Business Model Innovation and Industrial Internet of Things. An Explorative study on the Business Model Design of Small and Medium Enterprises

Author: Lorenzo de Virgilio
University of Twente
P.O. Box 217, 7500AE Enschede
The Netherlands

ABSTRACT, The Industrial Internet of Things is a current trend on which most companies want to grasp the opportunities unravelled by it. However, business level effects of this new phenomenon are still in its infancy. This explorative study wants to tackle this research gap by analysing in-depth how the distinct capabilities used by SME in the manufacturing industry, during specific technological development, could lead to specific IoT-based business model archetypes. Against the background of two previous studies, and a multi-case study, it was identified that companies approach business model innovation differently given which strategic development was sought. Furthermore, insights are presented on how and why SME implement and innovate their business model divergently. Thus, this study wants to contribute to the current research by creating a greater understanding of the business model innovation, and business model and additionally provide insights on the strategic decision-making perspective on the Industrial Internet of Things.

Graduation Committee members:

1st Supervisor: Dr. Tamara Oukes

2nd Supervisor: Ir. Björn Kijl

Keywords

Business Model Innovation, Business Model, Dynamic Capabilities, Industrial Internet of Things, Multi-case Study, Manufacturing Industry

11th IBA Bachelor Thesis Conference, July 10th, 2018, Enschede, The Netherlands.

1. INTRODUCTION

1.1 Industry 4.0, Business Model Design, and Business Model Innovation

In the year 2011, the German government passed the project "*Industrie 4.0*", which can be identified with the more academically and internationally known Industrial Internet of Things (IIoT). This term signifies the concatenation of the physical world with the digital, through an internal based network (Kiel, 2017; Kiel, Arnold, & Voigt, 2017; Reinhard, Jesper, & Stefan, 2016). This IIoT has also been acknowledged as the fourth industrial revolution, although its implications on established companies are still vague, being that solely its technological aspects have been studied. Although the current research focused on technological preconditions, Atzori et al. (2010) argue that technological enablers are essential to implement IIoT in business processes. It is safe to say that IIoT will have a direct impact on the firm level, as well as the industry level. Moreover, IIoT will account for the emergence of new business opportunities manufacturing firms can only make use of by addressing a successful Business Model Innovation (BMI). Conclusively, some academics have speculated that companies will have to readapt their Business Model (BM) to tend to the requirements of this revolution (Arnold, Kiel, & Voigt, 2016; Perspective, Brettel, Friederichsen, Keller, & Rosenberg, 2014).

To not miss on the novel fields of competition unravelled by the IoT, manufacturing companies will undoubtedly be ever-challenged to develop and implement successful IoT related business models (Chesbrough, 2010; Fleisch, Weinberger, & Felix, 2015). Despite the potential of IoT, there is a lack of literature covering IoT business models, and how business models can be created for different IoT applications (Gubbi, Buyya, Marusic, & Palaniswami, 2013). This is primarily caused by the uniqueness and novelty of IoT as well as ambiguity about its impact. However, the assessed magnitude of IoT permits further research, which in turn can help entrepreneurs create IoT business models that create and capture the greatest amount of value possible.

In a study conducted by Laudien and Daxböck (2016) three business model archetypes have been constructed on an explorative study of German manufacturing companies implementing IIoT in their routine processes. These archetypes are a framework for manufacturing firms to use while transitioning from non-digital industries to an IIoT-based business model (Laudien & Daxböck, 2016). They speculated that companies employ dissimilar business model design to respond to the shifting environmental requirements. By comparing which component(s) of the case firm's BMs, namely, Value Creation; Value Delivery; and Value Capture has been influenced by IIoT, they were able to expose three IIoT-based BM archetypes. The proposed business model archetypes are (I) Technology Adoption business model, (II) Virtual Diversification business model, and (III) Full IIoT business model.

Although the contribution to the research community, the study of Laudien (2016) has some limitations, the first to appear is the small sample size (n=11) and the limitation to solely medium to large German companies; which could bare the failure of a statistical generalisability, due in part to the qualitative nature of the study. It must be noted that it still yields analytical generalisability (Yin, 2009; Laudien 2016). Another key factor that has not been taken into consideration is the limited resources and capabilities that SME are faced with when a disruptive change in the environment is present.

This is said as SMEs in Europe represent over 99% of the established companies and represent over 50% of the gross added value share of the EU economy (European Commission, 2018). Not to mention that many SMEs act as suppliers or are themselves suppliers to other SMEs and MNEs, thus it is crucial to analyse how SMEs implement and integrate IIoT and how the latter will impact the value creation of the current industrial landscape (Müller, Buliga, & Voigt, 2018).
In juxtaposition to their MNEs counterparts, the implementation of technological advancements in established SMEs is lingering (IIoT through Enterprise Resource Planning (ERP), or other IT processes), or not fully integrated (sometimes only divisions or precise DMU's), and the possibility of leapfrogging is ever-present (Bughin & Catlin, 2017; Müller et al., 2018).

Although the undeniable groundwork presented by this study, literature still lacks a structured approach on how to achieve coordination between innovation processes. More precisely, processes that focus on diverse elements of a BM and avoid failure and harm to overall value creation. This lack is perceived more for manufacturing firms pursuing BMI systematically and purposefully in the fledging environment of IoT (Günzel & Holm, 2013; Mezger, 2014).

In an explorative study, Mezger (2014) creates a concrete guideline about how to systematically and purposefully approach BMI by conceptualising it as a distinct dynamic capability. His findings demonstrate that separate organisational routines and processes uphold the capacities of a company to iteratively identify opportunities for new business models, to grasp them through the advancement of valuable and unique business models, and redesign the company's competences and resources accordingly (Mezger, 2014). Therefore, a capability-based conceptualisation of BMI framework is constructed based on three dimensions: (i) Sensing; (ii) Seizing, and (iii) Reconfiguring. This model can be used to examine how manufacturing companies engaged in specific business model innovation practices to develop distinct IoT-based business models.

1.2 Research Question

Therefore the aim of this study is to incorporate the two studies, Mezger's (2014) and Laudien's (2016) to the established manufacturing SMEs, in order to, not only broaden the validity of the IoT-based business models archetypes but as well to propose a structured BMI approach for companies with limited resources that want to grasp the novel opportunities offered by the still-unfolding dynamic environment that is IIoT. Hence the following question is constructed:

"How do Small and Medium Enterprises create, extend, or modify their current resource base, internally and externally, to accommodate the novel IoT-based Business Model Archetypes?"

Sub-questions arising to further accommodate the research question would revolve around:

i. *What improvement was sought form IoT?*
ii. *How was the new business model opportunity identified?*
iii. *How was the new business model configuration tested and seized?*
iv. *How were the activities, structures and resources reconfigured?*

This paper addresses the research gap on business model innovation in the digitalised era by providing an IIoT-based Business Model Innovation approach that could help SME's in the decision-making processes of the integration of a technological innovation to achieve competitive advantage.

2. THEORETICAL BACKGROUND

Given the propositions addressed in this paper, the following chapter will briefly outline four key concepts, "Industrial Internet of Things"; "Business Model"; "Business Model Innovation"; and "Dynamic Capabilities. This section will serve as the foundation for our theoretical positioning and outlines the scope of the research.

2.1 Industrial Internet of Things

Correspondent to the definition of Bauer et al. (2014), the IIoT is defined as the "real-time capable, intelligent, horizontal, and vertical connection of people, machines, objects, and ICT systems to dynamically manage complex systems" (p. 18).

Manufacturing firms will face main challenges when trying to grasp the business opportunities enabled by IIoT (Mattern and Flörkemeier, 2010; Porter and Heppelmann, 2015). This is said as organisations frequently lack the necessary competencies, resources, and capabilities to diverge from their core business to accommodate the novel IoT solutions.

Hence one can assume that new technological, as well as business-related, challenges will arise as the IoT becomes more predominant (Bilgeri and Wortmann, 2017). In the studies conducted by Atzori et al. (2010) and Mattern and Flörkemeier (2010) some key technical implications can be identified, these difficulties vary from the lack of standardised rules of conduct, unclear scalability limits, and finite energy supply. Other than technical implication, some researchers have investigated the challenges that IoT has on the business-level of established firms (Arnold et al., 2016; Kiel et al., 2017; Kiel, Müller, Arnold, & Voigt, 2017; Cavalcante, 2014; Chesbrough, 2010). Some shared challenges that were found encompass the complexity of the ecosystem firms are in, the lack of skills and capabilities in data gathering and analysing, as well as the unawareness of revenue generation means. Overall, a proper IoT business model design is missing (Laudien and Daxböck, 2016b; Frankenberger et al., 2013; Koen et al., 2011).

2.2 Business Model

The first appearance of the term "business model" could be found in common newspapers twenty years ago (Demil and Lecocq, 2010; Magretta, 2002). Hence the research on this topic is young and still broad (Landau et al., 2016). Although the growing attention from both academics and practitioners since 1995 (Zott, Amit, & Massa, 2011), there is still an absence of a common business model definition (Zott et al., 2011). From a broad level, a business model can be described as a "strategy or construction of the value creation, delivery, and capture mechanisms" firm employs (Teece, 2010:172). A business model can be characterized as a company's approach for value creation, delivery, and capture through the classification of a value proposition and the portrayal of the underlying 'business design' (e.g., Amit and Zott, 2001; Casadesus-Masanell and Ricart, 2010; Chesbrough, 2010).

2.3 Business Model Innovation

Cortimiglia (2016) explains business model innovation as the transformational perspective on a business model that has been triggered by new technological advancements. The current research on the matter although is still in its infancy and what BMI incorporates is still vague (Schneider and Spieth, 2013).

By taking the definition of Casadesus-Masanell and Zhu (2013), Business Model Innovation can be identified as the firm's efforts to "the search for new [business] logic of the firm and new ways to create and capture value for its stakeholders" (p. 464). By this definition two BMI approaches can be identified, the first being Business Model Development or the "modification, reconfiguration, and extension […] of existing business models" (Landau et al. 2016, p. 3). The second, Business Model Design, is the approach of designing novel and, often, disruptive business models (Cortimiglia et al., 2016; Markides, 2006). In relation to the proposition addressed in this paper, BM development and BM design will be arbitrarily considered as BMI (Cortimiglia et al., 2016).

It has to be further stated, that in the current days, knowledge regarding BMI processes is limited (Schneider & Spieth, 2013). Although some recent studies have begun to base their research on data gathered by case study (Laudien and Daxböck, 2016a), previous papers on BMI processes provide hearsay evidence (Tesch, Brillinger, & Bilgeri, 2017). In a study of Demil and Lecoq (2010) they define BMI as the transformational change in established companies. Firms that want to remain competitive in their markets will have to challenge their current business architecture by creating innovative value offerings, executing new value chain structures, starting new revenue models, and reconfiguring their resource base (Chesbrough, 2010).

While companies, customarily, struggle to innovate their business models, business model innovation in the environment of IIoT is subject to further hindrances, creating a greater challenge for manufacturing firms to auspiciously realise IoT BMI projects (Bilgeri and Wortmann, 2017). Henceforth the current literature only provides a narrow insight into the 'expertise' needed on the operationalisation of IoT business model innovation (Schneider and Spieth, 2013).

Although the extant literature, practitioners still have not been able to decide on an optimal BMI approach (Schneider & Spieth, 2013; Tesch, Brillinger, & Bilgeri, 2017). On an exploratory study, Mezger (2014) decided to tackle the gap in the literature by presenting an iterative BMI approach to IIoT.

2.4 Dynamic Capabilities

On the matter, the definition of Teece et al. (1997) on dynamic capabilities will be used: "[dynamic capabilities] are the company's ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments." (P. 516)

The central tenet of dynamic capabilities is to explain how organizations may dynamically adapt and align their routines and resources to achieve a competitive advantage (Teece et al., 1997). Helfat and Peteraf (2009, p. 91) state that this quest "might well be characterized as the Holy Grail of strategic management". According to Teece (2007), dynamic capabilities can be defined in terms of sensing, seizing and reconfiguring. Sensing comprises "analytical systems to learn and to sense, filter, shape, and calibrate opportunities". Thus, sensing includes all processes that help an organization collect and analyse market information to learn about customers, competitors, and channel members. Seizing relates to addressing sensed opportunities "through new products, processes, or services". Therefore, seizing typically evokes increased research and development activities. Reconfiguring refers to an "ability to recombine and to reconfigure assets and organizational structures" to match the organization's internal processes with seized opportunities. It may, thus, involve changes in the business model, mergers, acquisitions and divestments (Teece, 2010).

This set of capabilities provides an analytical framework that helps to capture how organizations adapt and respond to a changing business environment.

2.5 Research Framework

2.5.1 IIoT-Based Business Model Design

In a study conducted by Laudien (2016) three business model archetypes have been constructed on an explorative study of German manufacturing companies implementing IIoT in their routine processes. These archetypes are a framework for manufacturing firms to use while transitioning from non-digital industries to an IIoT-based business model (Laudien & Daxböck, 2016). They found that manufacturing companies experience opportunities and challenges in peculiar ways when a disruptive technology, which is IIoT, is present in the environment. Companies might develop technological advancements in diverse ways and hence their BM will have divergent changes according to the direction of the firm. The proposed business model archetypes are (I) Technology Adoption business model, (II) Virtual Diversification business model, and (III) Full IIoT business model.

2.5.1.1 Technology Adoption BM

In the first, technology adoption, firms implement IIoT to improve internal firm processes, with gears such as sensor technology, RFID, and Machine-to-Machine communication (M2M). These technological adoptions resulted in process innovation in close relation to quality control, inbound logistics, and inventory management (Laudien et al., 2016). It has been noted that companies implementing this model contrived a change in the value creation dimension.

2.5.1.2 Virtual Diversification BM

In the second type, virtual differentiation, studied companies shifted the focus from process production efficiency to broaden value proposition conferred by a network of firms to their customers. Companies falling in this type of business model utilise IIoT-related technologies to link their value creation processes to those of network partners, offering a greater diversity of parallel products and services (Laudien et al.,2016).

2.5.1.3 Full Industrial Internet of Things BM

The last type, full IIoT, as the name suggests is the full integration of IIoT in the business model. Through offerings of innovative products equipped with smart sensors, these companies can collect data about customers' consumption and product life-cycle. To provide remote services, such as installation, maintenance, product upgrade and increase connectivity between other products or consumers' smartphones. Companies that adopt the full scope of IIoT will face a radical innovation in their business models as the value creation processes and value propositions are drastically influenced by access to usage data and availability of digital services. It needs to be stated further that companies falling into this category have the capabilities to cut down retail and sales intermediaries and establish a direct contact with the consumers (Laudien et al., 2016).

2.5.2 Capability-Based Business Model Innovation

In a study conducted by Mezger (2014), case studied publishing companies where empirically analysed how they approached BMI given a radical technological change due to digitalisation.

Drawing from dynamic capabilities literature, Mezger (2014) wanted to study which capabilities – organisational routines and processes – a firm applies in order to identify, develop, and implement new business models.

Through a cross-case study, Mezger categorised processes and routines that the companies utilised to engage in BMI systematically and purposefully. Findings revealed three core dimensions of BMI-related capabilities: (1) identification of opportunities for new business models, (2) design of a new business model to address such an opportunity, and (3) implementation of the new business model. These core dimensions are analogous to Teece's (2007) framework on dynamic capabilities, which brakes dynamic capabilities in three categories: *Sensing, Seizing, Reconfiguring.* Mezger proceeded to use these three dimensions to define diverse capabilities for BMI.

2.5.2.1 Sensing: generation of new business models' idea

In this dimension of BMI, the identification of opportunities for new business models is addressed, given that digitalisation highly provides technological possibilities.

Mezger (2014; p.438) states: "[…] higher order technology competencies facilitate explorative product innovation. Similarly, firms apply technology competencies to identify opportunities for new business models."

It can be stated that firms with the ability to acquire new, emerging technological expertise and related knowledge to specific business model components are better able to identify opportunities for new business models (Mezger, 2014).

Other than technology sensing, an additional aspect utilised for opportunity identification is the systematic analysis of the business models of competitors, adjacent firms, as well as other industries. Firms that extensively broad their scanning activities to the evaluation of potential business modes in leading industries, show a prominent level of sensing capability.

This last perspective is novel and critical for BMI, as the business model of competitors, as well of other industries, provide insights for opportunities in a firm's own industry (Enkel and Mezger, 2013). Thus, processes for the assessment and evaluation of business models on other industries enable firms to systematically identify opportunities for new business models and generate business model ideas.

2.5.2.2 Seizing: systematically developing new business models

The ability to scout for new business model opportunities does not lead to a new business model per se, but the ability to transfer said opportunities into viable and valuable business model configuration is at the core.

Mezger (2014) stresses how the ability of a company to generate a new business model relies on the capability to successfully integrate new opportunities with the combination of technological, market, and business model knowledge.

This view entangles that companies ought not to focus on the core product or relevant production process but should assess an impact on all business model's components.

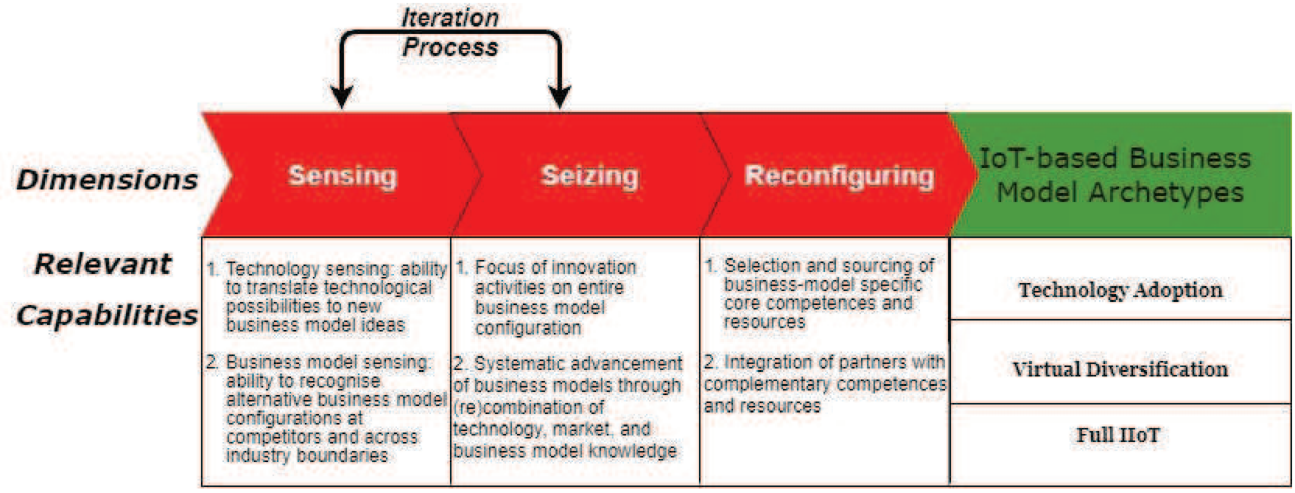

Figure 1 A theoretical model of capability-based business model innovation in relation to IoT-based business models (adapted from Mezger, and Laudien & Daxböck, 2016)

Subsequently, the combination of a firm's ability to discover new opportunities and testing the alignment between the novel business model with technological potential, customer needs, and market consideration can be seen as an iterative process between sensing and seizing.

Hereafter, the dimension of seizing is seen as the company's ability to deploy new knowledge into the new business model configuration systematically and iteratively. Thus, BMI is an iterative circle between opportunity identification (sensing), development and testing, and testing of new business model configurations (both seizing).

2.5.2.3 Reconfiguring: building new competencies and implementing the organisational renewal

In the previous two dimensions, companies identify potential opportunities and construct means to exploit said opportunities.

The dimension of reconfiguring is a necessary step to intertwine a firm's activities, structures, and resources accordingly. Hence firms will have to adapt and build up new valuable resources to implement new business models. It must be stated, that for established companies, who start with an already determined resource base, the necessity to reconfigure this base is especially high (Mezger, 2014).

In this dimension, various steps will have to be taken into consideration to successfully reconfigure internal structure to accommodate the change. Firm renewing competencies and resources will have to evaluate and select how to implement the internal changes and create additional resources and re-evaluate their current set of competencies and assets.

Mezger (2014) found that many companies implemented a structured process to evaluate and select the required competencies and resources necessary based on novel strategic business models, firms were able to map the existing and required competencies and, thus, were able to derive specific management tasks regarding competence acquisition.

Other possibilities were found by separate the established business model with the novel by creating a distinct subsidiary (Spatial Separation). Although ambidexterity was not regarded as critical, the separation of the business model is still seen as a reconfiguring capability. Corporate venturing and acquisition of start-ups were identified as an evident routine for sourcing and integrating related sources (Mezger, 2014).

Integration of partners with complementary competencies has been well seen as an alternative view on sourcing relevant competencies and resources (Chesbrough, 2006). Amit and Zott (2001), on this note, argue that firms implementing a new business model do not necessitate to own all resources and competencies required. This is said as the creation of a new business model mandates the successful implementation of novel technologies, and companies mitigate the technological uncertainty by collaborating with partners (Trispsas, 1997).

2.5.3 The relationship between Capability-Based BMI and IoT-based BM

By considering the dimensions and capabilities above mentioned, one can deduce that diverse degrees of sensing, seizing, and reconfiguring will unravel distinct business models. In the study of Laudien (2016) the IoT-based business models design were constructed by considering which business model component has been affected by the implementation of IIoT. In the model presented in figure 1, the process of a capability-based business model innovation has been collocated with the three distinct IoT-based business model archetypes. The aim of this model is to systematically assess the companies' degree of capability adoption in business model innovation to find a correlation with Laudien's archetypes. By analysing how and which technology has been sensed, how the innovation activities have been seized, and which capabilities and resources have been reconfigured to create a novel business model, it is expected to find the same improvements in the business model components as in Laudien's study. Discrepancies may arise, by identifying different BM components improvement, which is speculated will unravel novel IoT-based business models.

2.5.3.1 Capabilities for Technology Adoption Business Model

It will be expected that companies applying a Technology Adoption Business Model will employ IIoT-pertinent solutions to digitalise processes firm-wide to allow them to increase internal efficiencies. These firms will have, in the most cases, no interest in rethinking their value proposition hence it is expected to be found a high iteration process between Technology sensing (Sensing 1) and Innovation activities on business model configuration (Seizing 1). Due to the sole increase of the BM component value creation, firms adopting this BM archetype will scout the market for technological solutions that will solve their request (Sensing 1).

Companies falling in this category would seek out the market for IoT solutions to answer for internal problems. Reduction of overhead costs, reduction of time to market, automation of workflow, KPI improvement, and predictive maintenance will be the main drivers to initiate a Business Model Transformation. Moreover, it must be stated that the possibility that SMEs will scout the industry for viable business models of competitors (Sensing 2) is still a plausible possibility. This is said as SMEs are usually reluctant to change (Nieuwenhuize, 2016), and the lack of resources to tackle a firm-wide innovation hinders the investment in this field. Therefore, it is expected that SMEs could find comfort in the positive implementation of competitors and deter the fear of failure and reluctance to change.

In the Seizing component, a high focus on innovation activities (Seizing 1) is expected to be present for this group. The sole introduction of technological enablers for infra-firm enhancement will likely prompt companies to reconsider the correct alignment between the rest of the BM components. The Key Partners components, where it has been found that suppliers that have not implemented IIoT find themselves in a position of threat (Laudien & Daxböck, 2016), is a key component that necessitates configuration by re-establishing relations and partnerships. The re-alignment between the new technology, with market consideration, and customer needs (Sensing 2) is contemplated to be meagre as only the core product/process is enhanced, and the customers are not integrated into the value creation process (Laudien & Daxböck, 2016).

As for the final dimension, reconfiguring, Companies wanting to improve internal processes will doubtlessly need to re-adapt their internal talent pool to accommodate for the novel competencies and resources required (Reconfigure 1). It is expected that the introduction of the innovative technology will require an increase in employee qualification in the realm of IT proficiency. Human resource development and/or recruiting instruments will be necessary for the correct selection and sourcing of the unavoidable new required competencies (Erol et al., 2016). Regarding the integration of partners (Reconfigure 2), Kagermann et al. (2013) found that usually manufacturing firms show resistance towards opening to external partners, and in this case the introduction of partners is not mandatory for the correct implementation of the innovation, or integration of platform-based partner network (Kiel et al., 2017; Laudien & Daxböck, 2016).

2.5.3.2 Capabilities for Virtual Diversification Business Model

Companies falling in this type of BM will make use of IIoT-related technologies to digitally link their value creation processes with those of network partners (Laudien & Daxböck, 2016). In contrast with the above BM, these firms will make use of IIoT technologies for a coupled network of firms to order a vaster diversity of products and services, as well as to gather information of production processes, inventory, product sales of the partner companies. Given the nature of the use of the technology, it is envisioned that companies wanting to adopt this business model will scout the market for platform-based solutions or initiate it internally with an already existing network of partners (Sensing 1), although companies wanting to join an already existing network will/could copy the business model of existing partners (Sensing 2). This is said as it would offer an easier and already proven business model innovation (Mezger, 2014).

A high iteration is predicted to be still present between the components sensing (arbitrary between Sensing 1 & Sensing 2) and seizing, especially in the capability Seizing 2, where the correct alignment of the network with the market and customer is crucial for the accurate implementation of the new business model. Companies following this business model will have radical changes in the value creation as well as the value proposition components (Laudien & Daxböck, 2016), few alterations to the other business model components are still present and companies will have to readjust the overall business model in order to make it work (Seizing 1).

Regarding the reconfiguration dimension, firms in the Virtual Diversification are awaited to face the same implications as the Technology Adoption BM. Confound difference will be the Reconfigure 2, as the introduction of a platform-based partner network is expected to provide the neophyte firms to use and receive the novel capabilities and resources from the network partners. This could also improve the overall network by providing cooperation and sharing knowledge towards openness to innovation (Halse & Ullern, 2017).

2.5.3.3 Capabilities for Full IIoT Business Model

Companies that want to adopt this type of business model, as the name suggests, have implemented the full scope of IIoT enablers inside the company. By providing products and services that tap the customers' usage data, the value creation and value proposition of these companies drastically shift and necessitate a successful BMI (Laudien & Daxböck, 2016).

Laudien's study (2016) shows that case companies adopting this business model, have a common starting point, innovative offerings equipped with smart devices that allow a linkage between the customers and the company. Hence it is expected that companies falling in this category will scout the market for innovations (Sensing 1) or produce the innovations internally. It is speculated that these types of companies would still scout the industry for similar BM of competitors (Sensing 2), although it is envisioned that they will not copy it as it would hinder the possibility of competitive advantage.

In the seizing component, it is predicted, that these companies will unquestionably re-align all their BM components (Seizing 1) to address the drastic change in value creation and value proposition. One of the repercussions of this shift of BM can be seen in the value delivery component, where companies in this category create a direct contact with their customers and stop making use of retailers and sales intermediaries (Laudien & Daxböck, 2016).

As seen in the other two types, a high iteration degree is contemplated, and undeniably present also in this type, where the introduction of such a novel innovation will require companies to question their market position and customer base. Hence a prominent level of (re-)combination of the novel technology, with old/new market segments, and old/new customer demand, will be taken into consideration and addressed adequately.

As regards the aspect of reconfiguration, companies in this category are awaited to suffer from the same implications as the first and second BM, if not with more drastic requirements. This is said as a firm-wide change will require a new set of skills that employees lack, moreover the duress of new collaboration and networking between new partners and customers will spur these companies to seek out novel suppliers. As according to Porter and Heppelmann (2014), the IIoT will require new suppliers, that will compensate for the lack of unavailable resources such as know-how, software, hardware, etc. Therefore, it is expected to find a high degree of internal sourcing of competencies and resources (Reconfigure 1), but an equal or even higher outsourcing (Reconfigure 2) is expected.

3. METHODOLOGY

The aim of this paper is to create a greater understanding of the approach of business model innovation and the subsequent creation of the business model design. To achieve this, a multi-case study has been conducted.

This is said as a qualitative study approach will facilitate the possibility for in-depth insights and could untangle novel ideas and further points that have not been analysed before.

3.1 Selection of case studies

Being the scope of the study to analyse business model innovation process of established SMEs manufacturing companies that implemented IIoT in their day-to-day business practices, a suitable sample had to be identified. The selection of case studies will be on manufacturing companies employing between 10 and 500 employees and a turnover between €2m and €50m, in accordance with the definition of Small and Medium-sized Enterprises (SME) provided by the European Commission (European Commission, 2018). With manufacturing, in this case, it is intended that the companies will have to produce and/or assemble discrete products, as these firms are particularly affected by technological developments in the realm of IIoT-based solutions.

The analysis draws 6 case studies from the perspectives of two interviewees of two distinct Dutch IoT solution providers, which have had customers in the manufacturing industry.

The first case study deals with the production of flowers in the Overijssel's region (NL), hereafter *Flowe*r. The case study *Flower* is specialised in the production of several types of flowers with specialised greenhouses for the correct growth of the different sprouts. With 400-500 full-time employees, this company focuses on the Dutch flower market but has also a presence in most European countries. The second case study presented by the first interviewee is a company specialised in the cutting and refining of stones from a quarry in the Gelderland region (NL). This case company will hereafter be called *Stone*. With a number of employees equal to 100, this company focuses its market in the Netherlands and Germany. The last company provided by the first interviewee is a Dutch company with a broad scope of offerings in the environment of mechanical engineering with its focus in the European market. According to the interviewee this company has 150-250 full-time employees and introduced an IoT pertinent solution for the correct monitoring of the stockpile in the warehouse, hence hereafter this case study will be referred as *Tracking & Tracing*.

The second interviewee provided insight on three agricultural companies located in the Twente region (NL) specialising in the production of meat and dairy products with a focus on local markets. The first company with 10-50 employees has implemented IoT solutions to monitor the correct growth of their calves, it will be referred to as *Cows*.

The second company, still in the agricultural market, has specialised in the innovative health care of their livestock. With 50-150 full-time employees, this case company will be hereafter called *Manure*. The last company provided by the second interviewee is a consortium of competing dairy farmers with a range of employees from 10-200 depending on the firm in the consortium. This case company will be referred to as *Dairy*.

3.2 Data collection

In order to gather the primary source of empirical data, semi-structured interviews have been performed with founder and co-owner of two Dutch IoT solution provider companies, whose knowledge and experience on the matter offered useful insight by providing the possibility to build on the answers to explore further concepts. Selection of interviewees was targeted toward informants who are the most knowledgeable about the routines and processes targeting BMI, and how IIoT affects the way of doing the business of the firm. Follow-ups with the case studies were requested where the information was found to be lacking or misunderstood (Eisenhardt, 1989; Gioia et al, 2013).

All interviews were taped and transcribed, and they took place between the months of May and June 2018, each lasting between 30 and 60 minutes.

To the extent of avoiding any possible sense-making issues during the interview, a guideline has been structured in line with my research question. The guidelines for the semi-structured interviews covered three main sections and were based on the theoretical model previously outlined (see Appendix 8.2). The first section covered interviewees' general understanding of the business model concept, the general relevance and role of BMI at their firms, examples of BMI at their firms, and how the firm faced IIoT. This enabled an analysis of the proficiency and experience of individual firms regarding BMI and IIoT. The second section covered firm-specific processes, routines, and competencies related to BMI. Interviewees were asked about, their firm's general approach to BMI, the origins of ideas for new business models, the routines to design new business models, the relevance of experimentation, as well as the organisational integration and implementation of new business models. The last section wants to briefly analyse the firm's current business models so that to depict the three business model components value creation, value delivery, and value capture (Teece, 2010; Laudien and Daxböck, 2016).

3.3 Data analysis

The first analytical step focused on coding the interview data (Miles and Huberman, 1994; Strauss and Corbin, 2008). The identification of routines, processes, and specific structures that firms leveraged to identify, develop, and implement new business models, was the focus of the initial analysis.

The second step, aimed at constructing individual case reports for each firm, to facilitate within-case analysis (Eisenhardt, 1989). The within-case analysis generated descriptions of how distinct organisational routines and processes facilitated the development and introduction of new business models, in close relation and integration of theory (Miles and Huberman, 1994).

The last step of the analysis focused on cross-case analysis, which allowed to identify differences and similarities between the 6 case firms (Eisenhardt and Graebner, 2007). Data from each case study was sorted into tables focusing on the emergent dimensions 'sensing', 'seizing', and 'reconfiguring' (Teece, 2007), given which business model archetype was sought by the companies (Laudien & Daxböck, 2016).

One independent researcher did the coding of all qualitative material, which in turn might increase the bias of the coding (Eisenhardt, 1989; Yin, 2009).

4. RESULTS

In order to successfully grasp the novel fields of competition stemming from the IoT environment, the large majority of companies in our sample tackled the innovation approach through an iterative process to systematically develop IoT business models. Moreover precisely, various companies actuated continuous trial-and-error procedures, before implementing the novel technology, given from the high degree of complexity and uncertainty still present behind IoT. Table 1 in the Appendix summarises the results gathered from our case studies. Companies were found, initiate a BMI process after strategic considerations on developing capabilities and key processes and resources as a potential future competitive advantage. Overall the analysis revealed analogues modes on to the BMI process given what was the end goal of the innovation for each of the 6 cases.

According to the interviews, five of the companies initiated a business model innovation process to enhance firm internal processes. Reduction in overhead costs, decreased time to market, increase in production, predictive maintenance, workflow automation and data-driven production were the main improvements sought by these case companies. Their main goal was to improve their processes, hence to improve their value creation.

These companies, moreover, scouted the market for IoT solutions that could solve their request. From what was said in the interviews, none of these companies scouted business model configurations of competitors in their industry. With respect to the sensing dimension, the companies in question contacted the IoT solutions company directly, by posing them the problems and what was sought from the technology solution. In almost of all of the cases in this group, the technological possibilities were sought outside of the company and not initiated internally. For the seizing component, of this group of companies, it was found a prominent level of innovation activities on the business model configuration. The implementation of the innovation took from seven months up to one year and a half. In this period, the interviewee explained how an effective communication with the manufacturing company was the key to successful implementation. It was found that these companies had a high iterative process between the technology and the innovation activities, trial-and-error of the technology with the current firm architecture was always addressed. For the reconfiguring concept it was hard to find feasible data as the knowledge on the exact processes and routines was not directly known from the interviewees.

Our first case company, *Flower*, had initiated a research of possible technological solutions for the control of humidity in their greenhouses to have a greater overview of their production and reduce overhead costs and improve KPI. Their goal was to enhance production through data-driven knowledge, hence started to look for companies providing IoT solutions. The monitoring devices were carefully identified by a strategic team composed exclusively for the implementation project. This team was in constant contact with the solution company to address changes occurring with the implementation of technological prototypes with the extant architecture of the firm in order to assess their magnitude and start an innovation activity. The implementation took one year, and meetings were scheduled even after the implementation with Technical and non-Technical experts from the solution company to assess the correct implementation and resolve possible internal problems, arising from the devices or lack of knowledge on how to manage them.

In the case of the company '*Stone*', the implementation of an IoT solution was tackled with a state of fear from the managing director, said the interviewee. The risk of failure or the possible lack of tangible results was always present. This company sensed the need and possibility arising from the integration of data-driven production and realised it was the only way to solve the internal problems. Such problems were primarily to have a greater knowledge on the water exhaustion pipe and the possibility of remote access to the machinery in case of a breakdown or malfunctioning. *Stone* tackled the implementation by starting small and in confined safe spaces of the organisation. They tested over twenty devices on a small scale in order to seize an effective increase in key activities. The testing was performed on a timeframe of eight months in which each device was individually tested with the current state of the firm to assess the correct configuration. In this case as well meetings were scheduled with the solution companies to provide further help in the understanding of the correct use of the technologies.

The interviewee, moreover, also wanted to raise the point that this company after implementing and realising the opportunities of it decided to further implement other devices to integrate further into IIoT. This was also seen in other companies that dealt with this specific solution provider.

In one of our cases, we can also identify a situation where the firm had to re-establish relations with their suppliers. The case company '*Tracking & Tracing*' wanted to implement a firm-wide ERP system to automate workflow and reduce overhead and operational costs by predicting the need for new orders. This company found itself with suppliers that had not yet implemented IoT, creating a state of friction between the two parties. According to the interviewee, this case company had to look for new suppliers that had implemented IoT to have a better communication and smoother transactions.

In a follow-up interview, it was found that a company that integrated a communication solution with a platform management to monitor the correct growth of its calves, had tried to develop the innovation internally. This company started an R&D process to integrate an IT solution internally without the need of an outsider. According to the interviewee, this company failed to correctly implement the innovation and sought help outside, starting a partnership with the IoT solution company to reconfigure the lack of resources and capabilities and implement correctly the innovation. This partnership kept on growing over the years, which allowed the solution company to continuously improve the implemented solution by offering novel add-ons and the creation of an algorithm for the predictive growth of the calves.

Other than the five companies that have implemented IoT to enhance firm processes, the union '*Diary*' was found to have used the novel technologies to create a consortium of dairy farmers. This consortium of competing farmers had decided to integrate a network platform technology between them to create a co-development where the shared knowledge of competitors' cattle feeding, dry germs in the milk, silos cleaning process and bacteria percentage, helped in creating a standardised product creation and increased value proposition.

5. DISCUSSION AND IMPLICATIONS

Although many business model approaches exist, a dedicated business model type to support business model development for the Internet of Things has not yet been introduced. We see this gap is quite a contrast to the overall importance of this topic, and this research approach attempts to address this need. Moreover, referring to our research question, this thesis research wanted to tackle in even more depth, '*How do Small and Medium Enterprises create, extend, or modify their current resource base, internally and externally, to accommodate the novel IoT-based Business Model Archetypes*.'

The findings above presented, provide evidence that across the diverse IoT business model innovation project explored, all cases share an iterative approach between the novel technology and the correct business model configuration. The strategic consideration on the firms' development of competencies and resources often serves as a trigger to initiate a business model innovation in the ecosystem of IoT (Laudien & Daxböck, 2016; Mezger, 2014; Rub, Bahemia, & Schleyer, 2017).

In relation to Laudien's (2016) study, this research was able to find similarities with the business model archetypes constructed in their study and the findings here reported. Out of six cases, five companies integrated IoT to solve firm internal requirements. Key issues that these companies tried to resolve through digitalisation where a reduction in overhead costs, decreased time to market, increase in production, predictive maintenance, workflow automation and data-driven production. These enhancements could be seen as an improvement in the value creation component of their business model, and also their trigger to initiate a BMI, making these companies fall in the category of Technology Adoption BM (Laudien & Daxböck, 2016). On an external note, an interviewee wanted to put pressure on the fact that many, if not some, of their customers who are part of small and medium enterprises, face the technological implementation step by step. With this, what is wanted to be entailed, is that in small and medium enterprises, the resources for an investment at the organizational level is complicated, and companies of this kind prefer to start small and then implement on a larger scale. In our results, we were unable to find any companies that implement IIoT in all of its complexity, but we could assume that the business model of technological adoption, is a first step towards the complete implementation of IIoT, through a systematic trial-and-error of new innovations inside the firm.

The case firm '*Diary*' offered great insight into the Virtual Diversification BM. This is said as in the literature this type of BM is used to increase a company's product portfolio by aggregating with a network of partner companies to offer a vaster number of parallel offerings (Laudien & Daxböck, 2016). What was found, in our results, would steer the theoretical positioning of this archetype towards a new idea of this type of BM. This is said as this case firm used a network of competitors to increase the overall value proposition by sharing knowledge of their processes and livestock information. This led to an overall standardisation of production and a possibility to imitate competitors' decisions and processes for their own good. Although it has been studied that often SMEs in the manufacturing industry tend to have a resistance in opening up to external partners (Kagermann et al., 2013), a secure, strong, and reliable platform-based partner network could provide SMEs with the necessary capabilities and resources (Holtewert et al., 2013) and provide a better configuration of other BM components.

This research offers insight in the nature and purpose of the capabilities needed to approach BMI (Berghman et al., 2006; Demil and Lecoq, 2010), and contributes to the understanding of core elements of BMI with the achievement of distinct IoT-based business models (Laudien & Daxböck, 2016; Mezger, 2014; Schneider & Spieth, 2013). The distinct capabilities sensing, seize and reconfigure offer SMEs an ability framework to keep in mind when tackling a technology implementation.

The paper at hand focused and clearly identified that companies make use of three distinct subsequent capability-based dimensions across the analysed IoT business model innovation projects. Critically reflecting the results, it is argued that they contribute to scientific research by granting a novel meta-view on an iterative approach process in general, considering evidence from IoT business model innovation projects.

In terms of practical implications, it is anticipated that an understanding of business model innovation in the ecosystem of Industrial Internet of Things, will permit professionals to better coordinate their activities to strengthen the decision-based in diverse IoT BMI projects. The findings highlight that applying iterative approaches and following a clear procedure might result in a successful engagement in IoT-based BM. While it allows companies to test and experiment on an ongoing basis, it allows firms to slowly administrate changes in the architecture configuration without facing considerable investments. According to the analysis across distinct types of IoT business model innovation processes, three capability-based dimensions to BMI can be identified. Delivering a solid foundation for future publications, it is aspired to contribute in easing the complexity of BMI to allow a greater understanding of this topic and increase its manageability.

6. LIMITATIONS AND FUTURE RESEARCH

While this study provides significant contributions to the theory and managerial practice, there are some limitations. Because of the nature of qualitative research based on case studies, complete generalizability cannot be ensured. The cases were selected based on theoretical sampling (Eisenhardt, 1989) to analyse BMI processes to accommodate novel IoT BM in a competitive environment in which technological progress puts pressure on established business models. Additionally, all case study firms have their major business activities in the Dutch manufacturing market. There may be industry or country-specific circumstances that differ from the described context and provide barriers to the transfer of the proposed theoretical framework setup. Being the interest of this research to analyse SME in the manufacturing industry, further studies should be conducted covering other types of industries affected by the integration of IoT. In other words, different empirical settings will undouble improve further the validity (Desyllas and Sako, 2013).

Another limitation to bear in mind is the sample size of this research and the nature of the interviews. The two interviews were done with co-owners of two IoT solution provider companies, whose knowledge of the specific routines and processes of the companies is limited. As IIoT-based business models are still in their infancy, it is quite difficult to identify case firms that fulfil these criteria. Although they provided extensive data on the matter, future research should focus on SMEs manufacturing firms, with a closer look at companies that have not yet implemented IoT but are willing to. This is said as a longitudinal study of a company from its strategic decision until the complete implementation could provide useful insights into the multifaceted nature of the capabilities needed to innovate an IoT-based business model.

Moreover, quantitative research should focus on empirically testing the presented framework within or across industries. Structural equation modelling can be used to emphasize the multidimensional construct (Barreto, 2010) of BMI as a firm-level dynamic capability comprising sensing, seizing, and reconfiguring aspects. The theoretical foundation of BMI within the dynamic capability framework opens a rich area of literature for further studies.

Although this research has only scratched the tip of an unmeasurable iceberg, and raised more questions than those that it answered, research works on the frontier between knowledge and ignorance. As Neil deGrasse Tyson once said "We are not afraid to admit what we do not know. There is no shame in that. The only shame is to pretend that we have all the answers."

7. ACKNOWLEDGEMENTS

I would like to thank my advisor Dr T Oukes for her continuous support and patience. She has always given me expert advice, encouragement and understanding throughout this difficult but interesting project and topic which is up to now still being learned and studied. Lastly, I would like to express my gratitude for the University of Twente that in the last three years has thought me more than I could imagine and laid a path for my future that has shaped me as the person I want to become.

8. APPENDIX

8.1 Results Table

Table 1 Comparative data from case studies

	IOT-BASED BUSINESS MODEL ARCHETYPE			SENSING		SEIZING		RECONFIGURING	
CASE FIRM	*Technology Adoption*	*Virtual Diversification*	*Full IIoT*	*Technology Sensing*	*Business Model Sensing*	*Innovation activities on bm configuration*	*Alignment technology, market, bm knowledge*	*Selection and sourcing of Comp & Res*	*Integration of partners*
Flower	- Overhead costs % decreased, Production costs decreased, time to market decreased			- Monitoring devices to control the humidity of flower - Aim to reduce overhead costs and improve KPI production		- Technology sensing was very high, the process of implementation took one year, where the solution company was in contact with a strategic team to constantly check the correct implementation of the innovative Technology with the current architecture of the company - high iterative process between the innovative Technology and		- Several meetings were scheduled after the implementation with Technical, and non-Technical experts of the solution companies to assess the correct implementation of the Technology	
Stone	- Key activities enhancement, Increase in Production KPIs, predictive maintenance due to more data, which led to novel primary KPIs - Overhead costs % decreased			- High Technology sensing for hardware devices to monitor power usage, the stress level of pipes, Distance reboot of machinery - Aim to control the water overflow of pumps from a distance and decrease power if stress levels increased 10%. Reduction of		- High communication with the providing company - Small start, first 20 devices were chosen on a small scale of the firm to prove an effective increase in key activities. - High iterative process between different technologies and internal structure		- Constant feedback with location manager was key to the successful implementation of the innovative technology	
Tracking & Tracing	- Automation of workflow for reduced overhead and operational costs			- ERP Technology in the warehouse to monitor the stockpile production. - Better knowledge on number of inventory to predict new orders and increase productivity				- Suppliers were not IoT “friendly” and reduced the implantation of the firm. - Firm realigned internally and externally to find suppliers with IoT and increase communication	

Table 1 *(Continued)*

CASE FIRM	IOT-BASED BUSINESS MODEL ARCHETYPE			SENSING		SEIZING		RECONFIGURING	
	Technology Adoption	*Virtual Diversification*	*Full IIoT*	*Technology Sensing*	*Business Model Sensing*	*Innovation activities on bm configuration*	*Alignment technology, market, bm knowledge*	*Selection and sourcing of Comp & Res*	*Integration of partners*
Cows	- Predict correct calves growth to assess and prevent correct/wrong growth			- Introduction of Communication solution with a Platform to keep track of the growth of calves, a solution with an algorithm to constant detect any anomalies				- This company first tried to implement the innovative technology by itself but failed, Asked the IoT solution company for help in the implementation. - Solution company kept in contact with 'COWS' and worked together even after the implementation to offer a greater service, creation of an algorithm to predict calves' growth and predict anomalies.	
Manure	- Use of tecnology to constantly check manure level for best cattle feeding and cows health			- High tech sensing devices to monitor levels of Nitrogen and Methane in the manure					
Dairy Farms	- Network Platform technology - Creation of Consortium between competing farmers for overall standardisation			- Co-development of dairy farmers consortium - Sensors and Platform management to have a constant and shared knowledge of competitors' cattle feeding, dry germs in the milk, silos cleaning process and bacteria %					

Source: **Case data**

8.2 Interview Guideline

1. What is your job position? Please explain your responsibilities and role within the company.
2. How many FTE does the company employ?
3. Vision on automation/digitization?
4. Is automation/digitisation part of the company's strategy?
5. What do you understand by the term "Industrial Internet of Things"? Please define and explain.
6. What is your initial reaction to Industrial Internet of Things?
7. How important is Industrial Internet of Things to your company? What role does the platform play?
8. How could the current level of automation best be described? And the current level of digitisation?
9. What goals is the company trying to achieve by automation/digitisation?

10. What is the role of Business Model Innovation at your firm?
11. Could you provide some examples of engaged Business Model Innovation in your firm?
12. How did the firm face Industrial Internet of Things?
13. What is your approach to Business Model Innovation when implementing IIoT?
    a. How do you generate innovative ideas for business models?
        i. Do you scout the market for innovative technologies?
        ii. Do you imitate business models of adjacent industries?
        iii. Do you generate innovation internally?
    b. What are the internal routines to design new business models?
    c. How do you select and source-specific core competencies and resources to integrate the new business model?
14. Please think about your experiences in the Industrial Internet of Things. Please describe your experiences on a typical and comparable project, in which aspects of the Industrial Internet of Things played a high or very high and decisive role in the project's success.
15. How important were aspects of the Industrial Internet of Things for the project success?
16. Please describe your business model before the project has been run according to the following elements
    a. Value Creation
    b. Value Delivery
    c. Value Capture
17. Please describe the business model after it had been influenced by the project according to the following elements. Please also report on significant changes of each business model element ascribable to the project
    a. Value Creation
    b. Value Delivery
    c. Value Capture

8.3 Self-Initiated Plagiarism Check through Viper software

<img src="https://www.scanmyessay.com/app-viper/assets/images/document/checked-by-viper.png" width="162" height="58" alt="Checked for Plagiarism with Viper">

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