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DECISION-MAKING AND THE INTERNET OF THINGS

Influences and Impacts on Business Decisions and Supply Chains

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Abstract

Many researchers emphasize the increasing importance of the Internet of Things, the internet-based connection of devices, in relation to business decisions, but there still exists a lack of profound data about decision-making in supply chains that are facing IoT challenges.

The objective of the thesis was to underline, explore and elaborate the influence of the Internet of Things on business decisions especially in supply chain management. In addition, it emphasizes why and how businesses handle transformations. In order to lay a general foundation for the topic, the study was started with defining basic models and approaches, justified with practical examples. All of them were set in the context of IoT and their related impacts. Throughout the study, a critical point of view was maintained.

Qualitative methods, in form of theoretical research, literature review and analysis of 7 business cases, were executed in order to find conclusions about the influence of the Internet of Things transformation among real-life businesses.

The study revealed that decision-making is highly influenced by the Internet of Things in such a way that data is perceived as the significant element. It also showed that entire business models are about to change and there is a great gap for future research that needs to be filled. Rational data are a reliable source, but the final outcome is still highly dependent on the decision-maker.

Keywords

decision-making, data-driven decision-making, supply chain management, Internet of Things

CONTENTS

1 INTRODUCTION

Supply chains are complex systems that need precise concepts for people in order to make decisions. Especially the implementation of innovations is challenging, and the influencing factors to and impacts on the supply chain are wide-ranging. Nowadays and in the future, supply chains are dependent on collecting data by internet-connected equipment to improve the operational efficiency. The Internet of Things contributes to the ability to gather these data and combine the equipment, processes and people.

In daily life, the Internet of Things has already arrived in regard to wearables and applications for a smarter home. The term is not only a hype but truly implies the opportunity to affect and transform businesses and entire industries. Since nowadays businesses compete more and frequently with supply chains, the supply chain management is concerned by this issue. Facing this emerging evolution can lead to unforeseen outcomes, provided that the right decisions are made. That is one of the multiple reasons why accurate decision-making should be precisely considered.

The thesis examines the decision-making within the supply chain by the example of the Internet of Things. Decision-making involves threats and have far reaching positive or negative impacts. Therefore, a well-defined approach to make appropriate decisions is highly significant as well as the role of decision-makers and sources for the decisions.
Decision-making can be considered a topical subject since all industries are already facing and will face a major business shift. However, decision-making enabled by the Internet of Things (IoT) still stands at the beginning of its full development and potential.

The thesis aims to sharpen and analyze how to make decisions in supply chains enabled by the implementation of new software or equipment in relation to the IoT. Therefore businesses with certain experiences are analyzed and finally this

shall completed by insights in order to provide why and how the Internet of Things influences business decisions.
The topics were chosen because they combine three highly significant and promising areas in business life. Firstly, making decisions is part of every moment in life and thus a topic of which everyone should have at least basic knowledge available. Secondly, Internet of Things is an emerging topic with a promising future effecting personal and business life equally. Finally, supply chain management enables competitive advantages if correctly managed and executed. All of the topics played a particular role within my studies and emerged from a very personal commitment. A certain understanding of any of the areas will guarantee good preparation for the future profession.

This paper starts with the explanation of the research methodology and research design. The theoretical framework includes the three connected topics decision-making, supply chain management and Internet of Things. Within these three theory-based chapters, the main ideas and concepts behind and in relation to each of the topics will be presented. After that, chapter 6 outlines how the theories are brought into practice, how the companies benefitted and what kind of challenges they faced. The following empirical part consists of a structured business case analysis with reference to the theories discussed earlier. The conclusion will provide insights as well as a summary of the basic theories, all the findings and the empirical analysis. Finally, the thesis presents suggestions for future development areas.

2 RESEARCH METHODOLOGY AND DESIGN

The research method of this thesis is mainly a theoretical research for defining and presenting the basic and current models and strategies taken from sources in the fields of science and business life. Furthermore, this study will provide a comparison of several approaches including advantages and disadvantages such as those that have proved effective in practice.

2.1 Research Methodology

The distinction of both qualitative and quantitative methods cannot be conducted selectively. In a quantitative sense, it is impossible to cover and examine all cases. That is why a hypothesis can be verified if the initial one should have been disproved.

From a qualitative point of view, the emphasis lies on subjective and individual findings and insights that lead to answers to “how-questions” and “what-questions”. Therefore in this thesis, individual business cases are examined and reviewed for special characteristics whilst the results can be used for inferred general assumptions and statements. The truth and reality are not only dependent on figures and subject itself, its experiences and subjective cases are taken into account. In order to interpret the findings correctly, they are reflected critically. (Silverman 2013, p. 2-9).

In general, because of the openness of the approach, the cases are consciously chosen, which results in theoretical sampling. Due to the flexibility and openness of the approach, it can be also declared as exploration. The actual topic of the Internet of Things without much standardization correlates with this research approach. Hypotheses and theories will be created based on discussed literature. In addition, the research is a combination of qualitative research method and merely theoretical research. An attempt to interview experts failed during the thesis study process, and due to certain time constraints, several business cases are analyzed and taken from literature and were not personally established on the basis of interviews as initially planned.

One of the targets of qualitative research is to explore the interactions of (unknown) phenomena in order to generalize the findings in the form of conclusions (Fahrner 2014)**.** At the end, this will be the outcome of this paper: an attempt to state influences of the Internet of Things on decision-making in supply chains and vice versa. Since current literature do not provide a convincing model for supply chains regarding the Internet of Things, related and widely used

reference models are taken into account.

2.2 Research Design

Qualitative research's default framework of how someone is looking at reality is manifested by positivism. Positivism considers knowledge in any forms obtained by using the senses, experience and participation as reliable reasons. In short in a positive approach, science is the core issue that a person can trust undoubtedly. (Collins 2010). Due to the small number of cases reviewed, positivism is a suitable research design although positivism is not the most suitable concept in every section (Silverman 2013, p. 86).

Therefore, in order to receive new insights and to draw conclusions in the empirical part, an interpretivist research approach will be used. Apart from the fact that interpretivism criticizes positivism, the focus lies here on meanings and understanding the use of various, sometimes even contrasting, methods to explain an issue. While positive approach is descriptive and reveals poor subjective insights, an interpretative approach validly provides comprehensive trustworthiness. (Myers 2013, p. 64).

Although generalizations may not be encouraged because of the personal points of view within the business cases, it remains the aim to establish general assumptions. This is why this applied solution merely works for specific cases. Thus will be ensured that the findings and the personal outcomes are beneficial for everyone.

2.3 Scope and Ontology

Starting with the theoretical foundation, processes and charts will justify the basics of decision-making, supply chain management and Internet of Things. Later it will be discussed how decisions are made within the mentioned management disciplines and how they influence each other and how the Internet of Things influences them. In others words, it shows how influences such as the

business sector or technological progress influence decisions. This will lead to insights into how to make appropriate decisions or what approaches and technologies are significant. Additionally, recommendations are proposed to facilitate decisions in an IoT ecosystem.

For the sake of a better understanding of the different topics which will be discussed in this paper, an ontology is created to facilitate the understanding of the covered areas. Fundamentally, the term ontology is taken from the discipline of philosophy and is defined as the consideration of the subjective existence.

For a business related research, an ontology is simply defined as an image, overview or concept and ideas described as entities and relations to each other. It is proved that something that exists can be presented in a certain form and can be set in correlation and relation to other entities and their inherent ideas. (Gruber 1993).

For practical application, the ontology as defined here is a concept of especially business disciplines and related sup-topics. Thus, an ontology is the overall basis for the following discourse process and literature analysis. The following illustration in figure 1 demonstrates the covered areas.

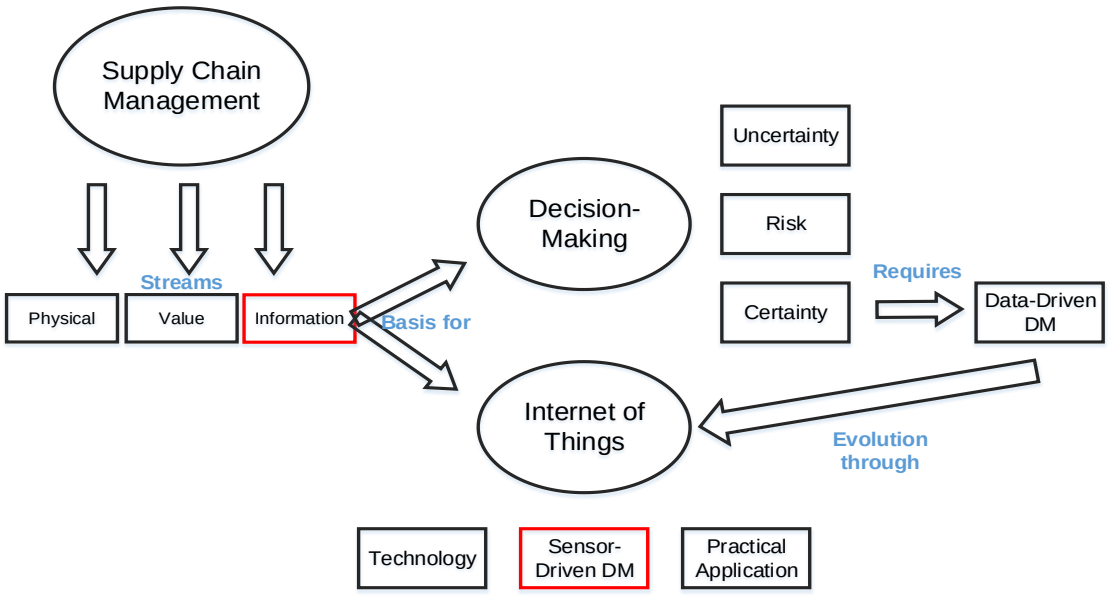

Figure 1. Ontology of the covered areas

One of the core issues within supply chain management is the information flow within and beyond the organization. A proper information supply is normally the basis for effective decision-making nowadays. Nevertheless, there exist many kinds of decision-making approaches under contrasting premises.
As the Internet of Things is a topical issue, the way how decisions are made is certainly affected. Although there has been little research into decision-making concerning the Internet of Things and especially concerning supply chain management, one major change can be seen: the drift from data to sensor-driven decision-making. The aim of this thesis is to clarify the influence on that decision-making approach utilizing common decision making approaches, technologies, supply chain management and the Internet of Things itself.

For the sake of further exploration and extension of the research area, the first two research questions are tried to be answered of whether and how the Internet of Things influence the supply chain management and involved decision-making processes.

- Research question 1: Does the Internet of Things influence decision-making in Supply Chain Management?

- Research question 2: How does the Internet of Things influence decision-making in Supply Chain Management?

- Research question 3: Can a machine entirely replace the human decision-making?

Answering research question 3 is an attempt to find reasons for the emerged fear in the society that machines will replace humans in their jobs or even become independent and conquer the world. However, this is only a small part of the study and can be seen as additional information.

3 DECISION-MAKING

The first chapter of the theoretical part will cover the history of decision-making, decision theories that are approached to decision-making. Since information-based decisions play a particular role in information technology and also in regard to IoT, Big Data as a source of information is highlighted as well as tools to analyse the data.

3.1 History of Decision-making

Chester Bernard is regarded the introducer of the term business decision making. Owing to his transformation of the term from public sector to business sector, a paradigm change evolved. Charles H. Lundquist provides an apt description of the term: "'Decision' implies the end of deliberation and the beginning of action." (Buchanan & O'Connell 2006). Other theorists such as James March and Henry Mintzberg laid the foundation for modern management decision making. In every part of everyday life, decision-making is a pivotal part if not even the most pivotal part. Decision making, described as a cognitive process, covers areas such as mathematics, philosophy, politics and natural economic sciences.

Bernoulli, for instance, tried to create and establish tools to make better forecasts on the basis of a persons' engagement. Neumann and Morgenstern were the founders of game theory focusing on uncertain entities. Another field emerged, called group decision making, further described by Drucker reaching from collective group thinking to the approaches of finding the best work teams. Due to technological evolution, this cognitive process can be imitated by intelligent software for example scenario planning while decisions are still bounded.

Due to the extraordinary work of researcher's in fields of organizational behavior such as Newell, Guetzkow and Cyert, the development of intelligent analytical tools and artificial intelligence made it possible to enhance the decision-making of humans. The first outcomes that found their way to companies were DSS,

decision support systems in 1960 within operational level. In the late 1970's, the focus switched to supporting strategic decision information systems.

During the 1980's, the term "business intelligence" evolved to describe systems used for supporting decision-making throughout the company. With the international establishment of the internet, customers were in the role between deciding and weighing alternative choices. The past ten years introduced the avoidance of risk and recovery of gut-feeling. (Buchanan & O'Connell 2006; Gigerenzer 2012).

From a cognitive more fundamentally point of view, researchers assume the nature of decisions as a merger of different possibilities and impact rates while the decision maker, as executive of decisions, being able to influence the impact by having ready several strategies and approaches. In order to find the appropriate decision among the vastness of information, alternatives (at least two needs to be given), separation and differentiation need to be conducted by these strategies. (Ranyard et al. 1997).

3.2 Decision Theory

The way how businesses nowadays compete has changed dramatically due to the invention, development and advanced usage of the internet. New forms of competition as well as innovative business models are created to survive in competitive markets. In order to fulfill these demands and face new challenges, companies have become involved in process and growth acceleration and expansion internally and externally. In this manner, three main connections have evolved: people to people, people to information and information to information (comparable with machine to machine in manufacturing). The extent to which an organization fundamentally manages and executes their operations is defined by its decisions. (Roberts 2016).

The current literature on decisions and decision-making abounds with many examples how to define decisions. Roberts (2016) propounds the view that

decisions are made constantly and need the presence of judgement. When judgment is not given, the issue is called calculation. (Roberts 2016, p. 2). Roberts (2016) claims that effective decision making arise from superior information about alternatives and is in line with Sharma (2009). Sharma (2009) is setting a strong focus on the quality of the information and underlining its importance for the outcome. Due to excellent information, the quality of a decision will imptove Decisions made in this secure environment with excellent information supply are called decision making under certainty whilst the outcome is known certainly. However, the majority of business situations are based on incomplete information supply considered as decision making under risks and conflicts. (Sharma 2009, p.61).

Nevertheless, decision-makers are trying to predict the outcome as precisely as they can by utilizing personal or secondary data in their calculations. Finally, if information and alternatives are fairly limited or wholly unavailable and the outcome is not likely to be estimated, decision makers take action and decide under uncertainty. This, in turn, leads to using a concept of intuition, creativity and trusting one's presentiment the so called "gut-feeling". (Robbins & Coulter 2016, p. 73-74).

3.3 Decision-Making Approaches

Gaining the foundation for a better understanding on business decision-making is the purpose of the following chapter. Therefore, it is necessary to distinguish different basic perspectives on decision-making and to define the main four decision-making approaches and their limitations.

Fundamentally, it is expected that managers make decisions in a fully rational manner to maximize the outcome in the greatest interest of the company. Still, for a normally functioning human, it is impossible to achieve this. A more businesslike and real-life approach is the idea of a bounded or limited reality. The result is not the most rational, but rather the most satisfying. Limitations lie mainly in the ability to handle the high amount of information and choosing among

alternatives. (Robbins & Coulter 2016, p. 81-82).

The basic premise of Roberts' (2016) theory is similar to Robbins' (2016) concept of bounded reality which says the foundation is fallible humans as decision makers in organizations occurring as individuals and groups with different levels of experiences trying to decide rationally, but often act emotionally and irrationally with fatal consequences. Famous examples of failed decisions have occurred at Toyota, GM and Yahoo. (Roberts 2016).

According to Robles (2012), Yahoo made several wide-ranging mistakes that cost the company's success. The internet firm failed to take over Google in 2002 because Yahoo considered the purchase price extensively high. This also happened with Facebook in 2006 when the company hesitated due to uncertain future prospects of Facebook. (Robles 2012).

Further evidence supporting the theory of bounded reality may lie in the findings of James G. March who outlines how strongly restricted rationality is regarded. The main reasons for the restrictions are found in timely boundaries, lack of attention and incorrect comprehension and wrong conclusions arising due to poorly defined objectives (March 2010, c1994). The decision-maker's habits, behaviors, desires and the extent of activities additionally are playing a particular role. (Ranyard et al 1997, p. 11).

Buchanan & O'Connell (2006) point out that making decisions on an entirely rational basis without emotions is unattainable (Buchanan & O'Connell 2006). Humans often trust their gut feeling or intuition. This second principle is characterized by the decision-maker's knowledge, practice, emotions, ethical standards, experience of similar problems in the past or even the subconscious mind helping them to find the right choice. (Robbins & Coulter 2016, p. 79). This principle is more common than expected since approximately 50% of managers are using this principle of gut-feeling in their everyday business activities (Miller & Ireland 2005).

From a consciousness point of view, intuitive decisions are related to absolute decisions but in weaker form. If a person is entirely convinced about regarding and identifying the truth due to their spiritual conviction and adaptation, and the results are quantifiable and correct, the decision is called absolute. As a consequence, absolute decisions are seldom made. The opposite of absolute decisions are relative decisions when one has to take into account data or knowledge. (Voss 2014; Young 2006).

The fourth and final decision-making approach considers evidence, particularly data, as the focal point. An alternative term for this sort of decision-making s technical rationality. Solid evidence is *the* enhancing factor in a decision-making process. This is the course this paper aims to follow (Briner 2009, p. 22).

Thus, in conclusion, the flawless idea of a decision can be considered as “cold, hard and logical” to avoid failures. Therefore, decisions are better off made by machines or computers using analytics, business intelligence (BI) and decision support systems (DSS). Business intelligence contains the recognition and analysis of relevant data and relationships of data concerning sales or turnover to make better decisions. Decision Support Systems assess possible actions by using computer power and decision theory. (Sauter, 2010). Both DSS and decision theory will be explained later in this study. Nevertheless, the wide and common use of these systems and a critical reflection is a crucial aspect to create a more precise and broader picture of the topic.

3.4 Management Decision-Making Process

Making the right decisions is important because the impacts stay permanently and may reach from harmless to extensively serious. Fundamentally, decisions are the essential management function. A decision consistently implies choice and is the foundation for further actions. Rather than a mere act of deciding which alternative to choose, management decision making is an entire process with several steps.

Robbins & Coulter (2016) describe basic management decision making as a sophisticated process split into eight steps.

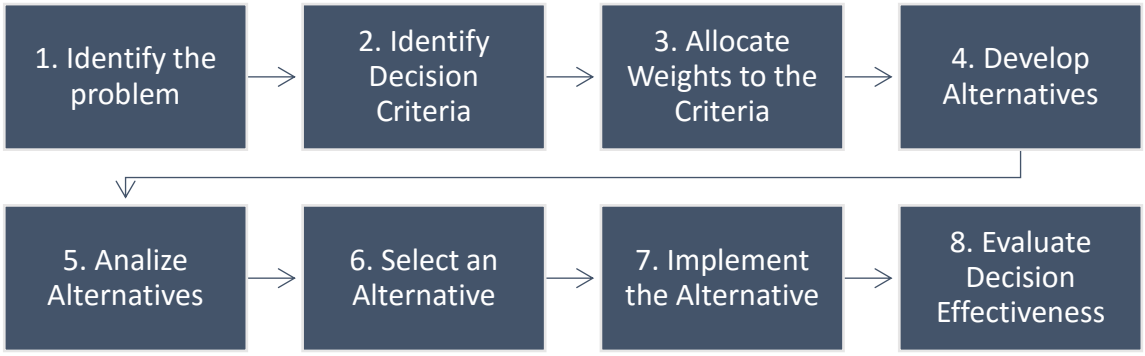

Figure 2. Decison-making process adapted from Robbins & Coulter (2016 p. 74-77)

Step 1 – The basis of every decision is a situation that is difficult to solve, more specifically a problem. This means that between the current and the desired status exists a mismatch. The perception of a problem is subjective.

Step 2 – Decision makers use certain decision principles. Different problems require different principles in accordance to the nature of the problem.

Step 3 – The characteristics of the issue are weighted based on their significance e.g. from 1 to 10. For instance, a decision be made whether the battery life of a PC is more important to a manager than the quality of the display.

Step 4 – Different alternatives are created in order to solve the problem. Creativity is the pivotal skill during this step.

Step 5 – All possible alternatives are analysed. This may be considered as the outcome of weighing all decision criteria for all created alternatives.

Step 6 – The alternative with the highest number of points will be chosen.

Step 7 – With respect to solving the problem, the best alternative is implemented and executed either alone or with the aid of others.

Step 8 – The outcome is assessed by deciding whether the problem encountered in Step 1 is solved or not. If the discrepancy still exists, one should review a previous step or even go through the whole process again. (Robbins & Coulter 2016, pp. 74-77)

On the one hand, people are more likely to execute decisions if they have prior experiences and have gone through a similar situation. On the other hand, this means that their decisions are influenced by experience, so the decision-maker is confronted by a bias. This has an influence on further decisions. (Goodman & Dingli 2013, p.23-25).

3.5 Decision Support Systems and Analytics

DSS, Decision Support Systems, is the overarching term for any form of computer- and data-based aiding software aiming to drive decisions and support the decision-maker. Fundamentally, data stream from several sources are assessed by models within a computer software. (Sauter 2010).
In-streaming data flow usually comes from databases and results e.g. in the form of a report which is visualized in a user-friendly way.

Analytics can be defined as the combination of figure-based models, lessons learned, forecast models and quantitative analysis that mainly uses algorithms to support decisions. In terms of IoT, the analytical software is called real-time analytics (Davenport 2010 & Harris, p.7).

Analytics has gone through two main eras. The first era was mainly focused on consolidating internal data and transforming them into a structured form. The second era was triggered by the raising trend of big data (explained in the next chapter). The second era is characterized by the development of new methods, types and the inclusion of data streaming from external sources (also in real-time). (Franks 2014, p. 30). In the appendix, an exemplary visual overview of an analytic software can be found.

The key to enhance business processes and thus decisions of any kind is to process data to analytics. Moreover, this can save energy, valuable time and money. An algorithm, the core of an analytical software, needs to be capable of distinguishing useful data from non-useful data. Figure 3, based on the model created by ATG a Swiss oil and gas firm, illustrates how data is transformed from

loose yet irrelevant data first to information, then knowledge and the finally into the basis for decisions.

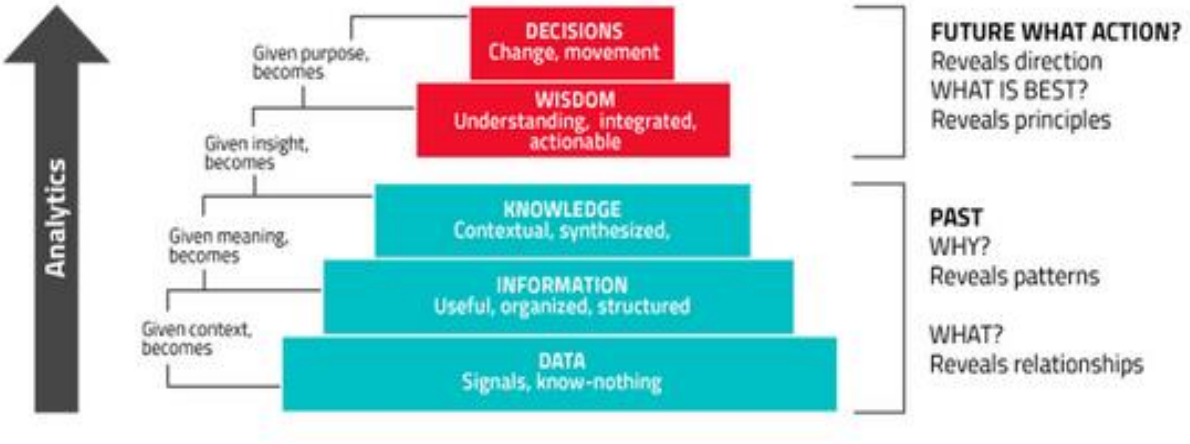

Figure 3. Process from data to decisions (Mannion 2015)

Thereby, analytics is a part of every step, and this shows also how the algorithms might work. Within an IoT based ecosystem, analytics assesses and evaluates streamed data in real-time including archival data from data bases to achieve the best results. Since different kinds of data flow into the processing analytical system, in-flows are analyzed in packages or clusters. The result is an outflowing stream with useful information. (Mannion 2015).

Although analytics seem to be a useful tool, there might be areas where it cannot be applied. The most obvious area is innovation because analytics is simply not able to access data from past times, so data must rely on similar projects executed in the past, for instance. In addition, certain quantitative models cannot cover specific innovative fields. This places decision-making in an uncertain frame. In order to solve this issue and to create a complete a picture of the decision-making based on analytics, intuition and personal experience are needed, hence qualitative data. (Sauter 2010, p. 57).

3.6 Decisions in an Era of Big Data

In this chapter, the topic of data-driven decision making is examined more in detail. The decision maker still remains a human, but the decision (or meaning in detail the selection among alternatives) is based on mere data and facts and not on knowledge, long experience or intuition. (Provost & Fawcett 2013). Telecommunication companies and the financial sector already applied systems during the 1990s to evaluate the vast amount of data they gathered. These systems supported trading, direct marketing, fraud detection and credit scoring. (Provost & Fawcett 2013).

Similar to the pace of relationship development among businesses, data-driven decision making evolved in response to the ongoing progress in information technology. The past few years have seen the rapid development of Internet of Things and artificial intelligence (AI) technologies combined with machine-learning that uses algorithms in order to make predictions in a more precise and generally in an automated way. Bearing this in mind, the potential of improving decision making seems to be limitless. Significant businesses deploying data-driven decision making are Amazon and Google. While Amazon derive benefits from data in terms of placing concrete product recommendations, Google aims at making decisions strictly on the basis of gathered data. (Rope, 2017).

The report *How Leading Organizations Are Adopting a Data-Driven Culture* by Harvard Business Review in 2016 has shown that companies making decisions based on collected data and use of analysis such as analytical tools boast higher productivity and profitability for instance return on assets and return on equity as well as improvement in market value. With regard to a statement by Jeff Bezos, CEO of Amazon, choices are distinguished into two different: those that can be undone and those that cannot such as impaired reputation and lack of trustworthiness (Brynjolfsson 2016).

The focus is changing owing to the purpose of the Internet of Things from data-driven decision-making to sensor-driven decision-making. At their core, sensors

such as WIFI (Wireless Fidelity), NFC (Near Field Communication), GPS (Global Positioning System), light sensors or even simple touchscreens are collecting desired data. (Vermesan & Friess 2015).

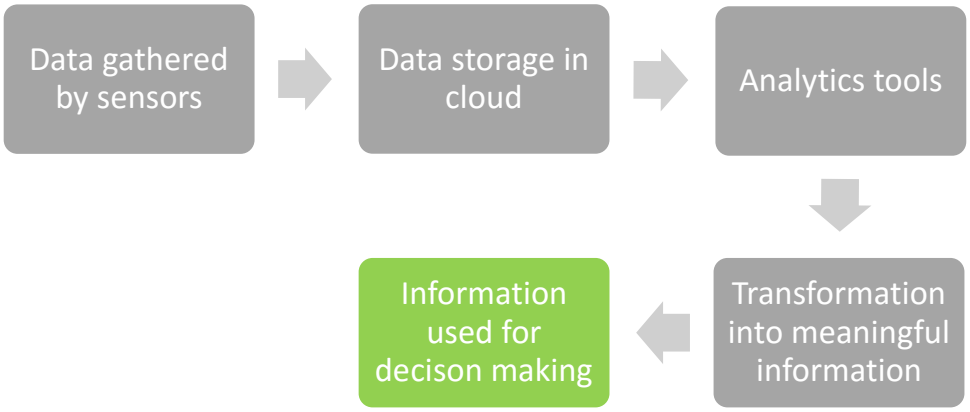

Figure 4. Data-collecting process

Figure 4 is a summary of the process of data-collecting. Data is gathered, stored, analyzed and transformed. The final information which is the outcome of the information-collecting process can be described as the basis of effective decision making. In terms of an evidence-based management approach, this information is *the* crucial element.

4 SUPPLY CHAIN MANAGEMENT

In this chapter the basics of supply chain management (SCM) are explained with emphasis on the information flow what one of the three major streams in SCM. After defining common models, a decision making framework is explained. The final paragraph introduces clouds in supply chains since they are a pivotal element of the information storage and processing.

4.1 Definition and Models

Supply chain management is widely considered as a developed, improved holistic approach of managing resources of an organization consisting of three basic streams: physical, information and resource (e.g. finances & talent) streams flowing upstream and downstream. The streams occur at every level of the

supply chain. In a more precise and correct manner, the supply chain is considered as “supply chain network” due to interwoven relationships in every phase (Christopher 2011, p. 3).

Martin Christopher, one of the most renowned experts in the field and a professor in SCM, consolidates this position. A supply network includes several suppliers on different levels (suppliers of suppliers) as well as multi-level customers and customers of customers. Figure 5 illustrates what the idea of supplier network looks like.

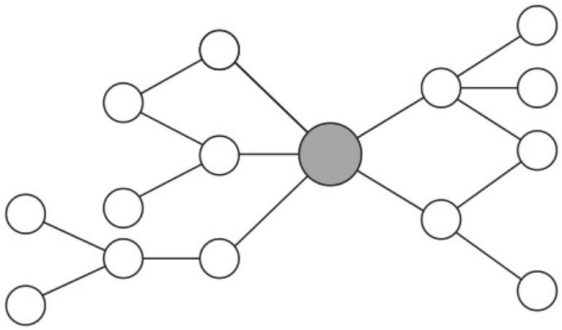

Figure 5. Supply network (Christopher 2011, p. 3)

Nowadays, organizations are following the trend of digitalization that shapes the supply chains to digital supply networks (DSN). For the sake of simplicity, DSN will be indicated later in this study as “supply chain”.
One of the driving forces behind the development and improvement of supply chain management (SCM) are innovative information and communication technologies (ICT), in particular the wide use of internet technologies. The automation of processes within the supply chain is merely possible by the implementation and use of internet and ICT. (Samson 2011, p. 314).

Integrated systems and data management enable a new approach to SCM based collaboration, (social) networking and sharing information online leading to collective intelligence with focus on the employee. This model which is often referred to “SCM 2.0” benefits from more lean, agile and decentralized features. (Samson 2011, p.315).

As an organization-wide concept, information technology and shared information enable businesses to become an organization with blurred or without borders where information flow beyond boundaries and enhance value streams. Thus, supply chains and involved organizations are becoming virtual as Figure 3 illustrates.

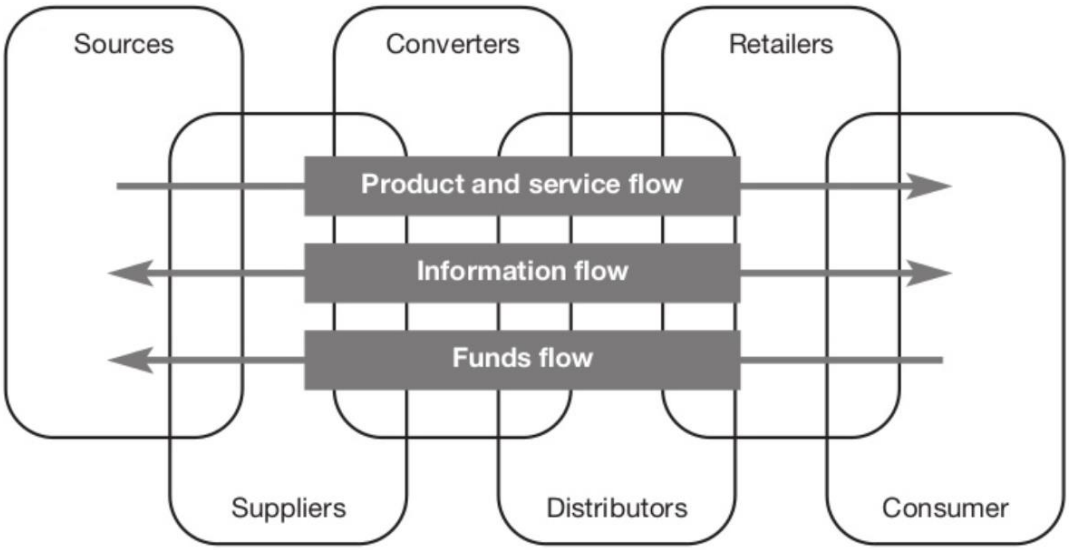

Figure 6. Virtual supply chain (Christopher 2011, p. 143)

Cisco System, for example, has created a visible network that consists of multiple stage members but performs and is managed as one big individual company (Christopher 2011, p. 142).

With this collaborating and borderless approach in mind, the necessity for connecting people increases to the extent that employees are able to access data regardless of place and device (Samson 2011, p. 320).

4.2 Decision-Making in Supply Chains

As previously was pointed out, decisions are part of any situation an individual person or group of people are facing. This means in effect, decisions and relationships are also a significant part of supply chains. On the basis of relations and relationships within the supply chain, the decision made in phase one of a supply chain influences the outcome of phase two, the decision in phase two

influences the outcome of phase three and so forth. (Kahraman 2007, p. 179). This conversely means that one needs to consider the aim of the previous phase in order to make an improved decision in their current phase.

Lee (2004) emphasizes the integration of supply chain partners and the prediction of their behavior as an essential element to improve the supply chain performance (Lee 2004). In other words, looking at a partners' objectives and decisions upstream and downstream the supply chain phases and having appropriate information leads to excellent supply chain performance.

A different approach, more metric-focused and strategic, will show the following passage, a decision making framework, mainly based on the work of Sunil Chopra and Peter Meindl (2015). Figure 7 presents the different roles of the drivers within the supply chain and the components of decisions.

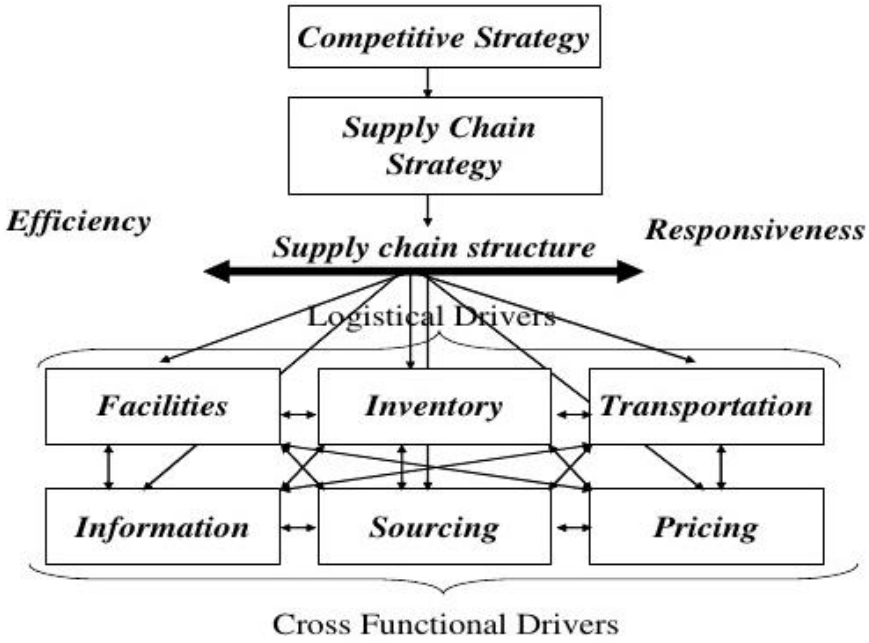

Figure 7. Supply chain decision framework (Chopra & Meindl 2015, p. 58)

The starting point and basis is the competitive strategy a company follows. A part of this overall strategy is the strategy of the supply chain. The supply chain is influenced by six drivers affecting the optimization of its performance. Vice versa,

the supply chain and overall strategy influence the drivers. (Chopra & Meindl 2015, p.59). Therefore, arrows pointing in two ways between the drivers and the supply chain strategy might be a better illustration. Table 1 indicates the roles and decision components of the six drivers.

Drivers	Role within Supply Chain	Decision components	Metrics
Facilities	Increasing responsiveness	- Role - Location - Capacity	- Production cost per unit - Quality losses
Inventory	Balancing mismatch of demand & supply	- Cycle inventory - Safety inventory - Seasonal inventory	- Inventory turns - Fill rate
Transportation	Moving items from one place to another	- Design of network - Transportation mode	- Incoming shipment size - Inbound transportation cost
Information	Increasing visibility and coordination of flows	- Push/Pull - Coordination & sharing - Technologies	- Seasonal factors - Variance from plan
Sourcing	Purchasing materials and services	- In-house/outsource - Supplier selection - Procurement	- Supply quality - Supplier reliability
Pricing	Basis for revenue	- Economies of scale - Low/high price - Fixed/manual price	- Average sales price - Average order price

Table 1. Structuring of drivers according to Chopra & Meindl 2015

In conclusion, each drivers comes with a particular role within the supply chain and a key decision component as displayed in Table 1. Generally, a company analyzes the drivers and their roles in order to improve efficiency and responsiveness. The components and the included metrics are the tools a

decision-maker takes into account for an enhanced supply chain performance. Every driver and thus component is connected to many metrics. These metrics are nowadays included in analytics software. (Chopra & Meindl 2016, p. 58-72).

The decision metrics support the decision-maker to fulfill the aim of making rational decisions. Nevertheless, there are two sides to this coin. Every driver comes with costs, and increasing the number of facilities or the amount of information is not always the betterchoice. The increasing complexity makes the supply chain more difficult to control and monitor.

4.3 Role of Clouds in Supply Chains

The deployment of cloud-computing within supply chains leads to benefits in better integration of business partners and suppliers due to improved planning and predictions, faster replenishment and advanced transportation. Clouds have potential to enhance processes within the supply chain and simplify work among involved parties. Benefits can be seen in improved information safety and compatibility, and in faster updates and real-time information supply. (Samson 2011, p. 324-325). Later in this study the pivotal role of clouds within an IoT ecosystem will be presented.

The model of SCM 2.0 discussed in chapter 3.1 has similarities to the cloud. Firstly, the structure and scope is unique and normally customized for a certain business purpose. Secondly, the shared information is visible, transparent and has a wide range of usability. The idea of transparency and visibility correlates with Christopher's' model of virtual supply chain (Christopher 2011, p.142-144).

In the days of modern business, the company's success depends on how effectively they share information among each other and across the supply chain. Thus, clouds play a particular role.

5 INTERNET OF THINGS

The previous chapter showed the importance of information flows in supply chains. This chapter will present key elements of an IoT architecture and expand the view of managing data. It starts with definitions and basics about Internet of Things, Big Data (including critics) and IoT technologies. The final subchapter deals with generally recognized impacts and challenges before leading to practical applications of companies in chapter 6.

5.1 Definition

According to Haller et. al (2009, p. 14), the term Internet of Things (IoT) was initially established by the MIT where researchers had a vision of a worldwide scenario ”where all physical objects are tagged with a RFID transponder with a globally unique ID – the EPC or electronic product code”. The IoT is considered one of the most topical approaches in technology and is still in its infancy stage. The idea is a hyper-connected ecosystem where humans and machines create, gather and share information with each other and among each other at any time from any place with the help of the internet. (Vermesan & Friess 2014). McEwan (2013, p.11) describes IoT as an equation by summing up physical objects, controllers, sensors, actuators (including the ability to generate outputs in the ”real” world) and the internet itself. Waher (2015, p. 19) describes the Internet of Things as the result of setting indepedent objects in relation to each other that work without human support and via the internet. In this paper, the term IoT also implies the industrial IoT and even though there is a difference between these concepts. For the sake of simplicity, both terms are used equivalent.

An IoT infrastructure is according to Gubbi and Buyya (2013), based on five main elements. Firstly, RFID tags are used to give an object a location and an identity and are additionally the enabler for connections. Secondly, wireless sensor networks (WSN) enable the consolidation of sensor-gathered data and thus further actions such as processing and analysis. Thirdly, the devices need to be assessed and this is conducted by addressing schemes. A widely-used protocol nowadays is IPV6 that can individually distinguish between devices.

The next pivotal element is storage and analytics. Both elements are of particular importance and was discussed and highlighted earlier. These elements are usually used cloud-based. The final element is the visualization of results presented on devices such as smart phones or tablets for uniting the decision-maker with the IoT ecosystem. (Gubbi & Buyya 2013).

5.2 IoT Reference Model

At the moment, there is no standard IoT model. Since Cisco's creation is one of the most suitable, it is chosen to illustrate IoT levels in a visually appealing way. Cisco's IoT reference model is based on information flow (in both directions) and might be considered a cornerstone for a better understanding of IoT relation levels and potential.

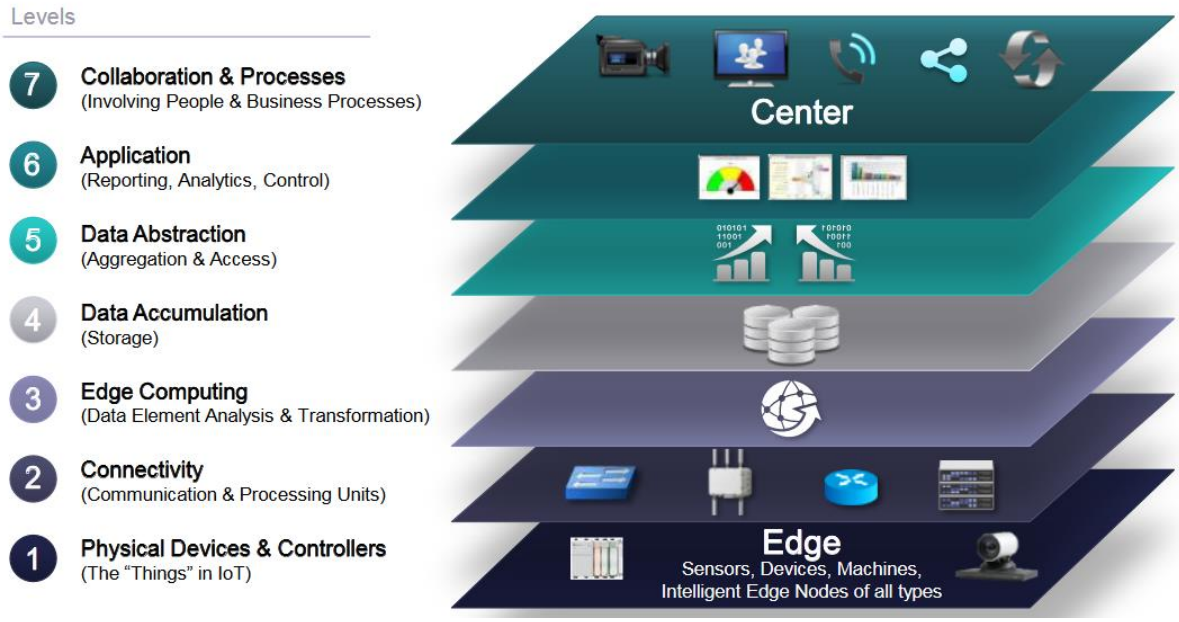

Figure 8. Internet of Things reference model (Cisco Systems 2014)

Level 1: Devices are equipped with certain sensors and are neither location-bound nor sizably restricted. They generate data and can be controlled.

Level 2: Networks enable the communication between devices, other networks and Level 3. This is done by encoding, switching and routing.

Level 3: Data is converted into storable information by filtering analysis. The analysis here includes here for instance evaluation, formatting and reduction.

Level 4: Data is stored and stays dormant and ready for further usage.

Level 5: Data is transferred and consolidated into other formats so applications can make use of and read them. This means they are now information.

Level 6: Information is interpreted by the specifically used application. Forms vary from control applications to BI and Analytics.

Level 7: Processes and people are triggered to take action and execute according to needs on the basis of the delivered information. (Cisco Systems 2014)

With this model it might be easier to understand the extent and steps within an IoT ecosystem and hence, this step might be necessary since the following chapters of this paper is built upon these ideas.

5.3 Big Data as Source for IoT Decision-Making

This chapter defines the term Big Data and its importance. An established way to describe Big Data is the 4 V-Model. In addition, complaints about and alternatives to big data in form of small/ less data are presented.

5.3.1 Basics and the 4-V Model

“Big Data” as a term evolved because it describes exactly what the connotation is about – an enormous amount of data far too high for ordinary analytic methods to process, whilst the exact amount is rather impossible to imagine.
“90% of worlds data have been created over the past two years” (Vermesan & Friess 2015, p. 46), emphasizes the dimension of data and the prospective opportunities. The main characteristic of Big Data can be seen as the handling process and analysis of the data in databases and storage systems. The storage of this massive amount of data is enabled by cloud platforms which make it

affordable. The storage is not the main goal, but how to make use of the data. (Vermesan & Friess 2014).

Big Data in the context of IoT is illustrated by means of the so called “4-V-model” which was firstly mentioned by IBM illustrated in figure 9. The four Vs stand for the following areas:

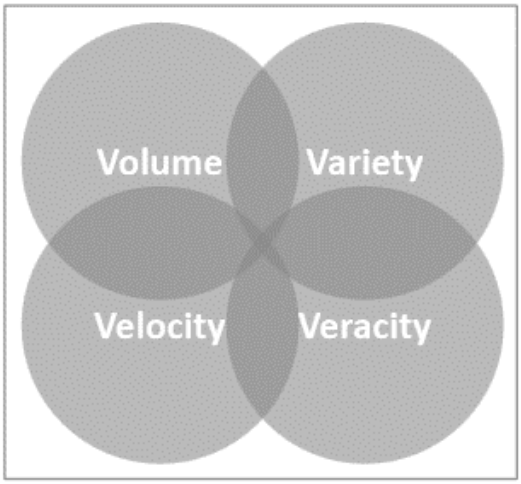

Figure 9. 4-V-Model (IBM)

Volume is considered a data scale. Forecasts assume that 40 Zettabytes will be created until 2020. This is an increase of 300 times in comparison to 2005. One of the main drivers are mobile phones. On planet earth are living 7 billion humans and almost 6 billion phones exist already.

Variety means that diverse data forms are created by diverse data sources. On Facebook, 30 billion different kinds of content are published and 4 billion hours of videos are watched on the video-on-demand- platform YouTube every single month.

Velocity is considered the analysis of the streamed data that flow in real-time. Some significant examples can be recognized in everyday life. For instance, cars consist of nearly 100 sensors measuring fuel level or status of the breaks.

Veracity rephrased is the accuracy of the gathered data. Many employers and employees consider collected data untrustworthy. One out three managers

mistrust the data used for decision-making. Furthermore, this poor data impair entire economies. Each year, the inadequate data quality leads to costs up to 3.1 billion $ for the US economy. (King 2014).

5.3.2 Critics: Less and Small Data as Alternatives?

What if, after analyzing all gathered data, the results remain still similar? Or even worse, when will too much data lead to paralysis? Due to the high amount of data, managers miss to set priorities, and this leads to weak and non-optimal decisions. In order to transform the loose data into useful ones, Menon & Thompson (2016) suggest the “DIET approach”.

The first step includes the definition of the problem (without thinking of a solution) and gaining perspectives from different points of view of the team. Topics such as reasons, pre-assumptions and different understanding of the problem are discussed. After that, the collection of data begins with critical assessment of data, whether the data will have any influence on upcoming decisions. The next step includes the integration of how the problems is perceived and data is gathered. Here the bridge between data and problem is made by setting both in correlation and sorting out causes and effects amongst each other. This might lead to eventual ideas. During the third step, specific ideas are created by team members and are passed to other team members who will develop the ideas. The process is supposed to be executed in a silent atmosphere. At the end of this step, the team has sorted out the most suitable idea(s). Finally, suitable ideas will be transferred into action with the aim of refuting and detecting failures and and an attempt to break down the solution. (Menon & Thompson 2016).

Obviously, in everyday situations of business life, a manager is unable to dense the high amount of data. The goal, in order to work with the data, seems to be in changing the data into those that are easy to access and apply for certain tasks. Banafa (2016) complaints about that mere the data scientist are capable to manage the vast amount of data. In addition, data is merely useful if a company can benefit from. He questions the general use of analytics software since

enterprises hesitate to invest in related measurements. Small data's emphasis lies on appropriate utilization of the resources and frugal technologies. An example related to marketing is social media. The data is created and gathered constantly and can be assessed with cheap trend web tools (e.g. Google trends).

The consumers also experience small data when websites suggest shopping items they have bought or the usage of wearable. A platform provider such as SAP and Oracle started to transfer data into easy and understandable data with focus on the consumer. The author points out that small data is the more appropriate way with a more promising future for meaningful usability. He predicts a shift from centralized to decentralized data collecting and a more intensive collaboration of users. (Banafa 2016).

I partly agree with Banafa and Menon & Thompson. Their approaches might work in a business environment of SMEs (small and medium enterprises). If one imagines a big company with billions in revenue, the aim would be normally growth. The growth is especially possible by development. These organizations are highly developed in such a way that their resources and technologies are simply exhausted. Therefore, there is a need for companies to use complex software and sophisticated data analytics, otherwise they reach their limits and will not grow.

5.4 IoT Technologies

This chapter proposes diverse IoT technologies. Beforehand, the limpet strategy is shortly explained. Due to the vast amount of options a company has to face the Internet of Things, it is necessary to mention a few of established alternative technologies.

5.4.1 Before Applying a Technology

Companies that are facing the need to implement new technologies, thus also in terms of the IoT, have three different options to manage these technologies (limpet strategy).

1) Complete adoption of the new technology and giving up the old one.
2) Further usage of the installed technology, but setting standards in order to achieve the quality of the new technology. This will lead to slight investments.
3) Further usage of the installed technology and start to invest in new technologies. This will lead to using the best of the both options (Goodman & Dingli 2013, p. 30).

5.4.2 Sample Technologies

SAP Internet of Things solutions ensure and simplify the interaction of the users of the devices and the device itself in such a way that supply chains become more visible and shortages in business logistics are rectified.
Microsoft Azure IoT Suite is an encompassing cloud platform for connected machines and equipment that aids decision-making and automation by analyzing and managing streamed data.

Xively improves the integration of the devices, their data and organization systems such as Customer Relationship Management and Enterprise Resource systems.
ARM emphasis lies on the production of the equipment needed for IoT applications and networks e.g. sensors and computer chips.
Intel IoT platform enables the storage, exchange and analysis throughout the entire data flow. The starting point is the sensor and the end is the data center with particular focus on secure transmission and compatibility within and across enterprises.

Jasper offers a platform in order to facilitate mobility aspects of a company by making networks visible and monitorable in such way that e.g. cars can be connected smoothly in real-time.

AllJoyn improves the mutual recognition and communication of devices by contributing a mutual used language.
Bosch Software Innovations Suite is a comprehensive solution for managing devices and processes that harmonizes with current information technology infrastructures. Hereby the suite connects humans, objects, organizations and their partners.
OpenRemote enables the linkage between devices and allows the customization of the user interfaces for browsers and mobile operating systems in real-time.
Echelon is a platform for manufacturing companies that offers hard - and software to establish and/or evolve own devices and applications.
(Vermesan & Friess 2015, p. 292-295).

This list provides information about several IoT solutions and clearly shows the enormous variety of solutions to choose from. It ranges from specific device providers to full suites with diverse services. Here it is made clear that those providers offering analytic software might enhance decision-making.

5.4.3 Impacts and Challenges

As already earlier reported, Internet of Things technologies change not only products but also industry sectors and whole industries. The prospective impacts are demanding to imagine as the topic and its developments are noticeably state-of-the-art. However, benefits and other positive impacts can be noticed.
Starting with the products, a new car is usually equipped with a large amount of embedded sensors and result in a considerable number of possible services. This in turn, may increase appeal and market value of the car because the services are accessible (even remotely).
A similar approach covers smart phones and application stores. It continues with enhancement of processes in value and supply chains due to connection and

automation. The potential impacts are waste reduction, punctuality likewise improved allocation and distribution e.g. by autonomous vehicles while intelligent technologies ensure safety and simplicity. Furthermore, closer relationships between supplier and buyer can be seen as a result due to precise customer segmentation and product segmentation, personalized products and value-added services. (Weinman 2015). In other words, suppliers strongly bound their buyers since closer relationships are more difficult to break.
Moreover, it opens opportunities for business models especially for the area of product-as-a-service. Thereby, the mere and necessary amount or time of the usage is paid. In order to reduce costs, especially small enterprises might benefit from open platforms and hard-/software solutions. (Vermesan & Friess 2015)

In general, the interaction of cyber physical systems and human behavior is demanding with emphasis on safety how Michael E. Porter points out: “As the ability to unlock the full value of data becomes a key source of competitive advantage, the management, governance, analysis, and security of that data is developing into a major new business function.” (Porter 2015).

6 BUSINESS CASES: THE INFLUENCE OF IOT ON SUPPLY CHAIN MANAGEMENT DECISION MAKING

The following description of business cases covers several renowned companies and represents a wide range of business areas using IoT technologies to improve their operational and strategic business activities. Burberry as a fashion business represents how highly innovative online and offline technology integration is executed. Nike is an excellent example for combining innovative software and sports products with each other. Netflix was chosen due to its success and major impact on the entertainment industry as well as due its virtual business operations. General Electric (GE) can be considered as a representative of the old established international conglomerate that has gone through several eras. Heidelberg covers the printing industry, Carestream the medical engineering and CNH Industrial the tertiary sector. Thus, the companies have their roots in the worlds’ highest developed areas: North America and Europe.

Firstly their drivers and applied technologies are explained. Secondly, the decision principles are analyzed that have been taken into account of each company. Additionally, the situation before and after the application is described. After the description, an analysis follows in chapter 6 in order to develop insights, general rules as well as similarities and major differences. In others words,, it is explained what kind of decision-making approaches are applied and how the gathered data were used for further decisions.

6.1 Burberry

Burberry is a British clothing manufacturer that is well-known for the “trench coat” (a long jacket) and the famous and patented check pattern. Burberry fabrics were used by explorers and pilots during World War I (BurberryPLC.com). Nowadays the company uses their customers to market their product. For instance, customers could sent pictures while wearing a certain garment and their style was evaluated. The customers could also kiss their smartphones and send the kiss shape that was made with a Burberry lipstick to someone across the globe. (Doran 2014).

In order to improve customer experiences, Burberry introduced an RFID enabled nail bar where customers could place nail polish on a certain bar and it showed on a screen the different performances, colors and styles. Additionally, the organization introduced RFID tags in several product of their product assortment such as unique customer RFID tags with the possibility to scan it at the stores. Digital mirrors are used to suggest different weather conditions. Within their production line, the made-to measure principle was applied. (Sonne 2011). In general, the applied software Burberry decreased the chance to come up with failures in fashion terms.

Results can be seen in reduced costs and improved overall visibility and performance triggered by excellent supply chain management. The integration and application of all measures and creating a vast technology network was

highly demanding. In result, the direct interaction of customers among each other and with Burberry as a business itself leads to improved products. (Burberry PLC 2014)

6.2 Nike

Nike is one of the world's most famous brands offering sports clothing and equipment. Their main business is clothing and innovations are one of their main drivers (Brown, 2014).
In terms of the IoT, the company connects their shoes and wristbands with clouds in order to ensure excellent tracking. Therefore, the data is analyzed by big data analytical tools. With the help of these technologies, especially athletes could measure and improve their performances by e.g. sensors integrated inside the shoe. The hereby gathered data can be shared with the community on social media or with coaches who will provide feedback. (Carr 2013). One of the main drivers is the remained philosophy of supporting athletes to become their best version throughout all business processes. Shoes such as the Hyperdunk+ and wearables are hereby connected with a tailored Nike application that includes GPS in real-time or Bluetooth and advanced services.

The key technology is the cloud, which processes and refurbish the collected data from a user's device and delivers them in form of the routes or the time needed to run. The resulting effects are interwoven. On the one hand, products are upgradable in terms of setting up Nano software so the product will not remain a fixed good. On the other hand, the gathered data can be used for further product and service enhancements. The true potential for this particular kind of innovations is hard to imagine. Nike allows their business partners, among others Withings, a body analyzing application, to securely access customers' data with the objective to develop new products. This open innovations approach leads to benefits for Nike and their partners equally. (RGA.com).

6.3 Netflix

Netflix is widely known as one of the leading online streaming providers. Before that, the main business was a DVD rental but the business declined. For the sake of probability and innovation and in the course of technologisation, Netflix started early to use cloud-computing in collaboration with Amazon Web Services. The clouds were one of the main drivers and mainly used to improve their clouds in form of contests and shared information among employees.

Netflix uses their data collection in such way that the mere sum of rating data leads to suggestions e.g. most popular film at the moment. By offering movies online, the organization can recognize the daytime, device, region of the customer and even how often the movie was paused. (Hastings 2005). In other words, Netflix uses this data to predict customers' behavior and make suitable suggestions for the customer and their friends (when recommending movies or series). Thanks to ratings and behavioral data, movies can be precisely distinguished into a vast scale. (Amatriain 2013). The data assessed by algorithms is the basis for recommendations made by Netflix. The recommendations and highly specific subgenres (76,897 in 2014) - which are broken down created by the customers themselves - are the crucial factor in order to acquire new customers and keep existing ones. (Madrigal 2014).

Additionally, this intelligent software has further impacts on logistics and especially marketing. In conclusion, the recommendation are mere assumptions - even though tailored to the customer - and the data systems are not able to make any forecast what customers are going to like (apparently only until the system recommends a movie). Netflix's decision to switch from a DVD rental business into a streaming provider changed the entire entertainment experience. (Carr 2013).

6.4 General Electric

General Electric, or GE in short form, is one of the oldest companies worldwide and was founded 1892. GE offers a wide spread of business operations such as engines, locomotives, nuclear reactors or commercial services. (Immelt 2012). From the point of GE, the Internet of things is a logical strategic step within the fields of information technology and concrete product realization. There is not only a paradigm shift in the way how to guide employees, but also how extensively products are connected with each other. For instance, a jet engine and jet engine computer model are connected via cloud systems and analytics to enhance the progress of GE's research and development and thus customer products and relations. The data that is created and collected from engines can be used for specific usability suggestions.

GE takes IoT technologies into account within its production line meaning machine learning, predictive maintenance and interconnectivity among devices and employees. For example, large amounts of money can be saved, e.g. $2 billion if the global fuel consumption of airplanes was reduced by mere 1 percent. In terms of the abovementioned change in paradigm, products turn into solutions and are part of an entire service ecosystem. The "DoseWatch" solution tracks the amount of occurring radiation caused by CT and x-ray scanners. Another solution, declared as "GE Healthcare Asset Management", can be used for sharing diagnostics images among doctors in order to gain better treatment and diagnostics results for their clients' therapies. (General Electric 2012).

GE's investments in Internet of Things technologies, for example mobile networks, big data, analytics and sensors, influenced many prospective decisions. Sample results can be recognized in increased acquisitions or partnerships e.g. shared laboratories with P&G and BASF or the extensive collaboration with Amazon Web Services. Needless to say that the real usefulness of consumer products improved dramatically. General Electric established a startup culture in its software development department and shrunk the team member sizes and hierarchy levels. Due to the need for innovation, GE

decided to shrink their teams so every team member has a sharpened overview of processes and can proceed and progress rapidly because in larger teams the communication and consistent time-consuming agreements decelerate progress. A considerable amount money was spent to ensure cyber security and analytics since the impacts of disruption and failures are in an industrial context particularly high. For future purposes, GE is heading to transform its business to an industrial software business and is making IoT to one of its corporate principles. (Power 2014).

6.5 Heidelberg

Heidelberg, originally called *Heidelberger Druckmaschinen*, is one of the major players in the paper industry offering larges printing, services for presses as well as software integration of printing machines. In the late 90's the company started to connect their presses with each other. They implemented just a few data points to gather information, but it impressively showed the potential of this approach. In 2002, the company decided to focus on expansion for further development and integration issues. That means redesigning to include more (up to several thousands) sensors to ensure remote access. It took several years until the transformation process was finished. The collected data from the sensors were processed and used to improve decision performance. Due to the gained benefits in the course of the years, Heidelberg decided to offer intelligent electronic services for their customers such as remote maintenance as a warranty service.

In 2012, the company introduced a service for monitoring and predicting future breakdowns. Thus, machines processed gathered data to analytics software where they were analyzed and evaluated. Responsible managers were given a notice if an incident is likely to occur and the manager decided further actions. In summary, Heidelbergs' transformation changed their business models and development entirely. (PTC 2016).

6.6 Carestream

Carestream, a Canadian high technologized provider of medical imaging software and equipment for MRI and CT scans, uses processed data gathered by the products itself. This data is transmitted to databases and systems that allow monitoring of their products apart from other benefits such as facilitated usability and minimal costs for customers. This means, products create data that is harnessed and analyzed and finally could be used to monitor the same product whilst the monitoring itself also creates new data and delivers information for optimization. The circulation of the data leads to a “circle of self-monitoring and self-optimization”. Thus, there is no or a few necessities for maintenance and processes are accelerated due to extensive monitoring.
There exists a challenge of network connections due to poor connectivity especially in remote areas. Another challenge could be recognized in the sales business model due to large payments per annum or increased cooperation with customers. In addition, internal processes need improvement since several areas are involved. (PTC 2015)

6.7 CNH Industrial N.V.

CHN Industrial is a London-based company producing vehicles for crop production and manufacturing in the tertiary sector. Due to the Internet Things, the company wanted to make business visible and customer relations to the focal issue. Before turning the IoT strategy into practice, the company made everyone in any department aware of the significant change. One of the major drivers was the competiveness in in the agricultural sector. The change to connected vehicles encouraged and enhanced further investments. The integrated systems provided services with emphasis on monitoring fields or controlling seed consumption on the basis of processed data to analytics. The basis are comprehensive algorithms, simple relations and open systems likewise a sophisticated software platform. CNH was depend on external providers when the new technology was implemented. Two strategic choices concerned the data management: data architecture and data security.

The company needed to shift the way they were doing business in general from a reactive approach to anticipation. In terms of supply chains, this means faster shipment of demanded parts while fleet, logistics, production, suppliers and customers are smoothly connected. Moreover, the IoT based business model is used to increase the product quality in terms of reduced failures but increasing simplicity, innovation and customer interaction. In addition, schedules and predictions may be prepared more precisely. Among employees there is a need for skill development or rather extension due to the technical transformation. For instance, they should be able to use a tablet and work with analytic software.
.
The results coming from exactly delivered information such as improved cost of a vehicle or acre helps the customer to facilitate their decision making. The transformation improved performance, replenishment and cost calculation among customers, introduced new standards and established the option to offer products as service solutions.
(PTC 2015).

7 UNITIZING FINDINGS – ANALYSIS OF BUSINESS CASES

According to Saunders et. al (2009), there exist no ideal, standardized process for the analysis of qualitative data. Nevertheless, the authors suggest an approach declared as “unitizing data” whilst data are transmitted into categories that functioning as units. The unit can be fragments of words, bullet points, sentences or whole paragraphs. Hence, for the purpose of a better overview, bullet points and words are used. In order to gain useful insights from the data, they are transferred into table form.

The companies are divided into two groups. The first group, consisting of Burberry, Nike and Netflix, sets the emphasis on the product itself and a high interaction with customers.

Criteria/Company	Burberry	Nike	Netflix
Needs/desired outcomes	- Improve image - Find way out of crisis	- Connect customers - Improve products	- Improve customer experience - Change in business
Actual outcome	- Increased sales - Increased customer segmentation - Improved customer experience	- Improved customers experience + performance	- Product suggestions - Improved customer and product segmentation -
Response to issues	- Using customers to market products - Made-to-measure production	- Create a customer-product-network - Offering added services - Open innovations	- Prediction of behavior
Advantages/ successful aspects	- Decreased chance of fashion failures	- Upgradeable products - Innovations	- Creation of new genres
Disadvantages/ failures	- Expensive and demanding change	- Data send to business partners	- No forecast option
Data gathered from	- Humans	- Humans	- Humans
DSS	- Yes	- Yes	- Yes
Main SCM member involved	- All	- Suppliers/customers	- Marketing
Mainly used IoT element	- RFID tags in nailbar in stores and clothes - Sensory screens	- GPS - Bluetooth - Cloud	- Cloud

Table 2. Analysis of Burberry, Nike & Netflix

The second group consists of General Electric, Heidelberg, Carestream and CNH Industrial since they are solid manufacturers with highly technologized production lines.

Criteria/Company	General Electric	Heidelberg	Carestream	CNH Industrial
Needs/desired outcomes	- Enhance R&D progress - Improve customer products	- Entering new markets	- Development of value-added services	- Competitiveness in agriculture
Actual outcome	- Usability suggestion - Performance improvement - Products become service/ solution	- Improvement of decision performance	- Improved usability - Decreased costs for customers	- Strong relationships - Products as service - Customer satisfaction
Response to issues	- Acquisition & partnerships - Start-up culture	- Expansion - Increased number of sensors - Offering added services	- Strong emphasis on monitoring products	- Making everyone aware of change - Connecting vehicles
Advantages/successful aspects	- Predictive maintenance -	- Remote maintenance	- Self-optimization	- Further investments from customers
Disadvantages/failures	- Expensive - Information security	- Long-term transformation	- Connectivity in remote areas -	- Development of technical skills among employees
Data gathered from	- Machines	- Machines	- Products	- Machines
DSS	- Yes	- Yes	- Yes	- Yes

Main SCM partners involved	- Undis-closed	- Undis-closed	- Undis-closed	- External supplier
Used IoT element	- Cloud - Mobile networks	- Sensors	- Data-bases - Cloud	- Monitoring systems

Table 3. Analysis of GE, Heidelberg, Carestream & CNH

Out of the empirical material it is shown that the basis for change of all companies is influenced by an unsatisfying status and the willingness to improve the business. While Nike and GE mainly were seeking to improve their products, Heidelberg wanted to enter a new market and CNH Industrial were facing strong competitiveness in its business sector. This basis can be described as the essence for an existing problem what is in its core the first step of the general decision-making process (Robbins 2016). It is expected that all companies have gone through the decision-making process because the approach is widely used and common. The influence of the new business environment could have resulted in skipping of some steps of the rational decision-making model.

The steps between the first and the last step cannot be assessed due to a lack of information. However, the final step of the decision-making process is in line with a quantifiable and measurable outcome. (Robbins 2016). The outcome differs among the companies since the faced problem was different. However, a similarity can be recognized since the improvement - either of products or processes - is leading to benefits for customers and the companies. While Carestream customers benefited from reduced costs, Burberry could increase the sales.

For instance, GE and CNH Industrial changed their business model to offer products as services or solutions as well as Nike and Heidelberg who included additional services in their portfolios. These results correlate with the findings of Vermesan (2015) who explains that the Internet of Things is a trigger for a business model shift resulting in products-as-services, for instance.

There is a coherent pattern between the companies how they benefited from improvement measures. But the way how they responded to the issues differ from each other in a way that might show a lack of standardized processes. While Netflix sets high emphasis on predicting the behavior of their customers with algorithms, Nike established a customer-product network. Carestream set the emphasis on high-level monitoring. Heidelberg initially implemented just a few sensors and experienced measurable results. That led to more sensors and expansion. Collins (2010) mentions that experiences are a strong influencing factor. Goodman (2013) argues that humans are more likely to execute decisions if they prior have made (positive or negative) experiences.

James D. March (2010, c1994) states that time is the main restriction that leads to profound decisions. Challenges and disadvantages found in the empirical material are mainly costs, time and security. For instance Nike sends their data to business partners and GE is facing intimacy data issues. Security challenges is one of the major points Porter (2015) states that will have high impacts on further development of the Internet of Things. Thus, security issues will influence the future business of organizations.

According to Briner (2009) and Sharma (2009), appropriate decision-making arises from information and is highly important for the outcome. The companies' proper outcomes mainly are the result of the gathered data transformed into useful information. In other words, they support decisions by evidence and therefore act technically rational. Every of the 7 companies collected and transformed their data in a certain way. The creator of the data at Burberry, Nike and Netflix is the customer itself, whilst machines create the data at GE, Heidelberg and CNH Industrial. Carestream mentions that the data is gathered by the products but since the company is selling machines, they will be considered as machines. Due to more data, Burberry and Netflix were able to segment their customers in a more precise manner, for instance.

According to Robbins (2016), companies and managers involved in important decision-making try to decide rationally but due to limitations to find the best

alternative among the high amount of information and alternatives, data needs to be separated and differentiated. (Ranyard et al 1997). This might be one of the reasons why all 7 companies used decision support systems (more specific analytical software) in order to process and assess data to finally take a decision. This means, the companies based their decisions on the accessible and available information about customers, products and processes such as monitoring. This is in line with Franks (2014) argument of the second analytics era that information stream from different sources externally and internally.

Also involved externally as wells as internally are supply chain partners. Especially CNH Industrial was depended on external suppliers when the company implemented new software. Netflix awards the organizational success to their marketing department and GE introduced a visible start-up culture within their information technology department. These effects corresponds with Christopher's' (2011) approach of the virtual supply chain. Hence, the supply chain becomes increasingly virtual in regard to relations and blurred boundaries, and the processes become interwoven.

The mainly used IoT elements in order to improve business and decision performance differ. In general, the companies used several sources of data-collection. Sensors as well as clouds were highly important. Burberry specified their sensors and stated that RFID tags and sensor touchscreens are the collectors of data. Gubbi & Buyya (2013) declare RFID tags the first and pivotal element. But still, the used IoT technology is depended on the purpose and the desired outcome of the company.

8 CONLUSIONS

In summary, this thesis provides a deeper understanding of the complex topic decision-making within supply chains in an IoT influenced environment.
From the empirical analysis, the findings reveal that decision-making in an IoT context is influenced by a number of different factors. One similarity extracted from the findings is the need to process and assess data by analytics. One major

influence is bounded to the unique problem so the situation the company is facing. The data-driven decision-making might have a greater influence on decisions related to the supply chain since the processed data (and then transmitted to information) is the trigger that transforms the supply chain to a virtual supply chain. An increased use of analytics might require that managers also have to be analytical, rational and are able to make reasonable, accurate and objective choices.

The decisions need to be monitored and perhaps changed or adapted to ensure high performance quality as well as for the purpose of decision completion. Since the decision making processes inside the company differ, there is a need for standardization in decision-making in relation to the IoT technologies and their introduction within supply chains.
After collecting information about the established companies and theoretical research, it might happen (in comparison with small companies) that large companies are much better prepared for the change of paradigm in technology and supply chain management.
The basis for implementation is mostly a challenge and the result of an implementation is also a challenge in terms of changes in business models or developing new models. More in detail, the Internet of Things might lead to a business model transformation from product businesses to service businesses (even though the companies offer products) with a need for advanced communication and cooperation. Resources could therefore be used for innovations, improving creativity or training of employees.

Due to competitiveness, there is a rising trend of creating additional value for customers. In addition not only additional value but both additional services and products might be a result of the IoT transformation. This means supply chains are highly concerned by this shift from product to service businesses. Corporate transformations such as partnerships or acquisitions are sample results of the applied use of technology. Due to the growth and maintaining overview of the big players and their suppliers, it might be reasonable to shrink teams and make the hierarchies flatter in order to increase innovativeness.

The collected data is used internally and externally to improve business operations. The data itself standalone is rather useless but the combination of the analysis and evaluation turns the data into a valuable form. A comprehensive data analysis in the IoT environment seems to be the enabling bridge for improved decision-making.
The data might not be considered separately for a certain department but rather interwoven with any department from sourcing over marketing to customers. For instance, providers of in-between solutions or data-processing are in a valuable and mighty situation. They possess the data of their customers (e.g. a big manufacturer) which are competitors. Thus, providers are in the position to share or even sell information of the competitors. It can be seen as one main reason why data security plays a major role to ensure a safe and fair business environment.
Due to the increased need for interaction with customers, machines cannot replace humans. Although the machine give suggestions and enhance the decision-making through rational data, the final decision is highly depend on skills of the human decision maker. At the end, the manager is still responsible to adjust and has high influence in making the final decision.

8.1 Reliability of Results

A crucial part of research is to explain to what extent the results are reliable and representative. During the literature review it was the aim to maintain a critical standpoint and to cross-check the material to ensure reliability. However, a few sources were translated from German into English, which increases the risk of misinterpretation. Since several business cases were examined, the conclusion and further recommendations can be seen as valid. In order to confirm the results of the analysis more comprehensively, the number of the examined business cases needs to be raised.

The possible measures that increase the reliability of the results are diverse. For instance, an increased number of quantitative data (e.g. statistics) should be taken into account and evaluated. As IoT is still evolving, different markets from

different areas around the globe need to be reviewed and compared even from emerging and less-developed countries to create an improved economic overall view.
That is why and also because of time constraints, the size of the study needs to be criticized. Since this thesis is a qualitative study, it is demanding to generalize the results due to the nature of a qualitative research.

8.2 Areas for Future Research and Recommendations

Likewise any kind of research, the findings within this thesis have limitations and thus imply space for future research. It mainly concerns the literature review and theoretical foundations as well as the practical application within a business context.

During the literature review of this paper, very few findings covered general supply chain decision-making in an IoT context. Figure 10 shows the gap that might need to be filled. At the moment, there is not such a standard model. The importance is high since the Internet of Things is an evolving topic concerning any business sooner or later.

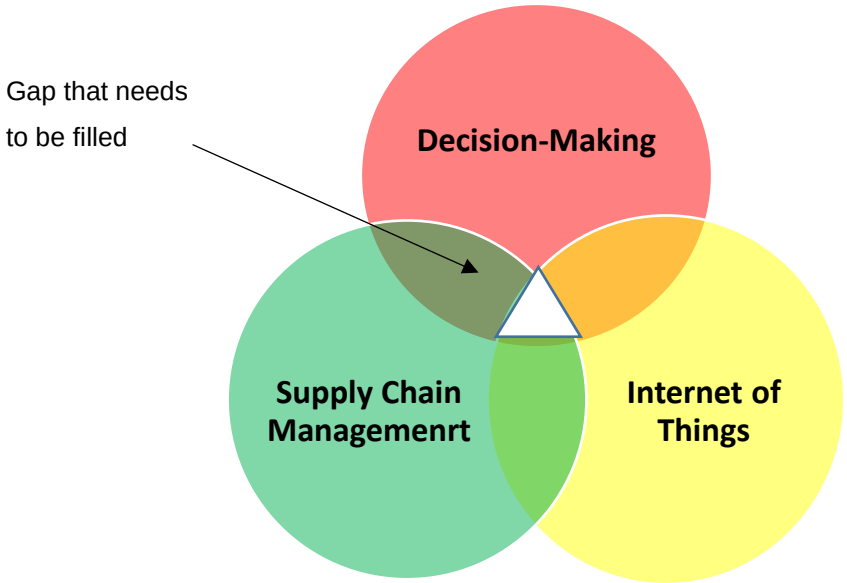

Figure 10. IoT enabled supply chain decision-making

The virtual supply chain presented in chapter 3.1 combined with the IoT reference model of chapter 4.2 could be used as the foundation for an IoT enabled decision-making model. I believe that Christopher's (2011) idea of an extended organization and virtual supply chain is the most suitable model for representing the emphasis on shared information since it correlates with the boundless data flow (meaning external and internal) in an IoT ecosystem.

Due to the lack of a commonly used IoT model that is widely accepted, Cisco Systems IoT reference model is the most suitable one at the moment. However, Cisco's model need to be developed and adjusted in such way that it might be applicable for supply chain management.

The general management decision-making model presented in chapter 3.4 and the supply chain decision making framework of chapter 4.2 could be used to establish an IoT enabled decision-making model. It will be supposed that this model is the most suitable way to simply structure the complex decision-making process and supports making a decision within the supply chain. The steps of the general decision process might remain the same in its core but should extensively adjusted to the purpose of enhancing supply chain performance.

Especially the data streams collected by sensors and analytics should be seamlessly involved. For instance step 1 (identify the problem) might be triggered by sensors or step 5 (analyze alternatives) might be replaced by "analytics". However, there is a need for the creation of a general model but obviously requires extensive research and tests on usefulness.
I want to finish the thesis with the striking famous words of Albert Camus that can be applied in every area of life, not only restricted in a business context because it sums up and points out the importance of decisions in every situation: "Life is the sum of all your choices".

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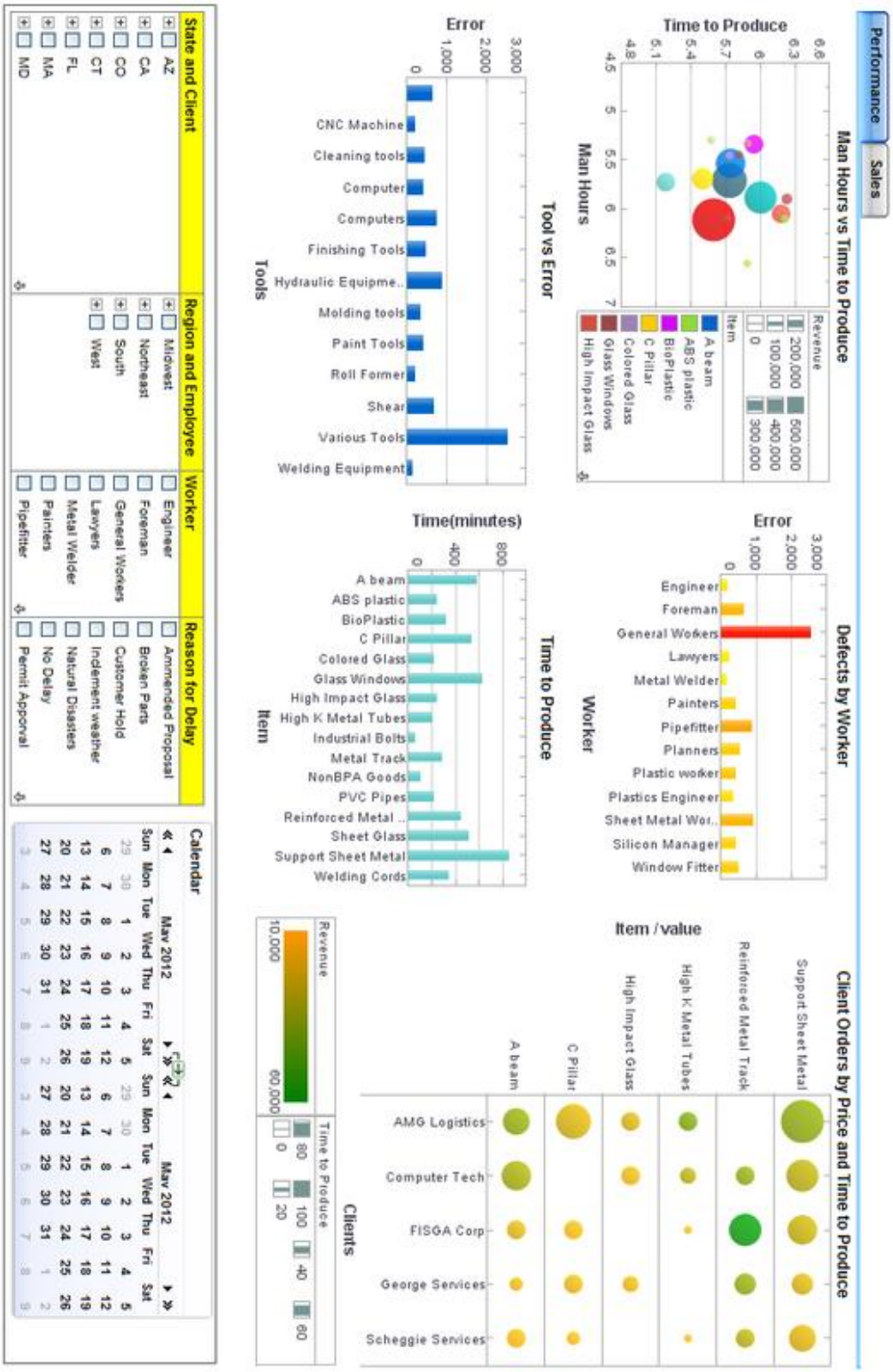

A sample visualization of a SCM analytics software accessed on https://www.cptech.com/manufacturing-supply-chain-analytics/