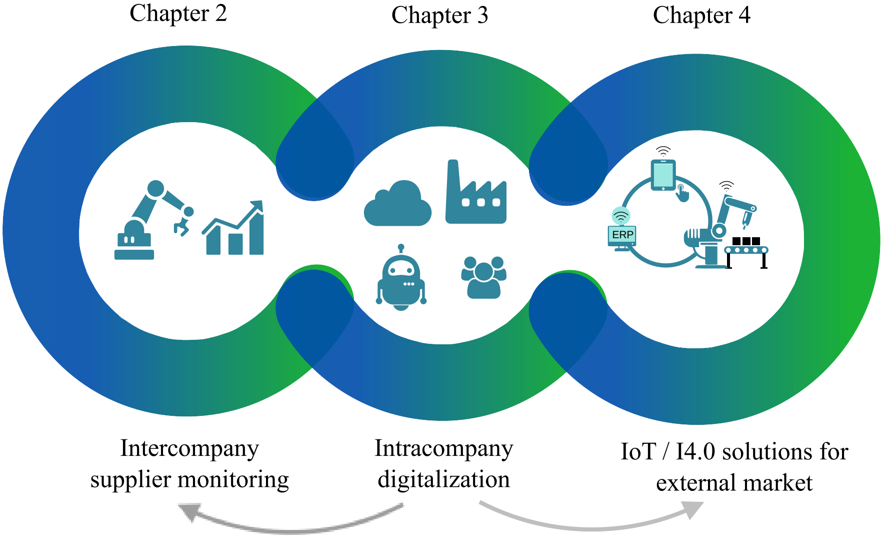
While Chapter 2 looks at the digitalization of supply chains from a company's external perspective, Chapter 3 explores the implementation of digitalization and automation initiatives in business operations within and across company´s internal organizations. The three chapters are empirical articles based on data collected through extensive interviews, company reports and working documents including company presentations.

In contrast to Chapters 2 and 3, Chapter 4 recounts an IoT product development story between a Supply Chain Management department and a start-up innovation center through a single case study aimed to provide valuable insights for practitioners and researchers about the actual hurdles and experiences of developing a new IoT-enabled solution for the external market.

Table 1.1 Summary of research articles

	Chapter 2	Chapter 3	Chapter 4
Literature background	Supplier integration and technology acceptance	Absorptive capacity	Innovation, Supply Chain Management, and product development
Type of case study	Inductive case study	Multiple case study	Single case study
Study design	Empirical	Empirical	Empirical
Data source	> 35 hours of interviews with customer and supplier employees located in 4 countries, notes, company documents.	> 30 hours of interviews with customer and supplier employees located in 9 countries, notes, company documents.	> 15 hours of interviews with the customer and supplier employees located in 2 countries, company documents.
Research question	How to implement IoT-enabled tools at the buyer-supplier interface?	How are RPA solutions being adopted and implemented in large multinational companies?	How to develop a marketable IoT solution based on an internal supply chain process innovation?

Figure 1.1 Research focus diagram



1.3.2 Abstracts

The corresponding abstract of each chapter is included in the following paragraphs:

Chapter 2 abstract

Supply chain performance crucially depends on information exchange, which is supported by IT tools as well as embedding of buyers and suppliers. IT tools formalize part of the interaction between buyers and suppliers, but boundary spanners such as key account holders, machine operators, and IT specialists continue to occupy a role as gatekeeper for IT-based information exchange. Recent IoT-enabled tools, however, do not require human control, implying that buyers and suppliers will have to deal with unprecedented visibility into their operations.

Considering this absence of human control, we ask the question: How to implement IoT-enabled tools at the buyer-supplier interface? Especially, how will suppliers be convinced to accept and properly use IoT-enabled tools? We conducted a case study of supplier machine sensorization by Bosch at one of its metal stamped parts suppliers in Mexico, and found that the intentions of Bosch to help this supplier improve, dictated how the relation progressed, despite the hugely deviating metrics that the sensor recorded and which may have led the supplier to be to deselected. We shed light on this finding by combining insights from the Technology Management literature and the theory of Embeddedness. Although the wide implementation of this IoT solution eventually failed partly due to employee reluctance at both companies, the project served as a basis for new solutions in other regions.

Chapter 3 abstract

Robotic Process Automation (RPA) materializes the possibility of humans and robots working together in the same office. RPA is a technology offering professionals with no-IT background the opportunity to program a robot that emulates the actions of humans when interacting with IT systems to execute tasks as part of a business process. RPA has been becoming a trend among new and long-established companies including IBM, GM, Bosch, and Siemens.

However, there are many questions regarding the reality behind RPA solutions, where its effects for the company-internal organization remain widely unexplored. Based on a multiple case study spanning Bosch supply chain and IT development offices located in 10 countries across 4 continents, this research explores an actual RPA adoption process which was not successful at a multinational firm and aims to provide insights into its intrinsic challenges. It subsequently discusses how the company's internal organization, rules and games of power can make technology implementations fail. This empirical study contributes by proposing a framework based on absorptive capacity theory, to explain and support the implementations of digital technologies in operational business processes.

Chapter 4 abstract

This single case study explores the process of developing a new IoT solution aimed to make supply chain operations more efficient and mitigate the risks for disruptions. Initially, this solution was developed to monitor the production lines of Bosch automotive sub-suppliers, however, it was then turned around as a new value proposition targeting a broader industrial market. In the early spring of 2017, the Bosch automotive sales department in North America was facing monetary compensation charges by one of its most important customers, a car manufacturer in the USA, due to unmet product deliveries. This was not a minor isolated incident which could be justified as a natural fluctuation of production volumes but a long-standing problem with probably serious implications to the company´s relationship with its customers and possibilities for future sales opportunities. It was found that a lack of monitoring of supplier production indicators increased the probability of having unexpected supply chain disruptions. This case explains why the development if this IoT solution was not successful.

Chapter 5

In this chapter I integrate and review the findings of the above described articles, I also provide my comments on research limitations and insights into future research opportunities.

1.4 **Practical relevance**

This dissertation provides new insights into technology management at operations practice; it is particularly relevant for supply chain management at large companies. At the time of conducting this research, the use of IoT Technologies and Industry 4.0 was being used for the first time by large incumbent companies worldwide, it was the perfect time to witness how these technologies were gaining traction and were being implemented in real-life industrial and corporate settings. Having followed the implementation of digital technologies during 4 years from the moment they were conceived as just an idea of a company’s regional top management until they became a physical reality, provided me with a complete view of the digitalization phenomena.

Chapter 3 describes how a worldwide implementation of digitalization and automation technologies like Robotic Process Automation (RPA) can go in the wrong direction if the organization is not properly prepared for it; forcing a new technology onto an organization with not sufficient technical background can create difficulties. Chapter 4 reviews the process of a new IoT product development to aid supply chain management activities at a large corporation. It integrates the research findings into a Single Case Study to facilitate the understanding, reflection, analysis and learning from a real experience of a large transnational company.

The frameworks developed through the research articles included in the following chapters are the result of an intensive analysis of data, they can serve to understand why the implementation of digital technologies can fail and which factors are to be considered when aiming for a successful inter- and intracompany implementation of digital technologies.

1.5 Declaration of contributions

Chapter 2

The research work and resultant article included in this chapter were developed by the author of this dissertation in tandem with Dr. Merieke Stevens and Dr. Juan Pablo Madiedo. Most interviews, the research question and the majority of the literature research were performed independently by the author of this dissertation. Dr. Stevens developed the theoretical framing, participated in some interviews conducted in Mexico City and Guadalajara in the spring of 2018 and led the data analysis and framework construction process. Dr. Madiedo provided specific support by further complementing the theoretical background for subsequent versions of this article during two R&R processes for the Journal of Operations Management.

Chapter 3

The research work and article included in this chapter were independently developed in full by the author of this dissertation. After completing the final draft version, feedback was provided by Prof.dr. Jan van den Ende and by Dr. Merieke Stevens. A revised version is under review for journal submission.

Chapter 4

The case study and data analysis included in this chapter were independently worked in full by the author of this dissertation, whereas the majority of the interview data used in this chapter comes from the work done in Chapter 2 with the support of the coauthors of Chapter 2. After completing the final draft version, feedback was provided by Prof.dr. Jan van den Ende and by Dr. Merieke Stevens. A revised version will be used as material for Supply Chain Management and Product Development courses in master's degree programs at the Rotterdam School of Management.

Chapter 5

This chapter was written independently by the author of this dissertation.

1.6 Declaration of funding

The research work used for this dissertation was partly funded by the following organizations by a total amount of less than 30% of the research costs:

- Rotterdam School of Management – Technology and Operations Department
- Consejo Mexiquense de Ciencia y Tecnología (COMECYT)

2 TALKING TO MACHINES: IMPLEMENTING IOT-ENABLED TOOLS AT THE BUYER-SUPPLIER INTERFACE

Joint work with Merieke Stevens and Juan Pablo Madiedo Montañez.

2.1 Abstract

Supply chain performance crucially depends on information exchange, which is supported by IT tools as well as embedding between buyers and suppliers. IT tools formalize part of the interaction between buyers and suppliers, but boundary spanners such as key account holders, machine operators, and IT specialists continue to occupy a role as gatekeeper for IT-based information exchange. Recent IoT-enabled tools, however, do not require human control, implying that buyers and suppliers will have to deal with unprecedented visibility into their operations. Considering this absence of human control, we ask the question: How to implement IoT-enabled tools at the buyer-supplier interface? Especially, how will suppliers be convinced to accept and properly use IoT-enabled tools? We conducted a case study of supplier machine sensorization by Bosch at one of its metal stamped parts suppliers in Mexico, and found that the intentions of Bosch to help this supplier improve, dictated how the relation progressed, despite the hugely deviating metrics that the sensor recorded and which may have led the supplier to be to deselected. We shed light on this finding by combining insights from the Technology Management literature and the theory of Embeddedness. Although the wide implementation of this IoT solution eventually failed partly due to employee reluctance at both companies, the project served as a basis for new solutions in other regions.

2.2 Introduction

Supply chain competitiveness hinges on interorganizational information exchange, which in turn is enabled by IT tools as well as buyer-supplier embeddedness. Correctly managing the flow of goods and information in a supply chain can make or break an organization (Cachon & Fisher, 2000; Frohlich & Westbrook, 2001), and adequate, technology-based, information-sharing routines between buyers and suppliers are fundamental to this capability (Balakrishnan & Geunes, 2004; Fawcett, Wallin, Allred, Fawcett, & Magnan, 2011; Ke, Liu, Wei, Gu, & Chen, 2009; Liu, Ke, Wei, Gu, & Chen, 2010; Malhotra, Gosain, & El Sawy, 2005; Saeed, Malhotra, & Grover, 2005; Zhou & Benton, 2007) . To achieve smooth coordination it is necessary to integrate IT-based tools into your own production facilities (Liu et al., 2010; Zhu, Kraemer, & Xu, 2006), but increasingly also into those of your suppliers. Clearly, effective participation of suppliers is crucial here.

We will examine this in the context of Internet of Things (IoT)-enabled tools, which are embraced by supply chains worldwide. Compared to their predecessor IT-based tools, IoT-enabled tools take access to supply chain partner data one important step further, by removing the human actor as gatekeeper (see Table 2.1). To examine this topic, we conducted a case study at Bosch in Mexico during the implementation of an IoT sensor-based machine tooling monitoring system at the site of one of its stamped metal parts suppliers. We refer to this supplier as “Tier 2” in this paper to indicate its position vis-à-vis Bosch’s automotive OEM customers. Despite repeated attempts, this sensor project did not move beyond the pilot phase due to organizational deficiencies during the solution development process.

Our research question is: How to implement IoT-enabled tools at the buyer-supplier interface? Our study consisted of three phases: First we collected dyadic interview data about the implementation process of the IoT sensor and visited key sites of both Bosch and Tier 2. Secondly, once the sensor was implemented, we analyzed the data it had generated. Lastly, we conducted additional interviews to reflect on the sensor data collected by us. Table 2.2 in the Methods section provides an overview of our three data collection phases.

We found that while interorganizational IoT-enabled tools revealed large discrepancies between reported and actual data (see Figure 2.3), instead of using this in an antagonistic manner and punish Tier 2, both Bosch and Tier 2 used the –at times painful—additional supply chain visibility to improve their processes and hereby strengthen their relation. We reflect on this finding in the light of the Technology Management literature and the phenomenon of Embeddedness in supply chains.

IoT-based tools can not only solve classical OM problems related to the planning of inventory, logistics, production processes, etc. (Devaraj, Krajewski, & Wei, 2007), but also hold predictive power with regards to problems such as disruptions, machine downtime, and shortages (Yan, Meng, Lu, & Li, 2017). Unlike IT-based resource planning tools, the new generation of IoT-enabled tools can collect a wide range of data autonomously and in real-time, without interference of a human actor. The conditions for, and outcomes of, letting go of human control of supply chain data exchange, is as yet understudied.

While advanced tools and internet-ready machines are available, it is unlikely that most organizations will completely replace their existing production facilities with new IoT-ready machines. Instead, many organizations are digitizing their existing facilities—mostly on a trial and error basis. This led one executive that we interviewed at Bosch Automotive for this study pose the question: "How can we make an analogue machine from the 1980s talk to us through the internet?" In our study on how to implement IoT-enabled tools at the buyer-supplier interface, we ask the additional question: Why *should* a machine talk to you, instead of the person operating it? And will such IoT-enabled information exchange replace humans? Without human control, questions of data use and ownership become salient. Particularly when buyer-supplier relations are not exclusive, as is the case in many industries including the automotive industry in which our study took place. Based on our case study we can only provide some insights that apply to the dyad we studied regarding the role of humans in IoT-enabled supply chains.

2.3 Theoretical background

We follow Tushman and Nadler (1978) in viewing the organization as an information processing system that faces uncertainty. Their observation that *information* is "data which are relevant, accurate, timely and concise … [and] must effect a change in knowledge" while *data* may not be information (Tushman & Nadler, 1978: 614), is particularly relevant in the current digitalization[3] wave in which recording *any* data seems to hold the promise of improvement.

IT-based tools however are still enabled by a human actor who retains a certain level of discretionary power about what to exchange with other organizations, and when. IoT-enabled tools take the availability of data a step further, as they make automatic and continuous data collection possible, hereby bypassing buyer and supplier personnel as key players in making data available across organizational boundaries. This drastically reduces the ability of organizations to disclose information on a discretionary basis.

Both traditional, and later IT-based, systems focus on the monitoring and control of operations based on the exchange of limited sets of data, the importance of which is determined by *prior process performance*. The obtainability of such data depends on the availability of human resources that take care of data management (Spencer, 1994). With IoT tools however, automatic collection and real-time analysis of a much broader array of data (e.g. machinery status, environmental conditions, parts location, inventory levels, etc.) can be used by

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[3] Related terms for initiatives that rely on digital technologies are: Industry 4.0 (or I4.0; the "fourth industrial revolution"); digitalization; sensorization; Artificial Intelligence (AI); manufacturing through the Cloud.

organizations to *predict future process performance*. Table 2.1 compares traditional, IT-based, and IoT-enabled data exchange between organizations.

Table 2.1 Types of data exchange between organizations.

	Data	**Exchange**	**Tools**
Traditional	Limited (parts produced, parts incoming, inventory)	▪ Buyer and supplier boundary spanners interact about specific topic ▪ Data is gathered and processed manually ▪ Data is shared selectively	Excel; manual records and charts
IT-based	Extensive (real-time process data)	▪ Buyer and supplier can grant each other real-time access to their data ▪ Data gathering and processing is enabled by human choice and discretion ▪ Prior process performance dictates which data are collected	ERP; EDI
IoT-enabled	Everything (machine status, environmental conditions, inventory levels, etc.)	▪ Continuous real-time access without human interference in what is shared ▪ Full transparency regarding actual measurements ▪ Data gathered on a vast number of metrics is used to optimize and predict future process performance	Sensors; gateways; User Interfaces

Supply chain performance depends on information exchange, which in addition to technology tools is also enabled by embedding between buyers and suppliers. Embeddedness denotes the extent to which an organization is rooted in its context. In the supply chain literature, research on Embeddedness partly overlaps with research on Supplier Integration (Lockström et al., 2010) and Social Capital (Cousins, Handfield, Lawson, & Petersen, 2006; Lawson, Tyler, & Cousins, 2008). We argue however that only Embeddedness entails all-encompassing and clearly operationalized subdimensions –structural, relational, and cognitive, which each have been shown to play key enabling roles in supply chain performance—and therefore is best positioned to gain a deep understanding of supply chains.

Structural embeddedness refers to operational integration (Carey, Lawson, & Krause, 2011; Cousins & Menguc, 2006), joint projects and engineering assistance (Clark & Fujimoto, 1991), and shared access to points of monitoring and control of operations. Relational factors are mutual trust, friendship, goodwill, and respect (Dyer & Chu, 2003; Uzzi, 1997, 1999).

Cognitive factors consist of a shared culture, norms, meaning, and understanding (Lusch & Brown, 1996; Nahapiet & Ghoshal, 1998), as well as a willingness to learn and improve together. A shared sense of belonging to a clearly delineated network –referred to as *keiretsu*— is a cognitive factor that was key to the success of Japanese carmakers during the 1980s (Dyer, 1996a; Nishiguchi, 1994; Sako & Helper, 1998). Note that the three types of embeddedness factors are linked, but that they each have different lead-times for change, and that there is no predefined causal relation between them (Stevens & van Schaik, 2020).

With respect to the relation between IT-based tools and Embeddedness, it has been found that operational coordination (structural factor) supports the competency with which IT-based tools are used in the supply chain (Liu, Wei, Ke, Wei, & Hua, 2016; Vanpoucke, Vereecke, & Muylle, 2017). Trust (relational factor) in the supply chain can be a predictor for the adoption of IT-based tools (Obal, 2013), as well as the smoothness with which information is subsequently shared (Obal, 2017; Obal & Lancioni, 2013; Prajogo & Olhager, 2012; M. C. Tsai, Lai, & Hsu, 2013). Obal (2017) found that the general phenomenon of overly trusting buyer-supplier relations leading to complacency (Anderson, E., & Jap, 2005; Gargiulo & Benassi, 2000; Sting, Stevens, & Tarakci, 2019), also happens when organizations in search of supply chain IT tools, overly rely on their trusted suppliers who may not in all cases have the best offering. Shared norms (cognitive factor) are found to positively impact the breadth of information that is exchanged trough supply chain technology (Liu et al., 2010).

Extant research often focuses on factors that drive the *adoption* of IT tools at a single organization (Sodero, Rabinovich, & Sinha, 2013; Zhu et al., 2006). It is however the process of *implementation* which unfolds after adoption that organization often struggle with (Harland, Caldwell, Powell, & Zheng, 2007). To unpack technology implementation as a process, we discuss two key dimensions described in the Technology Management literature, namely, technology readiness and technology acceptance.

Technology readiness is a structural dimension that entails an organization's absorptive capacity vis-à-vis new technology, i.e., "the ability of an organization to recognize the value of new, external information, integrate it, and apply it to commercial ends" (W. M. Cohen & Levinthal, 1990). An organization's absorptive capacity vis-à-vis innovations is considered to be mainly a function of its extant knowledge and its ability to learn (W. M. Cohen & Levinthal, 1990). Lane and Lubatkin (1998) find that interorganizational learning depends on the similarity between two organizations in terms of knowledge and structure, and define absorptive capacity as a "learning dyad-level construct".

Technology acceptance is a cognitive dimension that entails the approval of technology features and the behavioral motive to exploit it; it is determined by its observed utility and the observed practicality (Davis, 1989). Before a new technology is implemented, beliefs about it are "vague and ill-formed" leading to subjective norms playing a significant role (Hartwick & Barki, 1994). After implementation, as knowledge about a technology increases, the role of subjective norms lessens (Venkatesh & Davis, 2000).

Research on technology acceptance mainly focuses on individual acceptance, with few recent studies extending it to the interorganizational setting (Autry, Grawe, Daugherty, & Richey, 2010; Brandon-Jones & Kauppi, 2018). These studies show that identifying the right technologies to achieve an organization's goals is a critical challenge for operations managers. Particularly the acceptance of supply chain technologies used for operational coordination between supply chain partners is critical in realizing performance. Autry et al. (2010) find that, similar to an individual's acceptance of technology, in a supply chain setting the actual implementation of a technology depends on the users' cognitive approval of technology features and their behavioral intention to use it.

2.4 Methods

According to Cooper and Zmud (1990), the adoption of a technology may be a rational choice, but its implementation requires a process of learning. Barki and Pinsonneault (2005) argue that to understand IT implementation, interorganizational integration must be understood. Venkatesh and Davis (2000) showed a difference in technology acceptance before and after its implementation. These findings point to the importance of longitudinal research design, which we follow in this study.

Our data was collected during three phases (see Table 2.2). During the first phase, which lasted from March 2018 to February 2019, we conducted 32 semi-structured interviews with 20 employees considered to be key players in Bosch's supply chain digitalization initiative, and five employees of Tier 2 (see Table 2.3). We also visited Bosch's technology hubs ("Connectories") in Germany and Mexico where its IoT and business process digitalization efforts are concentrated. In addition we visited the production line of Tier 2 in Mexico where we observed the IoT-enabled sensor being used in real-time. At the Connectory in Mexico, located at 40 kilometers from Tier 2's production line, we saw the data from the sensor coming in and being analyzed by the Bosch IoT team in real-time.

Our second data collection phase ran from March 2019 until March 2020 and consisted of negotiating access to, as well as analyzing, (1) Tier 2 machine tooling sensor data gathered by Bosch; (2) Tier 2 factory level production plan data; as well as (3) Bosch incoming parts data about this Tier 2 factory in particular (see Figure 2.3). This phase was extended by the unexpected decease of Tier 2's CEO, who had been the main advocate of implementing the sensor technology.

The third and final phase took place in August 2020[4] and consisted of five interviews with four key stakeholders at Bosch and one at Tier 2, to reflect on the sensor data. Two of the Bosch interviewees, as well as our Tier 2 interviewee during this third phase, were also interviewed in Phase 1. In total we conducted 37 interviews with 27 key stakeholders. We were able to ensure full access to all stakeholders in this project as well as all relevant project data, because the second author is the project leader for this supplier digitalization effort at Bosch in Mexico and North America.

Table 2.2 Data collection phases overview.

	Time	Participants	Data
Baseline	Mar 2017 – Mar 2020 *37 months*	Second author	Involvement in this project throughout its lifespan as the project leader for this supplier digitalization effort at Bosch in Mexico and North America
Phase 1	Mar 2018 – Feb 2019 *12 months*	All authors	▪ 32 interviews with 20 Bosch, and five Tier 2 employees ▪ Visits to Bosch Connectories in Germany and Mexico ▪ Visit to Tier 2's production line in Mexico
Phase 2	Mar 2019 – Mar 2020 *13 months*	Second author	▪ Negotiate access to sensor data ▪ Negotiate access to Bosch incoming parts data (SAP) ▪ Negotiate access to Tier 2 factory level production plan data
Phase 3	Aug 2020 *1 month*	Second author	▪ Four interviews with Bosch key stakeholders ▪ One interview with Tier 2 key stakeholder

2.4.1 Case selection

We identified Bosch and its supplier network as a critical setting (Barratt, Choi, & Li, 2011) to study the diffusion of IoT tools. Bosch has publicly stated its desire to become a leader in digitalization. According to its CEO Denner:

"The digital transformation is … changing our lives. Bosch regards this transformation as an opportunity to shape the future. The effects of this can be felt throughout the company."[5]

[4] Phase 3 started later than planned due to the global COVID19 pandemic.
[5] Bosch Annual Report 2017.

The digital dream of Bosch's top management consisted of improved business relationships, process visibility, information transparency, and availability of data—all leading to precise analyses and predictions, better decisions, and ultimately an enhanced overall supply chain performance. Bosch's top management hoped that a better strategy would emerge from having better information available. A procurement top executive commented (BV2):

"We need to create something more automatic and digitized so [SCM employees] have key information about suppliers [available to them] for making decisions."

Placing sensors at suppliers' machines is just one part of Bosch efforts to digitize all dimensions of its supply chain. In recent years it has invested hundreds of millions of euros in a wide range of digitalization initiatives. The goal of these investments is merging the physical world of production with the virtual world of IoT. Bosch CEO Denner suggests that this combination of the physical and the virtual world will help machines to "understand each other."[6]

Bosch's Automotive division (renamed to Mobility Solutions Sector), represents 60 percent of Bosch's total sales; it is the only division that has actively started digitalization projects. More specifically, we looked at the placement of a sensor by Bosch on the tooling of one of its 60 automotive metal parts suppliers in Mexico[7].

To shed light on the interorganizational integration of the physical and virtual worlds of producing automotive components, we took an inductive case study approach. Such an approach is generally considered to be particularly suited to gain a comprehensive understanding of new phenomena (Gioia, Corley, & Hamilton, 2013). Essential to answering

[6] www.bosch.com/explore-and-experience/denners-view. March 15th, 2017.
[7] In 2019 the automotive industry in Mexico represented 3 percent of the national GDP and 21 percent of the national manufacturing GDP. Mexico is the number 3 global car exporter; number 4 global car component exporter; and number 7 global car producer. In 2019, 3.75 million vehicles were manufactured in Mexico, of which 457,000 were sold domestically.

our research question is querying both sides of our focal dyad. We share McEvily et al.'s (2017) viewpoint that focusing on one side of the dyad in buyer-supplier studies results in partial and inaccurate understanding. By conducting our study at a matched dyad, we underscore the importance of collecting data from the buyer and the supplier (Poppo & Zhou, 2014; Vanpoucke, Vereecke, & Boyer, 2014).

An additional step we took when delineating our sample, was to interview the Bosch account holder of a main automotive OEM customer of Bosch Mexico (for the importance of studying triads, see T. Y. Choi & Hong, 2002) . From this interview we however learned that the locus of IoT-enabled innovation in this case lies not at the OEM. While Bosch was gradually advancing the sensorization of Tier 2, the OEM customer for these Tier 2 parts still relied on traditional information exchange with Excel as its main tool. We subsequently decided to focus on the Bosch-Tier 2 relationship and leave the OEM out of our sample for this paper (our OEM interview therefore is not included in our total count of 37 interviews).

2.4.2 Case description

Bosch has built up a complex network consisting of thousands of suppliers around the world delivering components every day to one of its more than 440 subsidiaries in 60 countries including 245 production plants. Any supply chain disruption can quickly result in losses of hundreds of thousands of euros per minute. The promise of deep transparency offered by IoT-enabled tools, appealed to Bosch's management as an important possibility to reduce the risks of costly disruptions and improve the overall versatility of the supply chain.

Each of the tens of thousands of parts that are used by Bosch every day in its manufacturing processes, requires tooling at a supplier's factory. This mostly consists of a mold that gives the component the exact shape and dimensions as specified by Bosch. Every piece of tooling is specific to both the machine in which it is used, as well as the part to be produced.

Tooling for automotive applications can cost hundreds of thousands of euros, while their fabrication process can take on average up to six months from design to release. Tooling in poor condition, damaged, broken, or approaching the end of its lifetime is a serious threat to the entire production process, and has high priority in Bosch's supply chain risk management.

For this study we selected Tier 2 because it was the first supplier to accept Bosch's tooling sensor. At the time of our study, Tier 2 had lost its preferred status in Bosch's North American region (encompassing Mexico, Canada, and USA) due to continuous quality and delivery issues. While Tier 2 had opened a factory in Mexico following an invitation from Bosch Germany, it was not promised any automatically awarded contracts. The IoT project was seen as a chance to improve the deteriorating relation.

Metal stamped parts are widely used in automotive components such as gearbox casings, housings, covers, lamination stacks for electrical motors, and plates. Bosch Mexico is responsible for all Bosch suppliers of metal stamped parts in Mexico and the United States. These parts represent 20 percent of the overall purchasing volume of Bosch in this region.

The metal stamping process consists of a hydraulic press transforming a flat sheet of metal into a component formed to specific dimensions and characteristics, by means of a tool and a die fixed inside a press. These presses mostly have a large tonnage and are capable of pressing metal with a force of up to one thousand tons. They can be as large as a medium-sized house and can produce up to fifty parts per minute. The environment in which these presses are used is often characterized by the presence of oil and metal scrap, and rarely contains an advanced electronic control system capable of measuring process performance exactly.

Costly delays in deliveries due to unavailable tooling at the agreed start of production date, is a widespread problem in the automotive industry and, also experienced by Bosch. Due to the threat that incorrectly stamped metal parts pose to the automotive production process, sensorization of the tooling that stamps such parts, was selected by Bosch as one of the first projects to tackle with new IoT tools. The organization we focus on, Tier 2, is the first supplier that Bosch is working with in terms of IoT tools.

To minimize the bias that may result from the second author being employed by Bosch, we took the following precautions: The first and third author designed the interview protocol; did the majority of the interviews during the first phase, and most importantly; coded and analyzed all data collected in phase 1. The second author was not a respondent in our sample but provided a list of potential interviewees ranging from interns up to executive managers working at Bosch and Tier 2, based on their involvement in digitalization efforts. Due to the sensitivity of the data gathered in Phase 2 and discussed in Phase 3, only a Bosch employee closely involved with the IoT project could have executed these two phases, and the second author conducted these interviews. The first author analyzed all data gathered during Phase 2 and 3. Interviews were conducted in English or Spanish, depending on interviewee preferences. Both the second and third author are native Spanish speakers.

Most interviews during Phase 1, and all interviews in Phase 3 were taped. During all interviews we took extensive notes. In the first phase, 13 interviews were conducted face-to-face in Mexico and Germany, while 19 interviews were conducted using video conferencing. Due to COVID19 restrictions, all interviews in Phase 3 were conducted using video conferencing (to enhance anonymity, only audio was recorded). We asked the same questions during all interviews but made small adjustments to the specific role of each interviewee. A list of interview questions is included in Appendix A.

The duration of each interview ranged from 30 minutes to two and a half hours. All taped interviews were recorded with explicit permission of the interviewee and later transcribed verbatim. The ones in Spanish were translated into English by a Spanish native speaker, and subsequently back translated by the authors. In some cases, follow-up meetings with interviewees took place for content clarification.

Table 2.3 Overview of interviews.

Position	Department	Code	Location	Time	FTF	Note	Rec	FT
BOSCH								
Direct buyer	Direct Purchasing	BB1	MX	1:00	✓	✓	✓	✓
				2:30	✓	✓		
				1:00		✓	✓	
Purchasing Intern	SCM Digitalization	BT1	MX	0:45		✓	✓	✓
Vice President	Purchasing	BV1	MX	1:00		✓	✓	✓
				1:00	✓	✓		
			DE	1:00	✓	✓		
Vice President	Purchasing	BV2	US	1:00		✓	✓	✓
Project Director	SCM Digitalization	BD1	DE	1:00		✓	✓	✓
				1:00	✓	✓		
Manager	SCM Digitalization	BM2	DE	1:00		✓	✓	✓
				1:00	✓	✓		
Manager	IoT Innovation	BM3	US	1:00		✓	✓	✓
Specialist	IoT Innovation	BE1	MX	1:00	✓	✓	✓	✓
Senior buyer	Direct Purchasing	BB2	MX	1:00		✓	✓	✓
Specialist Supplier Development	Automotive Supplier Development	BE1	MX	1:00		✓	✓	✓
Senior buyer	Direct Purchasing	BB3	MX	1:00		✓	✓	✓
IT developer	IoT Innovation	BD1	MX	1:00		✓	✓	✓
				2:00	✓	✓		
				1:00		✓	✓	
IT developer	IoT Innovation	BD2	MX	2:00	✓	✓		
IT Sales	IoT Innovation	BS1	MX	2:00	✓	✓		
Leader IT dev	IoT Innovation	BM4	MX	2:00	✓	✓		
Manager	Purchasing	BM1	BR	0:45		✓	✓	✓
Buyer	Purchasing	BB4	BR	1:00		✓	✓	✓
Manager	Project Purchasing	BM2	MX	1:00		✓	✓	✓
Buyer	Project Purchasing	BB5	MX	1:00		✓	✓	✓
Manager	IT Development India	BM5	MX	1:00		✓	✓	✓
Manager	Logistics	BM1	MX	1:00		✓	✓	✓
Quality Engineer	Supplier Management	BQ1	MX	1:00		✓	✓	✓
TIER 2								
Sales	Sales	SS1	MX	1:00	✓	✓		
IT Manager	IT	SI1	MX	1:20	✓	✓		
Account Manager	Sales	SM1	MX	1:20		✓	✓	✓
				1:30		✓	✓	✓
				1:00		✓	✓	
IT Engineer	IT	SI2	MX	1:30		✓	✓	✓
Manufacturing Process Manager	Manufacturing	SM2	MX	1:30		✓	✓	✓

Notes: In bold are respondents interviewed in both Phase 1 and 3; in italics are respondents only interviewed in Phase 3. All others were interviewed only in Phase 1. FTF: face-to-face interview; Note: extensive notes taken during the interview; Rec: full recording made of interview; FT: full transcript made from recording.

2.4.3 Data analysis

Our interest in Bosch was triggered when we learned about the sensorization of one of Tier 2's presses. The newness of this phenomenon led us to adopt an exploratory research approach (S. Cohen, Glaser, & Strauss, 1969), following an inductive design (Gioia et al., 2013). Our initial review of the technology implementation literature pointed us into the direction of longitudinal process tracing (Dyer, Singh, & Hesterly, 2018; George & Bennett, 2005; Langley, 1999). We developed a research protocol taking advantage of our academic and practitioner backgrounds. Two pilot interviews were conducted to further refine this protocol. As a first step in our data analysis, and as an outcome of the process-tracing that we undertook together with interviewees, we divided the IoT tool implementation project into five stages that we named according to the terms used by our interviewees. Figure 2.1 show an overview, while Table 2.4 describes the stages. During the interviews conducted in August 2020 for Phase 3 of our study, we asked interviewees to reflect retrospectively on the sensor data obtained in March 2020. The sensor continued to be used after March 2020, but we did not include the data recorded after March 2020 due to the substantial impact that COVID19 was having on the global automotive industry.

Figure 2.1 Phase 1 – Timeline of IoT-enabled sensor implementation.

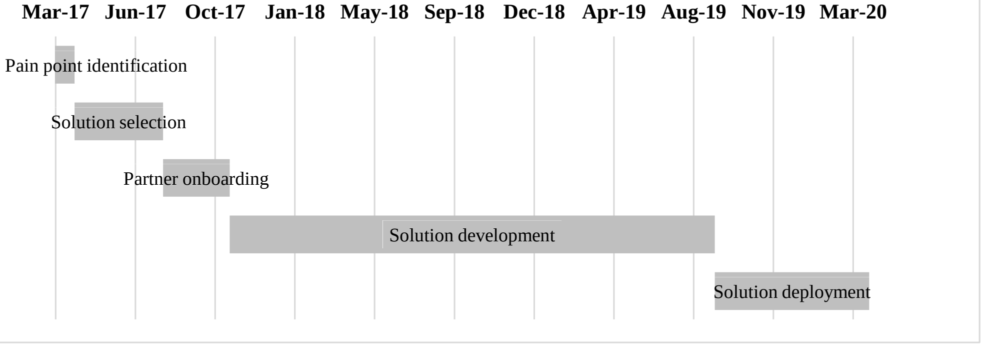


Table 2.4 Phase 1 – Stage description of IoT-enabled sensor implementation.

Stage & duration	***Main Bosch action***	***Main Tier 2 action***
Pain point identification *1 month*	Identification of supply chain problems that can be tackled with digitalization.	*None.*
Solution selection *4 months*	Selection of existing hardware and IT capabilities that can be used for potential digitalization solutions.	*None.*
Partner onboarding *3 months*	Search and onboarding of supplier with long-term relationship; high level of trust; interest in *kaizen* projects; and in proximity to the Connectory in Mexico.	Recognizes its quality and delivery issues vis-à-vis Bosch. CEO embraces digitalization project as an important improvement opportunity.
Solution development *22 months*	Design of low investment solution by relying on existing hardware and software. Requires that all tool development must be done inhouse.	CEO meets with Bosch purchasing manager; technicians meet several times with Connectory IoT developers. Provides solution improvement ideas and actively participates in solution testing.
Solution deployment *7 months*	Certification of the final tool compliant with local regulations. Formulation of a strategy for wider implementation into the North America region.	Uses the data generated to calculate process efficiency; detect bottlenecks; and optimize machine's utilization. Provides data to Bosch development team to fine tune the solution.

2.5 Case Findings

In this section we report our analysis of the successful IoT tool implementation between Bosch and Tier 2. We structure this section according to the three phases of our research.

2.5.1 Phase 1: Interviews and site visits to learn about the IoT implementation project

Figure 2.2 presents our inductive coding and the aggregate dimensions we found in Phase 1. We first coded the factors that according to our interviewees were important. For this first step, we relied on open coding, closely following informant terms (Glaser & Strauss, 1967). As we grouped similar remarks to come to our second order codes, the correspondence with the three factors of Embeddedness became apparent. However, we found that many technology-related first order codes were left uncategorized. For these technology-related first order codes and their second order codes we iteratively relied on the Technology Management literature. In our description of this first phase of data collection in the section below, we aim not duplicate what is in Figure 2.2, but rather provide additional background information and particularly revealing interviewee quotes.

2.5.1.1 Mutual investments in structural embedding

Tier 2 has its headquarters in Germany and a production plant in Mexico from where it delivers metal stamped parts to Bosch's final assembly lines in Mexico according to Just-in-Time (JIT) and Ship-to-Line systems. Bosch and Tier 2 have been working together for more than twenty years. Bosch represents 10 percent of the global sales of the supplier and 25 percent of its Mexican sales. Of Bosch's worldwide automotive components production, about 15 percent takes place in Mexico.

2.5.1.2 Mutual investments in relational embedding

Our interviews indicate that the long-term relationship between Bosch and Tier 2 in Germany; the business growth ambitions of Tier 2; a perception of shared solution benefits; as well as the high purchasing volume were key in supporting the IoT project. Personal trust between the buyer and the supplier representative contributed to reaching an agreement relatively fast, despite everybody's lack of experience with the new technology. One of the senior Bosch buyers noted (BB2):

"If people know you, it is easier than if there is no relationship and trust. That greatly improves the life of this project."

A supplier representative underscores this view (SM1):

"There are advantages that this project brings us as a supplier of Bosch. [It is not only about] the benefits they are going to get, but also the benefits that we are going to get."

2.5.1.3 Mutual realization of necessity of change

The automotive industry is going through a period of unprecedented change caused by rapidly changing consumer demand, stringent public scrutiny, and an explosion of digital options to both producing (B2B), as well as using, vehicles (V2X: vehicle-to-everything). Daily operations are affected by a plethora of external factors: macro and microeconomic changes, currency fluctuations, socioeconomic crises, natural disasters, technological breakthroughs, and trends. Clearly, both Bosch and Tier 2 are feeling the pressure of these issues on a day-to-day basis. Both also realize the necessity to change and invest in IT tools.

2.5.1.4 Buyer and supplier technology acceptance

Bosch identified several supply chain pain points that could be identified with IoT tools, including a lack of visibility of supplier processes and components; late deliveries from suppliers; and delays in getting tooling ready for production—all leading to frequent expedited freights that incurred high additional costs. The list of pain points was confirmed based on triangulation with historical data provided by suppliers, customers, and other internal departments at Bosch. Next, issues were prioritized based on risk, occurrence, severity, and their resulting financial losses. The challenges present in the metal stamped parts supply chain of Bosch are common for all other commodities too (e.g. plastic injection, aluminum castings, and machined parts). However, because metal stamping is one of the top commodities for Bosch Central Purchasing North America (CPNA), in terms of volume and the effect on costs and productivity, it was targeted first.

Once potential solutions were detected, a supply chain partner had to be identified. The high uncertainty associated with the novelty of the technology, led CPNA to select a supplier who was geographically close, and interested in cooperating with Bosch. This supplier would have to give Bosch representatives unlimited access to its facilities, IT network, and manufacturing processes, in order to develop, set up, and test the IoT tool. As a first step in the selection stage, CPNA supplier account managers were asked to identify potential partners.

Bosch was very eager to find multiple partners to collaboratively implement solutions. One big hurdle at this point was the concern of suppliers regarding production lines on which they did not exclusively run Bosch products. Suppliers feared that other customers –which could be Bosch competitors—would not accept the deep integration of Bosch IoT tools on those lines. Whenever a supplier makes any change to anything related to a machine, even if it is just moving it a few centimeters to one side, every customer who receives components that are manufactured on that particular machine has to be notified. Subsequently, all components must go through a thorough "quality release process" and cannot be assembled into any passenger vehicle until the long and expensive release process is properly approved. That is why suppliers are hesitant to touch a machine that has been already released. Other customers of suppliers could feel uneasy about Bosch installing sensors on machines that also produce parts for them, as it might enable Bosch to gather information about its competitors.

Data privacy management was a topic of deep concern and resulted in suppliers declining to discuss IoT opportunities. The senior Bosch sponsor of the digitalization team commented on one such case (BV1):

"The reactions were negative… [the supplier] did not want to share information because it did not only run Bosch products [on their line] and did not want Bosch to know their internal productivity [for all customers]."

Tier 2 had been experiencing several quality and delivery issues vis-à-vis Bosch and was eager to improve its relation. In addition, being part of Bosch's IoT initiatives, was seen as an important opportunity that would also enhance its attractiveness vis-à-vis other buyers. Tier 2's willingness to participate was further supported by Bosch's promise of an easy opt-out at any point, in case Tier 2 would become uncomfortable with the extent of information-sharing. The final step of this stage was a negotiation process in which agreements were drafted, and an NDA was signed that strictly limited all data use to Bosch and Tier 2 only. The sales manager of Tier 2 explained the willingness to participate (SM1):

"[Digitalization] allows for the entering of technologies into the production processes, which connect customers and suppliers. And in the end the data provides ideas to define actions for a specific topic. So from my point of view this project has a future and I believe that our company was right to accept this project."

Employees at Tier 2 specifically expressed their interest in using IoT tools to improve their manufacturing process in order to regain its position of Bosch's preferred supplier which it had lost due to recurring quality and delivery issue. However, Tier 2 had no Wi-Fi at the factory floor, no experience with technological add-ons to production machinery, and no in-house IoT skills at the start of the project. This resulted in limitations to the collection, exchange, and analysis of data. Many compatibility problems were solved through application programming interfaces (APIs) that bridge legacy systems and new technologies. However, some intended project features had to be disregarded because the available tools did not have the capability to interact with any of the longstanding internal IT systems.

There was a clear commitment of the Tier 2 CEO to being part of the Bosch supply chain. This included an overall commitment to the technologies that Bosch selected for supply chain information exchange. Our interviews revealed that the clear definition of resource requirements, data collection goals, and data usage, was crucial at this point. The Bosch project team was granted a mandate by its top management to decide freely at each step of the solution development stage, which meant that they could fully involve Tier 2 in any decision regarding data collection and usage goals. However, not all Tier 2 employees were immediately welcoming the notion of sharing all day-to-day operational information without being able to control it themselves, and some machine operators had to be convinced not to tamper with the sensor during their shift. We come back to this finding in our section on future research.

Informal information sharing, which was part of the relational embedding that existed between Bosch and Tier 2 before the IoT project, appeared very important to overcome this. The development of the IoT tool required coordinating between buyer and supplier employees that were working on different parts of the project. As these technology solutions comprise a diverse array of programming languages, sub-systems, sensor, and peripherals, uncertainty regarding their correct functioning when the different elements are assembled is high. Once prototype testing was completed successfully, trust levels among Bosch project team members, and supplier IT and manufacturing representatives, increased notably according to our interviewees.

Another important enabler at this point was Bosch's flexibility to dynamically adjust to the environment in which the sensor would be implemented. The roll-out was seen as a natural outcome of the entire process. It was not pre-planned, and the final stages took place at the supplier's facility. Adjustments to the algorithms in the sensor and the gateway were made on site. Finally, the sensor was set up as to measure additional variables of the manufacturing process (e.g. tooling temperature, idle time, and pressure). The additional information was considered to provide a more robust and complete overview of the production process on a real-time basis.

Once there was a working sensor in place, our Tier 2 interviewees found it easier to identify the benefits of the project. They were able to access the system and use the data generated to conduct further continuous improvement activities along their own supply chain. At this time, it was possible for both parties to do a more accurate assessment of the benefits derived on the basis of the IoT tool implementation. The Tier 2 sales manager explained (SS1):

"The project brings added value. First, recognition as participants in the pilot program, but additionally we also see a benefit based on which we can continue venturing into this type of models and continue learning."

Success of prior project stages served as an incentive for Tier 2 to continue developing the project. However, as we will discuss in our section on future research, final deployment of the tool faced resistance from some Tier 2 employees due to lingering suspicion regarding the motivations driving the project and the future role of human workers at Bosch and Tier 2.

2.5.1.5 Buyer technology readiness

A project team comprised of a project manager; a Vice President; IT programmers; and a professional buyer was established in August 2017 to study and assess CPNA's operation. The project team first sent out a questionnaire by email to all CPNA employees in Mexico and USA working in the automotive division. Subsequently, it set up ideation sessions with CPNA employees—ranging from the Vice President level to junior buyers—to detect general areas of concern and specific issues affecting daily operations. The results of the questionnaire, as well as process maps describing inputs, outputs, and bottlenecks, were used as discussion points during these ideation sessions.

Our interview data suggest that access to existing IT-based solutions for many different applications was key during this process. To access new IoT-enabled solutions, Bosch had set up three Connectories in Mexico (2017), the United States (2017), and Germany (2018), and three in 2019 in the United Kingdom, Brazil, and China. Connectories are physical spaces that function as incubators by bringing together external technology experts and Bosch internal customers. Through the Connectories, the CPNA project team obtained access to IoT-enabled tools and software applications, mainly developed by start-ups. The CPNA team subsequently customized these to address the pain points they identified. As stated by the IT development leader based in the Connectory in Mexico (BM4):

"We develop the solution or find a solution that already exists but adapt it to Bosch by adding something when needed."

Internal networking and communication among those involved in digitalization initiatives enabled cooperative search for solutions, and resource sharing in order to solve problems. However, due to the newness of the technology, Bosch lacked a formal scouting process for IoT tools. The project team resolved to informal networking, internal as well as external to Bosch, in an attempt to match the needs of CPNA to offerings that were available in the market. An extensive list of solutions and technology providers was drawn up that included global players such as IBM and Google, but also local start-ups. The solutions were assessed and classified on the basis of the project team's perception of technical viability, match with the identified pain point, and projected costs.

Despite the opportunities that were identified, the project team faced challenges during the solution selection stage when a suitable tool or sufficient budget to develop a tool were not available. A major concern was the absence of a modular tool that would allow for project scalability using IT resources already set in place by the focal organization (e.g. ERP). An entirely new, end-to-end system overruling company-wide systems already in place such as CRM, ERP, and SAP, was ruled out as it would imply duplicating resources and functionality already present in Bosch's operations. No modular solution that could be customized to, and used at, the specific pain points of CPNA only, appeared to be available. A senior purchasing manager based in Mexico reflected on this in the following way (BM2):

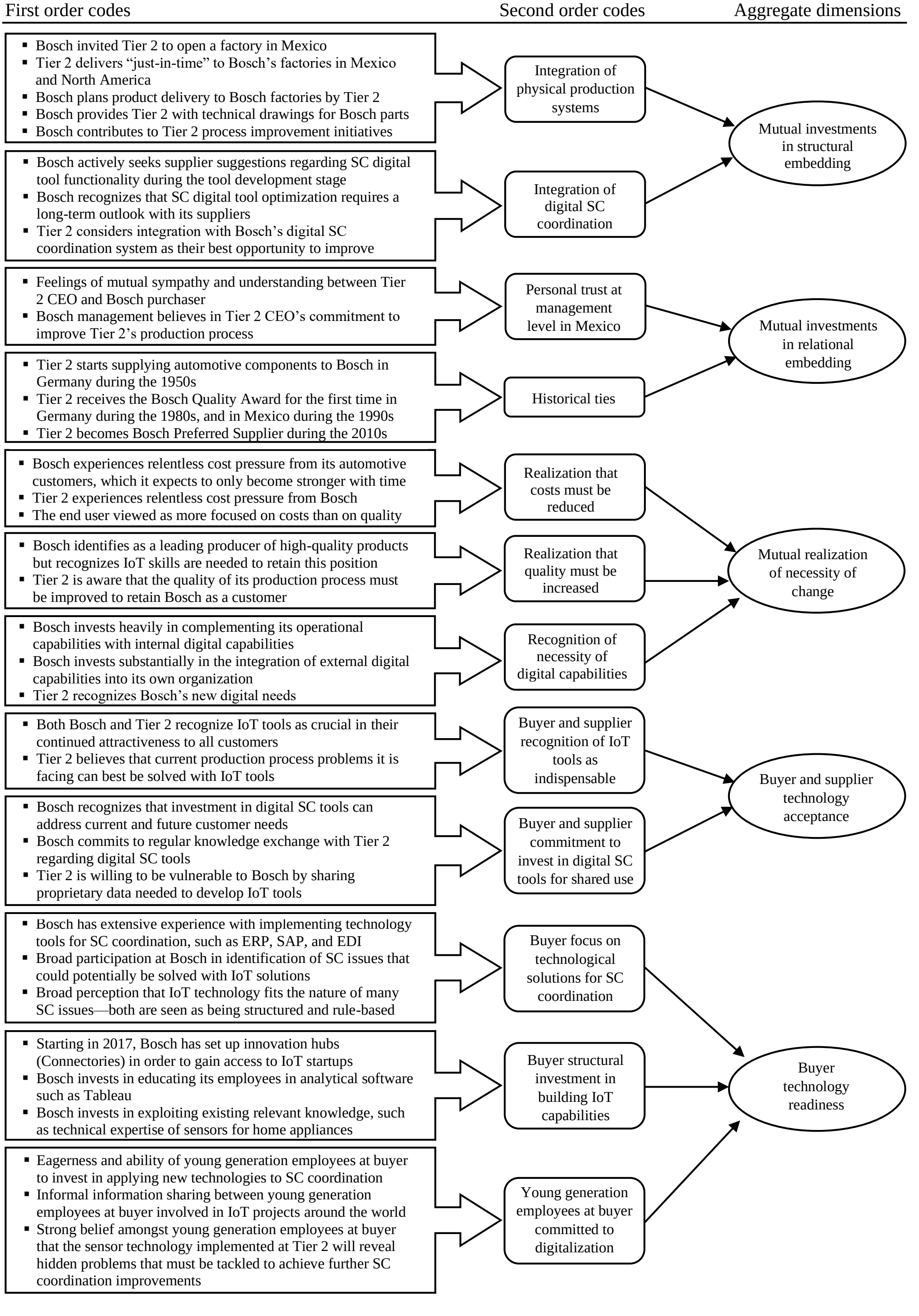
"I would be inclined to use the resources we already have either in India or Mexico and get a programmer to develop an internal, tailor-made solution. We do not need a [IT] provider to sell us a [SCM] package."

Bosch has historical experience with solutions that are related to the IoT sensor technology it implemented at Tier 2, such as sensors used for its home appliances. During the solution development stage, sensors were installed on a laboratory device simulating the movements of the supplier's machine, in order to measure them with the first pilot version of the new software developed by the Bosch IT team that would read sensor. Data from the Tier 2 metal stamping press was obtained and transferred via the Cloud, analyzed through algorithms that predict production output as well as imminent process failures, and finally shown live on a front-end, web-based dashboard. Having a multidisciplinary team in place, with extensive experience in Bosch's processes, complemented by the support of IT specialists, was crucial to develop all parts of the solution. A Bosch IoT innovation executive commented (BV1):

"We are working together with the customer and the supplier. To [leverage IoT tools] we need the IT guys and the guys who have deep knowledge about the processes, the shopfloor, and purchasing and logistics."

The supplier however, while having previous experience with a successful SAP implementation trajectory that Bosch viewed as valuable, had no IoT experience or inhouse experts that could support the project at this stage.

Figure 2.2 Phase 1 – Code aggregation diagram of IoT-enabled sensor implementation.



2.5.2 Phase 2: Gaining access to and analyzing sensor data

Due to the sensitivity of the data gathered in Phase 2 and discussed in Phase 3, only the second author –who in his role at Bosch was closely involved with this project—could execute these two phases. To guard against bias, the first author analyzed all data gathered by the second author during Phase 2 and 3.

As Figure 2.3 shows, the sensor revealed large discrepancies in reported and actual data with Tier 2 producing almost twice as many parts for Bosch as they deliver to Bosch. All parts that were not delivered were scrapped. And whereas we indeed learned from our interviews in Phase 1 (as reported in our coding tree in Figure 2.3) that Tier 2 delivered to Bosch Just-in-Time, it certainly did not produce parts Just-in-Time. What is more, Tier 2's production report, which Bosch can access during audits and visits to the supplier plant by the Bosch Supplier Quality Team, did not match with the sensor data. However, instead of using the delta that was found as a way to penalize Tier 2, Bosch used the additional supply chain visibility as a starting point for helping Tier 2 to improve its production process. So instead of cutting Tier 2 off when they learned that its production schedule differed substantially from actual production, Bosch not only helped them improve, but rewarding its willingness to participate in this project by selecting it as "Supplier of the Year 2019" in the category of "Innovation". This was meant as an encouragement from Bosch to all of its suppliers to grant access to their real production data.

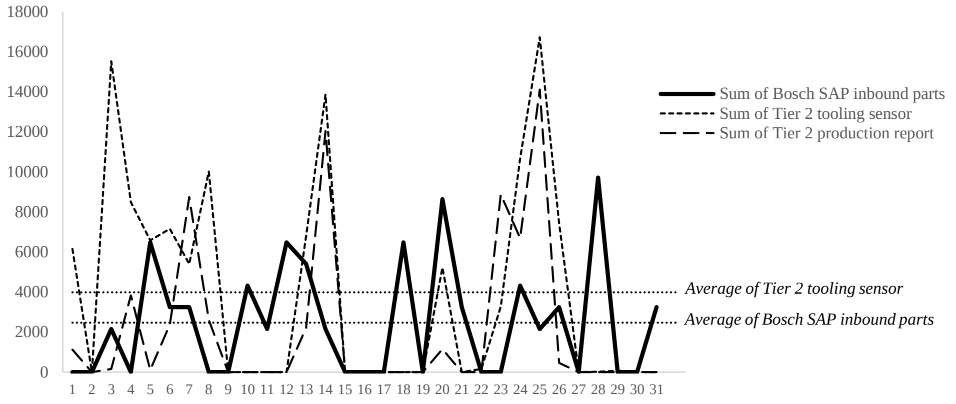


Figure 2.3 Phase 2 – Sensor versus Bosch SAP data of parts produced by Tier 2.

2.5.3 Phase 3: Interviews to reflect on the sensor data

The third and final phase took place in August 2020 and consisted of five interviews with four key stakeholders at Bosch and one at Tier 2, to reflect on the sensor data. One of the Bosch interviewees, as well as our Tier 2 interviewee during this third phase, were also interviewed in Phase 1 (see Table 2.3).

One key decision that would have been made differently when actual production data would have been known, is when to conduct tooling maintenance. If maintenance is not timely, unplanned, urgent repair is necessary, paid for by the Bosch Purchasing Department. In the three-year period 2017 to 2019, the amount spent on such ad hoc repair ranged between 100,000 and 600,000 euros per year, only for stamped parts tooling within the North American region.

Figure 2.4 summarizes the comments made by these five interviewees. In bold are explanations for the cooperative stance of Bosch towards Tier 2 even after they found out there were large discrepancies between actual and reported data, offered by at least three of our five interviewees in Phase 3. The overlapping area of the two circles indicates when mutual goals were mentioned. Points that were only mentioned by one of five interviewees are not included.

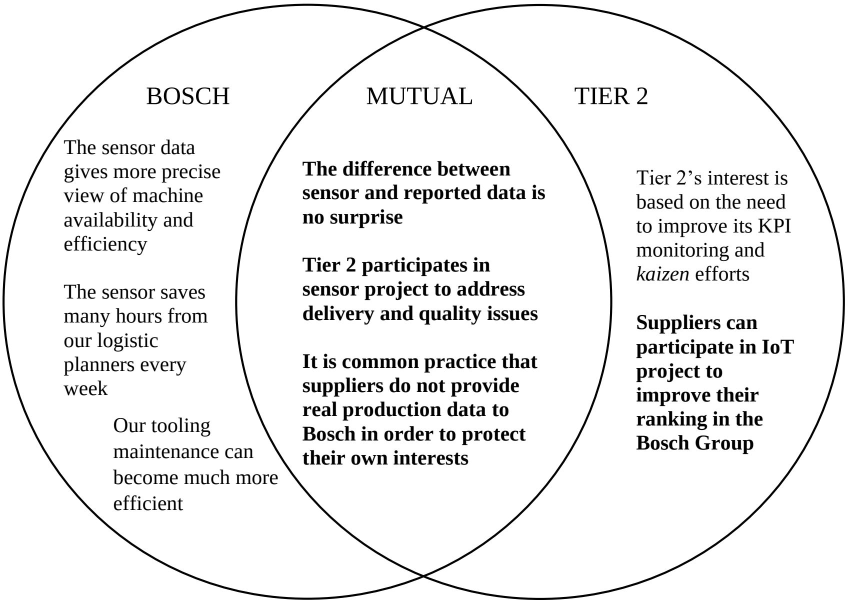


Figure 2.4 Phase 3 – Use of sensor data to enhance Bosch-Tier 2 relation.

2.6 Discussion

We addressed the question of how to implement IoT-enabled tools at the buyer-supplier interface, and additionally asked: Why should a machine talk to you, or machines talk to each other, instead of the person operating it? And will such IoT-enabled information exchange replace humans? Based on our case findings we suggest that humans will not be replaced because the intention of buyers and suppliers plays a key role in the future supply chain that they build. The big discrepancies in sensor data and production schedule of the supplier may have led a machine to deselect Tier 2, but because a human interpreted it, Tier 2 was not deselected, but on the contrary was rewarded for its openness and invited to improve together with Bosch.

2.7 Theoretical implications

If in an embedded buyer-supplier relation, information is exchanged transparently, why is a sensor needed? Part of the answer lies in the fact that hitherto unmeasured data now becomes available. But that does not tell the whole story. Our interviews in the third phase indicate that buyers may be aware of differences that exist between what a supplier reports they are producing and what they are actually producing, but do not turn to IoT tools to “expose” their supplier, but rather to help them improve their processes by supporting better and new measurements. It is well known that competent suppliers ultimately benefits buyers.

A second way to approach this is to assess the role of different coordination mechanisms –such as trust and IoT-enabled tools—in the different phases of buyer-supplier relationships during which they are used. In Table 2.5 we show the different factors of Embeddedness and Technology Management, and note that there are no relational factors of Technology Management. Future research should investigate how relational embedding and IoT solutions interact—or to put it more bluntly, whether trust and sensors are complements or substitutes. Relational embedding has been shown to enable efficiency gains due to open and transparent information sharing. The popularity of IoT tools then leads to the question whether trust has failed? Are buyers and suppliers in trust-based relations still hiding information from each other, and are IoT-enabled monitoring tools simply better as a supply chain management mechanism? Or, as seems to be the case between Tier 2 and Bosch, is relational embedding a key enabler for IoT tools to even be implemented? In other words, would buyers and suppliers without mutual trust, refrain from participating in a data-sharing system that would bypass a human controller?

Table 2.5 Link between Embeddedness and Technology Management factors.

	Embeddedness	**Technology Management**
Structural	Operational integration, joint projects, shared access to points of monitoring and control of operations.	Technology readiness and a willingness to teach of at least one partner.
Relational	Mutual trust, friendship, goodwill, respect, long-term relationships.	
Cognitive	Shared culture, norms, meaning, understanding, goals, willingness to learn and improve, focus on shared future.	Technology acceptance of both partners.

2.8 Managerial implications

Our two case companies—Bosch and one of its metal stamped parts suppliers—are confronted with a turbulent industry, highly complex coordination requirements between many different actors, relentless cost pressure, rapidly changing demands, as well as an avalanche of IoT technologies that all promise to solve costly supply chain problems. Supply chain disruptions quickly result in millions of losses as well as painful reputation damage, and it is therefore not surprising that IoT-enabled tools hold an unquestioned appeal to supply chain managers.

We studied Bosch first IoT tool implementation project at one of its metal stamped parts suppliers and found that relational embedding was a key enabler of the successful implementation of IoT-enabled tools.

2.9 Limitations and future research

Whether relational embedding will continue to be important as IoT tools become more advanced and more entrenched in specific buyer-supplier relations, is a question that requires further study.

Another finding that requires additional research is that some employees at Bosch and Tier 2 did not welcome the project, but both groups did so for different reasons. Some Bosch employees were reluctant because they were from a generation that took great pride in Bosch's mechanical skills and were not motivated –neither intrinsically nor by Bosch—to learn about new technologies and see the advantages they could bring. In the case of Tier 2 employees, some did not welcome the sensor project because of their difficult economic situation. We learned that Tier 2 worker wages are directly linked to Overall Equipment Efficiency (OEE), and considering the economic hardship that many workers in production line jobs in Mexico face, hampering with this KPI can simply be necessary to provide their family with basic necessities. Both of these topics –technology acceptance and generational differences, as well as the relation between poverty and worker compliance to KPIs—deserve exploration in future research.

While we were able to capture the dynamic nature of the process of interorganizational IoT tool implementation, and provide a fine-grained overview of the enablers of this implementation, as is a common concern for case studies, our study also gives rise to questions of external validity. We conducted research at two companies only, in one industry, four countries, and during a limited time span. In our research design, and by iteratively relying on the extant literature, we tried to minimize the risks entailed in a small sample.

Another limitation is that our study was conducted in the automotive industry. This industry is characterized by long lead times and integral products. This clearly is not the case for all industries. What may be more generalizable about the automotive industry is that it is switching from offering products (vehicles), to offering service (mobility) to its end users—a trend seen in other industries too. Its customer base is also changing drastically. From the traditional family with its own driveway, customers now have become cities, companies, and urbanites without space to park. The supply base is no longer predominantly populated by traditional mechanical parts suppliers, but now includes mobile network providers, software companies, and insurance companies, amongst many others.

Due to the unprecedented opportunities provided by IoT, questions of implementation are more important than ever. Especially when tools offer uncontrolled visibility while buyer-supplier relation is not exclusive, as is the case in many industries. We hope that in the digital wave that is hitting supply chains worldwide, our findings provide some guidance regarding how buyer and supplier firms can deal with these new challenges.

3 Robotic process automation in Operations Management: a look into the intraorganizational game.

3.1 Abstract

Robotic Process Automation (RPA) materializes the possibility of humans and robots working together in the same office. RPA is a technology offering professionals with no-IT background the opportunity to program a robot that emulates the actions of humans when interacting with IT systems to execute a business process. RPA has become a trend among new and long-established companies including IBM, GM, Bosch, and Siemens. However, there are many questions regarding the reality behind RPA solutions, where its effects for the company's internal organization remain widely unexplored.

This research explores an actual RPA adoption process which was not successful at a multinational firm and aims to provide insights into its intrinsic challenges. It subsequently discusses how the company's internal organization, rules and games of power can make technology implementations fail. The findings of this research indicate that intra-company organizations can make technology adoptions fail due to a combination of factors including inadequate management strategy and cross-functional collaboration. RPA is not a solution by itself for every problem, nevertheless a lack of education on the subject is causing some organizations to fall into the Maslow's (1966) hammer cognitive bias: when "all you have is a hammer, everything looks like a nail". Each tool has its own limitations, the real strength might lie in the combination of different tools. This empirical study contributes to adoptive capacity theory in a technology business setting.

3.2 Introduction

Operations Management requires a precise orchestration of diverse activities in order to run efficiently. The more people, activities, data, and decisions, the greater increase in the number of variables that influence how efficiently a company can run. Along the decades, Operations Management has found in IT technologies a possibility to become faster, leaner, and more effective. In the case of highly integrated Supply Chains, performance can be improved through "data standardization and systems integration enabled by a highly flexible IT infrastructure" (Liu et al., 2016). Nowadays it is hard to imagine how big companies could survive without Enterprise Resource Planning systems which can go from basic Material Requirements Planning systems to fully integrated SAP software versions, and sensorized internet-connected Industry 4.0 enabled shop floors.

The term Digital Transformation comprises two main streams, namely Digitalization and Automation. Digitalization refers to the development of digital tools, interfaces and platforms that can alleviate the daily efforts of the workforce by enabling faster and more effective communication as well as by analyzing great volumes of data to provide a better overall visualization to enhance decision making. On the other hand, automation takes on the role of emulating, replicating, and optimizing activities performed by humans with the help of complex algorithms.

Software as a Service (SaaS) and Platform as a Service (PaaS) have made it possible for firms to adopt third party technologies that would otherwise have taken significant efforts and resources to develop in house. These solutions are usually cloud-based instead of "on-premise" which means that the customer does not have to make great investments related to the purchase of costly software licenses, infrastructure to support them or provide continuous maintenance. Cloud-based systems take over those costs and maintenance activities in exchange for a monthly fee per user.

Robotic Process Automation (RPA) is the automation of manual human-driven processes through a software interface which records, and mimics actions performed by human users on operational IT-systems like SAP; it offers a low code, easy-to-use solution (Fersht, 2018). RPA allows automation development through graphical user interfaces instead of traditional computer coding which requires from the users previous software-programing background.

The aim of RPA is to relieve human workers from non-value-added repetitive administrative tasks (e.g., issuing purchase orders and invoices, processing payments, report data analysis and management). RPA is designed as an easy-to-learn platform which can be used by employees with no software programming background; it has the aim of alleviating the workload of the human work force, eliminating human errors and increasing productivity (Capgemini, 2020). RPA can support and possibly replace a human worker by taking over repetitive and tedious tasks with the main objective of augmenting the employees and helping them to dedicate their time to more value-added activities. RPA enables an automated control of existing graphical user interfaces when a proper Application Programming Interface (API) or a tailored software solution is not available.

According to RPA technologists, RPA is a cost-effective solution that can reduce processing costs by up to 80% and achieve ROI in less than 12 months (Utermohlen, 2018). RPA contributes by automating tasks through a software that mimics human actions when no complex decision-making or artificial intelligence is required. RPA robots can log into systems and applications, download and upload files, manage data, execute transactions, and interact with databases among other actions. However, as this study shows, it might be a short-term solution but not a long-term strategy.

In the dawn of the automation era, the uncertainty of how RPA should be adopted within a multinational organization is a ubiquitous question. Adopting new technologies into an organization has always been a challenge, there are a number of studies that have been conducted in this area depicting its effects on organizations and sharing useful insights about how to approach it (Autry et al., 2010; Obal, 2013, 2017). Therefore, it is important to study the adoption of RPA technology in the organization, particularly in long-established global organizations as it is aimed that robots take over tasks that employees have been executing manually for many years. The adoption of RPA technologies in the workplace constitutes a new phenomenon; compared to other technologies, RPA is a robot and it is expected that the collaboration between humans and robots entails greater acceptance resistance. I am interested in exploring and understanding its essence, variables, and implications inside a multinational company by researching the why and how of RPA adoption.

There are many factors which determine if an activity can be automated, these include structured rule-based processes and repetitive tasks among others. Algorithms and robots could help to automate operational business processes, however, "occupations involving complex perception, manipulation, social intelligence, emotion recognition and creative intelligence tasks are unlikely to be substituted by computer capital over the next two decades" (Frey & Osborne, 2017). Therefore, RPA's are currently only able to take over structured, systemic, and routine tasks where no higher cognitive analysis or creative intelligence is needed.

I address the following research questions:

- How are RPA solutions being adopted and implemented in large multinational corporations?
- What are the main challenges of adopting Robotic Process Automation in large multinational corporations?

It is estimated that 47 percent of total US employment is at high-risk to be automated within the next 10 to 20 years where logistics occupations, production labor as well as office and administrative support workers in service occupations are amongst the employments most likely to be substituted (Frey & Osborne, 2017). The main interest behind this research study is mainly driven by an expected intra-organizational resistance to adopt robots inside the human office workspace.

This study focuses on RPA solutions adopted by the Bosch Group between 2017 and 2020 at a multi-industry European company with a strong global presence. The purpose of this paper is two-fold: it first aims to unveil the process and effects of intra-company's organizations on the adoption of RPA technologies. It subsequently, intends to provide an insight about the challenges that a company must overcome in the RPA adoption journey. The Bosch Group was chosen as the unit of analysis of this research for three main reasons: first, it is a large corporation with a diverse array of internal organizations and with a strong global presence; second, it is a company dedicated to produce technology with an intense focus on innovation in its products and in its internal processes; third, the researcher has access to an ample personnel network inside the company.

I iteratively collected and analyzed data related to the technology adoption process in a multinational company setting. After an initial analysis of the data I decided to use Absorptive Capacity theory to explain the RPA absorption phenomena by using the framework developed by Zahra and George (2002). I empirically examined how the dimensions included in the Absorptive Capacity theory describe the technology implementation process at multinational corporations. I finally contribute to theory by adding a new dimension to the 4-dimension framework of Zahra and George (2002) which helps to comprehend why technology absorption can sometimes fail and part of the absorption strategy should be reversed and replanned; this dimension which I named “Dissolution” has not been studied in the Absorptive Capacity theory yet.

3.3 Theoretical Background

3.3.1 Digitalization and automation in Operations Management

Holmström et al., (2019) defines Digitalization as the “straightforward replacement of processes or tools with digital analogues” whereas “Digitalization as the use of digital information to fundamentally revisit intra and inter-organizational decision-making processes and architectures” (Holmström et al., 2019). System integrations like Supply Chains require a robust IT infrastructure to attain higher performance by strengthening the standardization of data. There is conflicting evidence on digitalization’s influence to foster innovation within organizations (Scuotto, Santoro, Bresciani, & Del Giudice, 2017; Usai et al., 2021) , as studied by Aspinall (2005), keeping a proper balance between innovation and complexity of value chains can optimize operations and improve relationships with customers.

The big data era brings new challenges to Operations Management regarding data analytics and processing which requires sources in different formats and from diver systems e.g. ERS, SAP, cloud platforms, internal company-developed IT systems (T. M. Choi, Wallace, & Wang, 2018). The supply chain structure is a driver for the use of IT and the innovation of internet-based technologies due to its high demand for enhanced information processing (Melville & Ramirez, 2008). Information with better quality can reduce inventory costs through better inventory tracking and superior information related to supply and demand (Kumar, Mookerjee, & Shubham, 2018). In the last 5 years, multinational corporations have looked more intensively for ways to increase operational performance through the integration of automated IT solutions; Choi et al.,(2018) discuss a variety of big data analytic techniques applicable to operations management including machine learning, AI and Data Mining.

3.3.2 Disruptive Technology

Robotic Process Automation (RPA) started to catch attention in 2010 as a radical technology with a potential for optimizing operations in diverse sectors. Firms should not ignore working with innovative partners such as technology suppliers as this may have a direct effect on the company's own innovation capabilities (Bellamy, Ghosh, & Hora, 2014). The importance of episodic collaboration between partners might have a direct impact on innovation provided that firms prefer to build core competencies in-house at the time of outsourcing non-core competencies, therefore they become more dependent on knowledge and expertise provided by external partners (Zacharia, Nix, & Lusch, 2011).

In some multinational big companies, internal organizations tend to be so diversified that could be studied as an interorganizational setting. Large multinational corporations are commonly organized in divisions, subsidiaries, and subunits across the globe, each one could develop its own local processes, rules and character influenced by location, culture, and environmental factors (Monteiro, Arvidsson, & Birkinshaw, 2008). In this sense, intra-firm organizations could exhibit similar practices as in inter-firm environments; each division may adopt different initiatives to manage their operations including digitalization. The digitalization of processes creates the opportunity for data to be accessed and used outside the boundaries of organizations. Sharing information openly with external actors is a risk that firms may not be willing to accept (Holmström et al., 2019).

The ability to combine internal and external developed knowledge and skills is becoming critical as innovations in new technologies may come from outside the current network. In this way, absorptive capacity has been studied as a highly influential capability during the acquisition, assimilation and distribution of new knowledge (Zacharia et al., 2011).

3.3.3 Technology adoption

Extant literature in Operations Management has highlighted different factors that drive the adoption and the continuous use of supply chain technologies (e.g., barcoding, warehouse management systems, collaborative forecasting and automated replenishment) (Autry, Griffis, Goldsby, & Bobbitt, 2005). Three theoretical perspectives, Transaction Cost Economics (TCE), Institutional Theory (INT), and the Technology Acceptance Model (TAM), have become well-established frameworks for identifying those aspects and the mechanisms that underly their relationship with technology.

The TAM explores the individual-level acceptance of new technologies, i.e. the elements behind an employee´s decision to use or reject a new technology which is determined by two cognitive factors: perceived usefulness and perceived ease of use (Brandon-Jones & Kauppi, 2018; Davis, Bagozzi, & Warshaw, 1989). Institutional theory (INT) analyses the isomorphism between groups or organizations by studying why different organizations implement similar structures, processes, or initiatives as others (Kauppi, 2013).

Transaction cost economics (O. E. Williamson, 1991, 2008) has provided the basis for frameworks in which technologies are considered mechanisms for managing boundary spanning activities (Johnson, Klassen, Leenders, & Awaysheh, 2007; Sanders, 2007; Young-Ybarra & Wiersema, 1999). As such, the argument for their adoption rests in the fact that supply chain technologies help firms increasing operational efficiency and reducing transaction costs (i.e., coordination cost and transaction risks) related to supply chain processes (T. Mukhopadhyay, Kekre, & Kalathur, 1995). For example, the adoption of some of these technologies reduce transaction costs by automating the exchange of inventory and billing information among supply chain partners (Aron, Dutta, Janakiraman, & Pathak, 2011). In other instances, they allow streamlining communication by means of electronic requests for quotations (eRFQ), and the automatic transmission of purchase orders (ePO) (Subramani, 2004). Similarly, it allows for inter-organizational collaboration by enabling the firm to engage in collaborative planning and sharing cost information with suppliers (Sanders, 2007).

Adopting a new technology in a long-established company is a complex challenge. While extensive research has been conducted in this area (Autry et al., 2010; Obal, 2013, 2017), there is a need however for empirical studies at multinational big corporations that show how a specific radical technology is adopted and assimilated across the organization in different regions, cultures, departments and functions. Companies must be able to detect new technology or knowledge and convert it into capabilities, failing in doing so will slow a company's reaction to market changes (Lane & Lubatkin, 1998).

3.3.4 Absorptive capacity

The dynamics of business and markets require firms to remain competitive by innovating and increasing performance. Large firms can have access to a greater breadth of internal knowledge generation and reduce the use of external knowledge (T. Schmidt, 2010); however companies should not only rely on internal knowledge generation but also on external knowledge, the ability to absorb it and use it for their own benefit (Aliasghar, Rose, & Chetty, 2019). The term Absorptive Capacity (AC) was first introduced by Cohen and Levinthal as "the ability of a firm to recognize the value of new external information, assimilate it and apply it to commercial ends which is critical to innovative capabilities" (W. M. Cohen & Levinthal, 1990). They suggested a 3-component model consisting of identifying, assimilating, and exploiting external knowledge. Absorptive capacity extends across several theories and frameworks including innovation performance (W. Tsai, 2001), learning & performance (Lane, Salk, & Lyles, 2001) and project management performance (Bjorvatn & Wald, 2018) among others. Over the years, AC has gone through many different re-conceptualizations, models and dimensions (Daspit, 2017).

Zahra and George (2002) propose a four-dimensions construct comprising acquisition, assimilation, transformation, and exploitation which can be grouped in two main categories: potential and realized absorptive capacity. Potential absorptive capacity includes acquisition and assimilation as "a way to explore, detect and bring new or relevant knowledge into the organization"; "whereas realized absorptive capacity includes transformation and exploitation of such knowledge on the way of using and eventually attaining financial gains with the absorbed knowledge" (W. M. Cohen & Levinthal, 1990; Zahra & George, 2002). Their model has been validated through a wide range of studies in the last two decades (Flatten, Adams, & Brettel, 2015; Jansen, Bosch, & Volberda, 2005). Innovation outcomes could be benefited when potential-AC leads to improved realized-AC (Leal-Rodríguez, Roldán, Ariza-Montes, & Leal-Millán, 2014).

AC has been targeted as a tool aimed to foster innovation; innovation happens when new technological knowledge helps to address unfulfilled customer needs. (Schweisfurth & Raasch, 2018). Trying to innovate with externally generated knowledge can in one extreme fall into the "Not invented here syndrome" (Christensen, 2011). To explore external knowledge by overlooking internal knowledge generation could cause knowledge exploitation to fail (Lichtenthaler & Lichtenthaler, 2009). Therefore firms with more internal research capabilities along with network connections and well-developed capabilities to assimilate and exploit external knowledge can innovate at faster rates (Fabrizio, 2009).

AC could open the doors to innovation, the acces to external knowledge is not enough for a firm to exploit it and produce value added from it; through a good developed level of assimilation capacity, knowledge must be transformed into specific capabilities useful for each firm (Zobel, 2017). Although acquiring and assimilating external knowledge is critical for innovation, it is just a part of the equation; companies must develop good internal capabilities for transforming and exploiting new knowledge (Aliasghar et al., 2019).

Organizational structures are a critical component of absorptive capacity, an organization's AC does not only depend on the access to external knowledge but also on how the knowledge is transferred throughout the organization (W. M. Cohen & Levinthal, 1990). AC can exert an effect on an organization's innovation performance through the cooperation and communication when using newly acquired external knowledge (S. Y. Yang & Tsai, 2019). AC can be additive over a period of time if the organization has the appropriate capabilities; additionally, prior related knowledge can promote absorption (Lane et al., 2001; T. Schmidt, 2010). Nonetheless, hierarchical centralized structures have a significant negative effect on knowledge sharing as they do not allow for social interaction (Gupta & Govindarajan, 2000; Lane et al., 2001; W. Tsai, 2001). Power, hierarchy, and politics inside a company can significantly influence knowledge absportion processes by determinig what specific external knowledge is accessible and which part of the organization is granted access to it (Easterby-Smith, Graça, Antonacopoulou, & Ferdinand, 2008).

AC has shown to have a stronger effect in organizations when it is done through informal means of interaction and communication; the less centralized and formalized the information is, the faster and less altered the transfer of new knowledge can be (T. Schmidt, 2010). Therefore, to maximize the benefits of knowledge transfer it is vital for an organization to sponsor a culture that encourages knowledge transfer through informal mechanisms of interaction among groups, departments, and regions. Zahra and George (2002) also highlighted the significance of social unification instruments as a promotor of AC by reducing the distance between potential and realized AC; this can be achieved by including joint project teams, face to face meetings, and other venues for sharing information (Leal-Rodríguez et al., 2014). Other studies have also highlighted the importance of creating internal informal networks for the assimilation of new knowledge (Jansen et al., 2005; Lowik, Kraaijenbrink, & Groen, 2017; Volberda, Foss, & Lyles, 2010). The individual ability, educational background and motivation of employees are crucial to absorb external knowledge (Minbaeva, Pedersen, Björkman, Fey, & Park, 2003). Prior closely related knowledge can facilitate the assimilation and exploitation of new knowledge; a firm without developed AC can fail in detecting new opportunities (Lane et al., 2001).

Yildiz et al., (2019) sees AC as a key for competitive advantage and considers that multinational organizations dispose of a plethora of sources of external knowledge; employees need to have a high degree of motivation in uncertain environments and an elevated receptiveness for new experiences. Inside Multinational organizations, knowledge transfer is a process driven by the demand of subunits and subsidiaries; operational performance and knowledge flow are higher in organizations that are more closely integrated to the head corporate organization compared to the more isolated groups (Gupta & Govindarajan, 2000; Monteiro et al., 2008). It is important to have internal experts with ample experience in their fields, procedures, processes, and needs of the company to successfully integrate complex knowledge (W. M. Cohen & Levinthal, 1990).

3.4 Methods

To find out how RPA is absorbed by an organization, which can be considered as an emerging phenomenon, I conduct an inductive multiple case study (Eisenhardt, 1989; Meredith, 1998; Yin, 2014) of RPA technology adoption at Bosch, a Tier 1 automotive supplier. I investigate projects adopting RPA software solutions in diverse departments and divisions located in Australia, Brazil, China, Costa Rica, Germany, India, Mexico, Romania, and the USA to reduce the risk of idiosyncratic applicability. By developing a case study in multiple regions and company's locations I intent to detect if a specific local organization's work culture, targets or rules contribute to technology absorption. I will specifically investigate the adoption and use of RPA technology in business process automation projects. Theoretical sampling will be used as a means to develop a multiple case study that will offer theoretical insights on a new phenomenon (Eisenhardt & Graebner, 2007).

A set of 26 semi-structured interviews with 26 employees (see Table 3.1 below) from diverse divisions, departments and regions were conducted in two rounds in March and August 2020 with key members of the automation development team, internal customer departments, stakeholders, executives, and an external RPA software solution provider. As a means to increase data validity trough triangulation (T. Y. Choi & Hong, 2002; Eisenhardt, 1989) archival data and documentation was gathered to further analyze pre-, during and post-RPA adoption phases. I was granted full access to all stakeholders, project team members and relevant data from 2017 to 2021. Data was analyzed through 1st and 2nd order coding to detect the dimensions describing the effects and phenomena around RPA adoption in big size multinational incumbent organizations (Gioia et al., 2013).

3.4.1 Case selection

As operations management becomes more complex, companies develop systems to help increasing efficiency and attain overall optimization. Systems including ERP and EDI have been under wide adoption for the last 30 years as a way to have full control over a company's operations; alternatively, companies have constantly invested in developing internal IT solutions to fulfill additional unique or idiosyncratic needs. Since 2010, digital automation of business processes gained more interest from firms in their search for cost reduction and optimization. Start-ups and tech companies started to make their efforts in seizing the opportunity of becoming third party providers of digitalization solutions to big size companies in diverse industries.

I identified the adoption of new technology at the Bosch Group as our unit of analysis for this study (Barratt et al., 2011) due to its consistent focus on innovation, its global footprint, its widespread internal adoption of RPA technologies since 2017, and our access to their employees. I provide a detailed description of the case and quotations from key informants as evidence (Yin, 2014).

As this new phenomena is being present at a global scale inside the company, I designed a deductive multiple case study which integrates the realities and experiences of employees around the world (Gioia et al., 2013). Therefore, I selected interviewees with diverse backgrounds and functions related to RPA in each of the bot development offices located in 9 countries covering North, Central, and South America; Western and Eastern Europe; South and Eastern Asia as well as Oceania.

3.4.2 Case description

In 2016 Bosch Worldwide commenced its journey into Robotic Process Automation as part of the company's bid on process optimization through digitalization. The worldwide initiative was started by the global president of purchasing based on a personal interest in the subject; since 2015 until his retirement in 2020 he remained as the main sponsor of these activities. Soon after designating a small team to take over the responsibility for digitalization projects in purchasing, a partnership with the corporate information systems (CIS) division was established. Together, they funded a new department and physical office in Germany to lead the digital transformation activities (DI); another team sponsored by the corporate offices in North America was established in the Chicago area. Both teams, following the lead of the German offices, scouted for digitalization and automation solutions providers in the market. After a careful sourcing process, the providers were selected and issued with purchase orders for the first user licenses.

RPA refers to the automation of business processes and tasks through software robots mimicking human actions. The RPA system watches the human user performing a task on a computer screen through the Graphical User Interface, records the actions and repeats them. RPA has a broad range of uses including Banking, eCommerce, Supply Chain Management, Accounting, and diverse data management applications; it is marketed as a low-code, easy to program, process centric solution.

The corporate information systems division (CIS) has extensive experience in software solution development, core systems maintenance, governance, and interface delivery. Part of the purchasing organization's intention of partnering with the CIS division was to have them manage the infrastructure, accesses, licensing costs and maintenance. Once the selected RPA third party solutions were onboarded, the newly appointed DI department in Germany and North America started to follow a democratization approach as an intent to massively diffuse the adoption of RPA technologies in a faster and smoother way. Digital Automation started to gain attention and momentum at Bosch worldwide, every department and division wanted to have their share of this initiative and started to follow their own path in RPA and digitalization without a common global strategy, standard procedures or overall governance.

By adopting RPA as a new tool in the company's portfolio and due to the size of the company, it is not possible for a single department to centralize and support all RPA related activities for the whole organization. Therefore, the chosen strategy to follow was to transfer all the knowledge into the global organization for each department and group to be able to create RPA bots by themselves without needing the support of a central RPA development department. This approach, called democratization, is the opposite of centralization and aimed at creating a culture of company-wide access to knowledge and technology which is also intended to lower organizational structure costs.

During the Covid19 crisis, the company endured a major re-organization at a global scale; a president was named to take over a newly created global division called Global Services. The new division absorbed a diverse set of departments ranging from accounting to technology; the organization was significantly reduced by removing senior positions all over the world. Most of the local RPA-promotor automation groups worldwide were dissolved and centralized under a new organization in charge of enabling new technologies; however, the democratization strategy , with the intent to provide each employee with direct access to RPA software so they could proactively program RPA bots by their own, was set back and all RPA developments were taken over by the Global Services division which charges development fees by the hour to all its internal customers.

3.4.3 Data collection

Data collection took place from March to August 2020, I conducted 26 semi-structured interviews in 9 countries covering all the regions where Bosch business process automation is present. Participants are Bosch employees ranging from IT developers to top management, 1 interview was conducted with the key account manager of an RPA solution provider located in the USA. Due to Covid-19 restrictions, all interviews were performed by teleconference and were taped with explicit permission of each interviewee. Additionally, notes were taken, and some participants provided documents, charts, and presentations as a support to their comments.

Every interview lasted for 1 hour and followed a protocol (Appendix C) prepared in advance by the researcher. All interviews were performed in English, transcribed verbatim and double checked for omissions and typographical errors.

Table 3.1 RPA Interview List.

Id	Department	Function	Location	Builder	User
1	Digital Automation	RPA developer	Mexico	✓	
2	Digital Automation	RPA developer	Mexico	✓	
3	Logistics	Planner	Mexico		✓
4	Digital Automation	Director	Mexico		✓
5	Digital Automation	Developer	USA	✓	✓
6	Digital Automation	Manager	USA	✓	✓
7	RPA External Company	Solution provider	USA	✓	
8	Purchasing / Automation	Manager	Brazil	✓	✓
9	Accounting Innovation	Developer	Costa Rica	✓	
10	Accounting Innovation	Manager	Costa Rica	✓	✓
11	Digital Automation	Manager	Australia	✓	
12	Finance	Manager	Romania	✓	✓
13	Digital Automation	Developer	China	✓	
14	Digital Automation	Manager	China	✓	
15	ERP System Mgmt	Planner/buyer	China		✓
16	Automotive Process	Director	China		✓
17	Finance	Manager	India		✓
18	Digital Automation	Developer	India	✓	
19	Finance	Director	India		✓
20	Logistics	Planner	Germany	✓	✓
21	ERP in Purchasing	Manager	Germany		✓
22	Digital Transformation	Manager	Germany	✓	✓
23	Digital Transformation	VP	Germany	✓	
24	Accounting Innovation	Director	Germany	✓	✓
25	Digital Automation	Developer	Germany	✓	
26	Power Tools Purch.	Director	Germany		✓

3.4.4 Data Analysis

Throughout the stages of my research and taking into account the unexpected onset of the Covid-19 pandemic at the time of the investigation, I adopted an exploratory research approach by which data collection and data analysis were conducted iteratively (Glaser & Strauss, 1967). Based on the newness of the RPA phenomenon, I decided to follow an deductive case design (Gioia et al., 2013) with a longitudinal perspective from 2015 to 2020. I focused my main interests on the challenges and effects of adopting digitalization and business process automation technologies in the organization, specifically RPA. All interviews were transcribed, coded and analyzed according to (Saldana, 2009) and (Gioia et al., 2013).

As a first step I employed an open coding approach by following interviewee's perspectives, expressions and opinions as precisely as possible (Saldana, 2009). As I grouped the first order codes into second order codes to relate them with existing theory (Eisenhardt & Graebner, 2007) the relationship with Technology Adoption theory was noticeable; however, due to the transformative nature of RPA in relation to intraorganizational operational processes some codes remained uncategorized and were more clearly explained though an Absorptive Capacity model. The success of innovation collaborations can depend on absorptive capabilities instead of already established knowledge sharing routines (Zacharia et al., 2011).

In this research study, I am looking at the RPA technology absorption phenomena from an intra organizational-level perspective at a large multinational company through Zahra & George (2002) 4-dimensional construct constituted by potential and realized AC where potential capacity consists of knowledge acquisition and assimilation capabilities. Potential capacity enables firms maintain a competitive advantage to adapt and evolve in high velocity environments. Organizational crises, performance failure or important events can moderate the influence of knowledge sources and experience on AC development. (Zahra & George, 2002).

Due to the multidimensional nature of absorptive capacity, managers struggle with understanding how to enhance the firm ability to acquire new knowledge. Results suggest that a four-component model of absorptive capacity as conceptualized is positively related to performance (Daspit, 2017). I follow the 4-dimension model as described by Zahra & George (2002) p.189:

- Acquisition: the ability of a company to a identify and acquire knowledge that was crated outside. The intensity and speed to detect and integrate knowledge have an effect on the ability of a company to acquire knowledge.
- Assimilation: Capability of a company that enables it to examine, evaluate, interpret, and comprehend data generated by outside sources.
- Transformation: Company's ability to define and foster processes which enable the integration of current internal knowledge and knowledge brought from the outside.
- Exploitation: capability to generate new competencies by embodying acquired and transformed knowledge. Exploitation requires knowledge sharing. Social integration contributes to knowledge assimilation (informal social networks or formal coordinators). Transformation and exploitation can possibly affect a company's performance by means of innovating its processes and products.

Based on the AC model proposed by Zahra & George (2002) I reflected on the data collected to assess its overlap on each dimension according to basic operational characteristics that I assigned as enabling factors for each dimension:

Table 3.2 RPA AC dimensions assessment.

Acquisition	Assimilation	Transformation	Exploitation
-Investment in new technologies -Budget for new tools -Innovation strategy -Leadership support	-Preexisting related knowledge -IT Infrastructure -Workforce acceptance -Perception of threat / benefit -Resource allocation	-Personalization -Organizational sponsorship -Empowerment -Motivation / Interest -Internal process/ technical barriers	-Success stories -Widespread use -Confirmed benefits -Perceived value added -Durable robust solution

3.5 Case Results

Throughout this section, I report on the analysis of the data collected about RPA adoption at Bosch worldwide. I have split the findings into categories based on the AC dimensions from Zahra & George (2002). Figure 3.1 depicts the coding and aggregate dimensions for my inductive multiple case study; the most important codes derived from our interviews are included.

My study spans 4 dimensions of RPA adoption at the Bosch Group which can be translated into the operational setting as shown in the following Table 3.3:

Table 3.3 Dimensions of absorptive capacity.

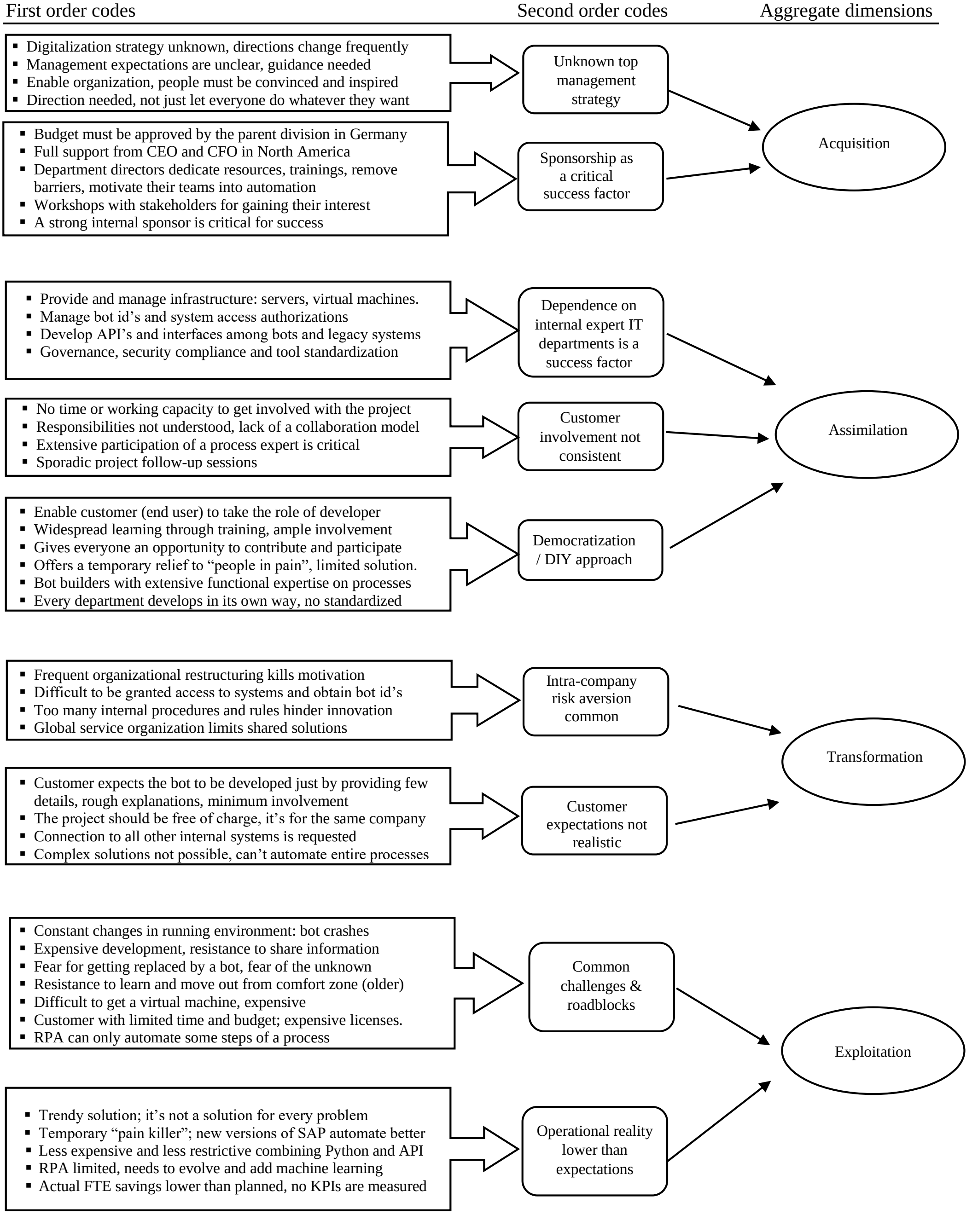
Acquisition	Assimilation	Transformation	Exploitation
The company gains interest in introducing Robotic Process Automation as a tool to make operations more efficient and reduce costs. They decide for a democratized adoption.	The new RPA technology is dispersed throughout the organization by means of short training- and "learn on the job" sessions following a democratized concept.	RPA bots are self-developed by each unit and division; hence development happens in silos. Duplicated efforts start to appear, software licensing costs become a concern.	Not all bot developments get implemented, some finished bots are finally dismissed or malfunction soon after becoming productive. Initial expectations are partially met.

Robotic Process Automation is aimed to increase the efficiency of operations by mimicking actions of humans when using software, platforms, and websites. RPA can login into a system as a human does, it selects options, clicks buttons, uploads, and downloads information. The motivation behind RPA is to release human workers from performing non value-added boring tasks and let them do jobs which in turn could bring more benefits to the company. RPA can automate sections of a wide variety of business operations processes ranging from the elaboration of finance reports to the management of candidate's details by HR departments.

Not every process is a good candidate to be automated through RPA; complex non rule-based processes are out of RPA's scope but can be handled through Artificial Intelligence. The main requirements for a process to be considered a good fit for RPA are:

- Standardized process, rule based with structured data
- Repetitive, time consuming, non-value-added activities
- Mapped, well understood processes
- Cost effective RPA development and scalable
- No interaction with multiple systems

Figure 3.1 Code aggregation diagram of company-wide RPA implementation.



3.5.1 RPA acquisition

RPA was brought into the company in 2016 following the interest of top executives in the Logistics and Purchasing division as a way to optimize operations. There was no clear strategy cascaded down from the top management and the directions regarding how and who can use the technology changed frequently. A couple of departments in Germany and USA took the lead in using the RPA software and administering the licenses for other interested users. Expectations form the management were not clear from the beginning, but their goal was to adopt RPA and find projects to solve with the new tool; the highly innovating company had the need to be part of this new wave of technology solutions. A digitalization manger refers to a lack of digitalization strategy from the top management:

"I'm coming from the organization that actually should determine the digital transformation strategy worldwide and I regret to tell you that there is no strategy, if there was one I would know about it and this is probably not a good sign" (Id 22).

Without having substantial knowledge and expertise in business process automation, department leaders worldwide focused on enabling their organizations by removing internal bureaucratic barriers, providing the financial resources needed to buy licenses, coordinate trainings, and perform internal bot programing sessions. However not all the employees chosen to take part in RPA projects were authentically convinced by the technology, interested nor inspired; they lacked motivation and interest at the same time of experiencing uncertainty due to insufficient or wrong information about this technology. It takes a big effort for a department to get additional budget authorized by the parent division in Germany to invest in new technologies, this lengthy process discourages innovative ideas and initiatives. In some regions like North America, it takes the full direct support from the CEO and CFO to remove those innovation hindrances as stated by a digitalization manager in the USA:

"From a North American perspective, the CEO and CFO positively champion these projects, they had been part of automation workshops and meetings, they have sponsored our mini RPA lab where people can get hands-on experience with automation and see its benefits" (Id 6).

Regarding intracompany acquisition among company-wide regions, divisions, and departments sponsorship plays a big role. Even when those technologies are already authorized for use by the global IT offices, user licenses are very limited and expensive; not every department can acquire them. Notwithstanding the resourceful support from local leaders, a lack of global RPA adoption strategy and standard directions translates into an undesired scenario. Every department and every region went about RPA their own way which unexpectedly had a counterproductive effect: automation projects being worked in silos which consequently set out a wave of internal rivalry among departments hindering team integration and cooperation as they do not share information with each other. Additionally, as pointed out by a RPA developer in Germany, the lack of cooperation, communication and integration induced by the democratization approach caused that different departments worked independently on similar solutions at the same time:

"It makes no sense that every plant or site develops their own bot version for the same common problem, this costs a lot of money, therefore it's better to have a centralized development approach for common use cases" (id 25).

3.5.2 RPA Assimilation

The process of developing an automation bot took many different directions at Bosch worldwide, some teams use a traditional project management approach while others an agile focus with multiple sprint sessions. Until the time of our research there was no standardized process in place for bot development, some simpler bots are created by the end user or functional department while more complex bots are delegated to a dedicated RPA development department.

The use of RPA requires the rental and maintenance of IT infrastructure that is costly for some organizations, this includes the use of servers and virtual machines that are used to run the bots on specific time schedules. An RPA bot will require access to all involved company's internal systems to obtain data, files and information needed to perform its tasks. Granting a user access account to a bot is not an easy task as a formal request must be formally submitted and approved by Director-level employees, this process is lengthy and not always successful; if an approver is not an RPA supporter the request is rejected and the bot project canceled. This is a challenging process according to an RPA developer:

"There is a lot of misunderstanding on how RPA bots are working because they are not artificial intelligence based, they are just programmed to record and replicate clicks and typed text that a human does on a computer. However, IT-unexperienced managers fear that the bot could suddenly gain intelligence to openly manipulate confidential or business-critical data by its own, which is not the case" (Id 2).

Once a group tries to start working on an RPA project, this often requires the involvement of other areas that are part of the process to be automated. There is no time or working capacity to get involved in the automation project which usually comes on top of the employee’s daily activities. An official collaboration model is inexistent, a clear definition of responsibilities or split of tasks is rarely present. Although the department’s functional processes are clearly defined, as the bot will be programmed to emulate a manual process performed by humans, the support of specific-process experts is required to effectively program the bot. The participation of experts is generally very limited which causes very long development lead-times as well as bots that will have to be discarded, reworked, or constantly fixed. Time availability to organize project follow-up sessions is also very limited which makes these sessions to become scarce, prolongs development times, and leaves some project requirements unknown and unmet.

“You can have the best tools in the world and offer them as optimization instruments in your organization but if no one is capable of or has the time to make use of them, you might as well not have those tools at all and achieve the same results” (Id 22).

The main strategy behind the wide spread use of RPA technology was to follow a democratized approach; anyone interested in it could use it. It aimed for enabling end-users with extensive knowledge of and experience with functional processes to take the role of developers and work on a solution that better fits their needs. This action would bring an immediate solution to departments in need for automation and process optimization; however, this turned to be a temporary limited solution for most of the cases. By having a democratized approach, groups in different locations were developing similar solution for the same problems as they had no communication among them. The company does not have a shared licensing model, therefore each user must pay for a license even if they barely use the software. A lack of specific governance for this kind of technologies severely affects and slows innovation down because the bot developments must be compliant with strict rules and procedures that were developed for traditional products in the past and not for software or bot's development.

"We do not want to be the only ones driving automation in the company, we want everyone to have the chance to be transformed, make their own bots with a "do it yourself" approach but we need coding guidelines and processes for it" (id 17).

3.5.3 RPA Transformation

Most departments interested in developing RPA bots have in mind to use RPA for connecting several legacy internal systems and provide a long-awaited solution to very complex problems. They await that a bot can be developed by providing not very precise details about the process but just general information, and minimum involvement from its team members. Moreover, they expect that an RPA bot development should be done free of charge as it is already part of the company's software suite offered internally. The reality is that RPA has its clear boundaries, it cannot automate instable processes and its development entails great efforts and development costs. After initial trials, non-IT expert departments find difficulties at automating complex processes; RPA can generally only automate some sections of a process as explained by an RPA developer:

"By the end of the project we realized that some data from SAP cannot be downloaded by the bot meaning that the automation was only achieved in a 90% as the data has to be manually obtained" (Id 1).

It was found that during the development phase, the non-IT departments draw upon the support of IT expert departments for the development of more complex RPA projects. According to our interviewees, once this project is taken over by an automation specialist department, the customer shows scarce time availability to work on the project; this is mainly due to a lack of an standard collaboration model with clear assignment of responsibilities for each team member as discussed by a department director in China:

"We need to be aligned through a collaboration model that clearly specifies responsabilities for each team member and establishes which person to contact in every case", (Id 16).

Two years after promoting RPA as a democratized tool accessible by anyone interested on it, due to a limited number of licenses, high complexity of projects, difficulty in getting system accesses approved, and low success rate in RPA implementation by non-IT departments, a global corporate reorganization took place which mostly reversed the democratization strategy and centralized all RPA development activities in expert programming teams. A global CIO for digital transformation was named; the organization reduced its hierarchies and disintegrated some teams, this decreased the motivation and raised uncertainty among RPA team members world-wide. Additionally, company's internal security rules and procedures for IT-systems hindered the development and implementation of automation bots.

"This organizational change killed our motivation, you can see it in the people around you; now, the people and management performing the change are motivated because they have the authority and power to change the world" (Id 11).

Organizational antecedents can have different effects on how well a company can absorb new knowledge (Jansen et al., 2005). C-level management succession has an influence on potential and realized absorbed capacity as the newcomer is hired for possessing new strategies, initiatives, knowledge of the organization and operations as well as access to an influential internal network and budget to make changes (Ramachandran, 2018). In regard to leadership, transformational inspirational leaders have more positive effects on knowledge exploration whereas transactional high-power leaders on knowledge management but with reduced knowledge assimilation (Flatten et al., 2015).

3.5.4 RPA Exploitation

Exploitation is the phase where the organization would use its previously developed capabilities to create new competencies by incorporating acquired and transformed knowledge; in this case study, however, exploitation is the stage that presented most challenges. Less than the 30% of the non-IT employees that were trained in RPA still create new automations one year after the training concluded; people went back to their normal working routines and rely on IT-experts for RPA activities. Exploitation requires knowledge sharing where social integration contributes to knowledge assimilation (Zahra & George, 2002), however, after the remote working schemes originated by the 2020 pandemic the in-person trainings, knowledge-sharing gatherings and RPA sprint sessions were canceled and reduced to very scarce short monthly meetings where a small group of users in every region share their experiences and knowledge about RPA. Instead of cooperation, the non-IT departments developing RPA bots compete against each other by sharing the minimum information possible and avoiding disclosure of their new project ideas; it is more a competition among Directors trying to attract the top management's attention required to promote their careers.

"If the management took an appropriate position in the project and left their pride behind we could definitely be more efficient at using these technologies, however every manager is trying to use these projects as a justification to get a promotion" (id 10).

On the technical side, as the RPA bot mimics human actions on a screen such as entering login information, clicking buttons and navigating through visual software front-end, any change to the company system's running environment or to the customer's software infrastructure will make the bot crash and become obsolete which is something that happens often. Therefore, RPA constitutes a temporary relief and is not a long-term robust solution by itself.

"Bots may easily crash if there is any change to the system's current environment, for example in SAP or any website that the bot uses to get data from" (id 2).

At this stage there is still some initial resistance from non-IT employees to accept RPA and similar technologies based on uncertainty, misinformation, and fear of being replaced by robots. There is also a considerable reluctance from some older employees to change the way they have been doing their job during so many years; they prefer to avoid substantial changes in their already mastered activities, i.e. moving out from their comfort zone. Although RPA adoption is not aimed at replacing human workers, I found that the fear for getting replaced by a robot is real in older generations followed by a generalized reluctance to provide process-related information and cooperate in the initial project phases as mentioned by a finance department director in India:

"Some people are really scared about how automation is done; they believe their jobs are at stake therefore we see a kind of resistance to get the information we need. It's not like we are trying to get them out of their jobs but just getting them skilled up so they can do a better job" (id 19).

After the bot is finished and implemented at the customer department, I found that no KPI´s are measured as a means to analyze and evaluate the benefits that RPA is yielding. Moreover, one of the main reasons for companies to be interested in RPA is the reduction of FTE human capacity, notwithstanding I have found that FTE savings are much lower than those initially planned. Despite having technical limitations, when combined with other solutions such as Machine Learning, Artificial Intelligence, API's or other interfaces, RPA has shown to significantly increase its power and benefits to the company.

"RPA can be a standalone solution. But if you want to increase its power by N number of times, you can also bring other technologies and the power will be kind of extrapolated" (id 20).

3.6 Discussion

What are the main challenges of adopting Robotic Process Automation in large multinational corporations? How are RPA solutions being adopted and implemented in large multinational corporations? This research focuses on studying the absorption of RPA technologies in the workplace as a way to determine its effects on internal organizations on a multinational company. A multiple case study was designed to collect data by means of semi-structured interviews with employees of the Bosch Group in 9 countries across 4 continents. The case study targeted multiple Bosch internal organizations responsible for supply chain management, operations and IT development. Through this research, results indicate that organization's internal culture, strategies and regulations significantly influence knowledge transfer as well as overall technology AC's performance; however, an organization's own internal limits and structures determine what knowledge and up to what level it is assimilated and exploited (Lane et al., 2001).

Absorptive Capacity (AC) has a direct beneficial effect on a company's innovation capabilities and performance if a high level of potential AC can be transitioned into higher realized AC and this consequently translates into higher chances to exploit new knowledge for commercial purposes (W. M. Cohen & Levinthal, 1990; W. Tsai, 2001). An organization's overall AC capacity can be regarded as the sum of its individual member's AC (W. M. Cohen & Levinthal, 1990). Prior knowledge diversity and external network diversity have an impact on individual's AC in the identification of innovation opportunities and absorption of new knowledge (Lowik et al., 2017).

The newness of business process automation can bring benefits and challenges to organizations, a lack of deep understanding of new technological tools create a set of misinformation and wrong expectations that are difficult to meet. Expectations from the internal RPA-interested departments are high in the sense of assuming that RPA bots could be developed by providing only few details about their processes and requiring the minimum involvement from internal customer's employees.

There were high expectations from the global top management in democratization as each department could enable their own functional and process experts to develop their own bots in their own way. However, their non-IT related backgrounds proved difficult to help them develop acceptable solutions which consequently drove them back to hire the support of an expert-IT RPA development department.

Democratization comes with a cost; throughout this study it has been found that it is complicated for a technology such as RPA to thrive in isolation; the value synergy caused by using complementary IT systems can positively influence a company's performance (Tanriverdi, 2006). On the technical side, an RPA bot needs to be issued access and credentials to the systems it will work with such as SAP. Obtaining approvals for a human user-id to be used by a non-human entity has been a long existing hurdle for the RPA developers, therefore a very close collaboration with the central IT department is an imperative but usually a highly difficult mission. Central IT departments are also in charge of managing infrastructure including the virtual machines where the bot runs, however, they are limited and expensive. They are also in charge of developing API's needed to integrate the bot with legacy systems which requires significant time and costs. Moreover, democratization causes that RPA developments start to happen in silos as there is no common platform where developers can interact and share information. Therefore, duplicated solutions started to appear worldwide; it's difficult to know what others are developing.

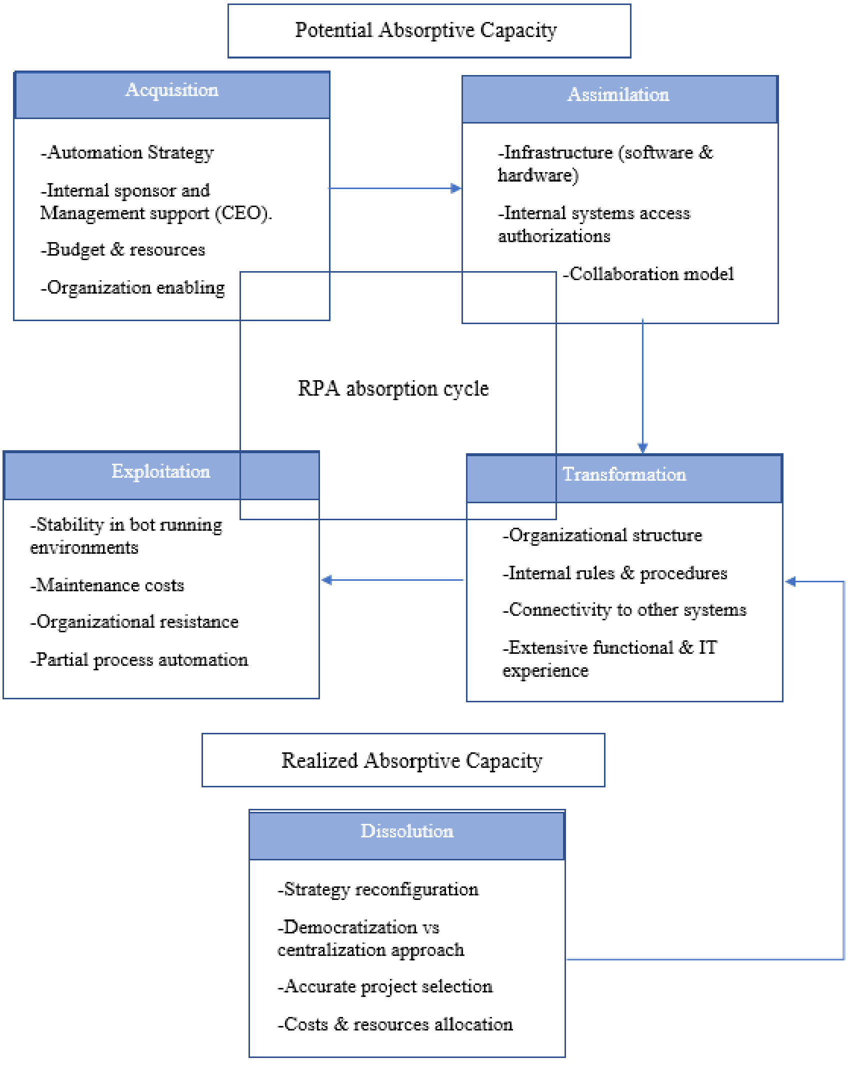
The process of developing and implementing an RPA bot endures numerous roadblocks along the way, hence some regions opted to have their own regulations. It is not appropriate to use a unique IT strategy in each business unit as it fosters interdependent actions and minimizes the firm's chance of creating cross-unit IT synergies. A lack of coordination among subunits in relation to their individual IT investments generate system redundancies and overspending (Tanriverdi, 2006).

Figure 3.2 depicts the RPA absorption process based on the AC model proposed by Zahra & George (2002). Based on my research at the Bosch Group, the diagram comprises factors which constitute components for success for each AC dimension. The failure of RPA absorption is the combination of a lack of these factors in some degree at every phase of the process. Consequently, as an outcome of this study, I added a new phase called "Dissolution" as described in the next section.

It is not the hierarchical power to impose changes and initiatives on the organization but the ability to create and foster an organizational environment that facilitates the adoption of new practices (Peeters, Massini, & Lewin, 2014). AC is an external arm of organizational learning (Sun & Anderson, 2010); however, to what extent external knowledge is unrestricted and who is allowed to take advantage of it is determined by power within the organization where groups compete for the control of knowledge based on their own identity (Easterby-Smith et al., 2008).

RPA is not a "one size fits all solution", it cannot automate full processes by itself, it can only automate some parts of a process which turns it into a temporary fix to an operative problem but it can be complemented by other technologies such as API's or Machine Learning in order to offer more robust solutions. Investing in processes and activities to promote the acquisition and assimilation of new knowledge as well as developing capabilities to enable knowledge transfer and exploitation is key for innovation success (Flor, Cooper, & Oltra, 2018). In the same way, managers can directly influence AC by acting as information providers within the organization and looking for individuals with related prior experience to enhance its assimilation (Lenox & King, 2004).

Figure 3.2 RPA - Absorptive capacity cycle.



3.6.1 RPA Dissolution

Based on my findings of this case study, the democratization strategy of this company behind technology absorption was not successful enough to consolidate and stabilize the use of RPA which led to setbacks at the final stages of the absorption process. I named this combination of setbacks technology dissolution, a phase through which organizations are pushed to reverse their strategies and replace them with opposite actions. Functional departments do not have the capacity and capability to continue with RPA due to its complexity; they finally opt to discard RPA and rely on experts.

One key example of dissolution in the RPA implementation process, is the return to reliance on a central automation expert after first relying on a democratization approach. RPA technical complexity, lack of IT-related background, different groups developing similar bots for the same company-wide problems, limited number of licenses, and additional infrastructure costs led groups with limited IT experience to rely on a central automation expert department to take over their RPA developments after first having used a democratization approach. By the end of this study RPA projects were being developed only by RPA experts and internal customers were being charged with hourly development rates including the costs of software licenses and the use of infrastructure like servers and virtual machines.

Many factors contributed to the initial failure of this RPA technology absorption process including: major organizational changes caused by a C-level management succession, misinformation, internal rivalries, lack of top management strategy, insufficient communication, extensive internal processes, overregulated access to infrastructure, internal data security rules and not having a proper understanding about what the tool is and what the tool can do.

3.7 Theoretical Implications

Using a 4-dimension absorptive capacity construct helped to understand at which of the dimensions is the technology absorption process having the biggest challenges and facing the greatest obstacles. As observed in this study, among other factors, technology absorption can fail due to inter-organizational silos, lack of internal collaboration and poor management strategy which constitutes an important outcome I named "Dissolution" which helps to determine the reasons of failure.

Current remote-working schemes are becoming dominant since the onset of the Covid-19 pandemic and so are digital and process automation technologies. As the work environments become more virtual and "dehumanized", organizational management is having a direct influence on how far a company can go in relation to business process automation technologies.

3.8 Managerial Implications

The multiple case study involving RPA technology implementation at a big transnational firm shed some light on how organizations can enable or hinder the absorption of new knowledge and technologies to modernize and optimize long-existing business processes. It was important to find out that it is not the technical infrastructure itself the main obstacle in the technology absorption process but deficiencies within the internal organization.

Companies should invest in developing their internal capabilities to be able to quickly change, reconfigure and adapt themselves to new market's requirements and challenges; it is interesting to know that many problems and limitations of a company's operations management come from the inside of its organizations and can be optimized by a suitable management strategy.

3.9 Limitations and Future Research

In this study I tried to cover as many regions and countries as possible to increase case applicability and reduce any cultural or local subsidiary-related bias; however despite including subsidiaries, departments, and groups as diverse as possible I only applied the research to one large company. Validating the results in a different market and region would help to understand the applicability of my findings.

The unexpected onset of the Covid19 pandemic brought several limitations and challenges to my research. The unfeasibility to perform interviews in-person and visit the corresponding Bosch locations restricted my data collection options to video conferences, virtual meetings, and emails. In-person visits to physical offices might lead to additional sources of information and access to a greater number of informants.

4 INDUSTRY 4.0: SENSORIZING THE SUPPLY CHAIN.

4.1 Summary

This qualitative case study explores the process of developing a new IoT solution aimed to make supply chain operations more efficient and mitigate the risks for disruptions. In the early spring of 2017, the Bosch automotive sales department in North America was facing monetary compensation charges by one of its most important customers, a car manufacturer in the USA, due to unmet product deliveries. It was found that a lack of monitoring of supplier production indicators increased the probability of having unexpected supply chain disruptions. This case study narrates the struggles to finalize the development of a supply chain's highly anticipated IoT supplier monitoring solution which had already taken 4 years, multiple tries from different teams and company's resources. Initially, this solution was developed to monitor the production lines of Bosch automotive sub-suppliers, however, it was then turned around as a new value proposition targeting a broader industrial market. This article explains why those efforts were unsuccessful and provides a roadmap to achieve better results.

KEYWORDS: IoT, supply chain digitalization, digital transformation, process, innovation, product development, project management.

4.2 Introduction

It was in the early spring of 2017 when a regional Vice-president of supply chain at Bosch North America could not stop thinking about significant monetary damages being charged once more against the Bosch automotive sales division in the USA by one of its most important customers, a car manufacturer in the USA, due to unmet product deliveries. This was not a minor isolated incident which could be justified as a natural fluctuation of production volumes but a long-standing problem with probably serious implications to the company´s relationship with its customers and possibilities for future sales opportunities. Bosch operations has consistently focused on optimizing its internal production processes with the latest technology available, however what happened at its supplier's own production plants might offer a different story.

This thought made him suspicious about the contribution of Bosch's automotive suppliers to the problem, but he was determined to find it out. He had allocated a special budget to create a small group of supply chain employees led by a regional senior purchasing manager and assigned them the task to further analyze the situation and provide a solution. It was found that a lack of monitoring of supplier production indicators increased the probability of having unexpected supply chain disruptions. The project team entertained the idea of designing a sensorized monitoring application that could share real-time data about the supplier's production process to Bosch supply chain management departments.

The initiative proposed a simple and open internet-based "smart" monitoring solution that could connect machines to an IoT interface to provide data analysis on a real-time and predictive basis. This solution not only had the potential to optimize supply chain operations but also to offer suppliers a plug and play product with the power to convert their production floors to IoT integrated productive systems. Gartner projected a $3.7 trillion of IT worldwide spending for 2018 with a 2.8% increase expected for 2019[1]. Therefore, while the project team focused on solving an internal supply-related problem, there was a growing interest in turning this idea into a new product that could be externally commercialized among the automotive supplier base.

However, the Bosch supplier management team knew this project was about to bring many challenges. The supplier monitoring system was a product that required a proper streamlined design and development process, and it would certainly not be a good candidate to be manufactured at its own production plants. There were several additional uncertainties surrounding this product idea, which included defining a business model, establishing an appropriate product pricing level, and creating customer demand. Launching this new product could require a big effort in terms of knowledge, technical capability, and experience that the purchasing organization did not have.

In July 2021, while facing the third wave of the Covid-19 pandemic worldwide and looking back at a 4 years-long history of an ineffective IoT product development effort, a question remains: why has the development of this IoT product failed?

This IoT development is analyzed by using a single case study approach which aims to answer the question: How to develop a marketable IoT solution based on an internal supply chain process innovation?

4.3 Literature review

4.3.1 Industry 4.0

The term Industry 4.0 was coined to describe the 4th revolution in manufacturing industry considering the first revolution as the steam-powered machinery, the second comprised electricity-powered serial production and assembly lines, and the third integrated computers and automation to production systems.[2] Nonetheless, Industry 4.0 enhanced machine computerization through sensors, data analysis, machine learning, predictive analysis and the digital networking of physical machines and production lines into digitally enabled productive systems[3]. Internet of Things (IoT) and 5G are the main enablers of Industry 4.0 through network connectivity and automation; it is expected that the IoT market would grow 13% annually from 2016 to 2020 reaching 1.1 trillion USD by 2021 thereof 15% is Industrial IoT.[4]

A smart factory is the core of an Industry 4.0 system which relies on wireless communication such as Bluetooth, RFID, NFC, GSM, and LTE mobile networks[5]. The 5G network, which is 100 times faster than 4G, would enormously increase the enablement of Industry 4.0 in manufacturing areas. The production data generated by IoT enabled systems could substantially improve overall operations by precisely monitoring and evaluating production processes on a real-time basis. In some Bosch locations where this technology had been used, productivity had increased by up to 25% and inventories reduced in 30%[6]. Smart factory systems could coordinate and control the milk-runs of materials and components from the warehouse to the point of use at the designated production line. Inventories are being discounted and managed on a real-time basis which helps reduce the risk of material shortage[7]. Logistic vendor's transport systems could also be integrated to smart factory systems[8] which enables Bosch to know more details about the shipping fleet, where was the material located, and which transport route was assigned to it.

An Industry 4.0 system also helped decrease the carbon footprint of a factory by significantly reducing up to a 40% the power consumption of machinery through and optimization of compressed-air systems; only in 2017 a Bosch plant in Homburg has saved more than 500,000 Euros with the help of Industry 4.0 systems.[9]

Converting a manufacturing site to a Smart Factory through Industry 4.0 started to be appealing for more companies, however the costs were staggering for smaller companies[10].

Large transnational corporations like Bosch had the means to either develop their own in-house Industry 4.0 solutions or to invest more than 1 million USD in converting a medium size production plant into a small factory. Medium to small sizes companies like Bosch's suppliers did not have enough budget to cover investments of those considerable proportions, yet they were highly interested as companies of smaller sizes heavily relied on information and indicators generated from manually collected data which was far from precise.

IoT and Industrial IoT systems opened the doors to new business models[11], IoT-enabled manufacturing sites could offer the free capacity of their machines to manufacture products for other companies which did not have the money to invest on new machinery to increase capacity, this is called Product as a Service (PaaS).

4.3.2 Supply chain visibility

Like Bosch, other companies have been implementing Toyota's Production System (TPS)[12] worldwide. Beyond the different types of waste of lean manufacturing described by TPS, there are important challenges that supply chains face every day. Supply chains can be divided in different semi-independent processes as explained in the SCOR framework (Supply Chain Operations Reference)[13] made available by APICS (Association for Supply Chain Management): plan, source, make, deliver, return, and enable. Supply chain operations can be regarded as an area with big potential for cost improvements; however its high complexity brings a higher degree of uncertainty to the equation. Causes for this uncertainty include: machine breakdowns (process performance unpredictability), growing inventories (safety stocks), supplier performance, fluctuating customer demands, deliveries (transport) and cancelation of orders[14]. Therefore, a company's operational strategy must focus on providing a certain level of preventive control over such uncertainties[15].

Some firms are dedicated to deliver functional products to meet basic needs such as milk, they focus on increasing their efficiency and decreasing their costs because there is more competition in their markets and as a consequence their profit margins are lower. Whereas firms that manufacture innovative products, have higher profit margins but their product demands (market size and customer behavior) are highly unpredictable; they do not strongly focus on costs but on delivery speed to meet sudden shifts in market demands. Therefore, supply chains must be agile and adaptable according to a product's complexity and market requirements[16].

There is a greater need for predicting customer demands and having a certain degree of control over fluctuating orders based on historical values which must be precise[17]; cross functional communication, data-sharing, and cooperation are keys in that process. Due to the immense amount of data being continuously generated by supply chain systems, data science and predictive analyses arise as important applications in forecasting customer demands and market behavior[18].

While some integrated companies perform most of their operations in-house, others like Apple, due to the complexity of their products rely on suppliers to manufacture subassemblies or even the complete final product[19]. There are greater risks with the later approach (i.e. commercial, legal, transport) but companies always look for a cost advantage. Supply chain visibility becomes essential in helping those complex systems to become more efficient; digital technologies offer tools to achieve it.

In the automotive industry, supply chain visibility is affected by multiple tiers of suppliers where an OEM company buys a subassembly from a supplier (Tier 1) who in turn manufactures the subassembly after buying components from its sub-supplier (Tier 2) and so on. A disruption at a Tier 3 or Tier 4 supplier's plant could have disastrous consequences for the OEM company without even having had the chance to foresee them. In this area, IoT-enabled systems and other digital solutions can contribute to overcome these hurdles[20].

4.3.3 Product development in the IoT era

Digital technologies can create value through data[21]; that same data can be stored in cloud systems and accessed through internet simultaneously by many people. Data can easily be analyzed in multiple ways and stored for future historical records. Collecting digital data has virtually no cost but the investment in the infrastructure behind storing it can be significant[22]; it really comes down to the budget that a company can invest in digital technologies. Previous computational or software systems can become obsolete by not being compatible with new digital technologies[23] and therefore lose their value proposition for the company.

Companies like GE have found in digital technologies new ways to do business with their products. In 2013 GE made a risky bet by deciding to change its revenue model to one based on IoT technologies; GE CEO decided not to sell a product but performance monitored through digital solutions. Hence, customers would not pay for the turbines GE produced but would instead pay an amount based on the customer's performance optimization generated by GE's Industrial Internet IoT system (IIoT). Through this IIoT system, GE monitored in real-time the performance of its machinery installed at its customers plants to reduce technical shutdowns and perform timely maintenance[24]. This bet, although risky, proved to be a success for GE's CEO who saw a reduction in product units sold but an interesting increase in revenue through its IoT productivity-based program; it transformed the way GE created and captured value.

Many other disruptive companies have entered the market by proposing new ways to create and capture value. Airbnb and Uber are two examples of how digital technologies can capture value in different ways to traditional hotels and taxis[25]. For these companies, digital technologies enhance customer experience by providing an immediate and uninterrupted sales channel with its customers; the value for its customer is the possibility to instantly purchase services from a reliable phone application and receive immediate delivery. All these transactions are done on a digital platform, through which the companies can easily track supply and demand to react accordingly to market's requirements[26].

The development of IoT-enabled products entails the application of new methods for product development execution including design thinking and agile project management[27]. Newer product development and project management methods targeting software and IoT products have detached themselves from traditional methods to increase flexibility, openness and responsiveness to the process[28]. Notwithstanding the wide appeal of agile methods, they also carry some risks; therefore, it is crucial for each organization to assess which method is the most appropriate for their specific product development to attain the expected outcomes[29].

4.4 Methodology

This research employs an empirical qualitative single case study. I decided to follow a single case study method based on the relative newness of the topic, the current low availability of previous research, and the recent commencement of the use of IoT technologies in the manufacturing stage[30].

4.4.1 Data Collection

To explore the product development process, longitudinal data was collected during 4 years; 20 semi-structured interviews were conducted in 2018 by using an interview protocol prepared for, and validated by, a preceding study (see Chapter 2). Additional data was collected from

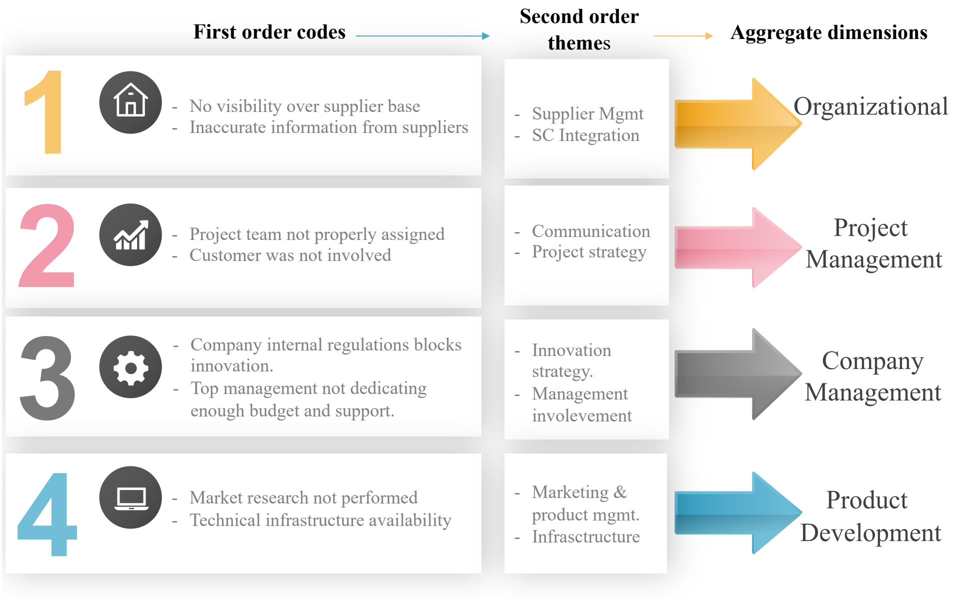
2017 to 2020 by means of direct observations, informal discussions, field notes and continuous access to project-related data. The interviews in 2018 were performed by one internal researcher (current author) to ensure access to data, and two external researchers to avoid the risk of bias. These interviews were recorded and transcribed for analysis. To perform data triangulation, I conducted additional open-ended interviews in 2020 and 2021.

4.4.2 Data Analysis

The interviews performed in chapter 2, together with the data collected from the additional sources, were transcribed and thoroughly analyzed to detect common patterns[31]. I later proceeded to qualitatively analyze the data through inductive thematic analysis and produced an initial array of first order codes which were subsequently grouped into themes and aggregate dimensions[32]. The data was iteratively arranged by using an interpretive approach trying to avoid creating constructs based on pre-structured frameworks, however, some themes were expected to occur based on my previous experience with the subject and familiarity with both Bosch strategic goals and actual practice[33]. This process of multi-dimensional data-gathering made it possible to create and refine a comprehensive overview as the empirical data continued to emerge.

The aim of this research was to develop an empirical case study to describe a real case of supply chain digitalization in the automotive industry and provide a useful overview as well as a roadmap for practitioners. This study provides insights on which factors should be considered in endeavors of this kind to increase the probabilities of project success. An illustrative extract from the thematic analysis performed is provided below.

Figure 4.1 Extract from the thematic analysis process.



4.5 Case study setting

a. Company background

Bosch, a private German company, was founded in 1886 as a precision mechanics and electronic engineering workshop in Stuttgart. After 135 years Bosch has become a global leader in the automotive, consumer goods, building technology, and industrial technology markets as a supplier of technology and, services; its product portfolio includes a wide range of products going from car components to home appliances and power tools. The growth of the Bosch Group around the world is consistent year by year reporting 71.5 billion Euros in sales revenue, 2.0 billion euros (EBIT) from operations and having invested 5.9 billion Euros in R&D in the 2020 fiscal year. In 2021 the Bosch Group employed 395,000 people in 440 subsidiaries including production plants, R&D locations, sales offices, and service centers in 60 countries[34].

Bosch had become a leading IoT provider and started framing a vision of sustainable mobility empowered by new technologies as well as improving the quality of life by facilitating products containing Artificial Intelligence.[35]

With its slogan "Invented for life" Bosch strived for innovation and quality; Bosch employees filed more than 600,000[36] patents only in 2017. Regarding company culture, the values set by its founder Robert Bosch were still deeply rooted in the company's culture:

"It has always been unbearable for me to imagine that someone could inspect one of my products and find it inferior in any way. For this reason, I have constantly tried to deliver only products that withstand the closest scrutiny — products that are, so to speak, the best of the best."[8]

Bosch was aiming at utilizing Internet of Things (IoT) and Artificial Intelligence (AI) as a foundation for their innovation strategy. Since 2015, the company had increased its investments and efforts in developing and applying a wide variety of digital and automation technologies. In 2017 it had also established a center for artificial intelligence at its R&D headquarters in Renningen, Germany with 6 international offices including California.

Besides of having started developments of automation technologies (IoT) for the external market in many divisions, Bosch had created departments to develop and enable digitalization and automation solutions to optimize its internal operational processes. The company had begun a rapid shift from being a major electromechanics automotive supplier to an automation and software integrated products provider.

"Today, we connect not just billions of people, but billions of things as well. This will trigger data-driven solutions, in manufacturing just as much as in smart homes and connected

[8] Direct quote from Robert Bosch (1919), Bosch historical communications department, Robert Bosch GmbH, 2021, https://www.bosch.com/stories/quality-doesnt-happen-by-accident/

cars. And again, these solutions will not be the work of a single individual, but dependent on open exchange among the companies involved — large and small, young, and old, wherever they are in the world."

Volkmar Denner, CEO, Bosch.[37]

b. The automotive division

Since 1897 when Bosch started delivering magneto ignition devices for automobiles[38], the thriving history of Bosch as a world leading automotive supplier had seen no stop. Bosch automotive had diversified itself into several divisions, business units and products. Based on the fast growing automotive industry in Germany and in the USA, the automotive business had become a core focus for Bosch since 1902 when they developed the high-voltage magneto ignition system and subsequently opened manufacturing plants for automotive components in France in 1905 and in the USA in 1912. The company, which had strong ties with innovation and quality, is continuously adapting its organization and products according customer's needs and technological advances. Partly based on the sales growth projections for electric light weight vehicles (21 million units in 2030)[39], Bosch accelerated its moves into offering automotive automation possibilities through its current and new products.

In 2017, the automotive division was renamed to "mobility solutions" as a first step to represent the company´s intentions to be part of the electric vehicle market which required an extensive automation of the driving experience facilitated by thousands of sensors and wireless communication. The mobility solutions division which consistently represented 59% of the total Bosch Group sales, 42.1 billion Euros in revenue was integrated by 229,000 employees worldwide in 10 subdivisions covering electronics, electrical drives, systems control, chassis systems, multimedia, connected mobility and powertrain.

Bosch was a global automotive supplier leader with a product portfolio including hardware, electronics, software, and integrated systems. Additionally, to its original equipment divisions, Bosch mobility solutions also housed other divisions: Automotive aftermarket, connected mobility solutions, Bosch eBike systems and more recently, cross-domain computing solutions to support software-enabled automotive products.

The company was betting on becoming a leader in automotive innovation by focusing on connectivity, electrification, and automation by investing more than 500 million euros in electromobility such as fuel cell in 2020 and in driver assist systems.[40]

c. A challenging Supply Chain

Bosch had complex supply chain operations and dedicated organizations for every division which were specialized in the procurement and delivery of manufacturing components to all Bosch production plants worldwide; for the mobility solutions sector 13.2 billion euros were spent in purchase of raw materials and semi-finished goods worldwide in 2017. The mobility purchasing division had 109 offices worldwide with 4,280 employees responsible for 4,600 suppliers.

Every supplier managed by the purchasing organization represented a different setting with its own complex processes, organizations, and conditions. Considering that a final product delivered by Bosch to its respective customers was composed by tens of subcomponents, which must comply with a high level of quality required by the customers and federal safety regulations, the supply chain complexity significantly increased. This scenario translated into a very challenging and stressful job for every employee at each purchasing and logistics department. In some low-cost regions, a purchasing employee was responsible to supervise and manage up to 50 suppliers simultaneously.

"One of the goals is to avoid that suppliers have the opportunity to give us inaccurate information, we know that many of them have the good faith to establish a good business relationship with us as clients, however, there are several individuals try to hide production information, then the transparency will be much greater and will allow for the entire supply chain to be monitored."[9]

d. Market needs

For some companies there was a sudden new opportunity to capitalize their knowledge and experience by meeting other companies' Industry 4.0 needs. Small and medium size companies (SME) could not monitor their operations as efficiently as larger ones, they practically had no other option than relying mainly on data collected by hand by their shop-floor personnel. Based on the productivity-incentive initiatives promoted my many companies, the manually collected data used to produce performance indicators was far from reliable. However, these companies had no other options within reach to monitor their performance, accurately detect process inefficiencies and measure the effectiveness of their improvement actions.

Furthermore, their inability to develop internal Industry 4.0 solutions and the unfeasibility to afford an expensive third-party solution opened a new market segment. There was probably a favorable opportunity for a low-cost Industry 4.0 solution to make its way into the SME market besides the possibility to apply this solution in a broad range of manufacturing industries, not only automotive.

[9] Bosch automotive commodity buyer part of the Industry 4.0 project development team.

"I think we need to find ways to address the pain-points that we have in our daily work, we have to do our processes more effectively and more efficiently, to deliver better services to our internal customers and internal business partners. So, I think this type of digitization can only help us to be more effective in our jobs and to find a solution to our customers. And that should be in a top of our motivation."[10]

There is a greater need for predicting customer demands and having a certain degree of control over fluctuating orders based on historical values which must be precise; cross functional communication, data-sharing, and cooperation are keys in that process. Due to the immense amount of data being continuously generated by supply chain systems, data science and predictive analyses arise as important applications in forecasting customer demands and market behavior.

"In the end the equipment will be installed in the machines and for the first time we will be able to see in real time information about what the machines are doing in our production lines and this information will be very helpful for optimizing our processes."[11]

[10] Senior Supply Chain Vice-president for Bosch U.S.
[11] General Manager of a Bosch automotive supplier production plant.

4.6 The development of the Supplier Monitoring System (SMS)

Phase 1 - A bright idea.

The automotive manufacturing industry was highly demanding, production reached 97.3 million units of vehicles (light and heavy weight) in 2017[41]. The supply chains in the automotive industry were extraordinarily complex and entangled; a car had about 1,500 components including subassemblies and each one of them was made of dozens of subcomponents; therefore in total, an average car had a total of approximately 30,000 parts in average.

Bosch, a global leading manufacturer and supplier of automotive subassemblies dealt with almost 5,000 suppliers worldwide on a daily basis; any problem at a supplier production plant had the potential to translate into a disruption of the whole supply chain and a possible interruption of final deliveries to automakers production plants. Any direct supplier to US-based automakers could be charged up to 1 million USD per the hour if the assembly production lines was shut-down due to a lack of any subassembly. Besides of these hefty fines, as a way to compensate the generated deliveries backlog, Bosch would have to cover the expenses of all expedited shipments which could often include charter flights to the automaker production plant location.

"We will try to create something more automatic, a more digitized way of collecting internal data and put it in a kind of dashboard so the buyers can have the key information about the suppliers to make them in a position to develop a strategy or a commercial negotiation."[12]

[12] Bosch Purchasing Manager part of the Industry 4.0 project development team.

These supply chain disruptions were unforeseeable, it was practically impossible to see what was happening at the supplier's production lines until it was already too late, and a delivery shortage was already a reality to deal with. A typical automotive supplier was usually not proactive enough to immediately communicate its customers that a production problem arose, and generally by the time they do it the problem had already grew to challenging proportions. The usual way to solve these kinds of situations was to commission a quality engineer to visit the supplier plant and stay there until the root cause was found and the problem was satisfactorily addressed. The engineer had to frequently visit the offending suppliers to check that the corrective actions were still in place and that process improvement activities were continuously implemented.

It took many years of delivery disruptions from the local supplier base, investment of resources and high efforts by the supplier quality engineers to finally raise a red flag and look at digital technologies as a possible solution. The Bosch Vice-president for automotive purchasing in North America made the decision to designate a senior purchasing manager to lead a small team of employees with the task of developing an IoT-based solution that could alleviate Bosch's supply chain hurdles. This team formed by supply chain specialists had no previous experience in product development but started by organizing discovery and brainstorming sessions with members of the logistics, purchasing, manufacturing and IT teams. A couple of automotive suppliers were contacted to discuss with them the initial idea of being part of the project team and supporting the development by sharing insights, data and allowing the pilot products to be tested on their machines. In return, once the solution was developed, the participating suppliers were going to receive the final version of this solution free of charge. Two regional automotive components suppliers accepted to participate and were invited for a couple of brainstorming sessions with the development team.

After 3 months of meetings, process mapping, and brainstorming the development team designed an IoT device consisting of a sensor, a gateway, an algorithm, and a web-based platform (see Appendix I). The sensor was placed on the machine at the supplier's production line, it counted the number of pieces produced by the machine in a specific timeframe and sent this data to a web-based platform through the gateway connected via Wi-Fi. The data was further analyzed and enabled the platform to predict product delivery disruptions based in real-time production data. This data also helped to monitor the production process indicators in a real-time basis and sent notifications to supervisors and managers when maintenance or corrective actions were needed. The platform was also made accessible to Bosch Supply Chain employees with the purpose of providing predictive analytics about the health of the supplier base and anticipate any supply chain disruption that might put a threat on timely deliveries.

A similar digital-enabling initiative called industrial internet was built by GE with the support of crowdsourced product development by adding sensors to machines, connecting them to a cloud-based platform and obtaining data for analysis to improve product performance along its life cycle. This innovation helped GE to create new business models and see an incremental income of more than $800 million USD in sales of digitally-enabled power-generating turbines and jet engines in 2013 alone. However, now with the "Internet of Things" the possibilities for connectivity of tasks, processes, machines and services were practically limitless; firms like Microsoft and SAP had made the change from selling products to cloud-based services.[42]

Phase 2 - Time for a big decision: external partnership.

In April 2018, one year after its conception, the project was showcased at the "annual supply chain week" to the global top management of purchasing and logistics; it was a great success and received unquestionable positive comments and constructive feedback. After the presentation, the development team was contacted by Bosch-internal department leaders of purchasing and logistics in the Americas, Europe and Asia locations requesting demo versions of the product and a date for the release of the final version. There was great enthusiasm and anticipation among the supply chain colleagues for this IoT solution, one of its kind. Additionally, the Key Account Managers and the CEO at one of automotive suppliers that participated in the initial development phase started to request their free devices as it was originally agreed.

However, a year had passed by since the development started and there was no final product in sight, the hardware was not ready for serial production, and the algorithms were not in an optimal shape; there was no chance for the development team to meet those initial orders.

By the end of 2018 the SSM was still in demo version, it was nowhere near completion; the legal data ownership issues were still unsolved, and the hardware had not passed beyond the prototype version. The project sponsor (VP SCM) and project team met at the innovation hub offices in downtown Chicago, he had an important announce to make. The offices were located on the 7th floor of one of Chicago's emblematic buildings just facing the Chicago river. The team assembled in one big meeting room with big windows offering a breathtaking of the river and Chicago's loop neighborhood.

VP SCM: As you know, I have been holding this position as VP SCM for almost 4 years in which we have gone through many substantial organizational changes worldwide and we have strived for making our processes more efficient. I have agreed to move into another role in the next 4 months and it is uncertain if my successor will also plan dedicated budget for IoT innovation projects as I had. Therefore, we have reached a point in which we have to decide about what to do with our unfinished projects, specially SSM.

Innovation Hub Leader: For some months now, we have been internally discussing during our weekly project meetings about the future of SSM, we are not there yet, there is a long way to go and we certainly do not have the time capacity to cover all the activities we have to do. We would like to suggest that the Innovation Hubs in Mexico retains the product ownership as product innovation is not within the Supply Chain department's scope. We will set an additional budget of up to 100T USD to take SSM from its status to serial production.

VP SCM: I could not agree more with the proposal, and I would additionally suggest that one person form the SCM department remains as an active part of the project team just as an advisor on SCM related topics.

Innovation Hub Leader: we would also like to mention that as a first step we will be forming a partnership with an external start-up which will redesign and build the final version of the SSM hardware and can also support with marketing and commercial activities.

VP SCM: Ok, it sounds promising, good luck.

Phase 3 - Which way to go?

The Innovation Hub worked as a semi-independent subsidiary of Bosch, in 2018 it had 4 locations: Germany, Chicago, London, and Mexico. The hub operated under the governance and budget of the Bosch Group; however, it had its own smaller organization, processes, and rules. This model, enabled the hub to operate without the burden of the indirect costs of a large organization and to adapt its processes to quickly react to the innovative market demands which needed a quick and agile reaction that a large corporation couldn´t normally offer.

This flexibility helped the Innovation Hub team to realign and streamline the new path for SSM with the aim not only to focus the problem of supply chains but also to improve customer's operative performance. The new plan included the following points:

- A technology start-up located near the Innovation Hub in Mexico was selected as partner for the remaining development phases.
- An automotive supplier within the Hub's geographical area was invited to participate as part of the prototype's live trials.
- Hardware design, construction and future serial production was outsourced to the partner company.
- Algorithms, software development, and web-based platform development stayed within the responsibilities of the Bosch Innovation Hub.
- The Bosch corporate legal department in Mexico City and Detroit were assigned as advisors for compliance regulations and certifications.
- Marketing, sales, and new business development activities were taken over by the cross-selling team at the Bosch corporate offices in Mexico City.

The project restructure also originated a change regarding the business model being targeted. With the fear in mind that profits may wane over time by offering an unknown retail product with technologies that most customers did not regard as essential at that time, the newly assigned cross-selling team opted for a new strategy. SSM was now going to be sold under a product licensing model through which customers were able to use the hardware, software, and the cloud-based platform for a monthly fee without exerting any ownership on it. The monthly fee was calculated based on the quantity of devices being used by the customer and the number of users operating the monitoring platform. In exchange, customers would get software updates, technical support, and system's maintenance at no extra cost.

The pricing structure included: a one-time license fee for software and hardware, a monthly fee for the devices in use as recurring revenue, it also planned for charging for major maintenance and technical support outside the contracted warranty. Additional income through cross-selling of premium upgrades and bundling with additional Bosch products was also included in the new business model in a bid to maximize the chances of financial survival of SSM.

During its first year of sales which kicked-off in January 2020, SSM had already seen a good start by selling 80% of its stock of 135 SSM devices by mid-March 2020, however the onset of the Covid-19 pandemic put a halt to all sales as the priorities of manufacturing companies switched from performance optimization through technology to a mere fight for survival. Amid the pandemic, a possible redesign of the businesses model and a product relaunch was deemed necessary, but no decision had been made by mid 2021 yet. In July 2021 the project finally came to a halt until the market conditions improved.

4.7 Case discussion

4.7.1 Hindrance factors

a. Development process

The SMS solution development brought several challenges right from the start; being a development team formed by supply chain experts with no previous experience in this kind of solutions brought a diverse array of caveats. Although the development budget was not a critical issue at this stage, it became clear that the development team at the supply chain department did not have sufficient IT knowledge nor expertise in product development to continue with the project. There were many technical and commercial aspects of the solution that were not considered from the start; the project was on the brink of being dismissed. An appropriate technical development team was not built from the start: software developers, hardware designers, electrical engineers, development engineers, etc. No formal product development process was followed; no milestones, quality gates, testing, product verification and validation took place. A suitable project management process did not take place, lack of project manager with digital or IT experience, a proper management methodology (predictive or agile), budget management, risk management, change control, etc.

The development team together with the project sponsor (Purchasing VP) decided to hand the development over to a local Bosch internal department specialized in innovation and software development. This new team offered a complete array of capabilities including Artificial Intelligence, prototyping lab, UX, and business models specialists; their offices were located inside a coworking space and start-up incubator 470km away from the rest of the project team and 220km away from the nearest Bosch production plant. Working with this new development team exceeded the initial project budget by 60% but this move looked promising for turning the solution into reality. However, the team was relatively young with no more than 2 years of working experience and they lacked knowledge about Bosch and its processes; they had never visited a production plant and openly admitted that did not know how the company worked. Now the project had an IT technically capable team on board but lacked the former functional experience from the Supply Chain experts and had no contact with potential customers as the SCM department had.

b. Product features and constraints

The product was called "supplier smart monitoring" (SSM); it was probably not the best name choice according to some colleagues in the purchasing department. The SSM consisted of:

- A sensor that measured light, sound, vibration, displacement, temperature, and pressure.
- A gateway that worked as the interface between the sensor and the Wi-Fi router.
- Algorithms and A.I. based analytic software
- A web-based platform accessible by computers, tablets, and mobile phones.

One of the biggest challenges that the system faced was related to data security; an inter-company system like SSM enabled many unrelated companies to have simultaneous access to the platform and therefore, any database leak would dangerously compromise confidential data which could be easily accessed by a competitor. Another point was how much internal data could a company share with its customer without getting into any kind trouble; as was common int the automotive industry, a supplier did not openly communicate every production issue or potential risk with its customer until it was unavoidable. All data gathered by the system was kept in databases for future analysis and historical records; data had become an extremely valued asset.

The demo devices were being assembled at the Innovation lab inside the Bosch start-up incubator, the production of each device costed about $120 USD and the serial production costs were expected to rise if production took place at one of the company's production plants due to the large infrastructure and organizational costs to be amortized. Besides the high in-house production costs, the product needed support from other divisions and departments including marketing, sales, accounting and legal which would add staggering indirect costs; hence the production of SSM devices inhouse were not a feasible option.

The project team was so excited about the initial company-wide popularity of SSM that they decided to move ahead with the production of the final version right away. They had no indicators about how big the potential market was, how many potential customers per region they had or the pricing levels of their competitors (if any); they had based their product development decisions on their initial work with the two automotive suppliers. A proper market research was not executed; there were no formal customer requirements, the product was designed based on SCM's own assumptions.

If SSM was going to be sold through the traditional sales channels, the automotive sales organization had to take over the product and commercialize it with their existing customer base (GM, Daimler, VW, BMW, Audi, etc.) which probably was not the appropriate market for this product. Another point of concern came out to be aftersales, what happened after selling and installing the product? Who was going to provide supervision and maintenance to it throughout the product's whole life cycle? Who was going to oversee the administration of users, databases, and overall product operations? Neither the Supply Chain organization nor the Innovation Hub had budget and infrastructure to create a new sub-organization dealing with an IoT novel product that no one had experience in.

Yet another controversy was brought up when the product owner started discussions with the top regional management about which business model should they follow. The company had extensive experience in selling physical products, but this was not the case for software; SSM was a mixture of both. The easier option was to sell it as an off-the-shelf product, plug-and-play ready, and to offer the monitoring platform as software on-premise; however, the intellectual property of the software and algorithms was a concern. Companies like Microsoft and SAP had already opted for licensing their products rather than selling them as retail, this was possible by offering cloud-based software licensing models with pricing levels according to license volumes. With a similar approach Bosch could perhaps secure a constant income in exchange for recurrent software updates and system maintenance to its customers; anyhow, its traditional organization had no experience in those innovative models.

c. Customer Engagement

Customer engagement was regarded as a major player in SSM's success as it integrated automation technology, intra and inter-company connectivity and data analytics with the customer's operational data. By accessing suppliers' operational data through SSM customers like Bosch were going to be able to detect potential disruptions to supply chains on a real-time fashion and perform predictive analyses based on historical data. As data access and analysis raised the concerns about data security, data ownership and intellectual property, the regional legal departments from Bosch were added to the project team. Bosch was the owner and administrator of the SSM web-based platform, therefore it had access to its customer's operational data; some of these potential customers were also Bosch competitors in other business units of the automotive division.

Although SSM was a product bringing production monitoring possibilities to its customers' workplace, it was initially conceived as a tool to meet Bosch's Supply Chain monitoring demands and not a product for meeting potential future customer's needs. Therefore, a product analysis and redesign were probably needed to streamline SSM design and features according to the market's real needs. These new tasks requested an excessive amount of additional work which the current project development team had no sufficient expertise, time, nor resources to fulfill. The SSM project was again approaching a crossroads at which a decision had to be made between continuing or cancelling all SSM related endeavors. To make things worse, the team did not consider whether customers would accept to share their data through the SSM system; growing customer concerns over data privacy turned out to be a big roadblock.

Summary of hindrance factors

The following table summarizes the hindrance factors that affected the project during phase 1 and phase 2. It also provides an overview of what was done differently in phase 3 as a way to turn the project around.

Furthermore, technical capabilities of the workforce should also be regarded as critical; is the company doing the development by itself? If so, does the company have software developers with the appropriate knowledge and experience for the task? If the company is outsourcing the development of the technology to a third party or buying it "ready to be installed", does the company have a robust purchasing process in place for sourcing new technologies or software? Is the company knowledgeable enough to deal with intangible assets and intellectual property? It is also important to consider that employees in the development, marketing and sales departments have experience in this kind of products.

Figure 4.2 Summary of hindrance factors.

	Phase 1	Phase 2	Phase 3
Product development	Done by SC employees with no IT or IoT related experience.	Done by IT experts with no SC knowledge or business experience. Customer needs were ignored.	Hardware outsourced to an external IoT start-up partner. Software & IP remained at Bosch
Project management	No formal project management process was followed.	No business model was planned, Governmental regulations ignored.	Formal project management in place. Quick and agile reaction. Business model selected.
Organizational	No involvement of technical or engineering experts.	Customer reluctance to accept new technologies and share data.	Flexible; IT, technical and SC functional expertise available. Legal compliance & marketing by Bosch.
Company Management	Sponsor with other interests. Internal regulations. No sufficient budget granted.	Sponsor left the project, new sponsor lacked leadership and power.	Semi-independent subsidiary. Own governance and budget.

4.7.2 Roadmap to IoT product development

Based on the hindrance factors detected in the previous section, this section provides a roadmap to increase the probabilities of attaining better results in similar projects. These findings aim to offer an holistic overview of success factors.

Success factors for intracompany innovation projects:

a) Supply Chain Management

Supply Chains are highly complex entangled networks involving hundreds of suppliers, components, locations, and tasks that should ideally move in a synchronous fashion. The reality is that supply chains are far from synchronous; supply risks are always around the corner and a manufacturer of electronic devices is mostly dependent on a specific supplier for one component. If the serial product is outsourced to a smaller and less experienced partner instead, the risks for failure will significantly increase. A precise supply chain strategy for each product should be developed case-by-case by experienced professionals.

b) Product development process

It is apparent all along the case that the product did not follow a rigorous product development process; team members frequently changed, sponsors changed, there were no proper design and product testing and validation phases. Therefore, the product's overall quality can be compromised; there were no Quality Gates (GC) along the product development process to iteratively improve the product's compliance with required standards and regulations.

Based on Bosch's extensive experience in technology development, the company has a set of robust processes and procedures in place. The Bosch Product Development Process (PEP in German) has been developed based on all the knowledge and experience acquired during decades of developing thousands of products. The PEP process has long been the company's gold standard for product development assuring success to every product launch, it has recently been adapted for IT software and hardware developments.

Product development lead-times can be a major hurdle in the race of bringing a functional product to the market. New technologies which are not readily available in the market could certainly have complex components that could take longer to develop. Furthermore, an absence of a rigorous product development process could make the team fail to detect problems on time which in turn will significantly delay the development timeline once those issues become apparent later in the process.

c) Allocate sufficient company resources

Besides assuring a financial budget, the company must ensure that the right personnel for the right job is assigned. For this project, functional experts in SCM and technical experts in engineering, development, digital technologies, IT infrastructure, software & hardware developers and a knowledgeable project manager are required. Once the product is ready, an IoT capable team in sales and marketing should also be appointed.

d) Project management

A project with constant changes could certainly exceed the initial budget and its profitability will consequently decrease; effective cost management is required. A diligent project management would have control over resources, customer requirements, change requests, purchasing of components and quality assurance.

Cost efficiency is the major drive in every development project. A product is created to be profitable, otherwise it would make no sense for a company to invest on it. The most important cost drivers in a product are frequently related to supply chain and operations: people, raw materials, subcomponents, manufacturing, and transportation. It is also critical not to forget about indirect costs including organizational structure, marketing, and sales.

e) Strong internal sponsorship

A new product which deviates from a company's core business and traditional products will meet diverse roadblocks along its development process. A strong leadership and a powerful sponsor are required to obtain the authorizations and resources from the top management to overcome numerous hurdles. The development of a new technology could face opposition by some sectors of the organization and management; the sponsor must have a wide internal network to be able not to follow the company's traditional processes when needed.

Success factors IoT developments targeting external markets:

a) Develop a precise product strategy

A new product requires to meet a market demand, fulfill a customer need. If a new product will be externally commercialized, its roadmap to the market must be planned. By taking customers' requirements into consideration, the functionalities of the new product can be effectively defined. It is also equally important to determine if the product can withstand the rapid evolving nature of technology and if it can be adapted to meet future requirements or if could be used to satisfy needs in a different market, otherwise its lifespan will be shortened and would perhaps not remain profitable in the midterm. Possible integration with other Bosch products and value propositions could represent a good market strategy for the coming years.

Product flexibility and scalability can help the product withstand the test of time by providing design engineers with the possibility to use the technology in future products or adapt the original product to new usage applications. Customer needs change in a short period and can quickly turn a product obsolete; scalability can make the product's profitability survive rapid market swifts.

b) Market readiness

A great innovative product with the newest technology could be ready but perhaps the market is not. A comprehensive market research must be undertaken well before a company starts thinking to sell the product. Few companies like Apple have gone the opposite way, creating the need in the market for its highly innovative products. It should be clear, however, that not every company has the market influence and media presence to force disruptive changes onto consumers like Apple does.

c) Study the competition

Ignoring the competition is an avoidable high risk in product development. Becoming a new competitor in the market could be a good reason to develop a product but the company must have clear which new value proposition is this alternative offering to potential customers. Moreover, the company must analyze if the product can be achieved within or below the current market prices, otherwise the company should be ready to convince the customer that the product offers an additional value proposition that justifies its higher price.

The project team should analyze the product's possible competitors, what value proposition do they offer, price ranges, product applications, and its market. The product's value proposition must be studied to define which customer needs will it meet and how. A useful tool to support this activity is the value proposition canvas[43]

d) Regulations and data protection

Company's internal legal departments and governmental institutions will require a new product to comply with safety regulations and certifications, these milestones often require substantial resources and significant efforts from the development team; therefore, they must be considered from the earliest phases of the project. IoT and digital technologies entail privacy concerns, hence a solid data protection strategy should be designed to establish the trust needed with potential customers.

e) Dedicated organization

A small innovative product being produced by a large company would be severely affected by the indirect costs of a large corporation. In order for this product to have better chances of success, a smaller semi-independent dedicated organization should be set up to take over the development. Therefore, the product would only have to recover the costs of the smaller organization and would reach the market with a more competitive price. Here is where an innovation hub or a star-up could play a decisive role.

f) Choosing a business model

A business model defines how the company creates value for its customers and how it capitalizes that value. Industry 4.0 and the technologies surrounding it opened doors for new business models as more companies started to see an opportunity to reach a significant level of optimization of their operations through digital technologies and automation. A new market was expectant for options whether they were services or products but industry 4.0 became an unexpected need to be fulfilled. Being an Industry 4.0 enabled company also referred about status quo and competitiveness, there was a growing gap threatening to separate companies in two types: digitally enabled and the rest.

Although innovating business models sounded like an exciting new venture, it could also lead to big failure. Large incumbent corporations which try to innovate business models could be tied to their previous experiences and knowledge which in turn could exert a big influence on the new business model. There are several factors to take into account in the process of creating a business model: understanding the nature of the innovation being attempted, analyzing the consistency with the priorities of their existing business model, creating a product and service that fulfills a need, scaling it to fulfil a demand, and making it cost-efficient and sustainable enough to survive in the market.[44]

However there is a decisive tradeoff to consider: the closer a new business model is attached to existing business units, the smaller the autonomy it would seize and the harder it could be for it to succeed and avoid getting dissolved into the existing company's business. A new business model that lacs independence, might be already doomed well before being born.

Once the company has dealt with the afore mentioned premises, it must decide what business model will it follow for this new digital product and/or service? To this crucial decision, there are many options:

- Sell the IoT product and give the software for free (intellectual property at risk).
- Give the product free of charge under a consignment contract in exchange for a monthly rental fee (software updates included).
- Create a productivity-based revenue agreement.
- Do not charge for the equipment and software but generate revenue from the usage and commercialization of third-party data.

Success factors for intercompany supply chain digital innovation:

Besides from the factors mentioned in the previous sections, specific points arise for innovation projects which directly address supply chain digitalization between companies. This research covered the development of an IoT solution between a customer and one of its suppliers, therefore, the factors included below were derived from that case.

a) Good relationship between the customer and its supplier base with open, direct and transparent communication. This level of relationship must be worked out by means of mutual trust and commitment.

b) Establish a win-win situation; suppliers become customer's partners and should not be forced to be part of the initiative. At some point during this case study, the supplier had an urgent need to improve the relationship with the customer which was damaged through previous quality and delivery problems. The supplier saw no other option than joining the project to gain the customer's trust again; this move proved to be successful.

c) Create Key Performance Indicators (KPIs) for suppliers; this is critical for the customer for measuring supplier's performance and determining how to digitally assess the effects of continuous improvement initiatives at the supplier's site.

d) A clear cooperation contract must be established between the customer and the supplier; legal departments at both companies must be included. This step will greatly diminish data privacy concerns and will lower the risk of future disputes.

e) Benefits and savings should be shared among partners; this will further increase trust and the interest of suppliers to participate in continuous improvement initiatives.

f) Usually, supplier's infrastructure might not be at the same level than the customer's and there is no possibility of improve it short-term. Innovations must be made compatible with diverse levels of digital infrastructure.

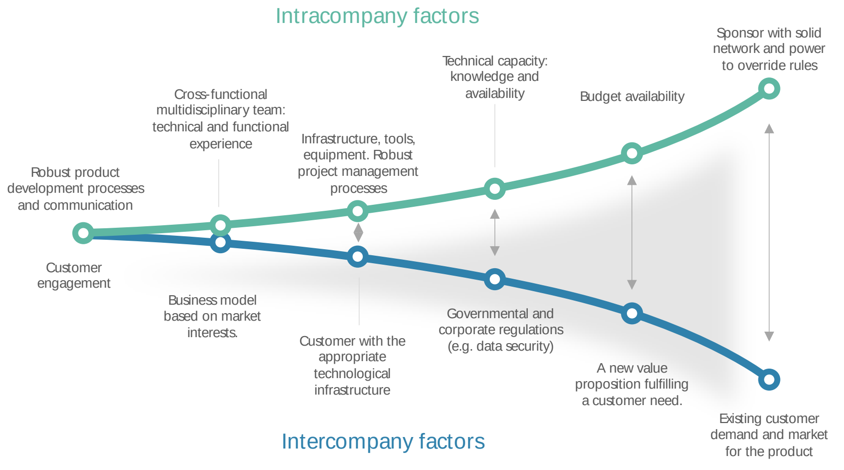
g) Suppliers rarely have the means to invest in additional human resources to provide maintenance and supervision to IoT systems. Therefore, an appropriate business model should be designed for those cases (e.g. yearly subscription, licensing, etc.)

h) Compatibility of ERP systems. The wide availability of ERP systems make the compatibility of IoT solutions an extra challenge as data must be automatically extracted, loaded and transferred among systems. An omission to this point could create false inventories and corrupt data.

i) Analyze partnerships for technical developments. Not all companies have the internal capabilities or availability to develop specific IoT solutions requiring special hardware and programming skills. Therefore a partnership with a high-tech start-up could be a cost-effective option to be considered.

The following diagram summarizes the key internal and external factors in the roadmap for success in IoT product development for supply chain applications:

Figure 4.3 Roadmap to IoT product development.



4.8 Contributions and implications for managers

The development and implementation of digital technologies in supply chain management is a current topic of interest in companies of varied sectors across the globe. Limited empirical research has been conducted to understand the implications of developing IoT solutions for operations management processes. The aim of this research was to develop an empirical case study to describe a real case of supply chain digitalization in the automotive industry and provide a useful overview and roadmap for practitioners. By focusing on the factors that made this project unsuccessful, I intended to help managers to detect common pitfalls at the right time during the project development. This study provides insights on which factors should be considered in endeavors of this kind to increase the probabilities of project success. The contributions of this research can be applied to diverse industries interested in digitalizing product development and operations management processes.

4.9 Conclusions

In the last decade (2010´s) companies started to lean towards digital technologies to find solutions to common operational problems and to find cost-effective ways to increase operational productivity. This case study aimed to shed light on the following factors:

- Inherent risks of supply chains and their reliance on digital technologies
- Complexity of IoT product development and new product introduction processes
- Importance of intracompany cross-functional collaboration
- Influence of a company's executive management decisions on a project success
- Inherent complications of intricate large organizations

There were many important mistakes and omissions in the whole development process of the SSM project. It is important to mention that the failure of this project is attributable to a wide range of causes which alone or combined can make any project fail, not only technology or IoT related projects. The most important failure factors attributable to the company include:

- ✓ Ineffective internal communication
- ✓ A robust product development process was not followed
- ✓ Support from sponsors and leaders was not sufficient
- ✓ Teams members not carefully selected
- ✓ Lack of a clear product and project strategy
- ✓ SCM department lacked product development experience
- ✓ The customer was not convinced to use the tool, lack of trust

For incumbent companies trying to dabble into the digital world, many steps must be taken. A thorough analysis of current technology and IT infrastructure must be done to determine if their current technology assets are compatible with the digital technologies being pursued, or otherwise calculate the investment needed prior to buying or developing a digital system. The robustness and wide applicability of the overview of hindrance factors, and the roadmap provided as a result of this study aim to support managers and practitioners in the creation and execution of a holistic strategy targeting the development of IoT-enabled solutions.

5 Conclusions

How do large companies implement new technologies? How do intra-company organizations absorb digital innovations? What role do management, employees, processes, and infrastructure play in the success of developing and implementing digital technologies to make operations more efficient? This dissertation aimed to explore the phenomena of digital transformation in operations management, especially in Supply Chain Management.

The so called “Digital Transformation” is driving more companies to invest in new technologies to pick up the pace with competitors and cope with the new demands of the market. For some industries like the automotive at which environmental policies, social changes, economic crises, technological advancements, and market trends put a great pressure on its products and operations critical decisions are being made. At the same time that we are witnessing unexpected changes at some large traditional companies like Volkswagen, whose products are transitioning from combustion vehicles to electric, supply chains are being affected worldwide[45]. To survive, some suppliers are reacting by modifying their products to fit new product requirements from current customers or by exploring other markets and applications whereas others are reducing the size of their workforce, selling production their plants, or finding new partnerships.

Although some of the above-mentioned external factors are usually uncontrollable from a company’s perspective companies must react by making internal operations more efficient and cost-effective. This is the part of the game where IoT and I4.0 technologies play a relevant role. Through the research articles presented in this dissertation, and based on a company’s real-life experiences, I intended to understand the digital transformation phenomena to subsequently shed light on the factors and decisions that influence its failure. I consider that most of the times it is easier to find stories of success of large corporations ,and get dazzled by its results and achieved numbers; it is however, overwhelmingly compelling, to dig into what went wrong at unsuccessful ventures that are not usually talked about.

By revisiting the findings and conclusions of the research studies explored throughout this dissertation, this chapter will summarize the main findings as well as discuss research limitations and flag directions for future research opportunities. The main objective of this dissertation was to shed light on the following specific research questions:

- Chapter 2: How to implement IoT-enabled tools at the buyer-supplier interface?
- Chapter 3: How are RPA solutions being adopted and implemented in large multinational corporations?
- Chapter 4: How to develop a marketable IoT solution based on an internal supply chain process innovation?

The importance of supplier integration for successful supply chain management is well established in the literature (Frohlich & Westbrook, 2001; Petersen, Handfield, & Ragatz, 2005). Particularly in the automotive industry, the integral nature of products as well as long lead-times demand close coordination between buyers and supplier (Dyer, 1996b; Fujimoto, 1999).

Recent studies have continued to confirm that IT technologies and inter-organizational information systems positively influence supply chain integration and consequently, operational performance (Afshan & Motwani, 2020; Amoako-Gyampah, Boakye, Famiyeh, & Adaku, 2020; He, Sun, Ni, & Ng, 2017; Radhakrishnan, Davis, Sridharan, Moore, & David, 2018). It has also been found that supplier integration increases the speed of new product introduction (dos Santos Bento, Schuldt, & Castro de Carvalho, 2020) and that its relation to operational performance is moderated by product complexity (He et al., 2017) and, more importantly, by the attitude of managers and the company's collaborative organizational culture (Y. S. Yang, Kull, Nahm, & Li, 2017). Those findings resonate with how this integration has positive effects on the performance of complex supply chains, like those at OEMs, where the successful production of a new product is dependent on effective supplier integration and company-wide collaboration (Wlazlak, Säfsten, & Hilletofth, 2019).

The diffusion of digital tools has the potential to radically change buyer-supplier relations by reducing the complexity of coordination and advancing supply chain integration (Balakrishnan & Geunes, 2004; Boyer & Hult, 2005; Fawcett et al., 2011). Supply chain integration has lately been found to be positively influenced by the assimilation of innovative and inter-organizational capabilities of digital technologies such as cloud computing (Manuel Maqueira, Moyano-Fuentes, & Bruque, 2019), blockchain (Büyüközkan, Tüfekçi, & Uztürk, 2021), and Industry 4.0 in general (Garay-Rondero, Martinez-Flores, Smith, Caballero Morales, & Aldrette-Malacara, 2020).

By sharing rich information in real-time, regarding for example production line status and inventory levels (Ke et al., 2009; Zhou & Benton, 2007), digital tools enable buyers and suppliers to jointly develop and apply technical knowledge to their processes and products (Malhotra et al., 2005; Salomon & Martin, 2008). Ultimately, this supports supply chain partner interoperability (Liu et al., 2010) and the development of competitive advantages (Ke et al., 2009; Saeed et al., 2005).

The work presented in this dissertation has contributed to fill a gap in the supply chain integration literature concerning the intra- and inter-organizational effects of implementing digital technologies in supply chains at large Tier 1 corporations. Although some recent work has studied the potential use of new digital technologies in operations management, they have largely addressed only OEM companies and none of them have used empirical data nor have studied their inter-and intra-company effects. This dissertation has been developed by using empirical data from a Tier 1 company, its relationship with highly demanding Tier 2 sub-suppliers, and its IoT product development efforts for external customers; this particularity represents a more complex and challenging endeavor for supply chain integration which has been covered throughout my dissertation work.

5.1 Findings and contributions

Digital transformation has brought new opportunities but also big challenges to companies implementing it; specially to internal operations and supply chain management. The purpose of this dissertation was to understand this phenomena within supply chain operations at large transnational corporations. Overall, findings of this dissertation revealed the many hurdles of a supply chain division of a transnational company with worldwide diverse internal organizations, divisions, and managers in its efforts of embracing digitalization technologies.

Considering the literature background of this work, supply chain integration is regarded as a key factor for reaching higher levels of overall operational efficiency and performance. In the last century, as a result of constant progress in IT systems, supply chain management has increasingly embraced the used of IT-enabled interfaces like MRP, MRP II and ERP. ERP implementation significantly assisted and escalated the integration of supply chains, customers and buyers.

The theory of embeddedness helps to understand the needs and depths of supply chain integrations and thereby realize the motivations behind trying to use IoT systems in supply chains. IoT has the potential to take integrations to unprecedented levels, there are however, constraints which limit how effectively can these technologies be adopted. By making use of

Technology Acceptance and Technology Readiness, findings suggest that the adoption of IoT technologies by a supplier are affected as a consequence of several internal and environmental factors: intellectual property, data privacy, lack of IT infrastructure and knowledge, systems' compatibility, and perceived benefits among other factors.

Considering the dimensions of Absorptive Capacity theory, we can improve our understanding of the challenges and effects that implementing technologies like RPA has over organizations. I analyzed the implementation of RPA technologies within a supply chain organization dealing with repetitive non-value added tasks such as issuing purchase orders, creating contracts with suppliers, exchanging information for sourcing decision processes, etc. Absorptive capacity theory provides an appropriate framework to study different stages of a new technology's implementation through the dimensions: acquisition, assimilation, transformation and exploitation. Findings suggest that although personnel's technical background and companies' IT infrastructure play an important role in the effective assimilation of new technology, it is however, a deficiency of the internal organization (management leadership, management strategy and the organizational environment) the main obstacle in the technology absorption process.

Results also show that the development of an IoT-enabled solution for a company's external supply chain partners (suppliers) is a very complex endeavor that requires the participation of competent and experienced cross-functional teams as well as the continuous support of top level sponsors. As data transparency, accuracy and availability are key factors for achieving an integrated supply chain, a high degree of supply chain integration can certainly be achieved through digital technologies. Nonetheless, an unsuitable product development process can make those efforts fail.

A selection of important findings are summarized in the Figure 5.1 below; they are intended to provide a general view of each chapter's results.

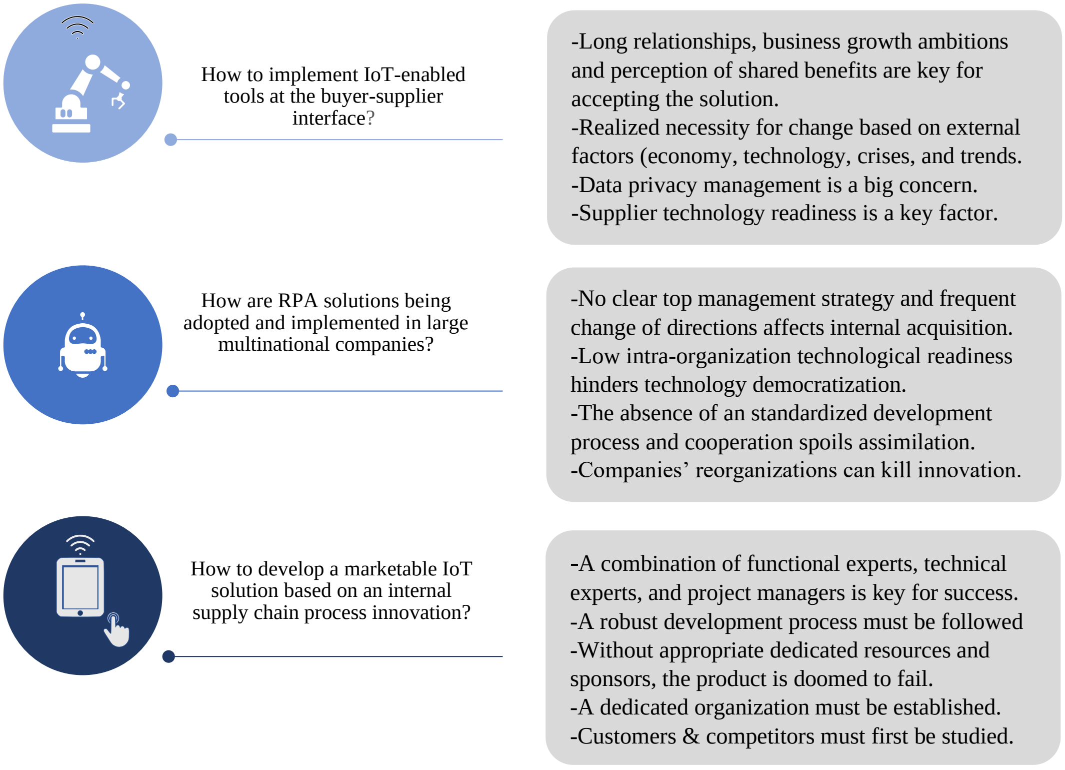


Figure 5.1 Synopsis of research questions and main findings

5.2 Main findings – Chapter 2

Chapter 2 discusses the implementation of IoT-enabled tools at the buyer-supplier interface and looks at the implications of process visibility and non-human controlled intercompany data exchange in the relationship between customers and suppliers. By means of an inductive case study we look at the implementation of an IoT monitoring tool at the production plant of an automotive Tier 2 supplier of Bosch Mexico. We address the question: How to implement IoT-enabled tools at the buyer-supplier interface?

After analyzing the data which we collected in 2018 and 2020 we found that the implementation of IoT- enabled solutions helped the supplier to improve its current situation with Bosch and further supported supplier's continuous improvement activities. The use of these tools will not replace human workers but will instead enable them to take on more active roles in the supervision, adjustment, and improvement of production processes at the same time of giving useful real-time data to buyers and logistic planers to make quicker informed decisions.

We looked at the IoT implementation phenomena in the supply chain by reflecting on literature about embeddedness, technology readiness and technology acceptance. Although this project was cancelled by Bosch before being formally implemented at the broader supplier base, the pilot phase gave us sufficient data and insights about its effects on the intercompany relationship. The Tier 2 supplier did not easily welcome the project but both companies reached an agreement based on different reasons; Bosch (Tier 1) wanted to have more visibility over its supply chain and the Tier 2 supplier needed to improve its relationship with Bosch to secure opportunities for future business.

5.2.1 Implications for practice – Chapter 2

Supply chains in the automotive industry are highly complex, time-critical and demanding; for Tier 1 automotive suppliers like Bosch, any disruption in the supply chain could cost millions of dollars in losses and penalties. We found that the use of IoT-enabled solutions could help alleviate and prevent those problems. By diffusing the use of digital technologies in the supply chain, Tier 2 suppliers can have enough visibility on their production processes to generate improvements and increase efficiency with the use of measurable real-time data.

5.2.2 Limitations and future research – Chapter 2

This research study was limited to the buyer-supplier relationship between one Tier 1 and one Tier 2 suppliers; it entails opportunities to verify its external validity. As discussed in the study, there was reluctance from both parties to initially participate in the project for diverse reasons; therefore technology acceptance allows for further exploration in future studies. Future research should also look at how relational embedding and IoT solutions interact with each other, and also investigate whether trust and sensors are complements or substitutes.

As our study took place in the automotive industry with its intrinsic characteristics, it is important to verify its application in other industries whose supply chain conditions, supplier base, and customer requirements might differ. The use of digital technologies in supply chains worldwide will bring future opportunities for research in the technology and operations management area.

5.3 Main findings – Chapter 3

Chapter 3 analyses the implementation of RPA technologies in the workplace in a company's effort to make its operations more efficient. I look at this implementation process through the lens of the absorptive capacity theory. I drew on my own experiences as senior manager in the previous implementations of new policies, processes, and IT-systems in operations departments of a large corporation. The intention of this study is to address the research questions: How are RPA solutions being adopted and implemented in large multinational corporations? And what are the main challenges of adopting RPA technologies in large multinational corporations?

Reflecting on the data analyzed, I found that it is not the technical infrastructure itself the main obstacle for technology absorption. It is, however, a combination of deficiencies in the decisions of the top management about its internal organizations the main source of failure. Thus, my main findings are that successful implementations of technology should consider a balance of infrastructure, people, and processes. Poor or limited IT-related infrastructure and a significant quantity of internal processes can seriously hinder how effective the absorption of RPA technology can be. Most importantly, a not appropriate strategy towards people and organization management can doom the venture to fail.

The main contribution of this study is the RPA absorptive capacity cycle which integrates factors that constitute strong components for success for each AC dimension as a contrast to the failing factors detected at each phase of the process. I further contribute to the AC model by adding a new dimension called "dissolution" which aims to shed light on how to rearrange the technology absorption process to increase the probabilities for a successful technology implementation.

5.3.1 Implications for practice – Chapter 3

At the time of this research, many companies are venturing into initiatives to target digital transformation within their organizations. This real-life multiple case study provides useful insights on how can technology related adoptions have better results and avoid failure. I agree with (Peeters et al., 2014) that it is not the hierarchical power of the management to impose initiatives a factor for success in the adoption of new practices but the ability to create an appropriate organizational environment.

Companies should avoid getting carried away by the urgency of implementing new tools with the only purpose of being at the leading edge of technology against its competitors, or investing in new technologies which promise great benefits but have not been thoroughly tested so far. Companies, should instead, exert caution when approaching new technologies and determine if it is a good fit for its current internal infrastructure, governance, policies and processes. Utmost importance must be given to develop a robust strategy targeting a company-wide technology implementation from the perspective of employees and diverse internal organizations.

5.3.2 Limitations and future research – Chapter 3

This study analyzed the absorption of RPA in one automotive Tier 2 company; although it covered many internal organizations, regions and countries, the research only included one large company which raises questions about its external validity. Therefore, it would be important to replicate this study in another industry with characteristics and challenges different from the automotive environment.

The analysis does not cover all the factors that I found during my study; my intention was to cover the most important factors but not to exhaust them. RPA implementation and its absorption by organizations offer more streams for research including open innovation, project management and technology scalability.

5.4 Main findings – Chapter 4

Chapter 4 explores the development and introduction of a new IoT product which was initially conceived as a solution for a Tier 1 company's internal supply chain problems. As a result of the great initial cross-company interest in the pilot solution; the development team changed its market focus from internal to external. This change brought a new set of challenges and requirements which in the end contributed to the project's failure and subsequent abandonment. This research evolved into a single case study which aims to provide researchers and practitioners with insights into the development of IoT technologies for supply chain applications. This case reflects on the decisions made by the management and cross-functional development team at Bosch Supply Chain in Mexico and USA.

The main question that this single case addresses is: How to develop a marketable IoT solution based on an internal supply chain process innovation? This study was developed with data obtained through extensive interviews and company's internal communications shared by the case participants. Over the course of this study I found that an IoT project with good potential can fail if its development process does not follow a clear strategy. This project development process faced numerous changes and transitions that contributed to an unsuccessful result. Thus, my main findings suggest that an absence of continuous top management sponsorship, the unbalanced involvement of both technical and functional experts, and insufficient experience in innovation management can negatively affect the development process of an IoT solution.

My main contribution is a set a of steps which, by means of a reflective learning process, can guide researchers and practitioners in the process of successfully developing innovative digital solutions.

5.4.1 Implications for practice – Chapter 4

The digital transformation era has captured the interest of intracompany non-engineering departments to adopt or develop specific digital solutions that could help to make operations more efficient and alleviate the workload for employees. It is, however, not an easy venture to follow; a lack of a proper development strategy entails a great risk for failure. This study provides insights on which factors should be considered in endeavors of this kind to increase the probabilities of project success.

5.4.2 Limitations and future research – Chapter 4

This case study captured the hurdles of a large incumbent transnational firm when trying to develop a very specific IoT-enabled solution for its recurrent needs. The conditions and realties inside other corporations and diverse industries could show a different picture; the replication of this case should be verified in other settings.

Additionally, this case was focused only on a product development perspective, consequently, future researchers can find equally beneficial research outcomes by concentrating on other angles including costs, intercompany relationships, product marketing, and new business development.

5.5 Concluding remarks

The research work discussed in this dissertation was motivated by my more than 15 years of industrial and corporate experience in the technology and operations management fields. The hurdles that I have faced in the course of my career, spanning from being a graduate intern up to a regional head of department, were the factors that constantly inspired me to take a deeper look into the influence that companies' internal organizations exert on causing their own operational failures. My inner curiosity attracted me to look at the internal factors that make company's endeavors fail to subsequently provide my contributions by shedding light on how to overcome the constant hurdles of everyday business life.

I sincerely hope this work can help researchers and practitioners to bring value into organizations and pave their way towards achieving more efficient operations with the support of new technologies.

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APPENDICES

Appendix A - Interview protocols "Talking to machines" (Phase 1 and 3).

Interview Protocol for Phase 1

A1. Sourcing Function Staff (Buyers) Interview

Intro questions (5 minutes)	• How long have you been in the company? • What is your current role in the company? (Please describe briefly) • What did you do before? (at BOSCH or prior employer if recently hired employee)

General questions about BOSCH Sourcing
 	
(15-20 minutes)
	• How is the sourcing function (department/unit) of BOSCH organized?
	  ○ Focus on getting a ***brief*** description
	• How does BOSCH select its suppliers?
	  ○ Focus on getting a description of the process
	
	• Can you influence the selection? How?
	  ○ Is there a "mismatch" between what the person does and BOSCH's stated process?
	  ○ Does "relationship management" play a role?
	
	• Are there any differences in the process regrading new supplier selection and sourcing "agreement/contract" renewal?
	
	• How do you manage a typical sourcing "agreement/contract"?
	  ○ What does managing a sourcing agreement entail?
	  ○ Are there different types of suppliers? What drives their categorization?
	  ○ Probe in search for differences among different types of suppliers
	    ▪ Does social capital play a role?
	• What problems arise in a typical sourcing "agreement/contract"?
	  ○ Focus on getting examples
	    ▪ This is important for the discussion of the problem identification stage of the digitalization project
	
	• How are the problems in a typical sourcing "agreement/contract" solved?
	  ○ Who is responsible?
	  ○ To what extent are contracts enforced?

Questions about BOSCH Digitalization
 	
(45-60 minutes)
	• Are you aware of the Digitalization Strategy of BOSCH?
	  ○ How did you learn about the Digitalization Strategy of BOSCH?
	
	• Have you taken part of any of BOSCH's digitalization initiative?
	  ○ How did you learn about the (SC) Digitalization project you took part of?
	  ○ Why did you get involved in the project?
	
	• Please describe the (SC) Digitalization project you took part of
	  ○ How did the project come to be? Why this project?
	  ○ How was the decision to run this project made?

	◦ Focus on the goal of the project – Does it make sense to do this? Is it aligned with BOSCH's strategy? • Please describe your involvement in the (SC) Digitalization project ◦ Focus on getting the informant to talk about her role. Does she perceive herself as a "facilitator", as problem identifier? ◦ Approach the project systematically ▪ What stages were you involved in (validate our info)? ▪ What did you do in each stage? ▪ Who did you work with? ▪ What did you get out of each stage? • Please describe the involvement of the supplier you work with in the (SC) Digitalization project ◦ Focus on getting the perspective of the buyer as a "representative" of the supplier within BOSCH ▪ Why was that supplier chosen? Did you have anything to do with that decision? ▪ Is this related in any way with the sourcing management activities described before? ▪ How was the project presented to the supplier? ▪ Who was the contact person at the supplier? Same as sourcing activities? ▪ What was the reaction of the supplier to the initiative? ▪ What problems were there for the supplier to join the project? ▪ How were those problems solved? By whom? • How would you assess the (SC) Digitalization project so far? ◦ What worked? What didn't work? ▪ If possible lead the informant through the stages of the project ▪ Because the informant may not have a clear overview of the entire project it might be useful to ask about the "bits" of the project that she identifies. ◦ Overall assessment? ▪ Assessment factors? • You mentioned that XXXXX worked "pretty well". Why do you think that worked? ◦ Probe on what the informant identifies as "successes" Transparency and good communication among team members and the supplier. ◦ Focus on getting the "enablers" Good supplier relationship, negotiation skills, project management skills and especially good communication. • You mentioned that XXXXX did not really work. Why do you think that was the case? ◦ Probe on what the informant identifies as "problems/failures" ◦ Focus on getting the "hindrance factors" ◦ How were these problems solved? By whom?

Appendix B - Interview protocol "Talking to machines" (Phase 3).

Project: IoT tooling sensor
Phase: Post-implementation

Interview for:

- Bosch Purchasing Manager
- Bosch Logistics Manager
- Bosch supplier quality Engineer
- Supplier Key Account Manager and Plant Manager

Time: 40 minutes
Location: Skype for Business due to COVID19 restrictions

Introduction:

As previously discussed, you have been selected to participate in this interview as part of our research on the implementation of IoT Technologies in Supply Chain Management. The interview will be recorded for analysis purposes, but it will be treated as anonymous and will not be shared inside or outside the company. The information gathered through this interview will be used as part of our qualitative research. This interview is planned to last no longer than 50 minutes and your participation is voluntary. We will follow a list of questions that were prepared in advance and we might add additional questions in case of needing more details about a specific point.

Background:

IoT has become a core area of interest in Bosch Operations worldwide, the use of these technologies in our daily work is intended to alleviate our workload at the same time of providing more accurate data to facilitate decision making processes. You have been part of our IoT tooling management project since September 2017, therefore the target of this interview is to obtain an overview about what has occurred after the implementation of this solution.

Interview:

General Questions	30min
▪ What has been your experience with the Tooling monitoring solution so far? ▪ What has changed in the way that you perform your work since the implementation of the solution? ▪ Have you seen a difference between the production process data manually collected vs the data collected by the IoT sensor? ▪ If the accurate production numbers were known in the past few years, is there anything that you would have done differently? Is there a decision you would change? ▪ Is there another way to obtain more precise data without the IoT sensor? Please explain. ▪ What has been your overall experience with this project? How was the involvement, inclusion and support from the other team members?	

Specific questions for Bosch Purchasing, Quality and Logistics	20min

▪ How critical is the difference among the production data detected by the IoT sensor and the data provided directly by the supplier and the Bosch ERP systems? ▪ What effects or consequences does this difference in the data have on Bosch operations? ▪ What are the benefits that this solution provides to your department's activities? ▪ What is your perception behind the supplier's interest in being part of this project and implementing the solution? ▪ What changes have you seen in Bosch's relationship with the supplier that implemented this solution? ▪ How do you see the application of these technology in the future?

Specific Questions for Supplier's KAM	20min
▪ How would you describe your overall experience with IoT digital technologies so far? ▪ What has been your experience with this project in particular? ▪ Have you detected any difference between the data you manually collect and the data that the sensor provides? Could you please explain? ▪ How have you used the data that the sensor provides? ▪ Has the IoT sensor been of benefit to your company? How? ▪ What has changed in your company and its operations since the sensor was installed? ▪ If you had access to this information before, is there anything that you would have decided differently or that you would had changed? ▪ Which are your expectations for this technology in the future? ▪ Has your relationship with Bosch and your responsible buyer changed during or after this project? Please explain.	

Appendix C - Interview protocol "RPA".

Robotic Process Automation
Interview for: RPA Developer (IT dept)
Time: 60 minutes
Location: Skype for Business

Dear participant,

As previously discussed, you have been selected to participate in this interview as part of a research study focusing on the implementation of RPA Technologies in the workplace. The interview will be recorded for analysis purposes, but it will be treated as anonymous, confidential and will not be disclosed inside or outside the company. This interview is planned to last no longer than an hour and your participation is voluntary. We will follow a list of questions that were prepared in advance and we might add additional questions in case of needing more details about a specific point.

RPA has become a new automation tool being implemented in Bosch Operations worldwide. It's application in our daily work is relatively new but it is diffusion has been increasing in the last 2 years. The target of this interview is not to evaluate any part of your work, experience or knowledge, our intention is to understand how RPA is unfolding inside the company.

General Questions	5min
• For how long have you been working at Bosch and in your current position? • What is your current role? • Could you please briefly describe it? • What was your previous activity inside or outside Bosch? • What is your academic background? • Could you please tell me your age range? (20-30, 30-40, 40-50, 50+)	

Function / Department	10min

• Which are the main activities performed by your department?
• How is your department organized?
  o Organization for Automation projects?
  o What resources are there available for you to develop these projects?
  o Relationship with Bosch Corporate Informatics (CI) or dependence on other Bosch departments. How do they influence your work?
  o How difficult is it to get a bot user ID?
  o Is there a resistance from other departments to grant a user ID? Why?
• How does your department manage projects?
  o Is there a specific methodology? Adopted or self-developed?
  o How much does the project management approach has affected the success of projects compared to other approaches you have used?
  o Is there something missing with this approach that you would add?	

Specific RPA Project related	45min

- What is your department digital innovation strategy?
  - How does it relate to the Bosch overall Innovation & Digitalization strategy?
  - In your opinion is there anything that could be added to the strategy?
- What is a Robotic Process Automation project?
  - Anything different/positive in these projects compared to other projects? What value added do RPA projects bring compared to previous projects?
- How did you get involved with Robotic Process Automation?
  - Which skills that you already had have helped you during your start in RPAs?
  - Please tell about any specific training or skill that you required to develop RPA bots?
  - Are there any skills you need or would like to have in order to improve your work as RPA developer?
- What are the reasons for starting an RPA project?
  - Who decides to use RPA?
  - How do you detect potential RPA project / internal customer?
  - How do you get internal departments interested and involved in RPA?
  - Do you make automation workshops? How well have they worked for you as a way to get new projects and customers?
- How do you assess if RPA is the right solution for a project?
  - Which characteristics should a good RPA project have?
  - Discovery phase?
  - Formal feasibility analysis process (complexity, resources, infrastructure)
  - Who pays for it? How has this approach worked until now?
- How do you select the automation tool to be used in your project?
- Could you please describe an RPA project that succeeded?
  - How did the project start?
  - How was the project selected?
  - Who made the decision from the customer side?
  - Who sponsored it? Which factors help the sponsor hiring an RPA project?
  - How was the solution chosen?
  - What stages did the project have?
  - Which role did you have along the stages?
  - Who did you work with from the customer side? Was it enough?
  - Please explain if the solution was programmed entirely by yourself or in a team?
  - What capabilities helped you to succeed in this role?
  - After this experience, are there silks that you would like to strengthen or acquire to manage/work on future projects?
- What was the involvement of your internal costumer in the project development?
  - How frequent did you communicate / update on the progress?
  - Who did you communicate with?
  - How did the cooperation flow?

- Was there any problem? How was it solved?
- Could you please tell us about a project that failed?
    - At which stage did it fail?
    - Reason?
    - Which reasons are behind a project that is was is cancelled? Resources?

- What are the main challenges that you, your department faced when developing and implementing RPA projects?
- Have you or your group encountered resistance or reluctance towards RPA and automation technologies in your customer's department? Fear for being replaced?
- How do you assess the success of RPA tools after the implementation?
    - Lessons learned?
    - Which problems has the project solved?
    - What problems have arisen with the use of RPA technologies?
- What has been your experience so far?
    - What would you do different in future projects?
    - What can be improved regarding RPA strategy in the company?
    - How should the future of RPA be? Will it become another legacy system?
    - Is RPA the right strategy for the company? Should it be changed?
    - Can Bosch create them or should keep in depending from external partners?
    - Is there any risk to depend from PaaS and SaaS external providers?
    - What should be done in the future? More / different technologies

Appendix D - Mobility Solutions division in the Bosch Group.[46]

MOBILITY SOLUTIONS

Powertrain Solutions
Chassis Systems Control
Electrical Drives
Cross-Domain Computing Solutions[1]
Car Multimedia[2]
Automotive Electronics
Automotive Aftermarket
Automotive Steering
Connected Mobility Solutions
Bosch eBike Systems

Other businesses:
Bosch Engineering GmbH
ETAS GmbH
ITK Engineering GmbH
Two-Wheeler and Powersports

1. From January 1, 2021
2. Until December 31, 2020

Appendix E - Strategy and vision at the Bosch Group.[47]

STRATEGY AND INNOVATION

Our vision of the future is for mobility to be sustainable, safe, and exciting.

We aspire to a leading position as the largest automotive supplier by revenue, even in a changing market, and to help shape change in the automotive industry.

As a company, we are committed to the Paris climate targets, even if they are very ambitious. We are pursuing a technology-neutral approach and are offering our customers a wide range of products and services.

We want to help make mobility carbon neutral. Electric vehicles powered by electricity from renewables are one part of this. On the other hand, in the transitional phase and in many applications (especially in heavy-duty and long-haul traffic), the modern combustion engine will continue to play an important role. It will also feature as part of hybrid configurations for many years.

Using carbon-neutral fuels, diesel- and gasoline-powered vehicles can also be climate neutral.

In electromobility, our strategy is to position ourselves as a supplier with a broad product portfolio. In our Industrial Technology business sector, new solutions arising from the convergence of electrical and hydraulic systems offer opportunities. In building technology, the use of heat pumps and renewables is playing a rapidly growing role and opening up new market opportunities.

It remains a key strategic focus to continuously expand our position in online retail, as this is playing an increasingly significant role, especially for our Consumer Goods business sector.

We want to be a data-driven AIoT company. In other words, we want to use connectivity on the internet of things (IoT), combined with artificial intelligence (AI), to continuously improve our products and services. Climate action is also one of our paramount strategic focal points for the future.

We intend to use connected, intelligent solutions to make life easier, more efficient, safer, and also more sustainable for as many people as possible. We regard our presence in diverse markets and industries as an advantage. This presence is a source of many insights for us.

Over the medium term, AIoT will especially help us significantly increase the proportion of annually recurring revenue, which is still low.

With respect to our goal of becoming a thoroughly customer-focused AIoT company, the importance of software and information technology in the value chain is growing significantly. For this reason, we are reinforcing the expertise and structures we need to achieve this goal. The technological basis is now in place across the organization.

In the shape of the Bosch Center for Artificial Intelligence, we have a center of competence which operates at seven locations in Germany, the U.S., China, India, and Israel.

We have published a code of ethics that governs our use of artificial intelligence. Our maxim today is that humans should be the ultimate arbiter of any AI-based decision. Our aim is to develop safe, robust, and explainable AI products.

For more about our strategy, read the group management report in the 2020 annual report at **annual-report.bosch.com**

Appendix F - Financial results 2016-2020, Bosch Group.[48]

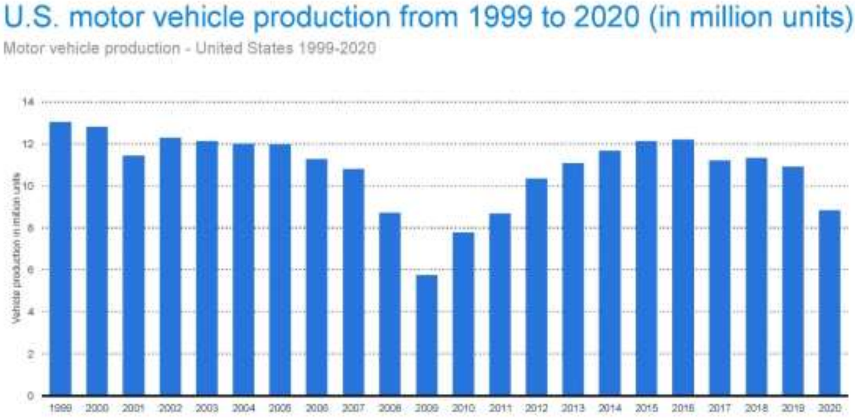
FIVE-YEAR SUMMARY
OF THE BOSCH GROUP

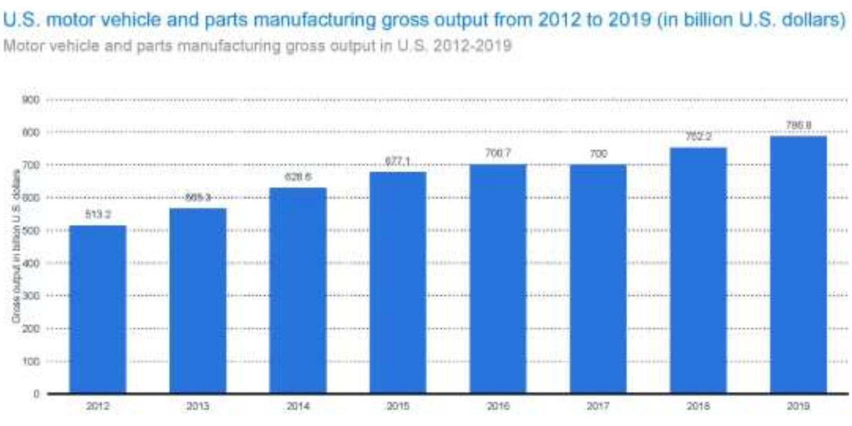
Figures in millions of euros

	2016	2017	2018	2019	2020
Sales revenue	73,129	78,066	78,465	77,721	71,494
percentage of sales revenue generated outside Germany	80	80	79	80	79
Research and development cost[1]	6,911	7,264	5,963	6,079	5,890
as a percentage of sales revenue	9.5	9.3	7.6	7.8	8.2
Capital expenditure	4,252	4,345	4,946	4,989	3,312
of which in Germany	1,580	1,546	1,757	1,718	1,469
outside Germany	2,672	2,799	3,189	3,271	1,843
as a percentage of sales revenue	5.8	5.6	6.3	6.4	4.6
as a percentage of depreciation	141	140	159	146	101
Annual average number of associates (thousands)	384	403	407	408	395
of which in Germany	133	137	138	136	133
outside Germany	251	266	269	272	262
at Dec. 31	389	402	410	398	395
Total assets	81,875	81,870	83,654	87,861	91,369
Equity	36,084	37,552	39,176	41,079	40,166
as a percentage of total assets	44	46	47	47	44
EBIT	3,335	4,916	5,502	2,903	1,657
Profit after tax	2,374	3,274	3,574	2,060	749
Dividend of Robert Bosch GmbH	138	241	242	119	67

1. Up to 2017, including development work charged directly to customers

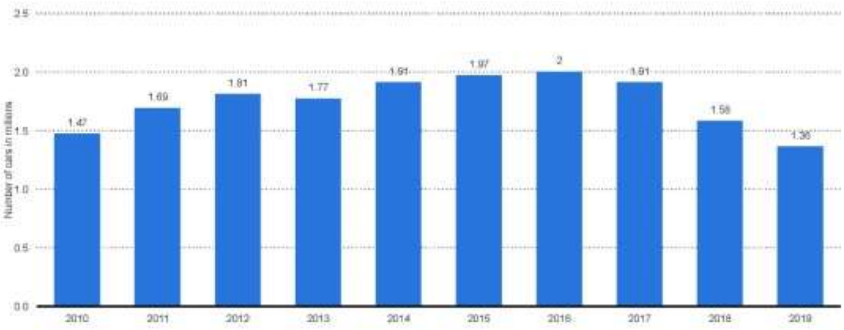
Appendix G - Automotive industry in the U.S. & Mexico.[49]





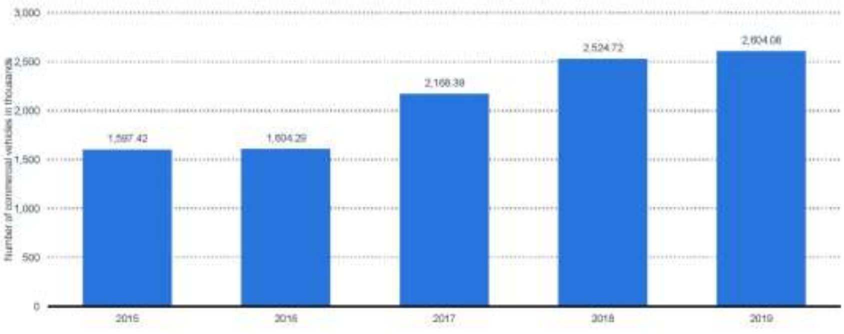
Number of passenger cars produced in Mexico from 2010 to 2019 (in millions)

Mexico: number of cars produced 2010-2019

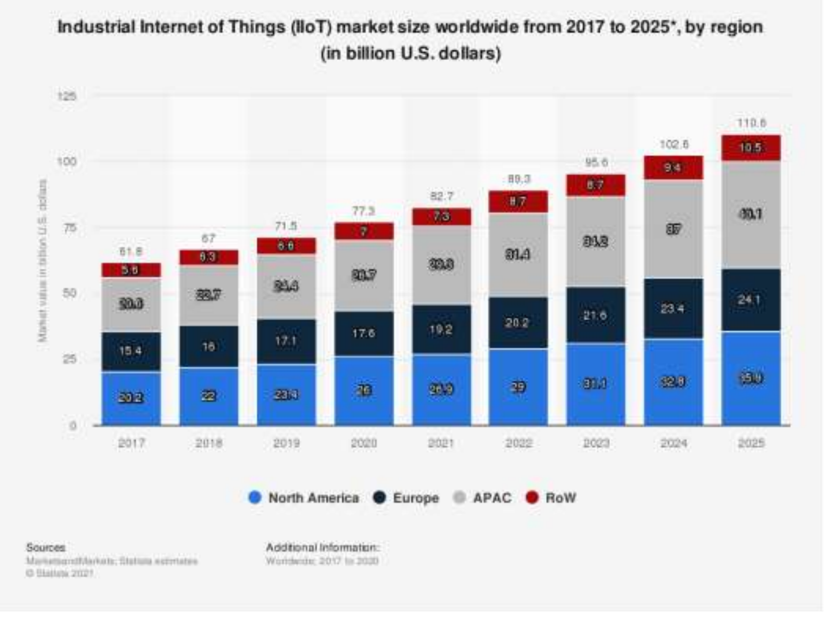


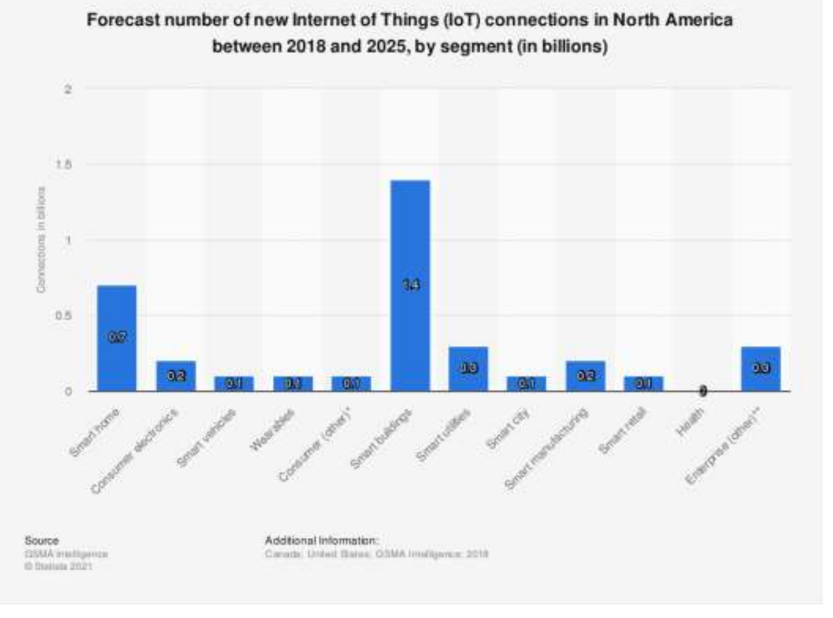
Number of commercial vehicles produced in Mexico from 2015 to 2019 (in 1,000s)

Mexico: number of commercial vehicles produced 2015-2019

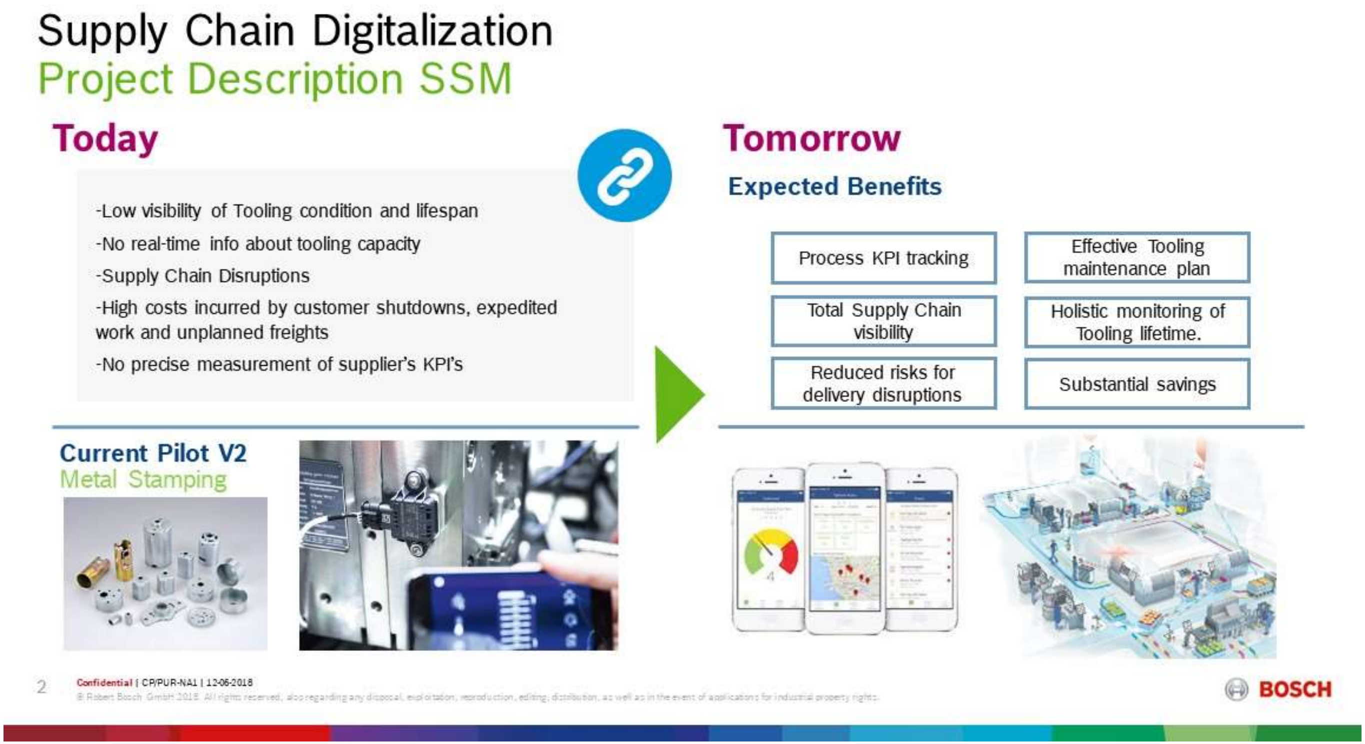


Appendix H - Internet of Things (IoT) in the U.S.[50]





Appendix I - Supply Chain Digitalization (SSM Project).[51]



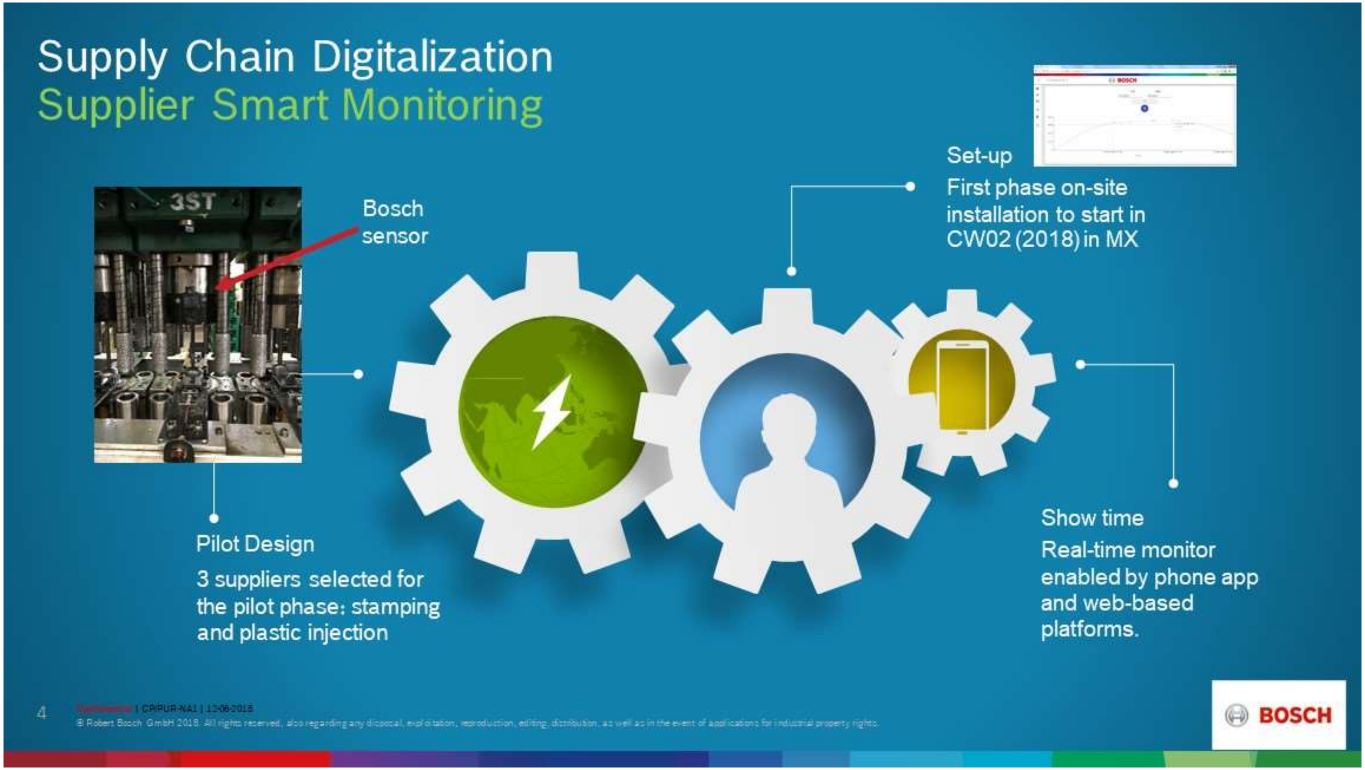
Supply Chain Digitalization
Bosch Sensor

- Humidity
- Acceleration
- Temperature
- Geomagnetic
- Gyroscope
- Pressure
- Digital light
- Acoustic

- IoT applications in rough environments
- 32-bit microcontroller
- Li-Ion rechargeable battery
- Bluetooth LE
- Industrial USB port

Aug 2017	Sep-Oct 2017	Nov-Dec 2017	Feb 2018	Mar 2018
Project plan	Supplier selection	Negotiation with supplier	Set-up and start	First pilot results

Current STM dashboard


Supply Chain Digitalization
Supplier Smart Monitoring
Bosch sensor
3ST
Pilot Design
3 suppliers selected for the pilot phase: stamping and plastic injection
Set-up
First phase on-site installation to start in CW02 (2018) in MX
Show time
Real-time monitor enabled by phone app and web-based platforms.
4
CP/PUR-NA1 | 12-06-2018
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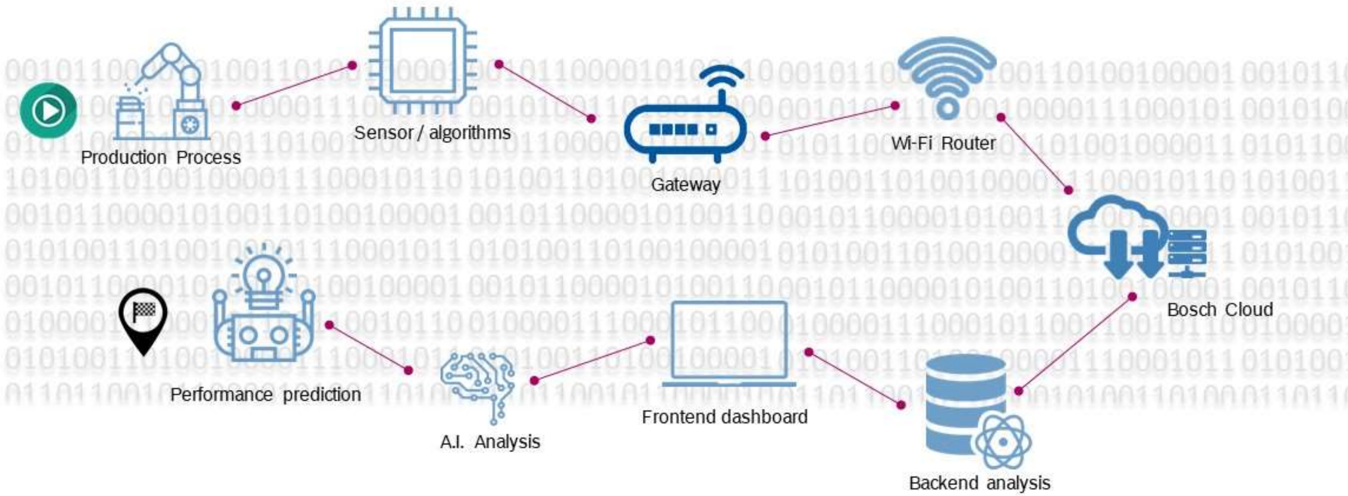
BOSCH

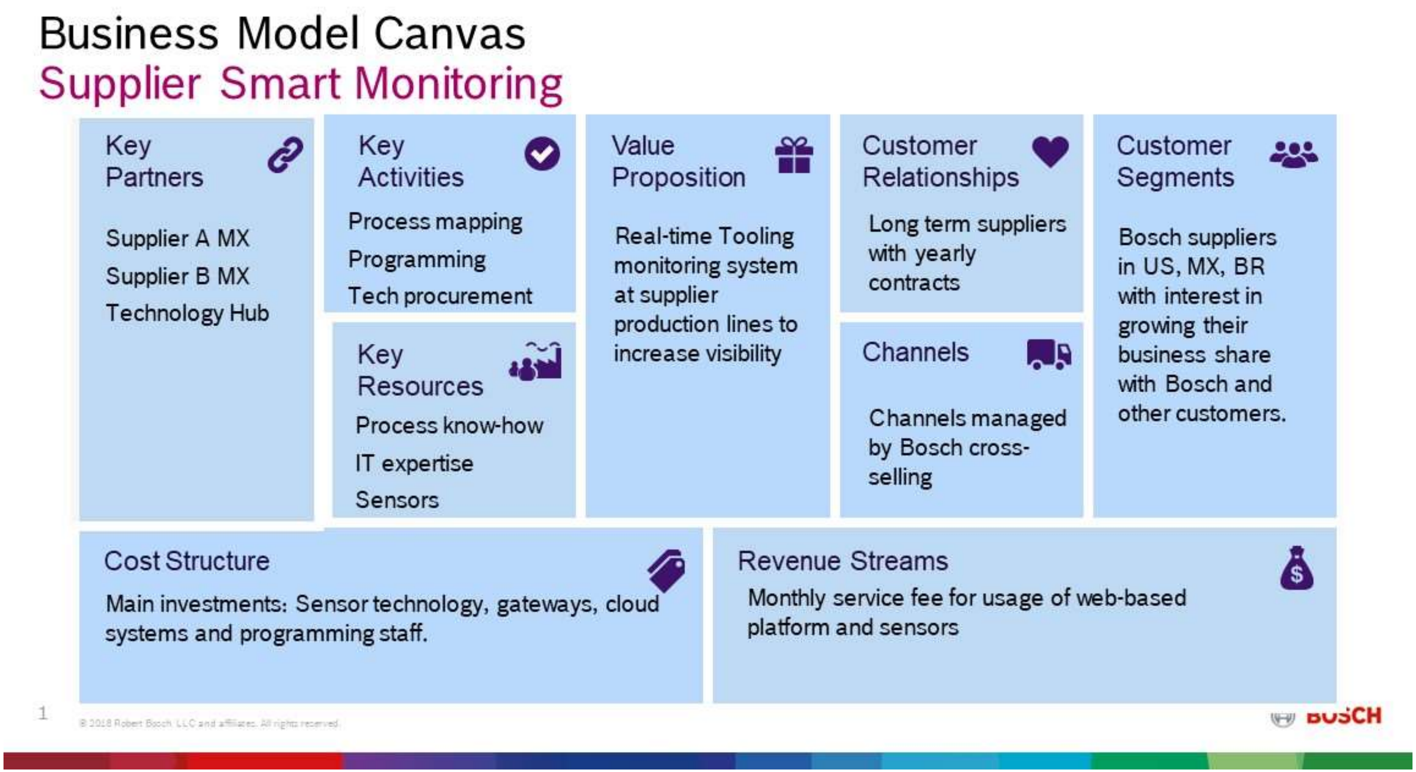
Supply Chain Digitalization
SSM Process



 Confidential | CP/PUR-NA1 | 12-06-2018

BOSCH

Appendix J - Business model innovation canvas.[52]



SUMMARY

STUNTED INNOVATION: HOW LARGE INCUMBENT COMPANIES FAIL IN THE ERA OF SUPPLY CHAIN DIGITALIZATION.

Companies face continuous challenges caused by new customer requirements, innovations, global economic changes, market shifts, and industrial evolutions among others. Many of them strive for surviving and remaining competitive, however, it is burdensome to keep up to speed with the industry. Operations management and specially supply chain management are highly complex areas that exert a direct influence on a company's efficiency, performance and profitability. Therefore, as part of their constant pursuit of processes optimization and cost reduction, companies turn their attention to solutions enabled by new technologies which could offer an opportunity to improve performance.

In the last few years, digital technologies including blockchain and the Internet of Things have captivated industrial technologists and executives with the promise of empowering the human workforce and improving overall efficiency by making use of data analytics, real-time process monitoring, robotic automation of business processes, simulations, and systems integration. These technologies aim for making operations more transparent by increasing their visibility on a real-time basis to aid employees and decision makers. Through extensive empirical qualitative work, this dissertation sheds light on how these technologies are being implemented at large incumbent companies and what effects do they bring to organizations.

Therefore, to research the digitalization phenomena, this dissertation starts (Chapter 2) by offering an empirical case study of a transnational automotive Tier 1 company developing and implementing an IoT-based monitoring system at its suppliers' production plants. This study

depicts how this technology is implemented and what are its effects on the relationship between the Tier 1 company and its Tier 2 supplier. After looking at the external part of the supply chain, Chapter 3 provides insights into the absorption of digital technologies inside the Tier 1 organization. The implementation of Robotic Process Automation within business process operations faces various challenges and obstacles within and across intra-company's organizations.

The development of IoT-enabled solutions for supply chains can offer a new possibility to generate revenue through their external commercialization. Chapter 4 analyses the development of an IoT solution by a Tier 1 company with the intention of taking the solution to the external market. This project encountered several obstacles and challenges throughout its development; chapter 4 depicts the hurdles of an automotive company in its efforts to create a new business model based on digital technologies targeting supply chain operations.

NEDERLANDSE SAMENVATTING

STAGNERENDE INNOVATIE: HOE GROTE GEVESTIGDE BEDRIJVEN FALEN IN HET TIJDPERK VAN TOELEVERINGSKETEN DIGITALISERING.

Bedrijven worden voortdurend geconfronteerd met nieuwe uitdagingen zoals veranderende klanteisen, innovaties, wereldwijde economische ontwikkelingen, marktverschuivingen en industriële evoluties. Velen van hen streven ernaar concurrerend te blijven, maar het is lastig om de snelheid van de industrie bij te houden. Operations management en in het bijzonder supply chain management zijn zeer complexe functies die een directe invloed uitoefenen op de efficiëntie, prestaties en winstgevendheid van een onderneming. In hun voortdurende streven naar procesoptimalisatie en kostenreductie richten bedrijven hun aandacht dan ook op oplossingen die mogelijk worden gemaakt door nieuwe technologieën.

In de afgelopen jaren hebben digitale technologieën, waaronder blockchain en het Internet of Things, technologen en leidinggevenden in de ban gehouden met de belofte om arbeidskrachten zelfstandiger te maken en de algehele efficiëntie te verbeteren door gebruik te maken van data-analyse, real-time procesmonitoring, robotische automatisering van bedrijfsprocessen, simulaties en systeemintegratie. Deze technologieën hebben tot doel operaties transparanter te maken door hun zichtbaarheid in real-time te verhogen om werknemers en besluitvormers te helpen. Door middel van uitgebreid empirisch kwalitatief werk, werpt dit proefschrift licht op hoe deze technologieën worden geïmplementeerd bij grote gevestigde bedrijven en welke effecten ze hebben op organisaties.

Om dit fenomeen te onderzoeken, begint dit proefschrift (Hoofdstuk 2) met een empirische casestudy van een internationale fabrikant van hightech auto-onderdelen (hierna: Tier 1)dat een IoT-gebaseerd monitoringsysteem ontwikkelde en implementeerde in de productiefabrieken van één van zijn leveranciers. Deze studie toont hoe deze technologie werd geïmplementeerd en wat de effecten hiervan zijn op de relatie tussen dit bedrijf en zijn toeleverancier. Nadat het externe deel van de toeleveringsketen onder de loep is genomen, geeft hoofdstuk 3 inzicht in de absorptie van digitale technologieën binnen de Tier 1 organisatie. Hoofdstuk 3 laat zien hoe de implementatie van Robotic Process Automation binnen de bedrijfsprocessen wordt geconfronteerd met verschillende uitdagingen en obstakels, zowel binnen en tussen de business units van het bedrijf.

De ontwikkeling van IoT-gebaseerde oplossingen voor de toeleveringsketen kan een nieuwe mogelijkheid bieden om inkomsten te genereren door de externe commercialisering ervan. Hoofdstuk 4 analyseert de ontwikkeling van een IoT oplossing door het Tier 1 bedrijf met de intentie om de oplossing op de markt te brengen. Dit project kende verschillende obstakels en uitdagingen gedurende de ontwikkeling; Hoofdstuk 4 beschrijft de hindernissen voor een van oorsprong niet-IT gericht automotive bedrijf in haar inspanningen om een nieuw business model te creëren gebaseerd op digitale technologieën gericht op supply chain operaties.

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We are living in the era of automation, bots, and artificial intelligence. The so called "Digital Transformation" is driving companies to invest into new technologies to remain competitive and cope with the increasing demands of the market. Machines are being integrated into digital virtual production systems where operations are facing much more automation than ever before. How do large companies implement new technologies? How do intra-company organizations absorb digital innovations? This research aims to explore the phenomena of digital transformation in operations management, especially in Supply Chain Management, and provides insights into the effects of inter- and intracompany digitalization in industrial and corporate settings.

This dissertation is organized in three empirical studies that look at digitization and automation initiatives from different perspectives. The first study researches the digitalization of automotive supply chains through a customer-driven implementation of IoT technologies into the production plants of one of its suppliers. Conversely, the second study analyzes the implementation of robotic automation technologies in business operations across a company's internal organizations. Finally, the third study delves into a failed IoT product development story of an automotive company through a case study aimed to provide a roadmap for practitioners and researchers. This dissertation explores failed digitalization attempts at large incumbent companies with the intention to pave the way for future successful endeavors.

This PhD thesis has sprung from the Part-time PhD Programme at the Rotterdam School of Management, Erasmus University (RSM). Part-time PhD candidates conduct research against the highest academic standards on topics with real-world application value, thereby contributing to the positive impact of RSM research on business and other societal stakeholders.
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