Internet of Things and New Product Development process: A study on the impact on success factors

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ABSTRACT

An increasing number of everyday products, appliances and physical gadgets are being embedded with sensors, actuators and connectivity mechanisms, connecting them to the internet and networks, thus forming the basis of the Internet of Things (IoT) anatomy. These "smart connected products" generate and exchange unprecedented levels of data which can be utilized as a part of discovering diversified insights from the products' environment and use context, making it a huge source of competitive advantage for businesses dealing with the crucial task of developing new products. However, the majority of the businesses are quite reluctant towards implementing IoT as a product development tool since they are unaware of the impacts of IoT on the success factors of the New Product Development (NPD) process. This research investigates how the data generated from the IoT impacts and influences the three key success factors, i.e. augmenting the products' fit with customer needs, reducing development cycle-time and lowering development costs, of the NPD process. With the help of a literature review and expert interviews, this research identifies the various determinants which can influence the success factors both positively and negatively. With regards to augmenting the products' fit with customer needs, the research presented strong evidences which reinforces that IoT can indeed augment the product's fit with customer requirement in the NPD process. Pertaining to the reduction of development cycle-time and costs, both experts and literature indicated that the data generated from the IoT could play a facilitative role in restraining the development time and costs. Although uncertainties concerning huge initial investments, modification of entire business processes, talent scouting, and lethargic development of inter-industry data collaboration platforms coupled with EU's new data protection regulation might impair the speediness of the development cycle-time and escalate development costs. The study also presented and discussed plausible recommendations in great detail which could help companies to deal with some of these issues.

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Keywords

New Product Development process, Internet of Things, Big Data, Stage Gate Model, BAH Model, Co-creation, Smart Connected Products, Heightened complexity

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1. INTRODUCTION

The technological amelioration and the accelerated confluence of wireless communication, digital electronics and micro-electro-mechanical systems (MEMS) technologies have led to the evolution of the Internet of Things (Vasilakos et al., 2017). The Internet of Things can be defined as sensors and actuators connected by a system of IP-connected networks to computing systems (McKinsey Global Institute, 2015). According to a Cisco report (2017), the quantity of connected objects has surpassed the total population of human beings and is expected to exceed 50 billion by 2020. These IP-connected objects can take the form of anything, starting from mobile phones, wearables, thermostats, refrigerator etc. and forms the basis of the sensor enabled Internet of Things (IoT) anatomy. The sensor fitted products are also called "Smart Connected Products" and they can produce enormous quantity of data. Due to their sensing capabilities, the data generated from these smart products can be utilized as a part of discovering insights from the products' environment and context of use. The brisk growth of smart connected products and their contributing data generation is having a disrupting effect on businesses. As the phenomenon of IoT grows rapidly (third big wave of the internet development), it appears to be essential for firms to comprehend the IoT and additionally the potential challenges and new opportunities these advancements may bring (Brown, 2017).

The process of developing new products and services is a crucial task as well as of high importance for companies. Research has shown that businesses achieve high performance in terms of profit generation through the introduction of new products. As indicated by Cooper and Edgett (2013), new products are equivalent to 42% of the aggregate profit for the dominant 20% of businesses. Nonetheless, numerous firms fail in introducing new products to the market due to its traditional closed innovation policy or a slow development cycle. Firms who lack the capability in changing the offerings what it offers to the world (product and service innovation) and at the same time who are also deficient in terms of making and conveying these contributions, risks its survival and development prospects (Bessant et al., 2005).

The emergence of Internet of Things and the unprecedented levels of data generation coupled with the switch from in-house, proprietary innovation towards open innovation/co creation can be potentially utilized by companies to enhance the New Product Development (NPD) process and subsequently curtail the high failure rate of new product launchings to the market. Over the course of the previous years, considerable amount of NPD models or processes have been devised but little attention has been paid on the role of IoT and its impact on the success factors of the NPD process. Furthermore, IoT being a moderately recent phenomenon since the term was first coined in 1999 and is still considered in its initial stages (Ashton, 2009), a gap could also be identified in the academic and scientific literature where not many researchers have scrutinized and operationalized the effect of IoT on the accomplishment factors of the NPD process. Given the above-mentioned contexts, this thesis will lay emphasis on IoT and its impact on the success factors of the NPD process.

1.1 Research goal and research question

According to Schilling (2013), for new product development to be lucrative, it must concurrently achieve three goals: (1) augmenting the product's fit with customer requirement, (2) reducing the development cycle time (the time elapsed from project initiation to product launch), and (3) reducing development costs. IoT and its influence on the above-mentioned success factors is broadly unknown and this thesis will serve to bridge that gap by assessing the possible effects of the data generated by Smart Connected Products or Internet of Things and its implication on the success factors of the NPD process. The research question which is proposed next encompasses the research goal and is constructed as follows:

"What is the possible impact of IoT on the success factors of the New Product Development process?"

At the first glance, the research question is wide-ranging and needs to be broken down into subparts in-order to address the central research issue. The sub-questions are as follows:

"Can the data generated from the Internet of Things help to augment the product's fit with customer needs in the New Product Development process?"

"Can the data generated from the Internet of Things help to reduce the product's development cycle-time in the New Product Development process?"

"Can the data generated from the Internet of Things help to reduce the product's development costs in the New Product Development process?"

The main idea of the sub-questions is to disintegrate the research question into conceivable separate entity. These different entities when discussed together, will pave the way to answer the main research question.

1.2 Methodology

Due to the exploratory nature of the research question, this study considered two research methods i.e. a critical literature review and an expert interview, for the collection and evaluation of data. The literature review was conducted by categorically inspecting and evaluating literature from scholarly articles, journals, conference papers, company reports and management magazines in order to provide a dependable synapsis of the existing knowledge. The articles used for this thesis were scoured and sourced mainly through University of Twente's Digital Library (literature databases) such as Web of Science and Scopus. They were then chosen based on the high relevancy and the number of times the paper was cited. IoT being a fairly recent phenomenon, scientific literature on this topic was very limited. As a result of this, it was not always possible to include peer-reviewed research papers. So, the inclusion of non-peer-reviewed articles i.e. various management magazines (Harvard Business Review, McKinsey Global Institute etc.) was taken into consideration. The primary focal point of the research was to discover the possible impact of IoT on the success factors of the NPD process, therefore, the literatures used for this study had strong affinity for either IoT or innovation management. By means of the literature review, it was possible to indicate, to what degree did the data retrieved from the IoT contributed to the success factors of the NPD process. In other words, the systematic review was able to demonstrate the resemblance and disparity between the standpoint of the literature sources on the sub-questions. The various findings of the literature review also served as the basis for devising the interview questions (refer to **Appendix H**). In light of the desire for an accurate comprehension of the topic, semi-structured interview method was chosen for the second research procedure. For the expert interview, this study considered individuals who worked for an organization that dealt with IoT solutions, researchers having vested interest in the field of IoT or entrepreneurs who helped to build an IoT related company. These experts were identified using a list of IoT experts provided by the thesis supervisor, browsing company websites (also LinkedIn profiles) and University websites. They were approached via email indicating a brief description of the research goal. Out of thirty-seven email invitations, three individuals responded. An interview guide was sent in advance and three separate face-to-face interviews were conducted. The interview guide entailed a short description of the research objective and a full list of the interview questions. The respondents were asked to provide their viewpoints in conjunction with the IoT and their likely effects on the success factors of the NPD process. Their responses were then analyzed in order to determine to what extent their answers relate to the previously found information and if not, what new insights did they provide. This enabled to draw concrete conclusion in relevance to the possible impact of IoT on the success factors of the NPD process based on the findings of the literature review and expert interviews.

2. LITERATURE REVIEW

2.1 Characterization of Internet of Things

The term "Internet of Things" was first coined by the MIT researcher Kevin Ashton in 1999 and it is still a developing phenomenon that has been characterized in various ways (Ashton, 2009). The phrase "Internet of Things" is comprised of a blend of two terminology. The first terminology i.e. "Internet" hints to the system or network arranged characteristics of the IoT, while "Things" asserts the amalgamation of everyday items or objects into a prevalent scheme (Mischo, 2016). Basically, Internet of Things can be characterized as a collection of tangible physical objects in which sensors are embedded and are also simultaneously connected with the help of an internet protocol, transforming them to a "smart connected product" (Constantinides et al., 2018). The aforementioned "smart connected product" can be represented by an uninterrupted ever-present sensing, data analytics and information representation with the help of cloud computing in an all-comprehensive framework (Buyya et al, 2013).

2.1.1 Smart, Connected Products

At the center of the Internet of Things lays the "smart connected product" According to Porter and Heppelmann (2014), smart connected products is an agglomeration of three core components: physical components, smart components and connectivity components. The smart segments enhance the abilities and value of the physical elements, while connectivity complements the capacities and value of the smart components and empowers a part of them to prevail outside the physical item itself, resulting in a righteous cycle of significant value enhancement (Porter and Heppelmann, 2014). The physical segments represent the product's mechanical and electronic portion, whereas the smart components are comprised of an array of various sensors, data storage system, microprocessors, controllers, software unit and all embedded in an improved user interface (Porter and Heppelmann, 2014). The last core component, or in other words connectivity can be understood as the various ports, protocols and antennas who have the capability to enable diverse wireless or wired linkage with the products (Porter and Heppelmann, 2014). The connectivity component takes shape in three forms and they are: one-to-one, one-to-many and many-to-many. One-to-one connectivity is a linkage between an individual product and a user or another individual product. Analogously, one-to-many is a union between one product and many products simultaneously. Finally, many-to-many connects multiple number of products to many other variety of products and external data sources (Porter and Heppelmann, 2014). Connectivity in smart connected products serves two objectives. The first objective is the facilitation of information swap between the product and the environment they operate in. The information exchange could also take place with the products' creators, users and other systems. The second objective is regarded as the enablement of certain capacities of the product to exist outside the physical space, which is popularly known as the cloud (Porter and Heppelmann, 2014).

2.1.2 Big Data

The fiery development in the quantity of smart connected products associated with the Internet of Things and the exponential increment in data utilization only reveal how the expansion of Big Data consummately overlaps with that of the Internet of Things (Vasilakos et al., 2017). The information created from Internet of Things associated smart products can be utilized as a part of discovering potential research trends (Vasilakos et al., 2017) and exploring the effect of specific occasions or choices. In-spite of the fact that IoT has generated remarkable opportunities which can boost revenue generation, downsize costs, and enhance efficiencies, collecting a colossal measure of data alone is insufficient (Riggins and Wamba., 2015). In-order to reap benefits from IoT, firms must establish platforms where they can compile, analyze and manage a colossal volume of sensor information in a scalable and economical manner and transform them into valuable insights (Riggins and Wamba., 2015). Given the background, utilizing a Big Data platform which can help with consuming and reading diversified data sources as well as in stimulating the data incorporation process becomes decisive (Vasilakos et al., 2017). The Internet of Things and Big Data are increasingly converging and need each other. The IoT needs Big Data to take all the information it gathers and turn it into something useful, actionable and in some cases automated. Big Data needs IoT because all that sensor data provides a world of valuable raw material beyond just things like social media sentiment analysis and public government data sources into two of the other big sources of the unstructured data that feed into Big Data.

2.2 Process of new product development

New Product Development can be regarded as the one of the most critical determinants of uninterrupted company performance and therefore can be considered as an instrument of innovation within firms (Oduola & Yukubu, 2017; Constantinides et al., 2018). The NPD's commitment to the development of organizations, its impact on revenue generation, and its role as a decisive factor in business planning have well been recorded in various management literatures (Bhuiya, 2011; Urban & Hauser, 1993; Booz et al., 1982; Cooper, 2001). The New Product Development is basically a process of sequential steps in-order to bring a new product to the marketplace. Businesses often need to engage in such a process mainly due to the developments in customer desire, heightened competition and technological breakthroughs or to take advantage of new favorable circumstances. Creative organizations flourish by comprehending what the market needs are and by cultivating new products which can either meet or surpass the clients' desires.

Various models have been created since the advent of the NPD process, but two models have become widely accepted across industries. Their basic understanding and functionality remain the same and the only difference can be observed in their unique nomenclature. The first model is widely known as the seven steps BAH model which has been created by the researchers Booz, Allen and Hamilton in 1982. The BAH model consists of 7 steps which is depicted in **Appendix A**. This is the best-known model because it dominates the NPD framework that have been introduced later. Another conceptual model which is highlighted significantly in the New Product Development literature is the Stage-Gate model developed by Robert G. Cooper. The Stage-Gate model consist of five stages (not including the Discovery stage), which is in its very basic essence comparable to the BAH model (see **Appendix B**). The Stage-Gate model can be particularly distinguished from the BAH model by its presence of gates. So, it has distinct stages which is separated by management decision gates (gatekeeping). Cross-functional teams must effectively complete a recommended set of interrelated cross-functional activities in each stage prior to acquiring management endorsement to proceed to the following stage of product development. The added value here is, each gate plays a part in reducing uncertainty and risk, which contributes significantly to the product development process.

Irrespective of the models mentioned previously, the first few stages or the early stages (for the BAH model prior to "Business Analytics" and for the Stage-Gate model prior to "Build Business Case") of the NPD process is shaped by chaos and uncertainties. In a study conducted by Gupta and Wilemon in 1990, found out that the extent of uncertainties associated with the early stages of the NPD is becoming more intense since companies are under constant tremendous pressure to create more superior new products to keep up with competition (Gupta & Wilemon, 1990). This less formal, unstructured stages i.e. the conception of a new product idea up until its approval for development or cancellation of the NPD process is commonly known as the Fuzzy Front End (FFE) of Innovation. The front-end of the NPD process is specifically influential because it can bring about either total success or total ruins. Apart from reducing the degree of risks of the innovation process, it also comprises a considerable part of the entire cost of the NPD process (Sandmeier et al., 2006). In addition to that, it has the major influence on the design of the new product and one of the important stages to be considered by firms for the improvement of the overall NPD process (Verworn et al., 2001; Sandmeier et al.,2006). The Fuzzy Front End of the NPD process requires the addition of various inputs from multiple sources in-order to increase the commercial success of the new product. This can be achieved by either closed innovation or open innovation. Companies who are inclined towards closed innovation, generally fetch new ideas and commercialize them within the internal boundaries of the company, which causes them to run out of good ideas and create products which deviates from customer requirements. Sourcing innovation ideas outside the internal boundaries (open innovation) can tremendously facilitate the Front-End activities (Quinn, 2000; Muller et al., 2002). Open innovation-oriented companies are not solely reliant on their own R&D department but rather consider their R&D department as an open unit where the development of a new product takes place from their own ideas as well as external sources for achieving success in the Fuzzy Front-End (Hippel, 2005; Chesbrough, 2003). Because of the new open innovation model, better approaches to consolidate clients' intelligence into the front-end must be investigated (Gassmann et al., 2006). One such approach is commonly known as co-creation, which will be described in a greater detail in the subsubsection 2.4.1. 5.. Note that this research will investigate the role of co-creation in association to Schilling's first success factor (augmenting the product's fit with customer requirements) only in the Fussy Front End of the NPD process since customer involvement impacts the front-end of the NPD mechanism the most.

2.3 Success factors of the new product development process

In-order to understand the impact of Internet of Things on the success factors (augmenting customer needs and reducing development costs and time) of the NPD process, it is of utmost importance to first understand how these success factors are fundamentally constituted or defined.

2.3.1 Augmenting the product's fit with customer needs.

In-order to increase the success rate of a new product in the market place, it must present more fascinating features, outstanding quality or more

alluring financial value than contending products (Schilling, 2013). In spite of the apparent significance of this objective, many new product development ventures have been unsuccessful in achieving it. This may happen for various reasons. First and foremost, firms do not have a reasonable understanding of the features customers value the most, resulting in the firm's overestimating in some features to the deprivation of features the customer desire more (Schilling, 2013). Secondly, firms may likewise miscalculate the client's readiness to pay for certain features, encouraging them to include unnecessary features which is unaffordable for the greater extent of customers and thus failing to achieve significant market penetration (Schilling, 2013). Furthermore, businesses might similarly experience issues settling heterogeneity in client requests. Different customer groups might have different demands in terms of product features. Firms should be extra careful while fulfilling such demands since they might end up manufacturing a product that makes compromises between these conflicting demands, and the subsequent item may be unsuccessful in appealing to any of the client groups (Schilling, 2013).

2.3.2 Reducing the development cycle time

Products can fail due to a long time-to-market trajectory. A firm who has the capability to bring products faster in the market may enjoy certain benefits such as building up a long-term brand allegiance, capitalize upon rare resources and build client switching costs (Schilling, 2013). Another reason for reducing the development cycle time is directly attached to development cost and shorter product life cycles. As the development process becomes lengthy, companies must bear the costs of paying their employees who are involved in the product development and subsequently the cost of capital increases (Schilling, 2013). Furthermore, due to the phenomenon of shorter product lifecycles, firms who are slow to introduce a particular generation of technology, might not be able to fully recoup the costs of development since by the time the product is introduced, the product is close to obsolescence (Schilling, 2013). Finally, a short development cycle-time guarantees that a firm can rapidly overhaul or update its offering as design flaws are uncovered or technology propels (Schilling, 2013). But according to some researchers such as Dhebar (1996), caution should be observed while reducing the development cycle-time since it might cause adverse consumer reactions. It is directly related to a psychological fear, where a customer might regret a purchase in the past and become increasingly reluctant or cautious in terms of new purchases since they fear that the product might soon become obsolete. Other researchers pointed out additional repercussions associated with product quality and sloppy market introductions since the compression of development time can seriously put pressure on the development team, which in turn might propel them to overlook problems associated with product design (Crawford, 1992, Schilling, 2013). Nevertheless, in spite of the above-mentioned dangers, majority number of studies have discovered a solid positive connection amongst shortened development cycle time and the commercial success of new products (Nijssen et al., 1995, Schilling, 2013).

2.3.3 Reducing development costs

In some cases, a firm takes part in an intense effort to build up a product that surpasses client expectation and puts it up for sale to the public early, just to find that its development costs have sky-rocketed so much that it is beyond the bounds of possibility to recover the development costs even though the product is enthusiastically accepted by the market. So, the key here is that the development efforts should not only to focus on effectiveness, efficiency should also be taken into consideration (Schilling, 2013). Crawford and Benedetto (n.d.) indicated that in the new product management process, development cost is at the lowest in its primary stages. As the project moves forward to the next stages, development costs can increase to a larger extent. Furthermore, the goal of a new product's process should be able to curb the amount of risk and uncertainty as one moves from idea generation to launch. It is of utmost importance to reduce the amount of uncertainty because each additional phase implies a greater financial investment.

2.4 IoT integration in the new product development process

This section will try to elaborate in detail the impact of data generated from IoT on the three success factors (Schilling, 2013) of the New Product Development process.

2.4.1 Augmenting the product's fit with customer needs

The massive volume of data retrieved though the IoT implies that businesses can utilize these intelligences to better comprehend the requirements and needs of their clients, prompting a superior understanding of clients' thought process and thus facilitating the product's fit with customer requirement (Duckworth, 2017). Given the above-mentioned prospect of IoT in aligning the product's fit with customer requirements, the succeeding subsections will try to elaborate this using five concepts: reiteration, continual improvement process (CIP), customer micro-segmentation, heightened complexity and co-creation (Constantinides et al., 2018). Both of the models, as mentioned previously in section 2.2, have three common stages in the New Product Development process. It can be classified as the front end of innovation, new product and process development and commercialization (Koen et al., 2014). For the purpose of this thesis, both the models will be confined to a simplified conceptual form. The simplified version is depicted in **Appendix C**. The simplified NPD process and its associated phases of the both BAH- and Stage-Gate model is depicted in **Appendix D.** The simplification is mainly done to be able to conveniently illustrate the implication of the Internet of Things on the concepts of r**eiteration circle**, **CIP** and **co-creation**. These are explained in greater detail in the following subsubsections (refer to 2.4.1.1, 2.4.1.2 and 2.4.1.3).

2.4.1.1 Reiteration

In this era where clients anticipate more from their collaborations with firms than ever before, adapting a reiterative technique to new product development can help businesses to develop future products which are better adapted to customer needs (Dhillon, 2017). In the context of IoT, smart connected products data can be used in the reiteration circle, for instance post-purchase usage data or data from former development processes can be fed back to the front-end of the development mechanism to enhance the nature of forthcoming development processes and new product improvement prospects in relation to product-customer fit. The mechanism is adapted from **Appendix C** and depicted in **Appendix E**.

Tata consultancy services (2013) emphasizes the role of big data analytics in this context. The majority of the user-related data generated from smart connected products come in large volumes and lack the valuable insights. It is of crucial importance for organizations to have sufficient customer analytics capabilities in-order to tap into those voluminous quantity of data and converting them into useful insights to enlarge the product's fit with customer requirement. Firms with analytics capabilities are able to apprehend the post-commercialization information created from guarantee claims, post-development quality testing and diagnosis etc., as an extra input to the framework, more specifically to the "front end of innovation" and thus assisting the progress of the new product development mechanism (Tata consultancy services, 2013). In addition to that, customer analytics can complement these endeavors with additional analysis such as finding correlation of the feedback sources to develop more customer-oriented products (Tata consultancy, 2013). Furthermore, efficient organizations and their corresponding NPD processes have started to consider data generated from social media platforms, such as information mining from customer comments of the product from social media platforms and feeding it back to the front end of the innovation process (Tata consultancy services, 2013). Some of the advantages of a data-driven approach are: 1. Persistent accessibility of the voice-of-customer information can be utilized to enhance the features and composition of future items (Tata consultancy services, 2013). 2. It helps firms to remain one step ahead of potential issues, as instantaneous or real-time fix is conceivable. For instance, a guarantee or field issue which is guided instantly to the firm's database, will warn the R&D department with regards to product imperfections which in turn can be eradicated while an assortment of products is still in manufacturing (Tata consultancy services, 2013). 3. Real-time performance data retrieved from smart connected product's sensors, taking the example of a car manufacturer in conjunction to engine performance or driver conduct can be utilized in the reiteration circle, in-order to help developers pin-point effectiveness issues or add new highlights to the vehicle (Tata consultancy services, 2013). Tata consultancy services (2013) studied a telecom hardware producer which enabled user-related data analytics to reiterate to the front end of innovation. The company was able to improve its gross margin by 30 percent within the timespan of 2 years. This success can be mainly contributed from the elimination of irrelevant features and adding those

which was deemed necessary and their willingness to pay from the customer's standpoint. Thus, reinforcing the importance of the reiteration loop and simultaneously enhancing the product's fit with customer requirements.

Cognizant (2015), an American multinational company which provides IT services, including digital, technology, consulting and operations services, conducted a recent study to investigate how connected products are shaping the industrial world. One of their findings indicated that the data retrieved from the smart products helped to capture useful customer insights across the entire product life-cycle and feeding it back to the innovation process substantially improved product design and performance in alignment with customer requirement. According to Cognizant (2015), if firms are able to understand customer usage patterns, it becomes easier for them to improve future product designs by including or abolishing distinguishing features and adjusting designs. Furthermore, according to Cognizant (2015), pharmaceutical organizations are investigating NPD frameworks that characterize the ideal production process for new products by coordinating data from various phases of the development mechanism such as R&D, maintenance, engineering etc. which is equipped with IoT to boost new product innovation. In other words, they are using historical data from their past processes to enhance the efficiency of the NPD process as well as the quality of their newly developed drug, which simultaneously increases the likelihood of a successful commercialization (Cognizant, 2015).

2.4.1.2 Continual improvement process (CIP)

A continual improvement process, abbreviated as CIP, is a continuous endeavor to boost the productivity or the value of an already existent products in the course of its product lifecycle, rather than enhancing future items. The CIP process is depicted in **Appendix F** (derived from **Appendix C**). In other words, it can be interpreted as extending the lifecycle of the product i.e. how will these products be supported and maintained over time. According to McKinsey Global Institute research organization (2011), data retrieved from embedded sensors in smart connected products can be leveraged to create proactive smart preventive maintenance packages to extend the life of the product. Even before the customer realizes that a component of a product is likely to fail, a repair technician can be dispatched to conduct necessary maintenance work. Additionally, assuming that it is a software glitch, the failure data generated by the product can be used to create software updates and thus extending the product's value during its service. Furthermore, Watson IoT IBM (2017), supports the notion of remote updates as a part of the maintenance service, so that they can be fed back to the development process in-order to offer new services or capabilities in the already existent product, which was completely outside the scope of the originally released product. There have been situations where products have been launched with hardware features not supported by the release software, but consequently added via software updates. For example, Tesla Model S came equipped with the "Auto Pilot" hardware but was not released during its original roll-out. It was subsequently released in October 2014 as an additional software package. Since then Tesla Model S and Model X received several over-the-air software updates containing additional features such as adaptive cruise control, auto lane change etc. These improvements were only made possible due to seamless data generation of the embedded sensors present in the Tesla cars, which continually improves the product and the corresponding customer experience.

2.4.1.3 Customer micro-segmentation

Customer micro-segmentation is a special type of segmentation which accumulates customers into very specific groups of audiences within miscellaneous niche markets. This type of segmentation produces a personalized product fit to the customer's needs. Tata consultancy services (2013) emphasizes the role of data retrieved from smart connected products, more specifically the automotive industry in this context. They explain how the automotive industry is leveraging upon sensor-fitted vehicles to augment the product's fit with customer requirements. Such smart, sensor-fitted vehicles have the ability to track each and every moment of both the driver's and the vehicle's performance. Additionally, these automobiles have the capabilities to present the new product development managers real-time data which can be useful for future iteration of the product in terms of fulfilling specific customer requirements in different segments. For instance, understanding the anticipated and real performance of two identical automobiles operating in Europe and Asia under various driving circumstances can help the manufacturers to customize the product to cater particular customer needs of two different continents. This notion could also be further extended by classifying among driver's gender and age category. Harvard Business Review (2014), a general management magazine published by Harvard University, featured a study in one of their publications to investigate how smart connected products is transforming competition. According to them, the constant connectivity in smart connected products is facilitating the notion of granular customer-segmentation (as presented previously by Tata consultancy services) since it broadens the nature of insights and allows development teams to examine how consumers are utilizing a product, the frequency of their use and the features that are being neglected. They emphasized the usage of data analytics tools which helps organizations to granulize or dissect their customer segments in more-modern ways, offering more tailored product bundles to each customer-division and price those bundles accordingly to generate more value. Such approach works perfect when products can be rapidly and proficiently custom-fitted at low incremental cost at the hand of software customization contrary to hardware changes. For instance, John Deere (engine manufacturing company) used to produce numerous engines with varying degrees of engine horsepower to serve distinctive client sections. Data analytics from their sensor-fitted engines revealed that certain customers could benefit from varying levels of engine power. John Deere revamped those engines and customers are now able to adjust the engine strength according to their preferences utilizing the software alone and thus simultaneously enabling a personalized product fit and quenching the thirst of individual level customer demands (Harvard Business Review, 2014).

2.4.1.4 Heightened complexity

The Internet of Things extends the capabilities for new sorts of frameworks and applications since these gadgets can talk to not only a central hub but also to each other. The notion of device-to-device communication contributes to the commencement of completely new classifications of applications and new products for the customers as well as for different industries. However, the surge in different types of applications and new products in the IoT environment can be associated with inherent complexity, and organizations require the correct measures to deal with the heightened complexity (Watson IoT IBM, 2017). The developments in IoT i.e. the intensification of new categories of applications and products, is contributing to the surge in Big Data and its implicit high volumes of data generation. Most of the IoT data can be characterized as coming from heterogenous streams which needs to be compiled and transformed to yield persistent, inclusive and accurate information for business analysis. As discussed previously in section 2.4.1.1, in-order to reap benefits from IoT, firms must establish platforms where they can collect, analyze and manage a gigantic volume of sensor data in a scalable and cost-effective manner and transform them into valuable insights. According to McKinsey global institute (2016), "most organizations are capturing only a fraction of the potential value of data and analytics" pg. 11. As the inherent complexity of the IoT environment increases, it directly influences the analytics capabilities of a company to capture useful insights negatively (Constantinides et al., 2018).

Furthermore, in order to exploit the prospects of IoT fully, smart connected products are nowadays manufactured taking the elements of interconnection and interoperation into account (Watson IoT IBM, 2017). In order to adjust constantly to evolving external conditions, these products integrate real-time analyses in association with machine-to-machine, user-to-machine and machine-to-infrastructure communication (Watson IoT IBM, 2017). This complex linkage with back-end frameworks adequately reconstructs present-day smart connected products into systems of systems, forcefully augmenting the degree of complicatedness (Watson IoT IBM, 2017). The extent of complexity is further intensified when many new features are guided by the intercommunication of software functioning both in the product as well as in the cloud (Watson IoT IBM, 2017). Harvard Business Review (2014), foresees heightened complexity in terms of consumer usability, a deviation of complexity from the developer's end. As the smart products matures and expands, its capabilities in terms of human-machine interface will shift from the physical product to the cloud, which might make it difficult for end-users to operate in such an environment. Complex end-user operating interfaces can be regarded as an impediment for the path towards augmenting customer experience and its associated product-customer fit. Cognizant and Economist Intelligence Unit surveyed (2015) over two-hundred product design and innovation

managers throughout the U.S. in-order to comprehend the phenomenon of smart connected products. According to the survey respondents, they found out that the prospects of the IoT can be in all respects exploited if the data from the developer's end can be combined with data from external third-party suppliers. So, the complexity or the challenge in this particular case would be the degree of openness of the developers and the suppliers (instead of being reluctant) to conjointly work together in-order to better comprehend customer requirements and needs. This result can be reinforced by another Cognizant's survey findings where it became evident that many managers or business leaders (32% out of 205 response base) are increasingly interested to share data with suppliers to strengthen product development. In addition to that, an increasing number of them are at the present working together with customers and suppliers with the help of co-creation, which is the topic of the next subsection.

2.4.1.5 Co-creation

According to Hippel (2005), the process of co-creation greatly facilitates the process of augmenting the product's fit with client's specification since the consumers can co-innovate exactly what they want (Hippel, 2005). Within the context of IoT and its promising potential for co-creation, customers can be regarded as inactive co-creators in the product development procedure and more particularly in the fussy front-end (**Appendix C**) since it lays the foundation of the successive phases and determines the commercial success of the new product (Sanders, 2005). Hence, it is feasible to expect that client-input requiring front-end endeavors will be improved by the IoT and more specifically by the data retrieved from the smart, IP-connected products. Voice of the customer research is a concept utilized as a part of business and information technology to interpret the comprehensive procedure of apprehending client's desires, inclinations and dislikes. The process behind understanding clients' needs well is usually a costly undertaking. In addition to that, traditional statistical surveying procedure or in other words consumer research only provide a one-dimensional superficial observation into clients' requirements (noise between what people say in what they do) and the procedures are tedious and troublesome (Hippel & Katz, 2002). Customer needs can be differentiated between articulated needs and latent needs (Griffin & Hauser, 1993). On one hand, articulated needs are those needs that a customer can readily and easily verbalize, if asked appropriately. On the other hand, latent need is a problem that a user or consumer does not realize they have. These needs tend to go unexpressed, either in light of the fact that individuals believe that they are excessively insignificant to be a focal point for someone to solve or in light of the fact that they have not generally taken notice at the underlying driver of their pains and frustration to identify what is wrong (Further, 2016). Analyzing these articulated and inert clients' needs provides colossal business opportunities and it energizes the fussy front-end of the development process, which in turn enables the organization to develop breakthrough products which truly excite the customers. Several methods such as focus groups, ethnographic research and lead user analysis have been used by companies, but these procedures require a considerable amount of time, the valuable time which firms may not have in-order to gain the first-mover advantage as well as given the recent developments in short product-lifecycle category. This is exactly where IoT intervenes and can significantly contribute to this process. The fundamental advantage of the IoT integrated voice of customer research is its ability to notify about how clients utilize products. This can be considered a noteworthy enhancement in contrast to past procedures since this data or in other words this intelligence was nonexistent before the emergence of IoT. Hence, it also signifies what the customer preferences are and what they do not really care for. It can identify enunciated needs and additionally latent needs of customers. Articulated needs can be recognized by equipping smart connected products with a graphical user interface on which clients can precisely communicate with firms. As a consequence, customers can verbalize their encounters, needs and issues associated with the product. Companies can utilize this possibility additionally to create a bilateral communication with customers. In addition to that, breaking down utilization patterns can be helpful in determining latent necessities. By evaluating the product usage course, a firm might be very successful in identifying needs where the clients were not even conscious about that such a need existed, subsequently acclimatizing the product development process to meet customer demands (Narver, Slater & Maclachlan, 2004).

2.4.2 Reducing development time and cost

This section will interchangeably talk about both product development time and cost since their effects are directly proportional to each other. Each and every time the product development time increases, the associated development cost experiences proportionately similar expenditure upsurge. There is a very interesting saying that "hardware is hard". To clarify this proverb in the context of IoT and its correlation to development time and cost, it is of sheer importance to first discuss the development mechanism of both hardware and software. Hardware involves as opposed to software longer development cycle and higher cost. So, unlike software, iteration processes in hardware take more time (Zubeldia, 2017). This means the company produces a prototype and there would be plenty of occasions where things would go wrong. In the hardware world that means companies would have to correct these issues and that would most likely trigger the development process all over again from scratch, which implies usually one iteration is not enough (Zubeldia, 2017). Contrary to hardware, companies can deploy, test and iterate software almost on daily basis with the help of IoT and these gives room for experimentation (Zubeldia, 2017). So, given the emergence of IoT, it can significantly reduce the need for multiple hardware iterations due to its real-time data analytics capabilities. In addition to that, the probability of making major development mistakes decreases too (Zubeldia, 2017).

From a slightly different perspective to Zubeldia (2017), Harvard Business Review (2014) argue that in smart connected products, comparative to physical components, the intelligent and connectivity components of products convey more value, which indicate that sooner or later physical components will be commoditized (in this context end up becoming simple commodities) or even be completely replaced by software. Software decreases the requirement for "physical tailoring" (multiple hardware iteration is reduced), and therefore the quantity of physical component assortments is reduced too. This actually signifies two things with regard to IoT's contribution to decreased development time and development cost reductions. Firstly, if product development is software affine or in other words if IoT supports the notion of physical components being replaced by software, the necessity of lengthy multiple iteration cycle is significantly reduced because a software development team is able to generate ten iterations of an application by the time only a single new version of a hardware is iterated (Harvard Business Review, 2014). This suggest that the development time will likely decline. Secondly, the redundancy with regards to physical components mean that these physical components will not add up to the final development cost.

The previous findings highlighted that the boost in the complicatedness of the IoT environment would further burden the data analytics capabilities and consecutively make the product development process far more complex. Reducing complexity is very important in this context since it positively affects the development time and costs. Contrarily to the heightened complexity of the IoT environment, some researchers argue that the extraordinary levels of real-time data generation and their concealed valuable insights would actually propel businesses to establish even more effective knowledge management approaches from data analytics and thus reduce complexity of the development process (Tata consultancy services, 2013). One way this can be achieved is through the proper utilization of product data. According to Tata consultancy services (2013), the explosion of low-cost sensor technologies has made every production equipment and component a potential data source which can be used to manage the product data. Nevertheless, the enormous datasets produced by the manufacturing equipment have remained undetected partially due to the absence of interoperability skills. Organizations can build a momentous Big Data opportunity by integrating these datasets with one another and to their enterprise systems. For instance, original equipment manufacturers can work together with their respected suppliers and make their datasets interoperable (in this context, transfer of skills and knowledge), which in the long run could help create products speedier and cheaper. Such methods of connecting valuable knowledge acquired by means of IoT integrated Big Data investigation with rules, rationales etc. can encourage quicker decision making, curb costs, enhance reusability and most significantly lessen product development time (Tata consultancy services, 2013). Another method of IoT product data utilization, as mentioned by Tata consultancy services (2013), is by exactly looking at how a particular product segment was devised and the potential constraints it experienced. By taking such measures, organizations can facilitate the design of new parts, assemblies etc. and at the same time bolster standardization by accumulating old parts from already existent databases, which consecutively aids the product development process by reducing the development time and costs (Tata consultancy services, 2013).

Furthermore, another fascinating technique within the IoT ecosystem and more specifically in the IoT product development process is predictive analytics. As opposed to data analytics, predictive analytics can be characterized as a "specific" form of analytics, which is used by organizations to predict future based outcomes (EDUCBA, 2018). As the name suggests, predictive analytics with its "predictive" capabilities such as detecting failure patterns, modelling correlations, prescribing remedies, prioritizing recommendations against cost constraint etc., can boost the product development process by reducing time to market (shorter development cycle) and strengthening the product quality while at the same time reducing development cost (Joshi & Kansupada, 2018). Predictive analytics can be used across all stages of the New Product Development process. One case where it is being used is during the ideation and concept stage or more precisely at the front-end of the development process. It can be used to conduct analysis of intellectual property rights since it provides decisive information to develop a product which is legally sound (Joshi & Kansupada, 2018). This can be particularly helpful given the context of shorter development time and costs. If not done correctly in advance, businesses might get into unnecessary legal battles which results in prolonged periods of development time and costs (Joshi & Kansupada, 2018).

Two functions of predictive analytics which are further relevant for development time and costs are cost- and supplier management. Taking the function of cost management into account, predictive analytics can support development cost evaluation and cost rollups for various arrangements and BOMs (bill of materials). Capabilities such as simulation and product costs optimization during the development phase guarantees that correct choices are made at the right moment which improves the chances of successful commercialization and at the same time ensures product profitability (Joshi & Kansupada, 2019). For supplier management, "it improves the visibility into supplier data by combining silos of data from multiple sources" (Joshi & Kansupada, 2019, pg. 6). This can be to some extent related to the approach of complexity reduction (supplier data interoperability) in the IoT environment and hence develop speedier and cheaper products. Now from a somewhat detracting viewpoint, Harvard Business Review (2014) argues that "Building and supporting the new technology stack of IoT (see **Appendix G**) for the product development requires substantial investment and a range of new skills – such as software development, systems engineering, data analytics, and online security expertise" (pg. 8). This can be interpreted in twofold ways. On one hand, the organizations that uses smart connected product data during the development process is faced with a very high upfront cost since establishing the entire technology stack requires additional budget requirement, which might be detrimental in containing the development cost. Additionally, "Industries with high fixed cost structures are vulnerable to price pressure as firms seek to spread their fixed costs across a larger number of units sold" (Harvard Business Review, 2014, pg. 14). This indicates that due to the higher development costs, firms tend to compensate the cost by raising the price of the end-product. On the other hand, it ignores the possibility of cost reduction for future developments of products once the costly technology stack has been established. In other words, it ignores the long-term effects on development costs once the high upfront cost is recouped.

Furthermore, "The huge expansion of capabilities in smart connected products may also tempt companies to get into a feature and function arms race with rivals and give away too much of the improved product performance which is not necessarily desired by customers, a dynamic that escalates costs" (Harvard Business Review, 2014, pg. 14). This phenomenon is commonly known as the "innovation race" or in other words the tendency for firms to not miss the boat. This might be disadvantageous for firms because it produces the lock-in effect, which might limit sight of the developers on other efficient developmental solutions, subsequently increasing the development time and costs. As opposed to Harvard Business Review (2014), Cognizant and Economist Intelligence Unit (2015), anticipates a significant cutback on the development speed and costs. They argue that due to rise of the smart product economy, the traditional product economy is experiencing a shift towards an interconnected product economy approach. They claim that products are becoming increasingly intertwined with each other since firms have realized the added value of combining product data and co-investment (Cognizant & Economics Intelligence Unit, 2015). Furthermore, they predict that new corporate structures and partnership will evolve, which diminishes the financial risks of working cooperatively since firms have more access to external resources and can share the risks. In view of all these factors, they indicate towards the reduction of development time and costs (Cognizant & Economics Intelligence Unit, 2015). A short summary entailing various findings of the impact of IoT on the success factors is depicted below in **Table 1**:

Table 1: Summary of critical findings

Product-customer fit	
Favorable Circumstances	**Impediments**
Reiteration circle →Reiterative approach enhances future development processes and subsequent products (scales down the drawbacks mentioned in section 2.3.1) →Data analytics plays a crucial role →Coordinating data from different phase of the development mechanism results in massive product design improvement such as elimination of costly features **Continual improvement process** →Post-commercialization product lifecycle extension through software updates **Customer micro-segmentation** →Individual personalization (settles heterogeneity in client requests, cited in section 2.3.1) **Co-creation** →Identification of articulated and latent needs →Other traditional market research methods are not accurate, costly and time-consuming →Reduces uncertainty of FFE	**Inherent Complexity** →New sorts of frameworks, applications, systems of systems, functionality convergence of physical products and cloud etc. →Data analytics under stress due to above-mentioned reason →Complicated consumer interface

Development cycle-time and costs	
Favorable circumstances	**Impediments**
In general, IoT reduces the need of multiple hardware reiterations → software iterations are even faster Reduces the probability of committing major hardware development mistakes Physical components being replaced by software affine product development Better data analytics and knowledge management capabilities → better product data utilization → increases data interoperability of production processes, ERP systems and suppliers data→ promotes standardization Predictive analytics for detecting failure patterns, IPR analysis, cost evaluation and supplier data visibility	New IoT technology stack requires substantial investments "Innovation race" –developing too many product features not desired by customers; might limit sight of developers on other efficient solutions

After having discussed the impact of data generated from IoT on the three success factors of the NPD process, the following interview questions were devised based on the above-depicted critical findings: 1**. What is according to your opinion the impact of IoT on the capability to augment customer needs in the NPD process? 2. What is according to your opinion the impact of IoT on the development cycle-time of the NPD process? 3. What is according to your opinion the impact of IoT on the development costs of the NPD process?** For the full length of the follow up questions, please refer to **Appendix H.**

3. EMPIRICAL STUDY (EXPERT INTERVIEWS)

This chapter discusses the main findings of the expert interviews. Various questions with regards to the three success factors were asked to three experts based on the summary of critical findings (**Table 1**) of the previous analysis. For the full list of interview questions and original transcripts, please refer to **Appendix H**. In the following sections, the results for each success factor is presented and assessed with the findings of the literature review, where applicable.

3.1 Augmenting the product's fit with customer requirement

Based on the responses, the impact of IoT on the capability to augment customers' needs in the NPD process is largely very positive. From a B2B perspective, Simon Philipsen, IoT portfolio manager at KPN, states

that their IoT solutions fulfils three main customer desires. With the help of KPN's IoT architecture their customers are gaining efficiency in their business processes, creating new customer value and developing disruptive business models. This opens up a new viewpoint since the B2B perspective was not previously discussed. Furthermore, he states that IoT devices are able to generate concrete consumer-specific data and this is a huge competitive advantage for businesses since they can comprehend their customer behavior much better contrary to companies who are not equipped with IoT. Additionally, IoT devices also have the capability to provide live or real-time insights of the product usage, which facilitates businesses to be in more touch with their customer and develop products which are suited to their needs (comparable to Duckworth's (2017) argumentation in section 2.4.1.). Dr. Robin Effing, an assistant professor at the University of Twente in the Business Information Systems department (IEBIS), explains the phenomenon of augmenting the product's fit with customer requirement with the help of smart home devices. According to him, by using data sets and analyzing them with big data analysis and predictive analysis techniques, companies are able to predict whether people would require certain new products. He exemplifies the situation where a company is able to predict a new need for specific type of air conditioning based on patterns between temperature and geographical data sets. So, companies could maybe even learn from smart home devices, whether people would need a new car or not. He definitely believes that the data generated from the IoT can play a significant role on the capability to augment and predict customer needs in the NPD process. Mr. Johan Stokking, CTO and co-founder of the Things Industries, states that on one hand, it is very useful to measure some form of quantitative data and the corresponding insights available, but on the other hand, it can also create a lot of clutter for example, conflicting concerns of different users identified by the IoT, which the company needs to consider. This argument made by Mr. Stokking reaffirms the notion of IoT facilitating the micro segmentation phenomenon of customer groups which helps to recognize the market segments' needs in detail (Tata consultation services, 2013). The concern regarding the clutter creation was previously ignored by the literature. All things considered, Mr. Stokking argues that with the help of IoT, companies are able to develop products which are more tailored to customer needs as opposed to companies who do not make use of IoT, but it can also be a big process of managing a lot of needs which adds a lot to the development time and costs in general. The concluding remark of Mr. Stokking is also applicable to sections 3.2. and 3.3.

3.1.1 Reiteration circle

3.1.1.1 Usage of data analytics capabilities as a feedback to the NPD process

Mr. Philipsen believes that it is absolutely crucial for businesses to establish data analytics capabilities or become a data-driven company. According to him, a data-driven approach will help companies to be in much more contact with their customers, which subsequently can enable companies to steer their product development with the help of a consumer-centric and quicker product iterations. Dr. Effing states that in today's modern era one cannot neglect anymore the fact that competitive advantage can be achieved from performing data analytics and it's a very fast and well-developed method now to get really reliable client data. He states that in the past companies had to set up a market agency to do this for them and the results were inconsistent, unfocussed and unreliable but the evolution in data analytics capabilities is making such procedure redundant and much more cost effective (similar to the argument made by Hippel & Katz (2002) in section 2.4.1.5.). He also points out that such procedure could be very different for established and new emerging companies. The unexpected advantage of an established company is that they can combine their readily available data sets to find out innovation potential for new products and services whereas the startups have scarcity of consumer data. Mr. Stokking states that it is very important to establish data analytics capabilities which can be used as a feedback in the NPD process, but it is also good to be aware that this is a process which requires one to always look back, so always after in hindsight. Companies need to possess some sort of characteristics which enables them to look in the future as well, such as competitors' assessment, key user identification etc. rather than just quantitatively analyzing data. So, it is useful, but firms need to consider other measures as well.

3.1.1.2 Product design improvement through the reiteration loop

Mr. Philipsen mentions that product design improvements with the help of the reiteration loop is rather difficult in hardware development, but he foresees a positive business case particularly in software development. He reinforces his case by giving an example of the Philips Hue lighting system. He argues that by selling the LED lighting system Philips is able to gain insights of the product usage and they exactly know what their customers are doing through the company-specific app. Hence, companies are able to iterate and reiterate product designs which is more suited to customer desire by eliminating unnecessary and costly features which can be controlled through software (can serve as reducing the drawbacks of the success factor mentioned in section 2.3.1). On one hand, his example partially reflects the business case of the telecom hardware producer studied by Tata consultancy services (2013) in section 2.4.1.1. Partially because the telecom company was able to improve product design and through that enhanced the product's fit with customer requirement, hardware-wise instead of software product design iteration. On the other hand, his statement fully approves the argument made by Harvard Business Review (2014) in section 2.4.1.3., where they state, "Such approach works best when products (..) at low incremental cost through software customization contrary to hardware changes". Dr. Effing sees the reiteration circle and the corresponding product design improvements as a part of the agile development process. According to him, it is increasingly important for companies to have a quick post-commercialization user feedback mechanism in order to continually improve and come up with more versions of the same product because the competition asks for this (analogous to the idea of "Continual Improvement Process"). Mr. Stokking states that the reiteration circle is not a good mechanism to improve radical new product design because it only enables to optimize the same feature sets in future products. He argues that after a couple of iterations and since everything is in hindsight, companies optimize to a point where they think this is good for the time being, but it does not give them the insight on what new features the firm could focus on or how could things be done completely different since firms always have the reference of the first design. So, companies are fixated to an anchor and that's their context.

3.1.1.3 Role of historical data

Dr. Effing states that when a company looks back at the data, it can determine or predict using predictive analysis the factors it should avoid for the next project and he is convinced that such procedures can be useful. But he also argues by indicating a recent research where blindly relying on computer generated algorithms or data is not enough and one needs to have some clear ideas about the specific industry and the R&D process. Furthermore, he specifies that by relying on data from past product development processes a company can signal waste, efficiency loss and key mistakes but that does not necessarily guarantee if the company does it otherwise it can do it better next time. Mr. Stokking believes that it can to certain extent help businesses to enhance their production processes with the help of data triangulation from diverse preceding processes (comparable to what Cognizant (2015) described in section 2.4.1.1) but at the same time he argues that these hindsight activities can hinder radical product innovation.

3.1.2 Continual improvement process

Mr. Philipsen affirms that smart connected product data can indeed allow products to become much improved during its service with the support of software and firmware updates. He adds to this by mentioning that some devices are developed which needs to be in service or in the field for a longer period of time. He presents a case where a water meter needs to be in the field for 15 years. According to him, it is very important for product developers to take software updates into account while devising a product. This implies that a product needs to fulfil current customer needs and more importantly it has to fulfill the need that a consumer will have in 15 years. Dr. Effing explains a development with regards to continual product improvement process where he observes that firms often lack a more direct link between maintenance data and service requests, which can be directly connected to the updating processes of the new product releases. The repercussions are that it takes a while before the customer feedback really enters the R&D department again. Comparable to what Mr. Philipsen described previously, Mr. Stokking mentions that software updates can be constructed from smart connected product data, which in turn would grant them to become much improved during its service. Furthermore, he states that in order to go to the market

with a product on a large-scale, it is of utmost importance to have an update channel since it can help to patch security issues and to add functionality later on (the latter part is analogous to the description of Watson IoT IBM (2017) in section 2.4.1.2; Tesla example)

3.1.3 Customer micro segmentation

Mr. Philipsen states that smart connected product data can help determine demands of particular customers groups in the B2C market, but it is rather difficult in the B2B market. He argues that in the B2B market, the product development of IoT and also the business case development of IoT takes a lot of time. He presents the case of one of KPN's business customer where they intend to equip ten thousand containers with sensors. Connecting them with such devices implies that the company has to change all their processes (the way people work, IT infrastructure, logistics etc.). So, the time setting up IoT until rolling out IoT equipped containers takes a lot of time. Dr. Effing suggests that today's marketers need a shift in their thinking about segmentation and customer groups since they focus more on mass market groups. Given the technology and distribution options of today, marketers and firms can really think of very niche markets and granular consumer groups to create more product relevance and thus value (long-tail marketing). With the help of predictive capabilities and new sources of data firms are able to foresee specific product needs and these needs can be used to create new markets which do not exist yet (This reaffirms what has been mentioned by Tata consultancy services (2013) and Harvard Business Review (2014) in section 2.4.1.3). Furthermore, this also helps to create different kinds of services and products that people are really willing to pay for.

3.1.4 Co-creation

According to Mr. Philipsen, IoT can identify articulated as well as latent customer needs. He once again argues this by presenting a business case where KPN collaborated with a bicycle insurance company. So, their collaboration required them to do a lot of co-creation activities together and this initially helped them to find some articulated needs (for e.g. the bike needs to be tracked) of the insurance company. However, since the insurance company was not acquainted with the technology, there were also many latent needs that KPN had to discuss with the bicycle insurance company. This answer could be marginally misleading because KPN was able find out the articulated and latent customer needs by conducting co-creation activities with them and it says nothing about how KPN's IoT solutions or in other words the data retrieved from the smart connected devices are helping them to investigate such needs. Mr. Stokking states that IoT can very much identify articulated as well as latent customer needs by analyzing how users use something. Firms are able to get more data on the ways that people are making use of existing products but in unexpected ways. So, it gives a lot of insights into how customers use the products that someone would not have thought of how they would use it before. He gives an example where a lot of smart features in cars have become successful where people thought that they would have never used it before or would have never come up with until the car maker introduced it because they were able to predict and identify certain customer needs with the help of IoT data.

3.2 Reducing the development cycle time

With regards to the impact of IoT on the cycle-time of the NPD process, some respondents indicated that the development time is likely to reduce but simultaneously some major concerns were raised as well. Mr. Philipsen acknowledges that IoT can have a huge impact on the speed of the development cycle-time in the NPD process. He states that, if a firm can use more and more data, the company will be much more effective with regards to development time and there will be much more chance that the product would turn out to be commercially successful. Dr. Effing agrees to a certain extent that the data retrieved from IoT can accelerate the NPD process since certain mechanisms could be efficient and faster (similar to Mr. Philipsen). During the development phase, what firms currently do is that they ask people and there is always a bit of noise between what people say and what they actually do (similar to the argument made by Hippel & Katz (2002) in section 2.4.1.5). This implies that the data obtained from such traditional market research could be deceptive and it consumes a lot of time. According to Dr. Effing, using data from smart devices can limit the time lag and firms can more speedily obtain the real insights pertaining to what is actually happening, use characteristic and use patterns etc. He also argues that only relying on IoT data is not sufficient and firms could make use of social media data, information from regular clients, questionnaires etc. To add up, firms require triangulation of data from multiples sources to further speed up the product development time. Mr. Stokking describes the impact of IoT on development cycle time using two different perspective. The first perspective is irrelevant for the purpose of the research and is thus omitted. He states that if companies are using IoT data retrieved from for example, smart industry or industry 4.0. or smart products, the development cycle-time might decrease to some extent since firms are able to make certain decisions quicker due to the availability of more insights (similar to Mr. Philipsen and Dr. Effing) but at the same time he raises his concerns about the various conflicting customer needs which the products manager needs to scope and clarify beforehand, subsequently slowing down the development time.

3.2.1 Heightened complexity

Mr. Philipsen argues that given the heightened complexity of the IoT environment, it is necessary to have right human resources in order to have a quick product development cycle. He states that getting the right people for example technical consultants, software developers, data scientists etc., in this context is always a struggle and also the most important thing. If the company is able to overcome such hurdles, quick product development cycle can be achieved. Dr. Effing argues that even though there is a surge in different types of application and new products in the IoT environment (elevated complexity), there will always be people who can quite easily operate such complex systems. According to him, both knowledge and technology capabilities of companies should not be underestimated, and it should not pose a great difficulty for firms to handle such complex systems. Furthermore, he asserts that these technical barriers and complexity might propel companies to try out many new different things. (this argument is exactly similar to the argument made by Tata consultancy services (2013) in section 2.4.2. "Contrarily to the heightened complexity of the IoT environment, some researchers argue that the extraordinary levels of real-time data generation and concealed valuable insights would actually propel businesses to establish even more effective knowledge management approaches from data analytics"; Dr. Effing's statement can also be regarded as a viable answer to section 3.2.2). Dr. Effing's argumentation seems to counter balance Mr. Philipsen's notion of finding skilled human resources. According to a report published by CEDEFOP (European Centre for the Development of Vocational Training; Centre Européen pour le Développement de la Formation Professionnelle) in 2015, between a half and two thirds of EU firms face difficulties in finding high-skilled workers. On one hand, given this evidence, Mr. Philipsen's debate of finding the right human resources is more assertive. But on the other hand, the latter argument of Dr. Effing "these technical barriers and complexity might propel companies to try out many new different things" can be decisive as well.

3.2.2 Complex inherent IoT environment propelling data analytics capabilities

Mr. Philipsen disputes that it is not a matter of becoming a big data company. It is according to him a matter of using the right data. The big risk with big data is getting all your data into a huge data lake and then figuring out what can the company do with this data. So, companies need to put more effort into the assessment of more specific and targeted data streams which is applicable to the business problem, which in turn can help companies to reduce development cycle-time. The respondent might have to a certain degree misinterpreted the main essence of the question. The context of the interview question is based upon the assumption that IoT and its extraordinary levels of real-time data generation is encouraging companies to become better in their data analytics or data retrieval capabilities, thus having a positive impact on the reduction of the development cycle-time. The respondent clearly indicates if more effort is put by the companies into the assessment of more specific data streams, it can help companies to reduce development time. He might have indirectly implied that the development cycle-time is likely to decrease even though the respondent's answer was slightly deviant. Dr. Effing suggests not to overestimate the effects on the development time given the new tools. The development of a new product or service is a very complex procedure since it involves a lot of manual labor and creative thinking. Furthermore, he adds that miracles in product development is not possible by only relying on enhanced data analytics capabilities since there are other struggles in innovative process and data analytics is only meant to support it. An interesting point to note here is that in the previous section i.e. in section 3.2.1., he seems to support the notion that the technical barriers and complexity might propel companies to try out many new different things. This implies that he unknowingly

confirmed that the increased complexity of the IoT environment might propel companies to enhance their data analytics capabilities, and with that reduce the development time.

3.2.3 Data collaboration

According to Mr. Philipsen, the data collaboration of product developers and third-party suppliers is very important, and it has a positive impact on the speed of the NPD process. Furthermore, he thinks that ultimately it comes down to a business decision. Companies need to trust their partners and vice-versa. If businesses are willing to co-create and exchange their data, it will surely improve the effectiveness of the NPD process. If the development process is effective, then there is a high probability that it will most likely speed up the development cycle-time. Dr. Effing opinionates that the data collaboration of product developers and third-party suppliers unequivocally influences the development cycle-time, but he also describes some challenges which might constrain the development process. The first challenge is related to creating a data sharing standard since manufacturers have their own unique ecosystems (Comparable to Tata consultancy services (2013) in section 2.4.2. "For instance, original equipment manufacturers can work together with their respected suppliers and make their datasets interoperable"). The second challenge is related to "commercial competition" which is holding innovation back. The last challenge is related to EU's General Data Protection Regulation which came into effect on the 25th of May and it is making things much more difficult with regards to innovation flourishment. However, Dr. Effing sees a shift happening now where an increasing number of firms are realizing that they cannot fully work independent and to a greater extent need each other's help. Such collaborative working nature gives them a competitive edge since they have access to more resources and risks are shared. This development mentioned by Dr. Effing is exactly similar to what Cognizant and Economist Intelligence Unit (2015) described in their paper (section 2.4.2). With regards to data collaboration of product developers and third-party suppliers on the speed of the NPD process, Mr. Stokking argues that companies are sometimes very reluctant in giving away confidential information due to the fear of losing competitive advantage. Furthermore, he describes the phenomena by specifying the challenges which Mr. Stokking's company faced while they collaborated. Since the Things Industries is a community based IoT firm, they had issues concerning data-ownership. This led them not to share user-generated data because they feared that the aggregated usage insights might reveal a lot concerning the reach of their skills which they consider as confidential. In general, on one hand, he thinks if the data is available, it is good for speeding up the development process since firms are able to reduce the quantity of product iterations. But on the other hand, he thinks that setting up the collaboration platform where the data is interoperable, takes a lot of time and might negatively affect the development time.

3.3 Reducing development cost

The anticipation concerning the impact of IoT on the costs of the NPD process is once again identical to what has been mentioned before in section 3.2. The effect on cost reduction is ambivalent since there are involvement of many factors. Mr. Philipsen states that with the help of IoT, companies are able to push better products in the market and with that fewer products that are not interesting to the market, which would have otherwise costed the company money. This implies that the effectiveness of the product development will have a positive impact on the costs. He proposes a fictitious situation where a company is running two different product development departments where one group is developing products sourced from traditional methods such as market research, customer focus groups etc. The other department is using IoT data sources and is able to build much more specified and targeted products for their customers since they know what their customer wants and with this they know it much better than the other department. In such a situation, the company might be able to shut down one of the departments and thus reduce development costs. Dr. Effing states that the fixed costs of setting up the IoT infrastructure is very high and that might spike development costs initially (analogous to the arguments of Harvard Business Review (2014) in section 2.4.2.). Companies should not underestimate the initial investment since IoT requires good data engineers, scientists and business consultants. He gives an example where skilled data engineers and data scientists in the US receives more than one million Dollar as yearly compensation. But at the end, the business case is positive since it is an efficient system and the running costs are very low. Mr. Stokking mentions that when it is about developing an IoT product itself, the development costs increases since everything gets much more expensive, especially connecting it when it is not connected today (not relevant for this research). In addition to that, it also keeps getting expensive since firms have to go through the certification process in an ongoing basis and there are a lot of updates with regards to new wireless technologies. If it is about the other situation, i.e. using the data retrieved from IoT to aid the development of new products, the development costs increases in this case as well because according to him, doing sensing right using IoT in order to observe consumer product usage is also a very expensive solution.

3.3.1 Additional budget

With regards to additional budget requirement for the IoT and its negative consequence towards containing development costs, Mr. Philipsen provides a positive outlook. He argues that firms would definitely require an additional budget for all kinds of software development and other mechanisms but on the other hand due to the emergence of IoT and its associated customer data, the costly and time-consuming process of conventional consumer research becomes redundant and hence the development costs might decrease. So, to some extent he agrees that firms will encounter some ordeal of cost escalation, but it also has the potential to reduce other types of costs which a firm encountered in the past. All things considered, he foresees the development costs to decrease once the firm has established all the IoT associated business mechanism. According to Dr. Effing, the strategic issue is of course to find out the sweet spot in terms of investment for IoT. So, what he basically implies is that additional budget requirement for IoT is contingent upon the degree of willingness of a firm to become a data-driven company. If a company is data-driven at full extent, it has to pay for developing the infrastructure and the people running the system, which could hint that the development costs might increase initially. He exemplifies the situation by drawing a parallel with an online-retail company called Zalando based in Berlin. Zalando has become more of a data driven company in recent years and according to Dr. Effing, Zalando was struggling to make a lot of profit initially since they incurred a lot of fixed costs due to their data-driven approach. A lot of e-commerce companies were being mocked since many people thought that they were just investing unnecessary money. According to him, in the beginning it was true but afterwards these investments paid out. Mr. Stokking argues that they themselves being an IoT company is not able to comprehend the difference whether the development costs increases given the additional budget requirement of IoT since they do not have a reference point. But they do see their business customers who are adapting their IoT solutions, perceiving that IoT can be very expensive to do it right because it is not only the product development itself but often it is also the functionality that may change the whole way the product is being used and that may even be more time-costly and a money-costly endeavor. The most time consuming and costly part of adapting an IoT solution is that firms have to change the whole business process from formerly being a pull-strategy company to make it more push-based. So, their entire processes of going by becomes irrelevant and with that the whole staffing, resources, planning etc. is also completely different. Taking everything into account, he indicates that the development costs will likely increase.

A short summary entailing various findings (i.e. new insights from the experts which was not discussed previously) of the impact of IoT on the success factors is depicted below in **Table 2**:

Table 2: New insights from the experts

New insights from the experts
Augmenting the product's fit with customer requirement
1.Universal B2B perspective →efficiency gain, new customer value and new disruptive business models **(Philipsen)** Conflicting concerns/needs of different users → huge clutter → can add to development time and costs as well → indirectly confirms the process of micro segmentation **(Stokking)** **2.Reiteration circle** **Usage of data analytics capabilities as a feedback to the NPD process** Consumer-centric product development & quicker product iteration → beneficial for development time and costs **(Philipsen)** Easier for established firms Vs. difficult for start-ups **(Effing)** Looking back in hindsight → need to consider other measures as well such as competition assessment & key user identification **(Stokking)** **Product design improvement** Difficult in hardware Vs. easier in software **(Philipsen)** A part of the agile development process **(Effing)** Radical new product design Vs. improving existent product design **(Stokking)** **Role of historical data**

Data analytics not enough → need to have clear ideas about the specific industry & R&D process **(Effing)** Signals waste, efficiency loss & key mistakes **(Effing)** **3. CIP** Software updates can patch security issues & can add functionality later **(Stokking)** **4. Customer micro segmentation** Difficult in B2B Vs. easier in B2C **(Philipsen)** Marketeers require a shift in thinking from mass market groups to granular customer groups → long-tail marketing → creation of new markets → new kinds of services **(Effing)** **5. Co creation** Making use of existing product in unexpected ways **(Stokking)**

New insights from the experts	
Reducing the development cycle-time	**Reducing development costs**
1. Universal Sole reliance on IoT data not enough → data triangulation from multiple sources **(Effing)** Management of conflicting user needs **(Stokking)** **2. Heightened complexity** More focus on finding the right Human Resources **(Philipsen)** Technical complexity & barriers might propel companies to try out different things **(Effing)** **3.Data collaboration** Data sharing standard difficult to achieve & GDPR will act as a hindrance **(Effing)** Setting up an interoperable data collaboration platform takes time **(Stokking)**	**1. Universal** Fixed costs of setting up IoT infrastructure very high → running costs very low **(Effing)** **2.Additional budget** Costly & time-consuming consumer research becomes redundant → development costs decreases **(Philipsen)** Contingent upon the degree of willingness of a firm to become a data driven company **(Effing)** The entire business process being changed → from being a pull-strategy company → making it more push-based **(Stokking)**

4. CONCLUSIONS & RECOMMENDATIONS

After having assessed the findings of the literature review and expert interviews, the following conclusion can be drawn (depicted in **Table 3**) concerning the research sub-questions since answering them paves the way to answer the main research question.

Table 3 What is the possible impact of IoT on the success factors of the NPD process?

Can the data generated from IoT help to -	Summarized answer
augment the product's fit with customer needs in the NPD process?	This research presented strong evidences i.e. eleven sources (comprised of eight articles and three expert interviews) were very optimistic and believed with quite certainty that IoT can indeed augment the product's fit with customer needs in the NPD process.
reduce the product's development cycle-time and costs in the NPD process?	Seven out of eight sources (five articles and three expert interviews) acknowledged in both cases, IoT could play a facilitative role in restraining development cycle-time and development costs but worries such as humongous initial investments for the IoT stack, modification of existent business processes, struggles with talent management and sluggish development of inter-industry data collaboration platforms coupled with EU's data protection regulation (GDPR) might impair the speediness of the development cycle-time and escalate developments costs.

This thesis served to investigate the possible impact of IoT on the success factors of the NPD process. As a result of the literature review and expert interviews, this research was able to identify various determinants which can affect the success factors both positively and negatively. **Table 4** which is depicted below, indicates the likely consequences with regards to whether smart connected products data either enhanced or imposed threats on the three accomplishment factors of the NPD process appertaining to various literature sources and expert opinions. The positive consequences, designated as "+", can be exploited by product development managers and the negative consequences, designated as "-" can be averted by pursuing the **Management Priorities** (discussed in subsection 4.1).

Table 4 Likely consequences on the success factors

Various sources	Success factors		
Literature	**Product-Customer fit**	**Development time**	**Development costs**
Tata consultancy services (2013)	+	+	+
Cognizant (2015)	+	/	/
McKinsey Global Institute (2011)	+	/	/
Watson IoT IBM (2017)	+, -	/	/
Harvard Business Review (2014)	+, -	+, -	+, -
Cognizant and Economist Intelligence Unit (2015)	+	+	+
Hippel (2005)	+	/	/
Griffin and Hauser (1993)	+	/	/
Zubeldia (2017)	/	+	+
Joshi and Kansupada (2018)	/	+	+
Experts			
Mr. Simon Philipsen	+	+	+
Dr. Robin Effing	+	+, -	+, -
Mr. Johan Stokking	+, -	-	-

Table legend: "/" not addressed by literature nor experts. Expert opinions derived from Appendix I.

The literature sources and experts disclosed diverse opportunities and concrete evidences of how smart connected product data augmented the products' fit with customer requirements. The magnitude of utilizing the reiterative approach to deal with the NPD procedure has turned out to be exceptionally useful as per the vast majority of the literature sources and specialist in this specific circumstance. Organization can use post-commercialization product utilization information or data from past development processes to enhance the characteristic of product innovation and the prospective development processes. Given this context, it is of unconditional importance that companies are outfitted with data analytics apparatus, which could then be subsequently used in the reiteration loop to improve future product design in relevance to elimination of underrated features and the customer's readiness to pay. In addition to that, it can also help companies to avert blunders with regards to exaggerative pricing or misjudging the importance of certain features. One important point to note here is the procedure of using data analytics can be significantly different for established companies as opposed to a newly emerged business. According to one IoT specialist, established companies can very easily combine their readily available datasets to find out new innovation opportunities whereas startups due to their new existence lack consumer data. Another expert adds to this argumentation by mentioning that the reiterative approach might hinder radical new product design improvements since it only enables firms to optimize the same feature sets in future products. Depending upon the individual business case one also has to consider the fact that companies like Apple, Samsung etc. have been very successful with regards to incremental design changes and coming up with more versions of the same product due to the shorter product lifecycles and immense competition. An additional perspective to indicate is the fact that the reiterative approach obliges an organization to always look back in hindsight, which might in turn hinder them to look in the future. Similar to the reiteration loop, it is anticipated that businesses could utilize smart connected product data in the continual improvement process to enhance

the value of an already existent product during the course of its own lifespan. Smart preventative maintenance packages and software updates are two cases, which companies could accomplish from smart connected product data so as to build and increase the post-buy value of a product. Few instances are patching security issues and adding software powered product functionality at a later stage. Besides, from a B2C point of view, client-product fit can be significantly amplified by recognizing and satisfying the requirements of granular customer categories. Such a method can help businesses to identify tiny market segments with great precision and also down to individual level. A distinct observation to note here from the expert is the B2B perspective. Customer micro segmentation within this sector is an ambitious procedure because the B2B market is not mature enough (lack of a substantial business customer base). Given the advancement of the IoT, B2B markets might also profit from this in the near future. Finally, with the assistance of IoT coordinated voice of the customer research (a front-end co-creation activity), organization can pinpoint articulated as well as latent customer needs which is irrefutably a superior method in contrast to other time-costly, money-costly (favorable for development time and costs as well) and imprecise conventional methods. It can likewise empower firms to obtain interesting insights if customers are making use of an existing product in unexpected ways, which might open up a new business opportunity. Despite their positive anticipations, there are some important obstacles which might to some degree constrict the path towards enlarging product-customer fit (also applicable to development time and costs). The most eminent concern is the heightened complexity of the IoT environment which is straightforwardly repressing the data analyzing capacities (countermeasures explained in section 4.1). Notwithstanding that, firms are likewise struggling to decrease the complexity with respect to consumer usability of the product due to the shift of capabilities from the physical product to the cloud. Furthermore, from an expert point of view, the utilization of smart connected product data can be considered a phenomenon which identifies a lot of conflicting needs of different users which might consequently create a lot of clutter and cripple the firm's endeavor to enlarge product-customer fit. This is very interesting since the expert's argumentation confirms the notion of customer micro segmentation in directly, as it determines various customer needs, which could subsequently help companies to target various customer groups in multiple market segments.

Concerning the second and third achievement factors, several positive outlooks were acknowledged here as well. It is anticipated that in the IoT sphere, software or software updates (refer to CIP in section 2.4.1.2) will be the fundamental deliverer of value rather than hardware. Given this context, it can be deduced that the development time and costs will diminish when elementary software updates can perform and operate as new products. In addition to that, it is also predicted that smart connected product data can essentially decrease the general requirement for multiple hardware reiterations due to its revelation of real-time insights (the probability of making major hardware development mistake reduces). A further imperative instrument which can lessen development cycle-time and costs, is the IoT induced predictive analytics, which businesses could exploit throughout the FFE stages in order to administer a full-fledged IPR analysis. Additionally, it also helps in having a decent perceivability of supplier data. This approach can be co-related with the broadening of supplier data interoperability, which therefore diminishes the overall complexity and the corresponding development time and costs. Moreover, due to the rise in smart product economy, the customary product economy is undergoing an alteration towards a mutually dependent product economy approach where businesses have more access to external resources and uncertainty is reduced by sharing the risks (remedy to the drawbacks mentioned by Crawford and Benedetto (n.d.) in section 2.3.3 and "innovation race"). Nonetheless, there are likewise some major concerns or obstructions which may bring about higher development time and cost surges. Both literature and specialists asserted that building and supporting the new innovation stack of IoT would demand firms astronomical starting venture and at same time businesses would might have to change their entire business processes, resulting in the expansion of development time and costs. One expert was very assertive about the fact that once these frameworks and business forms are built up, the running costs could be at a certain stage very low. Furthermore, the "innovation race" phenomenon might limit sight of developers to focus on other efficient developmental solutions. Contrarily, to the mutually dependent product economy approach, some experts dispute that co-operation between companies could be impeded or deterred due to the fights over data sharing standards and the subsequent establishment of an interoperable data collaboration platform will take a lot of time. To make matter even worse, the GDPR would bring along even higher levels of uncertainty.

4.1 Management priorities

There are some notable concerns which reappeared almost throughout the entire length of this research and its negative implications can be avoided by accomplishing the following recommendations. As mentioned previously, heightened complexity is one of the biggest hindrance since it negatively affects all three success factors. The boost in the complicatedness of the IoT environment burdens the data analytics competencies of organizations. In order to enhance data analytics capacities and with that augment product-customer fit and reduce development time and costs companies should strive to make all their manufacturing equipment (also suppliers data) datasets interoperable and link them to their ERP systems. This argument is also assuming that the production equipment is already outfitted with low cost sensors. The interoperability is one of those effective knowledge management practices which helps to analyze data more conveniently and thus reduces the overall complexity. Another method which can be utilized by companies is by precisely examining how a product component was constructed in the past and what potential restraints it encountered. This encourages the development of brand-new parts and advocates standardization by accumulating old parts from current databases. By promoting standardization, complexity could be further reduced, which in turn reduces development time and costs. In addition to that, this research recommends the product developers to engage in more IoT coordinated voice of the customer research to decrease the complexity with respect to consumer usability of the product interfaces.

5. LIMITATIONS & FUTURE RESEARCH

First and foremost, one of the main challenges while conducting this research was the scarcity of scientific literature in the context of IoT and innovation management. The IoT being a fairly current phenomenon, it is simply starting to become an intriguing topic for the academic world. As a result, several of the articles which were used might have had limited empirical validity since they were based on management magazines. Furthermore, it also proved to be very difficult in order to find experts who were willing to shed some light on this topic out of their busy schedules. Out of thirty-seven email invitations only three experts responded. This implies that due to the limited sample size, the insights which were provided by experts are not depictive and representational of the point of view of all IoT specialists. In addition, since only subjective and qualitative data was acquired, the outcomes might only just convey a sign of conceivable connections between the various interview questions and the three success factors but does not infer any causal inference between IoT (smart connected product data) and its positive impact on the three success factors.

One of the most debated topic in this research was the proper management of complexity and whether complexity could actually propel companies to develop more sophisticated data analytics capabilities and knowledge management techniques since the opinions of both experts and literature showed quite a lot of differences and anomalies. So, maybe it would be quite interesting to further research the impact of IoT on managing heightened complexity of the IoT environment. Furthermore, there are different organizational roles within the product development process such as operational level roles, strategic level roles etc. It could be very fascinating for the academic world to know which of these roles is going to make the most use of IoT data and how, given the inherent complexity of the IoT environment? How would it change the relationships between these different roles within the product development management team? Service economy has taken shape in recent years. Products nowadays have a much higher service element in comparison to previous years. More and more companies have vested interest in the servitization of products. Given such developments, another intriguing topic which this research did not consider is the impact of IoT on the development of new services or servitization of products. Having mentioned that, IoT is a game changer for both businesses and also for the economic prospects of a country. Why not start with an IoT integrated New Product Development process?

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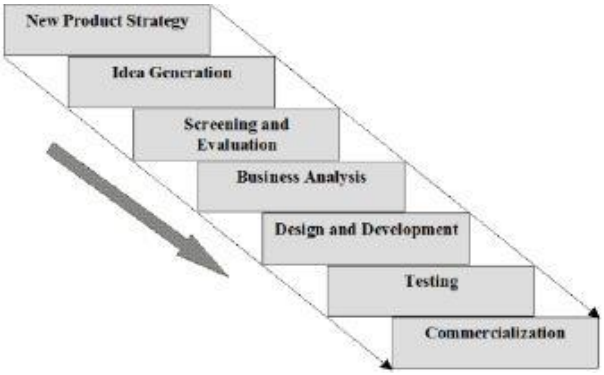
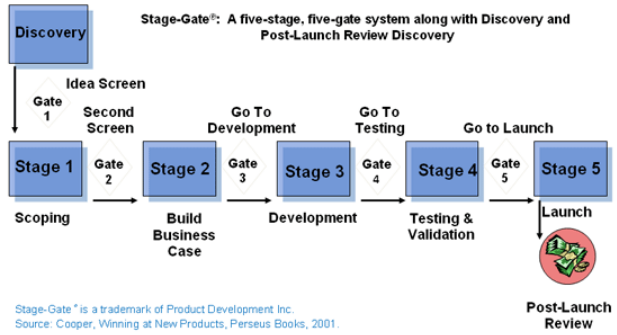
7. APPENDIX

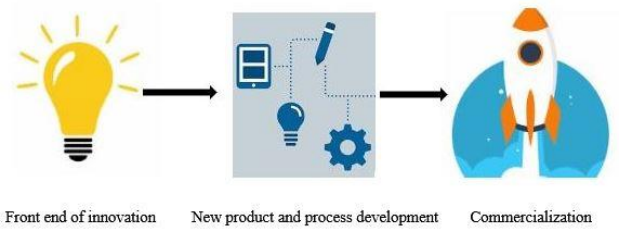
A. Figure 1 Seven Steps Model (Booz et al., 1982)



B. Figure 2. Stage-Gate model (Cooper, n.d.)



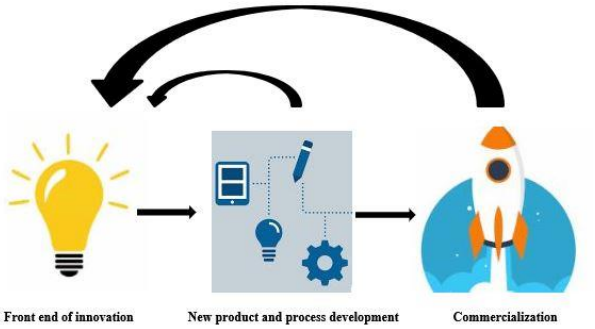
C. Figure 3. Simplified NPD



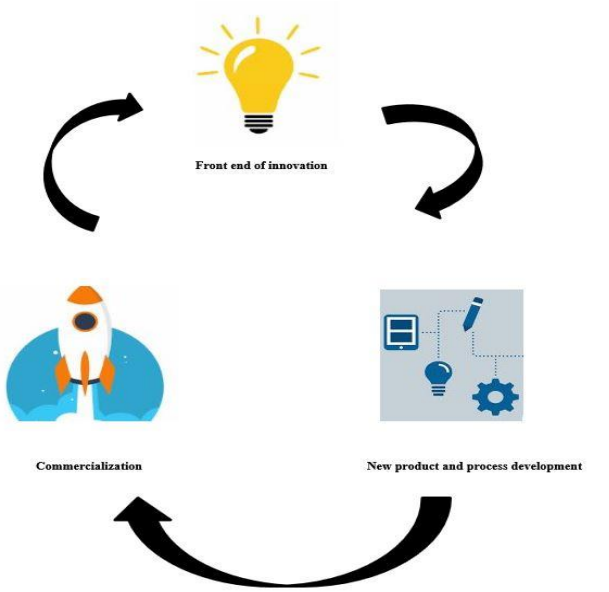
D. Table 1. BAH- and Stage-Gate model combined

Simplified NPD	Front end of innovation	New product and Process Development	Commercialization
BAH Seven-steps model	Idea generation, Screening and Evaluation and Business Analysis	Design and Development and Testing	Commercialization
Stage-Gate model	Discovery, Scoping and Build Business Case	Development, Testing and Validation	Launch and Post-Launch Review

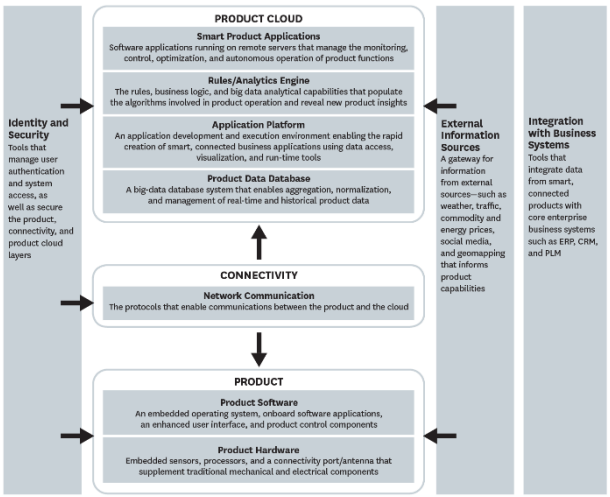
E. Figure 4. Reiteration circle of the NPD enhanced by IoT (derived from Figure 3)



F. Figure 5. Continual improvement in the NPD process (derived from Figure 3)



G. Figure 6. The new technology stack (Harvard Business Review, 2014)



H. Interview questions and original transcript of the expert interview

Interview Questions:

Augmenting the product's fit with customer requirements

1.What is according to your opinion the impact of Internet of Things on the capability to augment customer needs in the New Product Development process?

Reiteration circle

1.1 To what extent do you think it is necessary for firms to establish data analytics capabilities as a feedback to the NPD process, in the context of augmenting the product's fit with customer requirements?

1.2 To what extent can the reiteration circle be used to improve product design?

1.3 To what extent can historical data (i.e. data from past product development processes) be used to enhance the development of new products?

Continual improvement process

1.4 Can smart connected product data allow products to become much improved during its service?

Customer micro segmentation

1.5 To what extent do you think smart connected product data can help determine the needs of particular customer groups?

Co-creation

1.6 To what extent according to your opinion can IoT identify articulated- and latent customer needs?

Reducing the development cycle-time

2.What is according to your opinion the impact of IoT on the development cycle-time of the New Product Development process?

Heightened complexity

2.1 Given the inherent complexity of the IoT environment, what impact will it have on the speed of the New Product Development process?

Complex inherent IoT environment propelling data analytics (Big Data) capabilities

2.2 Given the convergence of IoT and its associated data analytics capabilities, what impact will it have on the speed of the development time according to your opinion?

Data collaboration

2.3 To what extent do you think the data collaboration of product developers and third-party suppliers influences the speed of the New Product Development process? What kind of challenges can be expected in this context?

Reducing development costs

3. What is according to your opinion the impact of IoT on the development costs of the New Product Development process?

Additional budget

3.1 To what extent would you consider the development costs to increase given the additional budget requirement for the Internet of Things?

Interview Answers:

Augmenting the product's fit with customer requirement

1.What is according to your opinion the impact of Internet of Things on the capability to augment customer needs in the New Product Development process?

Respondent 1: Simon Philipsen

KPN mostly works in a B2B market (active, most successful and mature market) and I'll try explaining using the B2B perspective. We sell all kinds of IoT solutions for business enterprises. There are basically three reasons in investing in IoT. First one is gaining efficiency in whatever way, could be in processes, could be in transportation, could be in cost. For example, we have a customer who is always tracking his container assets through our IoT services. For doing that, he has of course a pretty big investment to make. He has to purchase 10 000 devices. And also, of course paying for the platform and connectivity that we offer. Before doing that, he has to make a business case forecast. This will cost me this and that much and what will I gain from it. So, how am I going to integrate the IoT solution in my current existing processes. For example, he already has probably some processes around the retrieval of his containers and the invoicing of these containers (He rents out containers). So, there are three motivations for working with IoT solutions for a business customer. First one is efficiency, and the second one is new customer value. So, let's say again in this container with the tracking solution, our customer who rents out these containers to his own business customers, he can give a much better insight to his customers, where his containers are, if they are being used, gaining predictive analysis about will they get out of stock or whatever. By doing that, his customer will gain competitive advantage over other container rental companies and they can offer more insights in their business process and with that they will add new customer value for their own customers (at least for the next two or three years). The third one is that we see new business models and with that he will totally change his way of earning money. That will be the biggest disruption for our customers and for his company because he will have a totally different way of doing business with his own customers, maybe he can find new customer in new markets by offering different solutions and that's only because he has more insight into all the data that you gather through these IoT devices. So, for example we just closed the deal where we launched the new solutions for insurance company in the Netherlands. They insure bicycles for consumers. So, they give all their new consumers who purchase new insurance, they give them a device for free. The consumers know where their bicycles are and if they are being stolen. If yes, they will be retrieved by a retrieval company. With that they get much fewer claims. So, they have changed their entire business model around their insurances is cost based because their cost lay around paying. And now they have a totally different approach, they have much fewer cost on the claims. They have an investment to make on the IoT but with the fewer cost they can get into a different business and they can approach the customers with other business and pricing models. IoT is just another data source for companies to use in their commercial strategies, in their commercial goal to market. If they know better about their own assets or about the assets of their customers, they can advise them better, they can service them better, they know better what products to use, they know better what services to create. Let's say if this bicycle insurance company, they are rolling out their solution now. So, in a couple of years all of their customers will have an IoT device and all of those devices are one data source, very concrete data source about that specific consumer. With that you can have a huge competitive advantage in knowing your customer much better such as customer behavior contrary to companies who don't have these IoT solutions. Another example for the container business. Couple of years back, container rental companies and distributors, they only know when their container arrived if some manually registered it in the system. So, let's say it is somewhere in the dark and this maintenance person is scanning the containers. So, he knows a bit that the container is now at the Rotterdam harbor. During the journey whenever you know it is not at a place where you don't have a Bluetooth low energy or RFID, they have no clue where the containers are, if they are being used, if these containers have been opened. The market is getting more and more used to being always online and knowing everything, not only your people but also your assets. The containers equipped with IoT devices is providing live insights into the use of the containers. And also, by doing that, they are more in touch with their customers, by knowing what the customers are doing, the customers are knowing better what they are doing themselves. Some customers are renting 1000 containers, may they only need to rent 900 containers. You are creating much more value by showing them how they are using your product pro-actively instead of just sending them an invoice every month.

Respondent 2: Dr. Robin Effing

Let me answer this with one clear example. This is what we see in the world of retail shops that they've, for example, they place these Bluetooth scanners in shops. And these are invisible devices for people, a beacon like technology, and they scanned the Bluetooth activity in the shop. So in by using this technology, they can of course try new shop layout and see how people react on this. So, for the people, nothing changes, but you can really try out new concepts of shop layout of new, even also maybe give people new products and by monitoring them at the same time using Bluetooth technology or Wi-Fi technology, you can see what the effect on is. For example, the location of people, the patterns in behavior for example shopping behavior and so on. An example, how a data from internet of things can help in trying out also new products. And also,

fairly dating, maybe also some ideas about. How these new products effect also walking behavior or maybe waiting at specific place, looking in a certain direction? And the same is true for cameras can also use cameras, and it gives you a lot of data about the behavior of the clients. Taking the example of smart home devices, I think especially here the case is that if you collect and combine a lot of a smart home data, you can of course get a more sophisticated idea and picture of how people behave in their homes. And not only the people, but also you can see what our energy needs in a home, not always consumer activity, but also the let's say the needs of a house and so on. So, if you use big data analysis and also predictive analysis techniques, you can use those data sets about what is the activity in homes in order to already predict whether they need certain new products, or need existing products, or maybe you can already predict that there will be a spark in may be because you see patterns in also relationship between maybe other data sets like the temperature around or a geographical data. Maybe you can predict, for example, at least in this continent, there will be a new need for a specific type of air conditioning, or they will be a specific need for specific type of security solutions. So definitely I believe that you can use the data to predict consumer demand. So, it's kind of foresight activity. There are actually two techniques, we call this also predictive analysis, that's mostly about seeing trends and then you can explain trends and the other one is forecasting. That's also quite exciting because forecasting techniques, you can see their behavior today and may be after a window of three months or six months the other behavior. So, we could even maybe even learn from smart home devices, whether people would need a new car. That seems unconnected but based on the data that could be clear causal pattern. Because you can find many unexpected patterns there. I'm not saying that it is but could be.

Respondent 3: Johan Stokking

I think it's very useful to measure things to have quantitative data and insight available. On the other hand, I think, I can also imagine that it creates a lot of clutter, and you will be having a lot of maybe also conflicting concerns of different users that you need to take into account, and sometimes it's in a time to markets and in a development cost, it can be very good to basically build a product that you think is important or what the customer wants and needs without actually the customer knowing it or listening too much to him or her. So, sometimes some products are like quite innovative, for example, and they are very simple, and if you ask a user, hey, what do you think of these or if you get all kinds of usage data that's in general, that's good. But it can also add a lot of overhead in time well saying, okay, this is the product it's simple and this is our idea can have a very short time to market but I think we come to the reiteration after because it also affects that. I would normally say, with the help IoT, companies are able to develop products which are more tailored to customer needs as opposed to companies who don't make use of IoT. But the affect that it has can actually be a big process of managing a lot of needs that you identify which adds a lot to the development time and costs in general.

Follow up questions regarding: Reiteration circle, customer micro-segmentation, continual improvement process and co-creation in the context of augmenting customer needs.

Reiteration circle

1.1 To what extent do you think it is necessary for firms to establish data analytics capabilities as a feedback to the NPD process, in the context of augmenting the product's fit with customer requirements?

Respondent 1: Simon Philipsen

Being a data driven company is crucial in staying legitimate in your business. If you are not focusing on becoming a data-driven organization, you will probably lose from your competition (depends on the industry of course) between now and 5 years. Even us as a telecommunication company, three years back we were already doing a lot of data driven marketing. We try to understand the customers, when are they logging in, what are they looking at, when are they calling us, when and for what questions are they coming to the retail stores etc. Even a traditional telecommunication company is already working in a data driven manner. The trend is getting stronger and stronger with implementing IoT. Because with IoT, you are adding a huge amount of data to your processes and to your business. Whether this data is coming from your customers or whether from our own business process or whatever. So, becoming data-driven is absolutely crucial. We really have to understand our markets and customers much better. Again, the container example once more. Their business was, we rent out containers. Probably in the 4Ps, they probably did something about place (easily accessible) and price. That probably has been the case, for many decades. You can rent containers and if you rent them it will probably cost you X number of Euros per month and we will send you an invoice every month and our account managers will visit you twice a year. So, that's the only contact you have. So, you are contact with your customers let's say by annual meetings and invoices. If you are working data driven, you will have some much more contact with your customers, you know much better what your customers are doing. This way you can iterate much better and much quicker than just once or twice a year. By using the data, you can steer your product development. Are you implying that IoT helps to reduce hardware development time? This is a different case. Looking at the hardware developers, I think that IoT doesn't really has an impact on the speed of their product development because that's always been the case and they already did lot of co-creations. Let's say this container rental company, they don't produce their own hardware, they purchase the hardware in this case from us because we build an advanced solution with hardware that we sell through partners, but they are changing their business models. In more traditional industries like manufacturing, transportation, retail etc. there is much more data to gather and you can gather that through IoT and by doing that, by setting up your IoT in your processes or together with your customers you can speed up your product development.

Respondent 2: Dr. Robin Effing

Yeah, I think we have to make a distinction between a lot of data streams and intelligent information for I think all products. They also talk about social media data and about web data and all kinds of things. But I do not consider that as the internet of things. Of course. So IoT is also one of those streams in the total landscape of data available. So, I think today it's like you cannot neglect any more that you can get competitive advantage from performing data analytics, using data analytics and performing data analysis. It's a very fast and well-developed method now to get really reliable client data. I think it is very important. Just one example in target audience research for new products. In the past you had to set up a market agency to do this for you and you get in the end really unreliable data, really unfocussed and while the opportunities of Facebook now are decreasing, by using Facebook you cannot get a really reliable picture of the target audience for new products. This, of course, is also different for existing and new companies. For startups, they don't have already a big client-base they can learn from. So, this is sometimes an unexpected advantage of already existing companies they sometimes already have if they combined their data sets, that can really create a lot of innovation potential for new products and services because they already know a lot from their clients. So, what we see is that while startups can move faster but whereas the already existent big companies, they have the data.

Respondent 3: Mr. Johan Stokking

I think this is very important. But it is also I think it's very important, but also good to be aware that this is always looking back, but it's always after in hindsight, while sometimes especially in smart connected products, you build things also a bit more, you have to have a look in the future as well, and I'm not sure if you can derive new requirements or new features in future iterations only from data that you get in hindsight. But it's good to have, you can find out, you know, what is being used and what is not being used and things that are for example features that you want to keep in the new iteration of the product that you can do better, but only basically to that extent, I think. So, you think only using customer analytics wouldn't be that advantageous, you should think of other methods as all? Yeah. Especially, I think with many smart connected products, I think a lot of people don't even know what they want until they see it. And so, there's nothing to measure because people don't have it yet. And so, there are other things, of course, also, I mean, if it was only technical advancements, you know, putting things in the product because it exists or looking at the markets to see what the competitors are doing or identifying some key users that you have a really qualitative conversations with on how they see a product in their context, in their life and what they want rather than just quantitatively analyzing data. It's useful but it's not just the only one measure you take.

1.2 To what extent can the reiteration circle be used to improve product design?

Respondent 1: Mr. Simon Philipsen

Most companies working with IoT are becoming more service oriented. Even the OEMers, even they are let's say couple of years back, they were selling their products as a one-off fee. Now with IoT, because they can monitor their water meters to everywhere in the world, they can change from a product-oriented business more towards a service-oriented business. So, they can for example lease out their water meters or to monthly pay for the water meters. So, it is not only about products, but it is also about services, getting more in touch with your customers through service-oriented businesses. In hardware it is rather difficult. Because for IoT, especially looking at LoRa (long range low power technology). Low power is really important in this context. So, low power means that if I sell you an IoT device (LoRa device) and you put it on anywhere let's say in the field or under the bridge to measure the water level etc., you don't want to move it. The whole reason for LoRa is, for remote locations you put it there and leave it there for couple of years and then you replace it. So, in that case the product design reiteration is not possible because you know in the hardware it is difficult, it has to be right because we are rolling it out and you don't want to touch it for a couple of years otherwise you will risk in having a negative business case. But for the software side, let's say for the application side there is a huge gain in product design iteration. For example, Philips hue. They sold you a couple of lamps and their end-point and contact with you is through the app. So, they know exactly what you are using, are you using a red light, a green light or a blue light. Or are you only using the yellow and the white light. Maybe they should only iterate the products to only white and yellow lights, they don't charge you for the blue and the red lights. If I am selling you a hardware (IoT device), I have to make sure that the data which is coming from the IoT device is coming to me to get to know you as a customer better. If I do that, then I can speed up my product design iteration.

Respondent 2: Dr. Robin Effing

Yes, if I interpreted it correctly, I see some resemblance with agile development processes. I think we increasingly the importance of having a quick, post-commercialization user feedback in order to continually improve and come up with more versions of the same product because competition asks for this. If companies do not do this, you cannot make it right anymore with a big marketing budget, because people in a transparent world, people will say that your product or service isn't good, and that will affect your performance. So, I think I really encourage doing it with such a move.

Respondent 3: Mr. Johan Stokking

It basically comes a bit back on the previous answer I think. You can see I think sometimes you will see some features that people may use products differently over time the longer they use them and the older they are. And so, I think it gives definitely insight in what is being used in what are the really strong patterns on how people use specific products over time to optimize your products again. Still it's optimization of the same feature sets in future product and it doesn't enable you to come up with radically different product design. So, a major influence, not really. Unless you really started, if the goal is to do very iterative product development in general and start with a very simple NPD where you know we just try something out, then it will probably have a major influence. But over time after a couple of iterations and if everything is still in hindsight, then you optimize to a point where you think okay this is good for now, but it will not give you insight on what new features you want to do or how things could be done completely differently because you always have the reference of your first design. So, you already have that anchor and that's your context. I wouldn't say that the reiteration circle has a major influence with regards to improving product design.

1.3 To what extent can historical data (i.e. data from past product development processes) be used to enhance the development of new products?

Respondent 1: Mr. Simon Philipsen

No comments

Respondent 2: Dr. Robin Effing

Yes, I think not there are a lot of opportunities not yet being used enough because especially you can see may be also in product development cycles at factories and so on, and it laps every time they start over. While, maybe when someone is going to look at the data, from maybe what are the most key moments in the development process in terms of quality in terms of maybe cost or waste you can calculate maybe predict or been using predictive analysis to see may be these are factors in the next project you should go avoid and maybe do this or that. So, I see some of opportunities there and specifically the historical data sets. And now we also have the processing power with big data algorithms to look just for patterns first before having all kinds of ideas and theories of how things work. But also, recent research shows that you also should have some clear ideas about how does this R&D process work. So, you cannot only let it up to the computer, no, you have to have an idea about the R&D process and about the specific industry and together with data scientists, for example, you can really learn from past and to see what to avoid. At least you can also signal waste. You can signal efficiency loss. Also, maybe key mistakes. But that won't guarantee that if you do it otherwise that it will be better. In product development, especially when you want to innovate, sometimes you need mistakes as well to learn. So, it's not only I think you have to be a bit humble in expecting to learn a lot. You can work more efficiently but not more effectively.

Respondent 3: Mr. Johan Stokking

It can to certain extent help companies to enhance their production processes with the help of data triangulation from diverse preceding processes but just like I mentioned previously, it hinders radical innovation

Continual improvement process

1.4 Can smart connected product data allow products to become much improved during its service?

Respondent 1: Mr. Simon Philipsen

Yes, it can, especially with the more advanced IoT products and even with LoRa. You can do a lot of firmware and software updates over the air. You can enhance settings, you can change configuration. Let's say if again the water meter. Let's say the water company only needs to check the water meters of every households once a week to start with. By doing that they know already enough about their own water distribution and producing of clean water and invoicing the consumer. But let's say they have to cut costs because producing and distributing water costs a lot of money. So, may be if they know more about water meters of every households and they change the configuration of the device over the air by sending an update. By doing that they can gain for example 20% of water distribution and by doing that they have fewer costs. It is comparable to your laptop, cell phone etc. and you can do the same with IoT. That is very important to take into account when you are rolling out an IoT device. Especially, these water meters since they will be in the field for 15 years. So, if I am placing a water meter now, it has to be working for the next 15 years but more importantly it has to fit the need that a consumer will have in 15 years. Sometimes you can therefore decide to add more sensors to the device or add a stronger CPU unit in the device. You also have to convince your customers, customers are always about pricing. They are always probably debating about pricing. If you still want a good product in 15 years you probably need to add this and this and that now already because the developers don't want to touch the device manually for 15 years. Son, in this context software updates become really valuable.

Respondent 2: Dr. Robin Effing

What we do see is that there should often be a more direct link between maintenance data and service requests and more directly connect them to the updating processes of the new product releases. So now many companies those are like different silos of the company. And it takes a while before the customer feedback really enters the R&D department again. And you can make a big, big improvements there.

Respondent 3: Mr. Johan Stokking

Yeah, critical. Smart product data can help to devise software updates. If you don't have an update channel to an end-device or to a product, I wouldn't even go to market with that on a large scale. We see software updates very critical first of all to patch security issues but also to, for example, to add functionality later or even have a generic device that you can, and I think it's also later on in your questions that you can adapt precisely to specific user used case. Do you make any smart products? Yes. Do you also roll out continuous security updates to your products? Well, we are building a network that allows for updating end-devices and it can be our end-devices. We see end-devices that can be updated, and we also see a lot end-devices that cannot updated. But I think it's credible. Okay. Are you completely involved in the development process the devices you manufacture? Yes, I'm involved but I'm not on a very deep technical level.

Customer micro-segmentation

1.5 To what extent do you think smart product data can help determine the needs of particular customer groups?

Respondent 1: Mr. Simon Philipsen

In the product development of IoT and also in the business case development of IoT, especially in B2B takes time. Since not all businesses are ready for IoT. You have to understand that you are operating for example 10 thousand containers. You are connecting all them. The next day you have to change all your processes (the way people work, your IT infrastructure, your logistics etc.). So, the time for setting up IoT until rolling out 10 000 devices takes a lot of time. So, niches I'm not really sure. The market is not mature enough for that. There is still a lot of manual work and lot of stuff to find out before you can get into niches. However, in the B2C market there could be niches. You already see a lot of the niches for example for elderly people. There are already products in the monitoring of elderly people. Not only their health, but also their location. There are lot of instances where people are not very mobile anymore, they can still use a tracker when they are getting tired or getting lost or they trip, they are much more confident if they are using an IoT device. The elderly person pushes the button, and somebody picks them up. So, that is something you see in the healthcare market and in a way, it can be considered a niche in the IoT market. So, in the consumer market you already see some of it. Just to some up, some product data can help determine needs of particular customer groups in the B2C market and it is rather difficult in the B2B market. The product development especially the electronics is still very expensive, and it is very time consuming and resource consuming for to build a good IoT device. So, if you have 20 assets that needs to be monitored in a specific way, you have to invest a lot of money. A used case example is the money transportation. It is worth to track valuable assets and it is worth to pay a lot of money for it. That could be a niche. We have been talking to even jewelers since they are handling expensive personal adornments on a day to day basis using specific transportation mode. There could be a niche market for that. However, it is still a matter of business case. Are they willing, what is the true value of the investment. It is mass market first, then niche.

Respondent 2: Dr. Robin Effing

I think we currently need a shift in thinking about segmentation and customer groups. I think it's a big issue now in some traditional marketers keep thinking in big market groups. But with the technology of today and distribution options of today, you can really think of very niche markets and very small consumer groups and then it still be relevant and still be of value. So, this is called the long tail marketing I really believe in that and depending on the extent to which you can digitalize products. The more you can digitalize or electronically distribute the products on the surface, the more you can think of very tiny user groups, even to individual products. So, do you think that smart products data is going to play a big role in terms of meeting the demands of niche markets? We have new sources of data predicting being able to predict specific product needs, and maybe even you can use that to create even now new markers that do not yet exist and create new value. So, companies will rise now tomorrow. We think of using this kind of data to offer may be very specific with different kinds of service and products that people are really willing to pay for definitely.

So, markets will get smaller and smaller, and I don't believe in the mass media, depending on of course, there are also still have to have certain big products that serve a big market for example there always will be a milk market and gasoline market and that kind of things, but also now I can think of very specific products today. For example, tomorrow I can buy a bike which is unique in the world, completely fitted to my needs. And the bike manufacturers who can do that and who can give me my personalized bike as fast as possible for a reasonable price that will win the competition. Same has been through you see even Nike and Adidas doing that, by letting the customers customize according to their preferences.

Respondent 3: Mr. Johan Stokking

No comments

Co-creation

1.6 To what extent according to your opinion can IoT identify articulated- and latent customer needs?

Respondent 1: Mr. Simon Philipsen

I think there is quite a lot of latent needs in IoT because the technologies in IoT are rather new. So, taking the example of the iPhone, ten years back it was a product which could considered as a latent need. But now buying a cell phone is transforming to an articulated form of need. The same goes for IoT. Taking the example of KPN's collaboration with the bicycle insurance case, we did a lot of co-creation with the insurance company and they had some articulated needs (for example, the bike needs to be tracked etc.) However, they were not really acquainted with the technology, there were also many latent needs that we had to discuss with them. It is definitely both. Also, the example of the water meters. Articulated needs in this instance was: I need a very cheap water so that I can monitor every once a week for 15 years. The latent need is probably, we should have come up with and told our customers that we think that in 15 years you have much more different needs and much more variety of needs, that's why we want to add this and that feature already to the product. There is definitely both. For a lot of new technologies, there is a lot of latent needs. So, it is a product push in a sense. All in all, 90% of the businesses will between now and 10 years will use IoT in some form. But the most important thing about IoT is the way of gathering more data and what you are doing with the data. It is crucial that you become a data driven company otherwise you will not have not enough information on how you can serve your customers. And that is what something you and I are constantly demanding, we are giving constant feedback whether we know it or not about all the apps that you and I are using. We are giving constant feedback about all the technologies we are using and that will become more and more the case in the B2b market as well. With that IoT will have a very important role to play.

Respondent 2: Dr. Robin Effing

No comments

Respondent 3: Mr. Johan Stokking

IoT can very much by identify latent customers' needs by analyzing indeed, how users use something. They will find a way through functionality which gives a lot of insight into how they use the products that you would not have thought of how they would use it before and also, I think that sometimes device makers can introduce new functionality where users are like "oh, that's super nice and handy" where they never really realized never articulated before. Just by measuring how things were being used, yes definitely, I think so. A good example would be: yeah, I think a lot of smart features in cars where people thought that they have never used and also would not come up with until the car maker introduced it because they were able to identify certain needs with the help of IoT data. And you can measure things, you can automate things or have buttons or things to automate things that users would otherwise do manually in car like Adjusting the mirrors manually each time and that the car makers thought, let's make a key for example, the women and the men, if they put in their own key, then the mirrors would adjust and their seats as well and that kind of stuff. I think a lot of people wouldn't come up with that without the data. It is something that you can really find from monitoring how things are being used definitely.

Reducing the development cycle time

2.What is according to your opinion the impact of IoT on the development cycle-time of the New Product Development process?

Respondent 1: Mr. Simon Philipsen

I don't think it has a huge impact on the speed of the product development. I think there is a huge impact on the effectiveness of your product development. If you can use your data more and more, you will be much more effective with regards to development time and the products you are making and there will be much more chance that your product will be successful.

Respondent 2: Dr. Robin Effing

I believe you can limit the time lag. What you currently do right now is for example you ask people to expect what they say, there is always a bit of noise between what people say in what they do, and you have to ask them, and you have to do research. I could think of a way of using more and more let's say the data from devices directly so that you can more speedily get this real insight and with what is happening, use characteristic and use patterns etc. However, never will be, I think the only way to go, I think you always need also, you can also use information from social media data information from regular client, questionnaires and so on. To add up, I think you need triangulation of

data. You need multiple data sources, not only IoT data, to further speed up the development cycle time on what you want. But yes, I kind of believe that some processes can be more efficient and faster. Because you get to know a lot of consumer behavior and new processes and products without asking them you can directly use the source of the data instead of asking people. Will the vast amount of unstructured data affect the development time? No, not at all. If we're talking about needing more time, that will be milliseconds, maybe seconds. The computer power now is tremendous and it's not a problem at all. The processing power is no more a problem. Even the more advanced algorithms can run within minutes.

Respondent 3: Mr. Johan Stokking

Well, I think first of all, if to make an existing object connected, that was not connected before. It actually takes way more time than most people I think expects. Because you have to deal with whole different power constraints, batteries, communications, certification, security etc. One example is the smart mousetrap which is basically just a mouse trap, but then it sends a message to the owner when it's caught a mouse. And if you look the development process that can take years and just make to make it connected. Because it changes so many things. Well, I think it's going to increase a lot. But from a different perspective, in this case, using IoT data retrieved from let's say smart industries or industry 4.0 or smart products, it could be that the development time might decrease to a certain extent since you are able to take certain decisions quicker due to the availability of more insights which can be taken into account. I think it also comes a bit to the very first question. That you may find a lot of conflicting concerns that you as a product manager want to resolve or take into account and that significantly slows down the process.

Follow up questions regarding: heightened complexity, increased complexity and its effect on data analytics capabilities and data collaboration

Heightened complexity

2.1 Given the inherent complexity of the IoT environment, what impact will it have on the speed of the New Product Development process?

Respondent 1: Simon Philipsen

Human resources are the most important thing. Not only in IoT but you can also see this in data driven companies. Getting your right people is always a struggle for example getting technical consultants, getting software developers, getting data scientists and analysts etc. is the most important thing in that case. Given the complexity of IoT, you need the right human resources in order to have a quick product development cycle.

Respondent 2: Dr. Robin Effing

Yes, you have to acknowledge that these IoT Infrastructures will definitely create a new big stream of data and there will be complex collaboration and interaction and so on. However, the thing is, there will always be these people who quite easily can again use these complex systems. I think it doesn't break you out in development or anything. I think this both technologies and also the knowledge we already have for now, we should not underestimate that. We are really capable of handling that. I don't see any barriers there, not based on the plethora of storage need and that kind of things. And no real technical barriers and the complexity also is an advantage because now you have to try out many different things and people will definitely do that. So, I don't see a real barrier there.

Respondent 3: Mr. Johan Stokking

No comments

Complex inherent IoT environment propelling data analytics (Big Data) capabilities

2.2 Given the convergence of IoT and its associated data analytics capabilities, what impact will it have on the speed of the development time according to your opinion?

Respondent 1: Simon Philipsen

It is not a matter of becoming a big data company. It is the matter of using the right data. The big risk with big data is getting all your data into huge data lake and then figuring out what I can do with this data. So, u have to think about what if I had this and this and that specific data (such as invoicing data, customer behavior data), that is much more specific and targeted to your business problem, then you can speed up your product development. Big data is sometime a bit misunderstood term. It can be used in a wrong way

Respondent 2: Dr. Robin Effing

Don't overestimate the effects on the development time because given the new tools. The development of a new product or service is very complex, needs also a lot of manual and need staff to think about that. We have to avoid thinking that because we have big data and because we have IT we can solve all problems in product development and that kind of things. You still have to be creative even if you have the most sophisticated hammer available, you cannot maybe be as successful in making sports car tomorrow as Ferrari. So, it needs a lot more than just big data. And so please avoid thinking that only because we can use these data kind of things that we can do miracles with regards to product development. I really would say that please avoid thinking that this solves all kinds of struggles in the product development because product development is especially in innovative process, needs all the creativity and data is a mean to support it, but not more than that. And of course, you can also think of the data creating new products and services and there is a specific category for that. But in general, I don't think you should overestimate that.

Respondent 3: Mr. Johan Stokking

No comments

Data collaboration

2.3 To what extent do you think the data collaboration of product developers and third-party suppliers influences the speed of the New Product Development process? What kind of challenges can be expected in this context?

Respondent 1: Simon Philipsen

This is very important. The companies who are able and seeing that there is a huge opportunity not only using your own data but also using the data of your suppliers and other partners, those companies would gain a competitive advantage because they have more data than their competitors. And I think, at the end of the day it is a business decision. You have to trust your partners and your partners have to trust you. And if they do that and you are willing to co-create and exchanging the data will improve your effectiveness and the success of your products.

Respondent 2: Dr. Robin Effing

That is a big thing. For example, in the car industry now with autonomous driving and so on. No one can really solve the puzzle alone and now they are creating these ecosystems associated with data and BMW is doing that for themselves and Mercedes are doing that for themselves. And sometimes the other parties in the chain like Bosch, they know it better because they have contacts with many manufacturers. But due to the reasons of competition and of commercial competition, they don't share with each other and really putting a strain on innovation. So, this is kind of a barrier. And you need also standards for sharing. That's a problem because in many industries you see this, there is no real standards on how to share their data sets? A difficult thing, for example, in some areas, it is really a problem, for example, the basic infrastructure, creating basic infrastructure for energy or for self-driving and so on. Do you think the GDPR would further constrain the situation? It won't help. It will only make things more difficult for innovation and it'll be difficult. But we do see a shift happening now, we do see that many companies know that they are kind of dependent, they cannot work fully independent. They need each other, and many consortiums are being formed of companies working together to solve problems. And you see many more strategic collaborations? So, this will, of course, be a big deal. Some companies manage to create such great systems of collaboration. That will give them competitive advantage since they have access to more resources and the risks are shared. Companies like, they are big, big, big collaborative things like, for example, apple cannot work without some Qualcomm engineers and the same applies to Toyota where I think they are working together with other big car companies. So, no one is working on his own anymore. So, there I think is awareness already that they will need this. The next step is creating also infrastructures that can help them effectively share that, but it is difficult because of this reason, companies were already struggling implementing these enterprise resource planning systems and the companies think of that. And then thinking for an ecosystem of companies to having a really good data infrastructure, will be definitely a challenge.

Respondent 3: Mr. Johan Stokking

Companies are sometimes very reluctant in giving away confidential information. The reason behind this phenomenon is actually threefold. There's only typically a few parties that actually have useful information about how customers use the product, which is because especially suppliers, if you only provide components then basically the company that integrates those components, is the user for them. And. The second complexity is that, it's really evolves around competitive concerns or the fear of losing competitive advantage. What kind of challenges did you encountered when you collaborated? Well, sometimes you have to be careful with what information from your customer you share. And if you can anonymize it and if it is actually your data. So, if you build a platform that people use, then it's their data and that is not something that we share, and that might also give aggregated usage insights, which gives also a lot of information about how what our skill is in our reach, which can be a business secret information which is confidential. Normally if the data is available, I would say it's good for speeding up the product development process just to reduce the quantity of product iterations. On the other hand, I think setting this up and doing it right in a way, such as making the data interoperable, that takes a long time also. There could be some issues regarding intellectual property rights as well.

Reducing development costs

3. What is according to your opinion the impact of IoT on the development costs of the New Product Development process?

Respondent 1: Simon Philipsen

You are not especially quicker but your becoming more effective. You will be able to push better products in the market and with that fewer products that are not interesting to the market, which would have otherwise costed you money. In that case the effectiveness of your product development will have a positive impact on the costs. In the long term, costs will drop. Let's say you have two different product departments and they are both using some kind of data for example market data, customer focus groups etc. and by using that rather small data source you will built products. But if they see that using IoT data sources, they can build much more specific targeted products for their customers because they know what their customers want, they know it much better than the other situation, it might be able to shut down one of the departments and thus reduce costs.

Respondent 2: Dr. Robin Effing

That really depends on how you use it, of course, but depending on how you do it, the computer capacity won't take a lot of investments. However, if you need good data engineers, data scientists, you need to set up, also link with business consulting. That, of course, could be a big investment and the big bosses on board, since it is difficult to convince them. Some speak of well skilled data engineers and data scientists in the US being paid more than one million a year. So definitely it will not be cheap. Depending on the extent to which you come to design these kinds of things. I know some of the biggest data collecting companies in HR for example, where I talked to some of the multinational Randstad companies. They have created the data lake. They have created a big department of analysts and so on. So, that of course, in the end, the business case is positive, but it will take of course, first you have to create those kinds of systems like innovation and it will cost a lot of money. The infrastructure in itself is efficient and it is relatively to people cost efficient but do not underestimate the investment in infrastructure and the architecture at first. The running costs are very low, but the fixed costs as mentioned earlier are very high.

Respondent 3: Mr. Johan Stokking

I think time and costs very well goes hand in hand because the most expensive part of product development is time. When it comes to costs, this is also a twofold thing. When it is about the IoT product itself, I'd say yes, everything gets much more expensive, connecting it, especially if it's not connected today. And it also keeps being expensive because you have to go all the time through certification and there's a lot of updates on new wireless technologies and stuff. So, that's ongoing. If it's about IoT, that is used to measure and to give more insight in developing new products then I would say sensing or doing sensing right using IoT to see how people use it is also a very expensive solution which implies that the cost basically increases.

Follow up question regarding: additional budget.

Additional budget

3.1 To what extent would you consider the development costs to increase given the additional budget requirement for the Internet of Things?

Respondent 1: Simon Philipsen

You need additional budget for all kinds of software developments and other mechanisms but on the other hand costs might be fewer with regards to all kinds of consumer research that you do because you already get all the data through the proof of concept that you are building and that is another way of interacting with your customers. So, to some extent I agree that it can increase your fixed cost and especially your development costs, but it also has the potential to reduce other types of costs your encountered in the past. Maybe you need to change your sales force, for example focusing more on online sales instead of having a sales force of 20 people. So, once you have established all the IoT associated business mechanism, costs are likely to decrease.

Respondent 2: Dr. Robin Effing

The strategic issue, of course, to find out the sweet spot in terms of, I can also invest too much, and then lose the game. If I completely shift my business into almost being a data company, then I can also get into the scenario where the development cost might increase initially because these people have to be paid and I have to pay for all these IoT infrastructure and computer. But there are examples that big investments pay out to be give a positive business case. I personally was at Zalando office in Berlin. I was quite surprised that Zalando is next to being just a retail company really a data company. They have more than 80 internet marketeers working in Berlin for various countries. And so that's quite different than if you compare to 20 years ago in retail marketing. I am not sure whether of course that costs a lot of money and this also troubled Zalando to make a quite a lot of profit initially. Same is true with Amazon, it is more like a data company than an online retail shop. The key is that you see a shift towards other functions. First, they will need investments. A lot of e-commerce companies were being mocked since many people thought that they were just investing unnecessary money. In the beginning it was true but afterwards these investments paid out.

Respondent 3: Mr. Johan Stokking

Well, we are ourselves are in the IoT and that is our thing. We don't see a change because we don't have a reference point. We do see a lot of people in the industry that are adopting our technology for example and for them IoT is quite new and they realize that IoT can be very expensive to do it right because it is not only the product development itself but often it's also the functionality that may change the whole way the product is being used and that may even be more time-costly and money-costly endeavor. I think again, the mouse trap is a very good example. This is built by a pest control company and by law if you place mouse traps, you have to check them every 24 hours whether a mouse has been caught or not because otherwise the mice is in there for too long. So, the idea is to have mouse traps send notifications which in itself is a long and expensive process to make a smart mouse trap because it is completely different. Starting with the wooden thing with some metal to building everything in plastic. You need certification, battery, software, software updates and at the same time function as a mouse trap that in itself is a very hard process but may be the most time consuming and costly part of it is that they basically have to change the whole business process from pulling and checking every day to not doing that but instead make it push based. So, their whole processes of going by becomes irrelevant and so the whole staffing, resources, planning is also completely different due to connecting a mouse trap and that is a very simple example and we also see that in the supply chain. If you can monitor the supply chain and see for example, adapt to market demands already while products are in the supply chain because you can control things. The most expensive and only the product development part is very important to notice but I think the impact on connected objects in the context is even more expensive and time consuming to adapt to. So, would you basically say like for established companies wouldn't be that much of a problem to adopt to IoT in terms of budget but for new companies, it could become a burden? I think actually for established companies it is a bigger problem because they have their whole processes, their culture adapted to a certain way of working. Smaller companies are way more agile to adapt to new things. If you look at car makers for example, tesla for example as a new company for them it is much easier to incorporate connectivity, self-driving, electric cars but if you do that in BMW that's much harder. It's

just company cultures. Which is not only just making them connected, it is also accepting it and making it part of the entire design team and at the end making it relevant on a board level.

I. Table 2. Detailed expert opinions and overall tendencies

	Philipsen	Effing	Stokking
Augmenting the product's fit with customer needs			
Universal	+	+	+, -
Usage of data analytics capabilities as a feedback to the NPD process (reiteration)	+	+	+, -
Product design improvement through the reiteration loop (reiteration)	+	+	-
Role of historical data (reiteration)	/	+, -	+, -
CIP	+	+	+
Customer micro-segmentation	+	+	/
Co-creation	/	/	+
Overall tendency	+	+	+, -
Reducing the development cycle-time			
Universal	+	+	-
Heightened complexity	+, -	+	/
Complex inherent IoT environment propelling data analytics capabilities	+	+, -	/
Data collaboration	+	+, -	-
Overall tendency	+	+, -	-
Reducing development costs			
Universal	+	+, -	-
Additional budget	+	+, -	-
Overall tendency	+	+, -	-