Managing Organizational Adoption of IoT

Revisiting Rogers' Diffusion of Innovation Theory

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Abstract

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As a disruptive innovation, IoT has been creating a high impact over organizations’ current strategies and business models. This continuous process of change will have an increasing influence on how organizations and industries as a whole conduct their businesses, and is set to have an active role towards the development of entirely new business models and markets. With the development of IoT technologies, and its predicted exponential spread across all sectors of society, one can conclude that the future holds many opportunities for organizations looking to explore new ways of capturing and creating value, but at the same time there are also plenty of challenges to be addressed. While the diffusion and adoption process of IoT has been an ongoing phenomenon over the past decade, there is still not much certitude as to how organizations ought to adjust in order to successfully integrate IoT technologies in their structure and operations. In parallel fashion, there have also been many difficulties in ensuring that different smart, connected devices and ecosystems are able to effectively communicate between each other, as achieving interoperability has become one of the major concerns associated with IoT. The main focus of this study is to analyze the process of how organizations are currently integrating IoT within their businesses, while also investigating causes that hinder interoperability, and evaluating the future potential deployment of the Open IoT ecosystems in companies. For our research we have followed a case-study approach where we conducted semi-structured interviews with managers and project leaders from two organizations conducting pilot studies on Green IoT and Open IoT, and where one has been adopting IoT technologies in its business. Theoretically, we draw on a framework by combining Rogers’ Diffusion of Innovations theory and Christensen’s theory of Disruptive Innovations in order to analyze the integration of IoT into businesses’ core structure. The research goes through a functional framework that outlines the process of IoT adoption while also presenting the present challenges that are faced by the actors in the industry and the key enablers for successful IoT integration.

Key words: IoT, Open IoT, Internet of Things, diffusion of innovations, disruptive innovations, adoption, integration, organizational innovativeness
Popular Science Summary

Through the past decades, technologies have been increasingly changing societies and the way people live their lives. Information technologies (IT) are technologies that enable the connection between two parties and have vastly contributed and revolutionized the way information and data get diffused, and how people, and even machines, communicate with each other. At the forefront of this technological wave stands the Internet of Things (IoT). IoT represents systems where computing devices, sensors or machines constantly communicate between them, by sending and receiving data, without the need for human intervention. It has been seen as an innovation with potential to address many societal challenges, prospective applications to societies aim to improve energy consumption, transportation and city planning, air quality monitoring and traffic control. In the industrial and commercial settings, IoT provides solutions in several sectors such as agriculture, manufacturing, retail, and healthcare, among others. As an innovation with such potential and complexity, it also brings along a series of challenges and constraints regarding issues such as its integration process, and device compatibility. With the increasing amount of available solutions from different providers managing various systems simultaneously becomes increasingly troublesome for consumers who have a rather inconvenient user experience due to the issue where devices made by different manufacturers are commonly unable to effectively communicate with each other, hindering the process of adopting IoT solutions in everyday life. From the organizational side, such technological innovations provide challenges that require organizations to develop new strategies and business models to better integrate them into their businesses, and also keeping up with external changes happening industry-wide. The main aim of this study is to enhance general knowledge regarding IoT, while also investigating current issues and challenges being faced by the actors in the industry during the integration of the IoT technologies into their businesses and identifying factors that facilitate the process of integration about such technologies. The study was performed by conducting a comprehensive research on the existing literature regarding IoT and collecting information by conducting interviews with individuals working on IoT projects. The results obtained provided this study with various insights that led us to conclude that in order to better adopt and manage IoT there is a need for adjustments to be made by organizations both internally, and also externally as an actor that is a part of an industry as a whole. Internal changes pass by organizations, such as having to create the right conditions in their inner structure in order to accommodate themselves for innovative technologies, as well as focusing on nurturing customer / user relationships. The industry-wide solutions focused on increasing collaboration among actors in the industry and co-developing solutions that will greatly improve compatibility between devices, which will ultimately allow the industry to grow as a whole.
Glossary

**Internet of Things (IoT)**
System representing the interconnection between computing devices, tools or machines, objects and people, which are all provided with identical description over the system. A platform that allows the transfer of data over networks without the interrelation between human-to-human and human-to-computer.

**Web of Things (WoT)**
A software-based architecture and programming algorithms that allows devices, technologies, and daily objects to be in connection with the World Wide Web (WWW).

**Open IoT**
Open source middleware for receiving data flows from clouds.

**Cloud computing**
It is characterized by its high capacity of storage and its capability to be accessed remotely from different locations. The cloud is platform that enables sharing of resources, software, and data flow among multiple and various devices, such as computers, tablets, smart phones, and etc. (IFC, 2019)

**Artificial intelligence (AI)**
A technological science, which emphasizes upon the design of intelligent machines that operate like humans. Computer based artificial intelligence tools include activities as speech recognition, learning, reasoning and identifying problems, planning and finding a way to solve those problems (IFC, 2019).

**Virtual reality (VR)**
Simulation of three-dimensional image or an artificial environment generated by software by allowing the interaction of the user with seemingly real environment.

**Open source software (OSS)**
Type of computer software that is developed in collaborative manner, which is released under license that gives the users the rights to study, change and distribute the software (Wikipedia, 2019).

**Big Data**
Very large data sets that are analyzed by computational algorithms in order to get output regarding trends, patterns regarding human behavior and interactions.
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1. Introduction

In this introductory chapter we portray the current scenery and expectations surrounding IoT, while presenting some of the relevant problems and challenges currently being faced by different actors in the market. Based on this background, we further proceed to introduce the structure of our study by stating our research purpose and questions, our intended contribution to the field, and limitations faced throughout the study.

1.1. Background

The Internet of Things (IoT) is an innovation with future potential that has led to increase of rapid developments in various industries. The IoT is being described as a network of physical devices, digitalized machines, and digital objects that co-operate with software, sensors and other services of connectivity for enhancing the efficiency of information interoperability (Dogtiev, 2018). In recent years, IoT is considered to have a huge market potential and must be placed into companies’ objectives. There are provided IoT solutions in various sectors, such as: agriculture, automotive, healthcare, and so on.

After the maturity of the market between 2011 and 2013, the number of products in the field has been increased within the consumer, commercial and industrial segments (Gravina, et al., 2018). Many companies utilized their resources for developing in-house solutions in order to keep up with the speed to market newly developed products. While companies have been in need to accelerate their product developments to get ahead of their competitors, this has not been always the right solution to strive for. This rush led to forming a highly fragmented market for IoT solutions that were mostly non-interoperable, which resulted in higher costs, inefficiencies, and a slower rate of adoption and integration of IoT solutions (Gravina, et al., 2018).

The IoT is the expected evolution of the future Internet (Vermesan & Friess, 2014). The next step, after connecting people with various technologies and smart devices, will appear to be the management of inter-connection between heterogeneous things, and also with the Internet. One of the biggest current issues with the IoT is that most of its existing structures are set up in ways that hinder difficulties for communication between devices and the IoT ecosystem. Referred to as vertical silos, these structures are vertically integrated private systems that provide minimal to no interoperability with other systems due to their unique characteristics (Ahlgren, et al., 2016). One way for breaking these vertical silos could be the development of a platform where all devices and ecosystems will be able to interact between each other more seamlessly, and users will have easier access to data and information within all integrated ecosystems, which is defined as the so-called Open IoT platform. Soldatos et al (2015, p. 14) define Open IoT as an “open source IoT platform enabling the semantic interoperability of IoT services in the cloud”. To achieve this aim, the most recent developments are focused on creating value-added open and interoperable applications or services that are connected through one single ecosystem. It is expected that similar approach will bring new forms of business-to-business (B2B) and business-to-customer
(C2B) interactions that will be representing future shifts within the market. In order to achieve similar targets companies will be enabling business relations by working together with other businesses in a more cooperative manner.

There are multiple studies conducted within the IoT field that provide broad information regarding IoT platforms and their adoption into smart technologies, buildings and cities. One particular example involves a research conducted in a city that represents a structure with four technological building blocks fundamentally grounded within the IoT ecosystem and developed as a framework of European Union (EU) Horizon 2020 program (Robert, et al., 2017). In order to ensure reliability in terms of technological dependency and break down the boundaries of vertical silos, there is a requirement for deployment of those four technological layers, described as Access, Find, Share and Compose (Robert, et al., 2017).

The strategic vision of the EU is focused on solving issues related to vertical communication model. In this context, the EU fosters many projects for enabling Open IoT ecosystems and contributes to its growth and sustainability. There are initialized pilot projects for testing the practicability and the performance of an Open IoT ecosystem, such as the case of sporting event management for the FIFA World Cup 2022 in Qatar (Kubler, et al., 2017). Those initiatives provide the necessary basic information for supporting the development of reliable Open IoT ecosystems, but there are still challenges to be solved. Also, further research on security, privacy and safety aspects is a requirement.

While the European Commission has been fostering collaboration between stakeholders from different domains and creating multi-stakeholder platforms, still the obtained data to get deeper understanding of the overall situation of private organizations and enterprises in Europe must be further evaluated (Vermesan & Friess, 2014). Especially, today’s universally accepted tool for gaining competitive advantage in country’s economy and enhance internal productivity of firms is IT, which is further being followed by IoT. Therefore, understanding the drivers influencing IoT adoption is vital for the spread and utilization of its applications.

1.2. Problem discussion

Many companies from various areas have already initiated their activities in the IoT field and make investments in order to build an adoption approach that will contribute to the efficient usage of the IoT and serve companies’ needs. The firms use the IoT applications not only for their own purposes, but also for offering better services to other companies in the field. However, it is not an easy task to enable IoT adoption and the key problem while deploying its activities into the current business occurs to be the value of this innovation. While knowing its potential contribution to businesses will not bring its efficient adoption. The organization needs sufficient level of knowledge, technical background and experience in order to overcome the issues that will appear during this adoption process.

Together with the spread of IoT, there is huge amount of change occurring on various industries and reflecting upon their business models. Corporates and big firms have already
initiated business model innovations within their organizations. The IoT is a cutting-edge innovation, which has high impact over the existing businesses of organizations. The ongoing process of change will create the futuristic shape of the businesses affected by IoT and create potential of developing entirely new models and markets. It is apparent that the future hinders many opportunities but at the same time there are explicit challenges on the way. While the number of IoT connected devices is projected to reach out 75.44 billion worldwide by 2025 (Statista, 2019), which is a fivefold increase in ten years, there is long way to go before defining the best approach for integrating IoT into businesses.

Figure 1: IoT connected devices installed base worldwide from 2015 to 2025 (Statista, 2019)

End consumers prefer having the freedom of choosing the provider of technologies that they use, which may differ drastically according to their current needs. That’s why there is an urgent necessity of enabling different devices to be interconnected by using more than one specific vendor. It is certain that even in the future it will remain difficult to enable complete mobility in the field. Many vendors promote various IoT technologies capable of interaction only with their own devices, and not with other vendors’ technologies. The hundreds of IoT technologies provided by vendors are not bringing up any solution to this problem.

In our case studies, related to Open IoT projects, there are explicit approaches followed by companies in order to overcome similar issues. Those firms apply business strategies for adopting IoT applications by enhancing customer benefits and developing new services not only for B2B or B2C, but also for individual developers. On the other hand, the range of devices that the developers support in the market is mainly focused on one single vendor, which restricts the scope of businesses and the range of application developments. That’s why; the open source environment is the initial exit point that will allow many services to interact within a wider scale, velocity of innovation, and flexibility (Amyx, 2019).

The technical, economic, and organizational opportunities that are newly appearing on the market hinder many opportunities related to the developments in the IoT field. At the same time, the challenges and risks associated with IT security and privacy concerns are having
big attention about the information systems’ researches. While many organizations are aware of the development followed in IoT technologies, it is clear that in order to have possibility to enhance its applicability into companies’ business strategies without assigning additional resources on it will be a difficult task.

1.3. Research purpose

Nowadays, many companies devote themselves into the IoT business and building products in order to satisfy future technology trends in the market. On the other hand, most of the companies do not have rigid and structured business plan before even beginning with the product design. Considering this approach and the technological perspective of those companies, there are sufficient number of tools to meet products’ design requirements and provide the necessary connection to the Internet for enabling connectivity. However, this kind of an approach would not provide a permanent solution for enabling a complete connectivity or enhancing mobility in the field. In order for companies to advance and build upon their capabilities they need much more than being competent in the field. The necessity for cooperation between competitors, better established relationship between B2B customers and well-managed corporate activities are what will build the future of IoT. It is obvious that the digital transformation will be the most important milestone for becoming part of this bigger picture, however the main issue seems to be taking place on the question about how companies will fit this innovation to their current businesses, and the main critical aspect is why companies should demand this innovation.

While the main goal of this research is to investigate the current business approaches for enabling efficient IoT technologies and diffusing them into businesses, the following key aspects will be discussed in order to give us the necessary input for achieving this goal:

- Identifying challenges of deployment of IoT applications.
- Define the key enablers for building a reliable background for the integration of technologies and innovations, such as IoT.
- Giving overview of potential disadvantages and advantages faced during the process of IoT adoption by enterprises.
- Give insights about how IoT concept will shape the future of the IoT market.

For the purpose, we will use a comparative analysis based on two cases in the research field for discussing the potential applicability of Open IoT and its services into the businesses of private and public organizations. In the process of analysis, the various contributions of the IoT to business models and its influence over the market shifts and developments will be deeply investigated and used as a basis for our research.

1.4. Research questions

As previously defined, the aim of the research is to investigate the potential deployment of an Open IoT technologies and IoT innovations by identifying the requirements of the
businesses in the field and defining the factors that will benefit its efficient adoption into the business strategies of organizations or enterprises.

Research Questions:

- How the adoption of IoT is being managed in the case studies involved in this research?
- What are the potential key enablers and main challenges influencing the IoT adoption process for organizations?
- Why Open IoT ecosystem is the future of IoT technologies?

1.5. Contribution

By providing a thorough summary of already existing literature concerning this field, we seek to enhance general knowledge regarding IoT and Open IoT, while also presenting the current issues and challenges being faced by the actors in the industry during integration of the IoT platform into their businesses. Throughout the analysis of contrasting existing literature interpretations, the empirical research findings, Bower’s and Christensen’s value network, Tornatzky and Fleischer’s TOE framework and Roger's DOI theories, the research is aiming towards providing a general overview of the applied solutions in the IoT market. The research findings will provide our study with the necessary background information that will also identify the fundamental enablers of a successful implementation for adopting a technological innovation, in our case these are the IoT technologies and innovations.

1.6. Limitations

The following limitations have been considered while researching the adoption of Open IoT and IoT applications in organizations with technological background:

- **The fragmentation of data resources** – one big challenge when conducting research for already implemented solutions in the market appear to be the limitations generated by the fragmentation of the topic, which in our case is the IoT that is being fragmented in terms of technologies and systems (such as: cloud services, Big Data, network, privacy and security technologies), and in terms of application domains (such as: energy efficiency, smart grids, e-services, etc.) (Vermesan & Friess, 2014). The excess amount of information that can be found for each segment put into question the reliability of the data used as a resource.

- **The number of case studies included in the research** – there were different case studies analyzed, and the interviewees were only the project leaders or participants, which can be further improved, and the research can be complemented further with another study based on the relationships between the different participants in the business.

- **The competency level of the interviewees** – not all interviewees have the same level of experience and knowledge in the field that our research has been conducted. Therefore, the extracted data is limited, and it may be further improved by involving
other companies into the research or contacting the top management if possible in such cases. Additionally, considering the fact that we are Industrial Management students, topics such as the software development, cloud networking, and IT were not fully approached in terms of technical boundaries that they represent instead our research is focused upon organizational and managerial aspects of the topic.

- **Access to organizations** – for being able to acquire the desired level of access to the organizations that are being researched, it could be a general issue when conducting research, and we expected that to be one of the limitations to our study. In Case 1, for various reasons we were unable to conduct interviews with other relevant stakeholders involved in the project, such as Uppsala Kommun and some of the private companies. We were able to gather a great deal of knowledge about the project from Bengt Ahlgren, one of the leaders of the initiative, and also we benefited greatly from getting first-hand information regarding other stakeholder’s involvement and interests in the project.
2. Review of IoT Literature

In this chapter, we will provide a review of the IoT literature and get deeper understanding of different technological innovation adoption processes deployed by organizations by looking into how the adoption process is enabled and what are the implications of its diffusion into companies’ businesses.

2.1. Networks of Innovation: World Wide Web and Internet

ITs have evolved significantly through the past 50 years and have vastly contributed and revolutionized the way data and information gets diffused, and how people, and even machines, communicate with each other. Michael E. Porter (2014) points out that over this period of time; IT has been a subject of substantial evolution, fueled by the growth of other technologies that enabled development of new solutions that affected society in many ways.

The history of the evolution of IT is widely described by being divided into two separate waves that drove drastic development to the field. The first wave began with the rise of the computer, and the way organizations began relying on computers to manage their operations. Subsequently, the initial release of the World Wide Web (WWW) and the popularization of the personal computer were the first steps towards a truly connected world. Second wave is characterized by the rise of mobile devices, which revolutionized Internet access by making it possible virtually anywhere, at any time, and on a variety of different platforms (Tatham, 2017). Society is now witnessing a third wave of development in ITs, and the focus shifts upon how products and devices can work together, and along with humans. This wave revolutionized products and devices, which were once, composed of only electrical and mechanical parts, now products “have become complex systems that combine hardware, sensors, data storage, microprocessors, software, and connectivity in a myriad of ways” (Porter & Heppelmann, 2014, p. 66).

In the mid-90s, the main trigger for computing has been the Internet. Internet computing can be defined in a very broad term involving the evolution of set of models in distributed computing. In such sphere, where the creation of various tools and solutions rely on open, heterogeneous and ubiquitous network services and protocols (Lyytinen & Rose, 2003). Many studies conducted in the field provide some kind of evidence that Internet is the initial source for potential innovations in system and process developments. The Internet is also the turning point for the evolution of computing services into a global source of data utilization and requirement for shaping the future.

The term IoT, also known as IoT has come up as a way to describe this phenomenon of the rise in number of smart, interconnected products and devices that create vast intricate networks of information and data trafficking, which further connecting societies and making the world ‘smaller’. ITU and IERC have defined IoT as “a dynamic global network infrastructure with self-configuring capacities based on standard and interoperable communication protocols where physical and virtual “things” have identities, physical
attributes and virtual personalities, use intelligent interfaces and are seamlessly integrated into the information network” (Vermesan & Friess, 2014, p. 3). IoT should not be seen as a single tool, but as a system, in which there is an interconnection of various different devices and ITs, with the goal of facilitating data traffic, access and management.

IoT is the platform that provides an environment for connecting everything to the Internet and by defining identification addresses called IP to every object, which is also the first step towards IoT adoption. This step represents the communication layer, which is built upon four different application domains described above as Access, Find, Share and Compose. The way how the things are connected to Internet may differ, however this is not the same in the application layer and each one of them requires only one single path of rules for exchanging information or data flow, which is called protocol. Protocols used for the Access Layer are defined as D2D (Device-to-Device), D2G (Device-to-Gateway), D2C (Device-to-Cloud), and the recently emerged communication model is WoT (Web of Things), which by using and adapting protocols provides a digital existence for the Things on the World Wide Web (Robert, et al., 2017). After giving accessibility to the Things over one single universal protocol, it must be ensured that applications will “understand” each other and exchange information, which is achieved through the Find Layer. This layer gives description about Things by enabling automatic search, filtering, and integration of data or services that are connected to applications, which process is usually defined as semantic interoperability (Robert, et al., 2017). After achieving a good semantic interoperability, the next layer is the Share Layer, which is considering the generated data by Things and how it can be securely shared between providers and consumers by encouraging stakeholders for sharing or utilizing person IoT data. This layer has a significant strategic position within open innovation platforms, especially for software providing organizations, which open their platforms to third parties (Robert, et al., 2017). The last one is the Compose Layer, where cross-platform services are built, which means that the data coming from Things can be combined and connected to analytics software to deliver data to platforms in order to fulfill the requirements of the applications (Robert, et al., 2017). While achieving a good level of interoperability between those layers is one of the most significant factors for successful Open IoT application, at the same time different stakeholders must have the freedom to join and contribute to the development of applications within the ecosystem.

The next future evolution ahead is the open source IoT platform, which is a platform for unifying different IoT data sets by using the cloud as a tool for establishing an effective interoperability between the IoT and cloud computing services. One of the novel aspects of Open IoT is concerned with combining several cloud-computing activities and supplying the demand regarding the resources provided in the cloud by using enabled innovative utility-based model, such as the Open IoT applications (Vermesan & Friess, 2014). The open source infrastructure of the platform aims to achieve efficient data interaction between the IoT and the cloud computing services, and their deployment into one platform.
The researches done in the field involve various examples of comparison between different open source IoT technologies. To be able to dig into open IoT requirements and develop the necessary platform, those requirements need to be analyzed by already implemented and not yet implemented open source systems (Li, 2018). An example of the projects that have been used to evaluate the feasibility of the platform and define the factors influencing the market is the Web of Things (WoT) test bed called WoTT. It is a platform that provides flexible and open infrastructure for the design and development of different applications (Li, 2018). Another example is the SmartSantander; it is a broader scale of test bed with thousands of nodes deployed in different cities in Europe (Li, 2018). It has the aim to collect data from the external environment and enable smart city services. The essential goal of similar projects is to reach out efficient level of improvement on the connectivity between the layers of the platforms and enhance mobility through IoT deployment, which also will form the ground of our research.

2.2. Information Technology Innovations

Innovations occurring in the field of IT became milestones of creating new organizational approaches that transformed the environment of computers and digital technologies (Lyytinen & Rose, 2003). Especially, adoption of new technological innovations during the process of improving business performances by companies has been one of the common interesting study topics not only for managers, but also for organizational researchers. One substantial aspect during the adoption of innovation into organizational level is that it is difficult to distinguish the requirements of the various types of innovations. While there is no well-established innovation theory, it is also difficult to define the characteristics of innovative organizations. However, the common point of all studies is that they do not present a theoretical model answering the question of how the changes and developments occurring in Information Systems may show dependency over the prior changes in the capabilities of the technology itself (Lyytinen & Rose, 2003). By stating that it could be concluded that there is no clear division between the changes, which are formulating the disruptiveness of IT innovation.

Disruptive innovation or technology is a process that brings up new ideas to perform operations, develop products and services. The initial point that they start from can be seen as the bottom level of the market, and usually end up with replacing their competitors in the market or creating a new market for themselves. According to Christensen (1997), it is an innovation that reshapes existing products and transforms the market by introducing simpler, more convenient, and easy to get access to cheaper solutions.

Currently, compared to all innovative technologies emerging in the market, IoT has one of the biggest impacts over the industrial economy. Till 2025, the expected annual growth in the revenues and savings will be reaching out $11 trillion, and corporate profits are expected to show increase with 21% by 2022 (Forbes Insights, 2017). The IoT has the potential of influencing the main advancements in the field of technology. As many companies grow
bigger and try keeping pace with the changes appearing on the market, implementing IoT into their business models becomes indispensability. However, the necessity for IoT can be also one of the most overhyped new requirements that are currently present in the market. In such cases, it is difficult to separate hyper from reality and even more difficult to specify the steps needed to build this reality (Forbes Insights, 2017).

The impact of IoT has immediate results over the consumer technology. In comparison with virtual reality (VR) and artificial intelligence (AI), IoT has the functions of providing in-depth knowledge and operational algorithms by having higher level of involvement into people’s daily lives (Williams, 2018). The IoT is the initial point for building up the mobility and connectivity in everyday life by enhancing the experience of users in real time and presenting countless opportunities for businesses. While many companies are aware of the power of IoT, mostly they neglect or misunderstand the opportunities that it might bring right now. Williams (2018) explains that there are three major industries that will be mostly affected by the connectivity of IoT and become main source for new improvements for consumers. The first example of this case is the finance industry, especially the banking sector and the usage of bank cards in people’s lives. Regardless of the existing gaps in security and privacy concerns for the industry, it has still gotten big developments in the field. However, the regulations and approach of the countries’ governments has a huge influence over the industry. While there are countries, in which the usage of cash is almost coming on its extinction, such as Sweden, United Kingdom, and Canada and so on. It is not quite exactly the same in other countries, such as Japan, Switzerland, Hong Kong and etc. The second most influenced industry in the health care, as Williams (2018) stated, “With so many customer touch points, health care is ripe for IoT disruption.” However, the complexity of the business and partnerships slow down the process of adoption for the health care industry. Similarly, with the finance, the biggest challenges appears to be the privacy issue of the patients, therefore the industry may further consider an approach for protecting this privacy. In order to move forward, there is a necessity for establishing partnerships with organizations advanced in security. If new products can maintain the application of the privacy and security guidelines, the health care is one of the industries that may reach out a rapid progress in IoT technology adoption (Williams, 2018). Lastly, what Williams pointed out is about that most original equipment manufacturers are the ones, which also are missing out this new wave because all vehicles are still dependent on driver’s actions and do not build up on experience-boosting services. The autonomous cars are not solution for the upcoming change, and it is about developing cars that will be able to understand and maintain themselves and their roles in the society (Williams, 2018). The near future will form the basis of an IoT standard to be built in each and every industry.

2.3. IoT in Practice

IoT technologies are disrupting organizations’ businesses and operations by providing possibilities. The new products’ capabilities and infrastructure, and the data they generate
are reshaping the work of virtually every function in the value chain (Kilkki, et al., 2018). In addition, far more intense coordination among departments is now required. New forms of cross-functional collaboration and entirely new functions are emerging. Below we present some of the organizations’ functions that have been influenced by IoT technologies, while looking at examples of real-life cases of IoT implementation that are current practiced by organizations in their operations. The overview of current practices in the field will give us further information to compare with the conducted case studies, and also with the output extracted from the literature review.

Data Analytics

When it comes to the IoT and the smart connection and communication between devices, the main output that drives these new technologies and the solutions they create is data. Being able to harvest the full value and potential of the data generated opens up new window of opportunities and a key source of competitive advantage. As a result, the management, governance, analysis, and security of that data is becoming a vital business function for any organization that wants to create the most value out of the data they generate (Porter & Heppelmann, 2014). Organizations are already recognizing the importance of data management and analytics and began looking for solutions to explore this opportunity. A popular solution has been the assembly of a dedicated data unit within the organizational structure. This unit is responsible for the governance of all the data generated from across the different departments of an organization and manages it as an asset, in a way that maximizes the potential value it can create. As the same data can be valuable for different departments, this unit would be cross-functional working alongside the different departments by making data flow across the whole organization, facilitating collaboration between departments, and providing insights on how to better harvest and use information. Headlining this unified data unit is an executive position that has become more common in organizations, and this position is the Chief Data Officer (CDO). Being a member of the executive management team, the CDO reports directly to the CEO and CFIO, and has an active role in the development of business models and strategies, as well as helping the organization understand and harness the value of data as an asset. Large organizations such as Samsung, Yahoo, Bosch, Ford Motors, and Toshiba all have a CDO in the ranks, and a unified data unit incorporated in their organizational structure (Steele, 2017).

Product Development (R&D)

Smart, connected products and networks have become complex systems that are constantly evolving in terms of structure and functionality. The new capabilities from these devices are made possible through a process of structure redesigning, with vastly increasing amounts of software that give out instructions and process data, complementing the existing hardware such as sensors and other devices that execute the instructions. Software is not only present in the device itself, but also in the cloud infrastructure supporting the device by receiving and managing the data generated by it, and other devices that make up the network (Porter
In order to adapt to such changes in the devices’ structure and functionality, design teams are re-shaping their structures in order to accommodate more personnel that is capable of working on software. Tesla, Inc., an automotive company, has a software-first approach that relies on the capabilities of software to continuously improve the quality of their vehicles, throughout its lifecycle after it leaves the assembly factory. While the vehicle (hardware) remains untouched, the company keeps improving it remotely through software updates that constantly optimize existing features such as self-driving, parking, anti-theft system, and engine configuration. This software-first approach is made possible through IoT technologies, and a network of devices that are connected and communicate with each other sending and receiving data. The company receives various types of information from all its vehicles and uses it to develop improvements that will then come back to the vehicles as software updates (Bradley, 2016).

Manufacturing

IoT technologies have been changing manufacturing operations. Devices that are smart and connected with other smart devices through cloud platforms create ecosystems capable of communicating autonomously and optimizing operations through constant sensor monitoring followed by data collecting and analysis. By obtaining and analyzing performance-related data from the machines and other devices, such as engine temperature, energy consumption, the provided information that can be used to adjust and improve operations.

Organizations have seen the business opportunities revolving IoT technologies and begun developing platforms and solutions, targeting other organizations as the potential adopters. Some examples of such initiatives are Bosch’s IoT Suite, GE Digital’s Predix, ABB’s Ability, Sisco’s IoT System, and Siemens’ MindSphere. Bosch’s IoT Suite is an OpenIoT platform that provides device connectivity and management, as well as data management and analytics. It also consists of “various cloud services and software packages all aiming to help IoT developers create, implement, and maintain IoT applications in a fast, easy, and secure way” (Bosch, 2019). The platform is built upon open industry standards and a multi-cloud strategy, where the platform’s services can not only be run on Bosch’s own IoT cloud, but also through Amazon’s Web Services, Microsoft Azure, and Huawei. Bosch’s IoT Suite has had a steady number of adopters, with companies such as Holmer, Deutsche Telekom, and EnBW making use of the platform for device and data management (Bosch, 2019). GE Digital, a subsidiary of General Electrics, developed the Predix Manufacturing Execution Systems, which the company describes as “a suite of solutions that can transform a manufacturing business through insights and intelligence powered by data integration, the Industrial IoT (IIoT), machine learning, and predictive analytics (General Electrics, 2019). Various organizations that focus in the manufacturing industries have already made the decision to implement such innovative practices, with companies such as Procter & Gamble, Toray Plastics, and Volvo Engines all adopting GE’s smart manufacturing solutions.
Logistics

Logistics operations, such as the movement of production inputs and outputs, and the delivery of goods to customers, have been the subject to some of the first involvements of IoT technologies in organizations (Porter & Heppelmann, 2014); (Hwang, et al., 2015). During the 1990’s, radio frequency identification (RIFD) networks were used to track shipments by identifying with unique RIFD tags that transmit data about the object through radio waves that can be picked up by an antenna or scanner. When implementing IoT technologies such as RIFD in logistics operations, organizations can optimize various tasks such as inventory management, asset and production management, and supply chain management (Hwang, et al., 2015). A rather futuristic application of IoT technologies that has started to become a reality is the use of automated drones to deliver packages to customers by companies such as DHL, Google, and Amazon. Drone delivery combines GPS tracking, environmental sensing, route calculation, and real-time monitoring and communication technologies, allowing the machines to operate autonomously while constantly generating and reporting data to a control unit that oversees and manages the machine network’s operations (Grippa, et al., 2018).

Marketing, Sales, and After-sales Service & Support (Vendor-Customer Relationships)

One variable in common between marketing, sales and after-sales activities is the central role of the customer when planning strategies and operations performed in these functions. Acknowledging the characteristics of IoT solutions, organizations adopting and/or providing IoT technologies have to expect and prepare for constant interactions with vendors who will provide after-sales support for the different solutions and services being offered, or customers, who provide valuable feedback for vendor organizations (Porter & Heppelmann, 2014). Vendors will provide maintenance, consulting, etc. On the other hand, adopters provide data for the vendor regarding the product/service’s performance, efficiency, and effectiveness, also feedback in terms of product/service usability, and overall satisfaction transforming after-sales relations with vendors into becoming continuous and open-ended. Based on the feedback received in the data gathered from the customers, marketing and sales become more targeted, personalized and effective. The data gathered from the customers allows providers to compare usage patterns and optimize customer segmentation, and product personalization. This knowledge can also be used to develop practices for value creation such as pricing-strategies, special offers, and product/service bundling (Nguyen & Simkin, 2017).

Digital platform for enabling IoT in organizations

 Organizations strive for enhancing their knowledge and specialization in the IoT field in order to better position themselves in the IoT market. Facilitating global IoT solutions derives from the ability to build a reliable background through developing digital platform
for IoT businesses. A similar approach can be seen from numerous enterprises that are specialized in different fields. One example is the Nestle Institute of Health Sciences (NIHS), which is specialized in biomedical research, which have been doing investments on the research for developing predictive models in the field of health and disease for years (Nestle, 2018). The research resulted in developing a platform for processing and analyzing data about customers’ lifestyles, daily routines, activities and diet.

The company has been aware of the importance of the digital world and finding the right digital strategy and deploying it to the current business depends on many factors, such as its country or location in the world. There were several strategies that can be followed in order to find the right way of using the Internet in its more effective and efficient way in relation with company’s business model. The main concerns have been on how the nutrition platform could be deployed in order to enable R&D analysis for potential winning products, develop a direct and a reliable communication with customers and what are the necessary partnerships: organizations with powerful online background or high-tech manufactures (Nestle, 2018). While building a digital platform for achieving corporate’s goals, it is important to consider not only the changes occurring in relevant markets or segments, but also take into account the markets with high dependency on countries’ cultures. Through this process, companies must consider the pace of development and the level of openness to potential innovative changes of such industries.

A specific concept that had prevalence was the collaboration of e-commerce platforms with partners in the field. One of the key factors for stakeholders involved in the industry has been the ability to ensure that the users or customers’ expectations are covered by their products by making the necessary developments and improvements based on customer feedback (Nestle, 2018). The fragmentation of markets has been the key obstacle for the raise of monopolies. As Greg Beard, Nestlé Health Sciences CEO (Nestle, 2018), stated:

I think the pharmaceutical industry is our partner. Many of our products are not substitutes for medicines. Rather, they are used as supplements to increase the effectiveness of medicines or to suppress side effects. Indeed, we are working with a pharmaceutical company to collaborate regarding what we can do to provide a better solution for patients.

It can be concluded that the agreement and collaborative work with other businesses and build on B2B relations is the key enabler in order to succeed in the industry. The IoT has been used as an important tool to monitor the developments in the area, to identify the shifts in users’ needs and elaborate the potential for partnerships.
3. Theories used in adoption of IoT innovation

Throughout our literature review, we encountered a number of articles that approach our topic of IoT, with more emphasis on the adoption aspect of it in various different industries and environments. Different theories were considered during the process of choosing the right approach to analyze the case studies, which are further discussed below.

3.1. Tornatzky and Fleischer’s TOE framework

The broad application of IoT services in many private and public companies is an important sign of the technological advancements in the field. Many organizations need to develop their capabilities in order to gain competitive advantage in the market, and for the purpose there is a necessity for rigid and intensive use of IS (information systems), which serve as a vital source of innovations. That’s why many innovation-oriented organizations are being part of this innovation adoption process of IoT activities.

In this regard, there is growing amount of studies, and also theories used in the adoption of technological innovation. One of the most common one is the “Diffusion of Innovation” or the DOI theory of Rogers, and another theory that has similar level of applicability is the TOE framework. That’s why in our research, we will be using Rogers model blended together with the TOE framework in order to follow up a more holistic approach for the IoT adoption process analysis. In line with that, it can be seen that the environmental factor included in the TOE framework is not available in the DOI theory. The combination of those two theories will give us deeper insights about the internal structure of the firm during the adoption process. TOE framework developed by Tornatzky and Fleischer (1990) explains the influence of three main factors over the adoption and organizational usage of technological innovation. The technological aspect includes external and internal technologies that somehow have influence over the productivity within the organization. The organizational aspect considers the size and scope of the firm and its resources in terms of finance and resources. And finally, the environmental aspect involves company’s relationships and business with partners, competitors and government (Tornatzky and Fleischer, 1990). Below, the sub-elements of each aspect related to TOE are described and more details are given for each one of the factors (Hoti, 2015).

<table>
<thead>
<tr>
<th>Technological aspect</th>
<th>Relative advantage</th>
<th>Compatibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Relative advantage</td>
<td>The level of advantage, which the innovation is being perceived compared to its original idea</td>
<td>The level of perception regarding the consistency of innovation in terms of current values, past experiences and adopter requirements</td>
</tr>
</tbody>
</table>
In order to gain further knowledge about the organizational adoption of IoT technological innovation, there is a necessity of understanding its dimensions and characteristics. That’s why while using the TOE framework it will be combined with the DOI theory of Rogers, which will be further discussed in the upcoming section of this paper.

### 3.2. Rogers’ theory of diffusion of innovation

#### Why Rogers?

Rogers’ (1983) diffusion of innovations theory (DOI), has been regarded as a pivotal framework when it comes to studying and understanding how technological innovations get diffused, and potentially adopted by individuals and/or organizations (Tu, 2018); (Ammirato, et al., 2019); (Hwang, et al., 2015). As a pioneer in diffusion and adoption research, his work has stood the test of time and the diffusion/adoPTION process of recent
innovations still follow the approaches theorized by the author. While acknowledging the existence and the need to use other theoretical frameworks to study these phenomena, making use of Rogers’ work is still a sound approach decade later.

- **Theoretical concepts**

When looking at a technological innovation, its diffusion and adoption is one of the final steps if we look at its life cycle as a process. Rogers (1983) considers the existence of a process where there is a whole set of activities and decisions prior to the diffusion and adoption phase that highly influence the role of such innovations in a particular setting, or the whole society. The author (1983, p. 135) refers to this process as the innovation-decision process, and describes it as consisting of “all of the decisions, activities, and their impacts that occur from recognition of a need or problem, through research, development, and commercialization of an innovation, through diffusion and adoption of the innovation by users, to its consequences.”

![Innovation-Development Process](Rogers, 1983)

A brief description of each phase will now be provided below:

1. **Recognizing a Problem or Need** is the main driver from which R&D activities are conducted in order to create an innovation aimed at solving the problem/need. A problem/need can rise from various reasons, and even as a consequence from a previous solution to another problem/need, such as how Open IoT aims at solving certain issues rising from IoT, like the lack of interoperability between IoT systems and devices.

2. **Basic and Applied Research** is then conducted in order to create a knowledge base which will then be put into use for the planning and design of the innovation. Basic research can be defined as the “original investigations for the advancement of scientific knowledge that do not have the specific objective of applying this knowledge to practical problems”. And in the other hand, applied research “consists of scientific investigations that are intended to solve practical problems” (Rogers, 1983, p. 138). Based on the definitions, it can be implied that the research process starts with the basic research, which then leads to the applied research, and culminates on the start of the development stage.

3. **Development**: of an innovation is the stage where the idea starts to evolve and materialize towards the solution that potential adopters will use to be able to tackle the problem/need that it has been projected to solve. The development stage is a thorough such as process that can have various phases such as brainstorming, designing, prototyping and testing.
4. **Commercialization** is the stage that comes after the innovation is fully developed and ready to be used by the potential adopter and fulfill its purpose. This stage is also comprised of various stages such as “production, manufacturing, packaging, marketing, and distribution of a product that embodies an innovation” (Rogers, 1983, p. 143).

5. **Diffusion and Adoption** stage is where the innovation is made aware for potential adopters. The decision to begin diffusing an innovation is a vital one, as the different stakeholders and actors need to be in synchrony in order to make the diffusion process as effective as possible. Different stakeholders can be the entity producing the innovation, entity(es) funding it, and others, while different actors could be diffusion agencies/systems, change agents, regulating agencies, governmental agencies, and other actors that have the ability to communicate and disseminate the innovation to potential adopters. At this stage, organizational relationships become very important towards the diffusion and adoption of the innovation (Porter & Heppelmann, 2014).

6. **Consequences** are an inevitable result from the adoption, and even non-adoption of an innovation. Rogers (1983, p. 370) defines consequences as “the changes that occur to an individual or to a social system as a result of the adoption or rejection of an innovation”. Consequences can be classified as desirable or undesirable, direct or indirect, and anticipated or unanticipated (1983). At this stage of the process, the problem/need that originated the whole process has or has not been solved. Such ‘problems’ may only be deemed as ‘problems’ depending on the point of view. In the case of IoT, when trying to work towards the interoperability of devices and systems, vertical silos are seen as a problem towards achieving that reality (Ahlgren, et al., 2016). Meanwhile, for a company who owns an economically successful vertical silo, then this issue may not be seen as a problem.

In accordance with the research questions that guide our research, the focus lays upon the diffusion and adoption of IoT technologies from organizations. Furthermore, while the concept of IoT and its many applications have an ever-evolving nature, it can be considered that IoT has already gone past phases 1, 2, and 3 of Rogers’ innovation-development process (1983), and it is going through phases 4 and 5, which are the commercialization, and the diffusion & adoption phases respectively. It is important to mention the ever-evolving nature of technological innovations such as IoT, since these type innovations can make a process such as the innovation-development process turn out to be cyclical, instead of a straight line that has an end and a beginning. This means that when the technological innovation goes through the later stages of the process (commercialization, diffusion & adoption, and consequences), it can lead towards the recognition of new needs and problems, which then restart the whole process again, making it a cycle.
After looking at how innovations are created, it is time now to start shifting the focus towards the potential adopters, more specifically organizations, and how they perceive and eventually adopt and implement innovations. In his broadly inclusive theory, Rogers also attempts to describe the link between innovations and potential adopters, trying to determine factors and characteristics that influence certain phenomena such as innovations' rate of adoption, diffusion behavior, and organizational innovativeness.

Amid the most pertinent research questions raised by diffusion researchers, there is the question about how the perceived attributes of innovations influence their own adoptions rates, and if each of the attributes has a positive or negative impact on the adoption rate of an innovation. Below, a brief explanation of each of the attributes is provided:

1. **Relative advantage**: is the measurement from which an innovation is perceived by the potential adopter to be superior than the currently technology being used in the organization. Relative advantage can be measured in different dimensions such as economic, efficiency, ease of use and satisfaction. The characteristics of the innovation and how the adopter plans to use it are some of the facts that dictate which of the dimensions are deemed as important for the adopter when determining the innovation’s relative advantage. In terms of the impact on an innovation’s rate of adoptions, the higher the relative advantage, the faster the adoption rate. When it comes to IoT, researchers and organizations see the innovation as having a relative advantage in terms of automation, efficiency, instant data access, and cost savings (Porter & Heppelmann, 2014).

2. **Compatibility**: Rogers defines this compatibility as “the degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of potential adopters. (...) The adoption of an incompatible innovation often requires the prior adoption of a new value system” (1983, p. 223). This definition is very comprehensive, as it touches upon different dimensions where one innovation can be seen as compatible. In the case of IoT, compatibility is an issue that is related more to the technical aspects of it, and the relationship between IoT and existing infrastructures. Issues such as the lack of uniform standards and protocols IoT systems, and the existence of vertical silos make it hard for devices from different manufacturers to communicate with each other, creating several compatibility issues (Ahlgren, et al., 2016).

3. **Complexity**: relates to the perceived difficulty experienced when understanding and making use of the technology. The degree of complexity is an important factor when making the decision to adopt an innovation, as relatively more complex innovations are less likely to be adopted than simpler ones, especially when the adopter is an individual. In the organizational environment, complexity is also an issue, but when it comes to technological innovations, organizations are usually more prepared to provide the necessary support for the using members to attain
the skills and knowledge required to make use of the innovation (Rogers, 1983). IoT systems are known to be very complex, as systems are designed to be vast, very intricate, and constituted by many different devices that have to communicate between each other. Not only interoperability, but security/privacy issues related to IoT systems make it a very complex concept to adopt (AlHogail, 2018); (Almeida & Doneda, 2017).

4. **Trialability**: is the amount of experimentation that can be done with an innovation before reaching a decision towards its adoption. Innovations that can be experimented before adoption have a higher chance of being considered by potential adopters, as they are provided with an opportunity to reduce any uncertainty they might have related to the innovation. As a conglomerate of technologies IoT, through its many different applications, has a high degree of trialability, as most people have been previously exposed to the usage of IoT in some way (Porter & Heppelmann, 2014).

5. **Observability**: is the amount of exposure and visibility an innovation has once it is being implemented. Innovations whose results and consequences are more observable help reduce the uncertainty about its usage and what to expect from it. Observable results also stimulate discussions among members of a system or society and provide concrete material for the change agents and diffusion agencies in charge of diffusing the innovation, which contributes towards a faster rate of adoption.

Rogers regards the perceived attributes of innovations as an important factor towards the diffusion of innovations, as he uses these to help understand other different concepts, such as being considered a variable for the rate of adoption of innovations, alongside other variables such as the type of innovation-decision, communication channels, nature of the social system, and the extent of change agents’ promotion efforts (1983, p. 232). The author also uses the perceived attributes of innovations as a part of the persuasion stage in his model for the innovation-decision process, which is a model that attempts to illustrate the process through which an individual or an organization adopt an innovation. This model has five stages and starts with the knowledge stage where the potential adopter finds out and researches about the innovation. Secondly, the persuasion stage where the potential adopter searches for more information about the innovation and seeks opinions from others. Following is the decision stage where the potential adopter reaches the decision to adopt or reject the innovation. Upon the decision to adopt comes the implementation stage where the adopter puts the innovation to use. Finally, it is the confirmation stage where after continued usage of the innovation, the adopter evaluates whether to continue using the innovation, or to discontinue its usage (Rogers, 1983).

As the scope of our research is to study how technological innovations such as IoT can be successfully diffused, and adopted throughout organizations, it is important to not only focus
on the innovations themselves, but also to look at organizations, and understand how they arrange themselves in order to better embrace innovations and make the most out of them. Rogers (1983, p. 348) defines an organization as a “stable system of individuals who work together to achieve common goals through a hierarchy of ranks and a division of labor”. The author came up with a model that determines different characteristics that make organizations less or more prone to adopt innovations. These characteristics are considered variables that can have a positive (+) or negative (-) influence towards an organization’s innovativeness.

![Diagram of Organizational Innovativeness](image)

Figure 4 – Variables of Organizational Innovativeness (Rogers, 1983)

A brief description of the individual and internal characteristics/variables of organizational structure will now be provided below:

- **Individual (leader) Characteristics:**
  
  1. **Attitude towards change:** Most organizations have a hierarchy-type of innovation-decisions, where “choices to adopt or reject an innovation that are made by a relatively few individuals in a system who possess power, status, or technical expertise” (Rogers, 1983, p. 347). In this sort of scheme, having a leader(s) that has a positive attitude towards change, increases the chances of the organization adopting innovations, and also spreading the innovative mentality throughout rest of the structure, which can lead to a faster and more effective adoption rate within the organization.

- **Internal Characteristics of Organizational Structure:**
1. **Centralization**: is the amount of power and control concentrated within a select few members in an organization. With a negative impact on innovativeness, a high level of centralization means that the decision power rests with few individuals whose role positions them away from being exposed to day-today operations where one can better identify the need to innovate.

2. **Complexity**: is the amount of expertise and high-level knowledge possessed by the different members of an organization. A high degree of complexity within an organization suggests that there is a wide range of specialized occupations with different professional and academic backgrounds, which encourages innovative thinking.

3. **Formalization**: is the amount of strictness towards members following rules and procedures while performing their roles in the organization. An abundance of formalization discourages members from indulging in innovative thinking, but on the other hand, once an innovation is adopted by the organization this type of structured conduct helps its implementation process.

4. **Interconnectedness**: is the degree to which different units such as departments and organizational systems in an organization are connected through interpersonal networks. A higher rate of interconnectedness means that those different units communicate better, making the flow of new ideas and innovative thinking faster and more fluid, which translates into higher organizational innovativeness.

5. **Organizational slack**: refers to the uncommitted resources such as financial, material, staff, knowledge, and availability that an organization has at its disposal. Organizational slack provides additional means to support an innovative mindset, contributing towards organizational innovativeness.

6. **Size**: is widely related positively with organizational innovativeness, much due to the fact that an organization’s size is directly associated with vaster resources from which R&D initiatives and changes can get the necessary support to flourish. Size is also related with the availability of slack resources. While size contributes positively towards organizational innovativeness, it can also difficult the process of implementing an innovation, as changes take more time to take effect.

- **External Characteristics of the Organization**:

  1. **System openness**: is the level of interconnectedness between members of a system with external members of neighboring systems. Open organizations have a structure which enables the exchange of information across its own system, making it a positive characteristic towards organizational innovativeness and the organization more aware of its surroundings. Ruvio et al (2014) suggest that system openness also refers to an organization’s capacity to respond to new ideas and innovations.
Organizational innovativeness is perceived in contemporary literature as “desirable aspect of organizations because it energizes them and enhances their probability of survival and continued success” (Ruvio, et al., 2014, p. 1003)

It is also important to understand how organizations approach the adoption of an innovation within its structure, as depending on the nature of the innovation, certain adjustments need to be made to better accommodate for the innovation and better capture all the value it can potentially create. Rogers developed a model of the innovation process in organizations where he describes the steps through which organizations structure their strategy to adopt an innovation. This model has two main stages that are subdivided in different phases.

**INITIATION PHASE**

**Agenda-setting** → **Matching**

**IMPLEMENTATION PHASE**

**Restructuring** → **Diffusion** → **Routinizing**

*Figure 5 – A Model of the Innovation Adoption Process in Organizations* (Rogers, 1983)

The initiation stage refers to all the proceedings an organization takes upon to adopt an innovation. These proceedings can go from identifying a need/problem, and information gathering, to analyzing and conceiving an approach to adopt an innovation. This stage has two phases:

1. **Agenda-setting**: A need/problem(s) to be approached is determined, and research efforts commence in order to find an innovation that the organization perceives as a suitable solution

2. **Matching**: In this phase an innovation has been chosen as a solution to be matched with the problem identified. More advanced planning is made in order to conceptualize how the innovation will be implemented in the organization.

The implementation stage refers to all the proceedings an organization takes upon to implement an innovation after the decision to adopt it. A considerable amount of work has to be done surrounding the innovation and the system around it. This stage has three phases:

3. **Redefining/restructuring**: The adopted innovation is reinvented according to the organization’s environment and specific circumstances to better suit its interests. Innovations which are a more like a concept with many possible applications, like IoT, are more likely to be reinvented (Rogers, 1983, p. 180). Not only does the innovation have to be redefined to better fit the organization’s environment, but the organization itself also needs to adapt to the innovation. Changes in structure, processes and others might have to make to better accommodate for the innovation.
4. **Clarifying:** As the innovation begins to be used in the organization, a clearer picture starts to form surrounding its application, how it relates to the problem it is intended to solve, and how the members of the organization perceive its attributes.

5. **Routinizing:** As the innovation gets gradually more usage within the organization, it starts losing its own separate identity, and becomes a routine among the organization's processes and way of operating.

### 3.3. Christensen’s theory of disruptive innovation

- **Why Christensen?**

In order to research the deployment of an Open IoT ecosystem into enterprises, the nature of this new service or so-called business field was closely analyzed. The IoT ecosystem is a huge idea that has the potential of disrupting many industries that are already dominant or competitive within the market. Therefore, part of the research is focused on analyzing the disruptive changes that might occur in the technology and market structure. For the purpose, Christensen’s theory on disruptive innovation is used to analyze the applicability of the principles of disruptive innovation examined in the book “The Innovator’s Dilemma”.

- **Christensen’s theory and its principles**

According to Oslo Manual (2005), innovation in firms can be defined as “the product, process, marketing method or organizational method must be new (or significantly improved) to the firm[s]”. Another definition given by Kline and Rosenberg could be that the “process of innovation must be viewed as a series of changes in a complete system...” (1986). There are many other definitions given for innovation, such as Freeman and Soete make distinguish between innovation and invention by defining innovations as “the creation of a new idea and its reduction to practice and it includes all the activities required in the commercialization of new technologies” (1997). The main understanding of all these definitions is that innovation must represent something new like a novel approach or looking through a new perspective to the surrounding environment. While there are two categories of innovation established and defined by Joseph Schumpeter as radical and incremental, he also identifies innovation as a critical milestone of the change perceived in the economy.

The beginning of the new era of economy is determined to be the late 1990s, in which the high-tech devices and the Internet were integrated (Schneider, 2017). Schumpeter’s “creative destruction” is used for the simple reason that innovation has become a driving force of change causing transformations in the industry, and also in the society. The idea of “creative destruction” has a complicated structure but in its basis is much simpler. Joseph Schumpeter in his study of Capitalism, Socialism, and Democracy (1943, p. 83), he describes the theory as:

> The opening up of new markets, foreign or domestic, and the organizational development from the craft shop to such concerns as U.S. Steel illustrate the same
process of industrial mutation – if I may use that biological term – that incessantly revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one. This process of creative destruction is the essential fact about capitalism.

Here, the theory is being described as a system of processes that shape the industry or the society. The effects of the continuous changes occurring in the market over the monopolies, has been reviewed as described above by the approach of the economist Schumpeter, and secondly by the management theorist Christensen. Those two theories as much as similar they are not identical. Schumpeter’s theory gives a better understanding upon the bigger picture that describes the industry in a broader perspective, on the other side Christensen’s aspect is more analytical and the change is controlled on a microeconomic level by considering the small details in the process. In this regard, it could be said that the two theories in some sense complement each other and try to put light on the uncertain, dynamic and open-ended processes of innovation (Schneider, 2017).

The overall process of innovative change and the adoption of those changes to the industry is what defined as creative destruction (Schneider, 2017). Many traditional companies are forced to adapt these novelties into their market processes, production systems and business models. About disruptive innovation, its primary starting point is the technological change that creates innovation by starting at the low end of markets or by creating brand-new market (Schneider, 2017). The change doesn’t only appear on the market, but it may reshape all the characteristics of the market processes. Clayton M. Christensen, the originator of the disruptive innovation theory is also recognized as a leading expert in the field of innovation. In his 1997 book, The Innovator’s Dilemma, he gives detailed explanation of the reasons for the failure of leading companies that couldn’t adapt to the wave of novelties occurring in the technological field. He discussed in detail about the dilemma that most managers face in order to succeed in their business. The traditional way they follow includes: responding to the customer needs, making investments to the business, and building upon diversification by avoiding the risk factor coming from the small rivals. The monopolies are most likely to ignore the flexibility of this competitive force with “disruptive” innovations because usually they underestimate the quick reply to the changes occurring in the market by these forces (Schneider, 2017).

Another researcher who closely examined Christensen’s Disruptive Innovation Theory is Danneels (2004) who analyzed the issues related to Christensen’s theory and their too broad and diverse application by establishing a new definition of the theory. The unclear understanding of the theory is one of the major problems uncovered in this aspect to bring more detailed explanation of it, and additionally contribute to its understanding. While Christensen (1997) focused his research upon the technological change of the various markets, the theory became widely used in many industries. It can be looked further in its practice and advancement in the following years when Christensen and Raynor (2013) developed the theory over its scope by adapting not only to technologies but also utilizing
its use for different products and business models. Therefore, the difference between disruptive technological innovation and disruptive business model innovation has a clear line of separation that defines the fundamentals of the research. As a result, Markides (2006) explores those two types of disruptive innovations: business-model innovations and radical product innovations and gives a separate explanation for each one of them.

To begin with, radical product innovations may have stronger influence over the leading companies’ strength and position in the market. On the other hand, business-model innovations are what shaping the market or industry itself, which presents an opportunity for the company in order to make its choice whether to adapt to those changes or not. However, one vital aspect is that no matter if there is a change or not, there is always need for progress and innovation in order to remain competitive in the market. While this kind of an advantage can be obtained through classical product innovation, in recent years value creation is a key factor for success and it is mainly represented within the business model innovation concept (Pavie, et al., 2013). There is a serious amount of research based on those two theories, which can be thoroughly analyzed in terms of the challenges they hid for already established firms, the implications that each one of them pose over the managers and how they may impact companies’ goals in case of implementation.

While researching the effect of disruptive innovation theory on the business world, it must also be further discussed whether the theory really describes what actually is happening in the business. In order to identify the applicability of the theory and see whether this fit is reliable, initially the main drivers of the theory of disruptive innovation need to be pointed out. Related to Andrew A. King and Baljir Baatartogtokh’s article on “How useful is the theory of disruptive innovation” (2015), Christensen’s theory has four key elements applied on companies’ business models, which are used for guiding them through unsteady market conditions:

**First key element:** “Incumbents are improving along a trajectory of innovation” or the so-called concept “Sustaining innovation” is about continuous improvements made on the value-added areas. The management has the responsibility to produce better products that can be sold at a higher price to the customers who are not fully satisfied and there is a room for demand within the market (King & Baatartogtokh, 2015). The distinctive nature of disruptive technologies is the major driver for the improvements made on the product and a reason for the search of another potential customer segment.

**Second key element:** “The pace of sustaining innovation overshoots customer needs”, which means that the customers’ expectations are exceeded in a manner showing that the pace of development is too fast and can’t be utilized in its full potential by its users. In such cases, the advancements in the field exceed the pace of adjustment of users to the already existing products.

**Third key element:** “Incumbents have the capability to respond but fail to exploit it” means that most incumbents have the potential and the necessary capabilities to maintain and
contribute for the necessary developments in order to succeed in the market, but they are usually obstructed by the managers who are failing to adapt to the changes occurring in the market. Potential disruptors mainly focus on new and low-end customers that are avoided by the incumbents, and instead of making advancements on the product, they choose to invest on simpler and less expensive developments (King & Baatartogtokh, 2015). In case that the product appears on a different market, it is failed to be noticed by the incumbents’ managers, which leads to misdirection in company’s perceptions for innovation.

**Fourth key element:** “Incumbents flounder as a result of the disruption”, this represents the dead end for the incumbents. The situations, in which similar results occur, show a similar approach of what is defined by Christensen as “failure framework” (King & Baatartogtokh, 2015).

The four key elements of the Theory of Disruptive Innovation are showed within one dimension that is called “Performance”, and the customer needs are drawn as a line. However, how effective is this presentation must be argued (King & Baatartogtokh, 2015). It requires further specification on what are key performance measures to be implemented for keeping track of this progress. There is a need for setting a target and recording the measures in order to get better understanding of this graph, and also to define relative performance depending on the factors influencing its level.

Another key aspect that must be considered is the relationship between business models, new technologies and innovation processes over the basis of disruptive business models, which is represented in a systematic way in Figure 6 below. The concept “Disruptive Business Models” can be seen in its details, which is impacted by the emerging technologies and innovation processes of the current business model of the company.

![Figure 6. “Disruptive business model concept” (Schiavi & Behr, 2018).](image-url)
The focus is on the business models and how they are being affected by the changes occurring in the management of emerging technologies and processes of innovation. These changes might need to necessitate for improvement or replacement of the business models used in the company, sometimes even requiring new forms of business organizations in terms of leveraging the increase of products or services’ value delivered to the consumers (Schiavi & Behr, 2018). This is result from the disruptive business models’ occurrence in the business environment, which lead to segmentation of market or creating new markets, the existing business models lose their beneficiaries, and there is a necessity for gaining competitive advantage (Schiavi & Behr, 2018).

3.4. Proposed conceptual theoretical framework

The theories that we included in our research will serve for questioning strategic business approaches followed in the current industry by observing the influence of stakeholders, the main challenges faced by project leaders, the key advantages and disadvantages described by stakeholders, the factors enabling reliable integration, and the expected future shifts in the IoT market that will be playing key role in identifying the future opportunities of this adoption/deployment process of IoT.

In our research, we mainly focused our analysis upon the determinants that influence the IoT adoption at organizational level. In order to analyze the opportunities and challenges faced during the adoption process, we revised the DOI theory by implementing TOE framework and considered the amplitude of diverse aspects of IoT services and applications. While the TOE framework (Tornatzky & Fleischer, 1990) brings forward the specific organization or company’s structure influence during the organizational adoption decision-making process, the DOI will serve as a ground for researching the innovation adoption process that discovers the necessities for creating organizational innovativeness by looking into the variables affecting this output. This will give us the opportunity to look into the process of IoT or Open IoT adoption in firms and their strategic business approach, and also see the trends on the market.

This revised approach is not supposed to give us a concrete model of determinants, but it will provide the necessary tools for classifying the factors, which are constraining or contributing to the adoption and implementation of IoT innovations in firms. The dynamic shifts happening continuously in the market may have different impact on companies according to their structure or position in the industry, therefore this approach will give us further potential for researching similar cases in the field and reliable ground for building our findings upon. Christensen’s Theory of Disruptive Innovation, as we discussed previously, will be a supporting theory for discussing the potential value input or creation of IoT adoption in organizations or enterprises.
Figure 8. Proposed Conceptual Theoretical Framework – TOE & DOI
4. Method

In this section we described how this research is being conducted in terms of approach, strategy, design, and method. A qualitative study is being used based on abductive approach, and the analysis of the case studies. Data is gathered through semi-structured interviews, along with a theoretical framework and the existing literature on the topic. Finally, we went over the quality and ethical considerations related to our empirical research.

4.1. Research approach

While conducting this research, an abductive approach has been followed, which in our case is mainly used for questioning or reasoning the relevant framework for and its input to our case studies. The suggested theoretical framework was further applied for analyzing the key findings of the research. In order to analyze the relation and to assess the interconnection between theories and the extracted empirical data, we used a comparative analysis of two case studies and the interview outputs of different stakeholders involved in this process. For the purpose, the collected detailed data about businesses and individuals was further studied and discussed through Rogers’ DOI theory and Tornatzky and Fleischer’s TOE framework, which were inter-related in our theoretical framework in Figure 8. Additionally, and Christensen’s Value Network was used to evaluate the value of the IoT adoption in businesses. While evaluating the framework in terms of its validity, and, we will further investigate its utilization into the field of our research.

Using case studies in our research, we have had the obvious option of doing a comparison between organizations’ business strategies. Considering how descriptive the research questions are, this strategy can be supportive in providing answers to what it has been investigated. Especially that case studies are good way of looking into the details of the surrounding world and are used for creating the logical link between the collected data and the output to be extracted in relevance with the initial research questions. Also, they have detailed contribution and broader in-depth investigation of the relevant information.

4.2. Research strategy

In order to be able to study the integration of the IoT into businesses’ structures and its potential disruptive opportunities and challenges, the strategy that we decided to apply for this project is the qualitative approach, as we believe that this is the strategy that is better suited for our topic of interest for studying individuals and their point of view, the interaction between project leaders and organizations, and perform deeper analysis on the IoT innovation. The following topics that will be further investigated are also the root cause for our focus on qualitative study approach:

- the involvement of project leaders or managers in the deployment of IoT services,
- getting more insights about how project leaders perceive the integration of IoT into people’s daily lives,
• finding an approach to follow for adapting to the rapid shifts occurring in the industry.

4.3. Research design

In the previous sections, there was a detailed discussion followed through various theories used in the field of diffusion of innovations and their relation to the disruptive potentials of the IoT. Therefore, this section will be providing the structure of data collection and the approach followed regarding its analysis. Particularly, we will use a case-study approach to present our study. In terms of establishing scientific generality could be very difficult with case studies, especially when the study sampling is too small, and it is much more difficult to obtain generalizable results. However, building on objective setting and focusing on parameter establishment is major focus on similar approaches. The detailed description of the cases and the qualitative approach mainly produce better results while collecting data from real-life environment (Zainal, 2007). The case studies can assist on testing the adoption of ideas and produce novel hypothesis, which could be further analyzed. While case studies are not always the best research tool, depending on the nature of the research problem it could be a very good approach for understanding the complex social setting, which in this case is consisted of multiple variables interconnected to a phenomenon – the IoT.

We proceeded by following case-study approach, as we are presenting two real-life pilot applications of the IoT platform, with one being an Open IoT platform. We will go through the whole process from the planning stage, through the development stage, all the way to the implementation stage, and analyze the feedback acquired from the experiences, at all phases of the projects. The cases that are chosen will also serve as a supportive tool for researching the relevance and applicability of theories in regard to IoT diffusion and its management. We will look into the influence of managers, leaders and individuals over the spread of a new technological innovation (IoT) into companies’ business and the strategy followed during this process.

4.4. Research method

In order to compile empirical data on this topic, we plan on conducting semi-structured interviews at the two organizations conducting pilot studies on Green IoT and Open IoT, by devising an interview guide from which we will conduct the interviews. Due to the semi-structured nature of the interviews, and the fact that we have great interest in the valuable insights of the interviewees and how they will contribute to this research, we will come up with questions that will allow the interviewee to have some freedom to express oneself (Bryman & Bell, 2011).

About the interviews of the project leaders working in the company – the automotive business supplier, we aim to gather information about IoT projects that they have initiated in their business environment and daily lives, and also get further information on the different levels of deployment an open IoT platform in the industry. Similarly, about the Green IoT - Smart City Uppsala project we aim to gather data on the whole process from
planning through implementing an energy-efficient IoT platform for open data and sustainable development.

To conduct our research, we focus on disruptive potentials of the Open IoT and its diffusion within the market by analyzing the information gathered from interviews and cases. For the purpose, we will use one Harvard case, one Green IoT project case, and conduct a study on current businesses that have integrated similar IoT services and play an active role in the field. By doing this, we will see the impact of technological innovations over companies and their businesses. Those case studies that are already implemented in the field will let us validate the strategic approach that will be built as an output of our research. We will get further assistance from managers working in private organizations, and project leaders participating in the researches at governmental institutions in order to assess the current assumptions extracted during the research. The expected outcome of this research is to develop a new strategic approach or improve already existing one for the adoption of technological innovation, such as the Open IoT ecosystem, into companies or private enterprises. Additionally, the research has the aim to evaluate the effects of Open IoT over the current market and identify the main challenges to be faced during the adoption of a similar technological innovation.

### 4.5. Ethical considerations

As every other academic research conducted, there are ethical considerations that arose during the course of conducting our empirical research. We followed Bryman & Bell’s structure (2011) for discussing the ethical considerations related to our research, and divided them into four areas: harm to participants, lack of informed consent, invasion of privacy, and deception. As the authors pointed out, some of these areas can overlap with each other, and in our research the considerations related to informed consent and deception arise from the same nature.

Bryman & Bell (2011, p. 128) state that “it is the responsibility of the researcher to assess carefully the possibility of harm to research participants, and take all reasonable precautions to ensure that respondents are in no way directly harmed or adversely affected as a result of their participation”. In order to avoid the harm of participants in any way, we gave them the option of remaining completely anonymous or instead state which portions of information regarding their personal profile we are allowed to reveal in our research, such as name, education and occupation. As a result, the names of the participants, as well as the identity of the organization in case 2 will not be revealed, as the data shared could potentially jeopardize the security of their employment and career prospects.

As a study with voluntary participation, the interviewees hold the right to know exactly what they are giving their contribution towards, thus the “prospective research participants should be given as much information as might be needed to make an informed decision about whether or not they wish to participate in a study” (Bryman & Bell, 2011, p. 133). In order to avoid deception and lack of consent towards the participants, before the interviews were
conducted all the participants were provided with information regarding our own identity, the nature of our research, our aim, and most importantly how we intend to use the data generated from the interviews.

The first ethical consideration arises from the potential conflict between the objectives of the organization and those of project leaders. The influence of the organization may have high impact over project leader's thoughts and actions, which may constrain the real view and output of the interviewed individuals. While we are expecting to get reliable data and be fully informed about the processes followed in organization, it can be that interviewees are not exactly discussing what actually is being done in the respective companies. That is why having the possibility to make observations in the corresponding organizations or having previous knowledge or experience in the same working environment brings vital value into the contribution of the study's analysis.

The second is coming from the speed of changes occurring in not only in markets but also in organizations. About the information regarding the given responses to the disruptive potentials of IoT can be rapidly transformed in few years. The technological advancements in the field may reshape the industry in a totally different way, therefore the attention given to human resources and how ideas are being reshaped will add greater value to our research. On the other hand, the effect over people's lives can be relatively negative with the increase of adoption rate of IoT technologies. Many people, businesses and organizations will be more dependent on technology, which is not always a good thing. However, we could say that it will have its benefits as well as negative implications. This topic can be further examined in terms of social aspects in a specific study based on these aspects.

Finally, invasion of privacy was not considered an ethical consideration for our empirical research. Our research method for both cases did not involve any on-site observations or other methods that might have violated the interviewees or the organizations' own privacy.

4.6. Quality considerations

Our main approach follows a qualitative strategy, which it may look as more difficult to come up with exact figures and precise results, but it includes pre-defined rules and it gives a better approach for exploring issues that are not presented in numbers.

- **Reliability**

By conducting unstructured and semi-structured interviews, the open-ended nature of the question which allows the interviewee to have freedom to express one’s ideas, also allows for his subjective answers to be interpreted in different ways. While this detail could potentially affect the reliability of interviewees’ answers, it also provides opportunities for better observation of environmental characteristics in businesses and may include valuable evaluation of the existing theories and body of research by individuals and researchers.

- **Internal and external validity**
The internal validity of the research will be mainly focused on maintaining control over the different variables of the design problem. One common issue may appear in the process of data collection and accessing organizations and participants for the purpose. The second point to be considered is the external validity of the research and the range of findings to be applied in the field. It is important to contribute with generalized conclusions in order to be used for further research in the field, but at the same time the findings must give answers to research objectives. Our research is planned to be conducted in a specific pre-defined environment, which may have constraints in terms of topics that are involved, but it will definitely provide detailed and micro-level assessment to the environment and its relation to the IoT.
5. Empirical Cases

In this section, we will go over the two empirical case studies that we have analyzed and give further information about how the IoT adoption process has been carried out by describing two specific projects that the firms have implemented into their businesses. Both projects involved different number of stakeholders, with high variety of partners in their consortium, ranging from academic partners to private industrial companies or public organizations. We looked further into what were the value creation layers considered by the stakeholders before applying IoT activities in their current businesses. Each step of projects’ adoption had its own details by aiming to merge the technologies or devices and digital services for creating the needed solutions.

For the purpose, we have conducted interviews with project leaders as stakeholders involved in this process aiming to enable a reliable approach for IoT adoption and used this output as a qualitative data for evaluating different factors influencing the adoption. Data was extracted by getting information on details concerning stakeholders’ experiences in the field and evaluating their involvement by starting from the initial IoT adoption stages (such as planning, evaluation, and etc.) till the final stages of the implementation. We did not only consider the common services and applications that were deployed internally, but also into the IoT applications that were provided externally. The recorded information gave the necessary throughput for strengthening the final arguments of the study.

5.1. Case 1 – Green IoT Project in Uppsala, Sweden

The Green IoT Project in Uppsala is an initiative that combines smart sensing and cloud computing technologies to collect and process information on the city’s environment through different parameters. Various sensors were installed throughout the city of Uppsala, which collect different types of data such as temperature, humidity, pressure, and NO2 (GreenIoT, 2018). The data is then processed and stored in cloud infrastructures, which can be accessed and retrieved through an open interface (API’s). This platform with open data, standards and API’s is available for public use and allows thirds parties to access the open data and cloud services without being locked by a single device manufacturer or service provider. While organizations, researchers and developers can use the platform to explore opportunities for IoT business by developing innovative digital applications and services, the customer and target user for this platform is the public sector. Regulating authorities can use the environmental information for sustainable urban and transportation planning (Ahlgren, et al., 2016).

The online platform in development aims to provide the user with a variety of services based on the data collected from the sensors scattered throughout the city of Uppsala. A data visualization tool displays charts and graphs with different readings regarding air quality in real-time, with the possibility to select specific time windows. Data analysis techniques also provide the user with predictions of the values of gases for the next hours, based on data analyzed previously (GreenIoT, 2018).
The project has received a great deal of support from the community, with funding coming both from private and public institutions. A 10Msek fund was provided by Vinnova, Sweden’s government agency for innovation. The agency’s goal is to facilitate innovation and research, providing funding for projects aimed at developing sustainable solutions, and also by stimulating collaborations between companies, higher education institutes, public services, and other actors (GreenIoT, 2018). Another 10Msek of funding for the project was provided in a joint effort between the Uppsala Community and industrial partners.

To better understand the nature of the project, comprehensive semi-structured interview will be conducted with one of the project’s leaders, Bengt Ahlgren, who is the head of the Data-driven Networking and Analytics group at the Research institutes of Sweden (RISE). The goal of the interview was to obtain detailed insight about the project, and also discuss about IoT, OpenIoT systems, and the diffusion and adoption of such technological innovations.

5.2. Case 2: Open IoT Project at Automotive Business Supplier

The case study is based upon company’s strategy to build a ground on open source IoT for having the potential to deliver innovations that are compatible with the pace and scale of the current market. One of the projects applied in the company in this regard is about the use of open source software (OSS) for the implementation of IoT platform internally within the organization, and also providing the same service for their customers. The OSS application gives opportunities for creating open platform capable of competing with other proprietary IoT platforms entering the market. The benefit of this project is that open source platform creates the potential of external collaborations with companies or competitors in the IoT ecosystem by enhancing B2B relationships and enabling an environment that will provide better or more complete and efficient solutions to their IoT customers.

The company is one of the earliest innovators in the IoT field. Additionally, it is an automotive business supplier and one of the leading global suppliers that core business sectors are spread around mobility solutions, consumer goods, industrial technology and energy and building technology. Therefore, the company quickly has realized the necessity for a new field of software, or the Industry 4.0 applied in manufacturing and discussed in our case study by Project Leader A in Case 2:

In this project regarding the enhancement and deployment of Industry 4.0 into the core structure of the manufacturing processes in the company, the open source software integration occurred to be the most important connection. The IoT is the bridge between the Industry 4.0 applications in the factory and the utilization of services in this regard. The fourth industrial revolution will be achieved by interconnecting man, machines and environment in order to create a significant connection between consumers and manufacturers and optimize the management of devices in the IoT environment for more efficient and predictable work surroundings.
For the purpose, the company has joined an IoT community while being involved in open source projects, and also contributing to many other projects in the field. The main project of joining the community and building up an open source platform has been initiated with source code supporting activities from existing social and commercial projects. This open source development process has not been only adopted for the project, but also has been spread within the Software Innovations department of the company, especially managed by the product development teams. Such as, most of company's commercial products are based on this project and open development process is followed in order to attain the involvement of the customer in the process through the application of more collaborative and open approach. Similarly, we had the discussion with Project Leader B in Case 2:

The Industry 4.0 project applied in our plant was the umbrella of many other applications in the field, and one of them was the Energy Monitoring application. The efficient management of energy consumption didn't only add monetary value to the company but also optimized people's experience by reducing manpower used in different processes, saving energy and reducing the footprint of production activities. For our company, the picture is clear and it can be seen that IoT is taking over the core of everything that is being done by bringing factories, industries and consumers together through connectivity and cloud computing services. The combination of millions of sensors that measure and record data, which are transferred into the cloud technology is what speeds up the process of integration. The aim is to provide full-service package for IoT and connectivity, which can be achieved only by open source software platforms.

The company currently is offering innovative solutions for technologies and services in the field of connected industries. It has its own IoT cloud that mainly provides connected, cross-domain solutions from a single source. The company finds Open IoT very important for recruiting developers who would like to join the company, and this source is being used for discovering potential future collaborations or employees. The top management still continues on investing to this field in order to enhance its activities and build upon a strategic direction, in which the new startup initiated in this regard will also contribute to this Open IoT community. This strategic approach is used in order to involve as many as possible not only customers but also partners in the business. Customers benefit from using applications provided through the project by having more freedom of choices while at the same time have the opportunities for being involved in the process of Open IoT and have influence over potential future developments. The aim of this approach is to provide more transparent environment of development and management of commercial products and services.

At one side the company has initiated activities in order to enhance the connectivity between its own technologies; on the other side it established its own start-up that will be promoting the involvement of other B2B partners, organizations, individuals, corporations and many other stakeholders for encouraging a free environment of development of a similar open source community. The start-up is a subsidiary of the company that works on the development of innovative IoT software solutions, create businesses supplying open source
applications and build up communities that provide various core technologies for IoT solutions. For private companies in particular, the adoption of open technologies and standards has an important role for gaining success in the digital economy. For maintaining sustainable innovation in the digitalized world, the company allocates resources and makes investments in open source activities in the field.
6. Key Findings and Analysis through Theoretical Framework

This section will be providing a detailed analysis over the data gathered through the semi-structured interviews conducted in regard to the cases described. The output from the interviews will be used to evaluate the theoretical framework (Figure 8) and to achieve an effective comparison between the findings of the case studies. The process of innovation adoption will be followed through its main aspects, and the technological, organizational and environmental variables having impact over the IoT innovation adoption process will be considered for analyzing the key empirical findings. While performing the analysis and the comparison, already studied literature will be used for interconnecting the scientific output with the interviews’ data. The findings are mostly obtained by the interviews conducted with project leaders and managers or some participants involved in the deployment of IoT projects.

The search for research topic was structured in relevance with the issues that companies have been facing today in the IoT field. In the aim of conducting the research, two different cases were investigated deeply, and our primary data was obtained. These two case studies are the main resource of our research since they give further understanding about how private and public organizations deploy the IoT into their businesses, and potentially we will find answers to the research questions and fulfill the aim of this research.

By analyzing and comparing the two cases, the goal is to achieve the purpose of the study. The analysis will be carried out using the theoretical framework (Figure 8), as it follows:

- Rogers explaining users’ acceptance and attitudes toward new technologies and innovations will give us a broader understanding of how such innovations are spread among segments and users (Christensen & Huang, 2018). By considering the critical factors and challenges to be faced before the implementation of IoT services into companies’ businesses and how companies reflect these activities into their behaviors in terms of investments done in the field. According to Rogers (1983), “Diffusion is the process in which an innovation is communicated through certain channels over time among the members of a social system”, by taking this into consideration we will analyze the behavior of different stakeholders involved in the implementation of IoT into companies’ business strategies, such as project leaders, team members, employees, competitors, business partners and etc.

- The TOE framework developed by Tornatzky and Fleischer’s (1990) gives further explanation of three elements that influence the company during technological innovation adoption process. Those three elements, as previously defined in the literature review, are the technological aspect that considers both internal and external technologies relevant to the firm; the organizational, which follows a descriptive approach for discussing firm’s size, scope and managerial structure; and the environmental is the ground where the firm is conducting its business that involves various stakeholders. All contexts are also considering the constraints and
opportunities for technological innovation adoption. The framework serves the aim
to evaluate the necessities and the aspects of required business improvements of
the company for the successful innovation adoption. Its main activities are built on
evaluating company’s needs before even taking decision to adopt a specific
technology.

As this framework is consistent with the DOI theory in terms of individual factors
influencing the process, and both internal and external characteristics that have
impact over the structure of the organization, at the same time it complements the
DOI theory by also involving the environmental context. The TOE framework gives
better argumentation for the drivers enabling the intra-firm innovation diffusion
(Tornatzky & Fleischer, 1990).

- Christensen predicting the shifts that are happening in the industry will be used for
answering how small organizations with fewer resources show the potential of
challenging bigger firms in the industry by focusing their development into the
bottom line of the market, or the so-called low end (Christensen & Euchner, 2011).
By using his theory input, we will look into the value network of today’s rapid
changes happening in the IoT for getting further insights of big firms’ activities and
strategies in such cases. Questions, such as what the growth and innovation
trajectory of IoT is will be reviewed and analyzed by taking into account the
disruptive potential of IoT.

The process of adopting innovations internally in organizations is becoming more difficult
since the technology shifts on the market are not easily forecasted anymore and the nature
of these changes is far more complex than has been before. In order to analyze the data
gathered from our case studies and to structure the findings, we used a revised framework
of TOE (Tornatzky & Fleischer, 1990) by complementing it with the DOI model of Rogers
describing the innovation adoption process in organizations (1983). One thing is clear, the
evaluation of only those two cases will not generate any generic conclusions for assessing
the theoretical framework that was built, therefore we also used the samples of published
studies in the field in order to bring more valuable analysis, assess our findings in a broader
perspective, and illustrate key research findings that are relevant to our research questions.

6.1. Christensen’s Value Network

Clayton M. Christensen in his book, The Innovator’s Dilemma (1997), clearly gives example
on how startup firms possess skills and are being advantageous in neglected small markets
by challenging also the position of incumbents in high-end markets. There are few main
factors that allow innovative firms to disrupt incumbents in mature software markets; it
could be that they have a better technology, cheaper pricing, strong and reliable partners, or
simpler solutions to present. When it comes to the enterprise IoT market, we can see that
Christensen’s theory is defied and the incumbents have the necessary equipment and
foresight for keeping their dominance in the market.
In Case 2, according to what Project Leader A stated, the incumbents are now having the abilities to adapt to the rapid shifts happening in the market and build up strategies in this aspect:

The strategy flow in our company starts from the top management and company's strategy is changed accordingly. The company that I’m currently working is no longer a product-producing company and has the aim to be transformed into supplier of systems. Therefore, the new strategy of its business is based on 3S strategy: sensor, software and service. The company invests heavily in this matter and supports its employees.

From this output, we see that business models, enterprises’ cultures and their strategies may be reshaped or drastically enforced to change. Thus, the given example for the strategy followed to adapt to those changes points out the importance of developing a standardized model of business adoption, such in our case is the 3S strategy:

→ **Sensors** detect the activities on-going in the external environment, such as position, movement, heat and etc., such as, they may detect if parking space is vacant or not. The company has a good position in the market and provide micromechanical sensors, therefore it also possesses the required knowledge and capabilities.

→ The huge amount of data received from these sensors can be only processes by using a structured **software** platform, which in the case is a new start-up that the company has initiated in the field in order to enhance its influence in the market – the Open IoT platform deployment. By considering different environments of deployment, it may enable hundreds of possibilities for better management systems and enhancing proactive possibilities during early stages for preventing the occurrence of various issues.

→ Lastly, the **services** are the biggest part of the added value deriving from connectivity. If connectivity is fully utilized, services will be transformed into much more than after-sales model, which is happening now. The company is providing not only web-based services, but also assisting end-users.

The company involved in this case study is certain that IoT will simplify people’s lives by making their daily routine more convenient and secure, and also provide better managed and efficient environment for businesses and bring opportunities for enhancing more eco-friendly structure. That’s why the Automotive Business Supplier is heavily investing on IoT activities for extending its expertise and bringing up together those three elements for enabling the Open IoT platform.

Users and consumers of IoT technologies will ultimately capture the most value in future (McKinsey Global Institute, 2015). This value creation is also affecting firms’ organizational innovation adoption, as Project Leader B in Case 2 explains it:

The establishment of departments related to this topic is gaining pace in companies and it is something that we have recently observed. Nowadays, users are more aware about what is
IoT and have the experience on how to express more clearly what they want to do with IoT in their lives (what we see today was not visible in the past years).

In case 1, Ahlgren points out that those users/customers from the public sector, through their public procurement approach, specify the requirements needed for the solution they are looking to find through the potential vendors. In order to fulfill such specifications, the customer and the vendor need to work together to develop the best solution. Thus, the user ends up influencing and having an active role on the vendor’s product development and strategy. As a potential public sector user for the IoT platform developed in the GreenIoT Project, Uppsala Kommun not only co-founded the project, but also worked alongside the other project partners providing assistance and other resources.

Similarly, in the case study of Nestlé, the efforts of placing the customer-service experience as a core strategy of their new digital offerings were discussed by Pete Blackshaw, Nestlé’s global head/digital innovation & service models (Nestle, 2018):

> At a broad level, voice, chatbots, smart assistants, and smart kitchens – they all fall into what I call the “concierge economy.” How do you provide a reinvigorated customer-service experience for consumers? I think voice falls into that: it is both utility and entertainment. And, for us, it is a potential service layer that sits on top of our brand.

Considering the characteristics of IoT solutions, organizations have an increased interest in making the customers a variable in the equation. As a result, relationship with users/customers are becoming continuous and open-ended (Neto, et al., 2015). The data generated from the product’s usage by the customer provides an understanding of the product’s performance and effectiveness, as well as the customer’s usability and overall satisfaction related to it. The output extracted from the interview proves similar approach in companies, stated by Project Leader A in Case 2:

> Companies have also begun to benefit from the blessings of IoT. I think the most important benefit of IoT is that it greatly facilitates for companies to collect data. Collecting data in the production field is one of the factors enabling digital transformation. Of course, companies do not only benefit from the production data. The data collected from customers also play a role in improving the customer experience.

To sum up, the value network described by Christensen (1997) is the value created by the organizational thinking of companies and it provides some boundary conditions, according which the network is being drawn. Christensen’s theory differs from other theories in terms of the main focus of the research is based upon provided products and services instead of the firms or employees producing or providing them. His approach has more incline towards managerial and systematic implications by mainly considering the growth, innovation and customer expectations as the most vital organizational values (Christensen, 1997). This could bring good approach for identifying the characteristics followed for different technological innovations, but it does not provide the necessary input for managing the innovation adoption process. Therefore, by considering those characteristics of the IoT
adoption, we will further analyze the adoption process of it through the TOE and DOI framework.

6.2. IoT Innovation Adoption – Revised TOE framework

6.2.1. Technological factors

• Relative advantage

Within the aspect of IoT technologies, the relative advantage characteristics can be defined as the level of connectivity efficiency between objects and devices with physical networks, which results in the level of improvement in adopter’s operations. The businesses adopting IoT must have its beneficiaries and the expected improvements in their processes in order to define the relative advantage of IoT. Often within the IoT, this could be explained as the data that devices produces, which is also what brings value to the product.

The point to be considered in this aspect is the relative advantage of Open IoT when it is being compared to IoT itself. Open source technologies, tools and devices are widely spread but their efficient utilization by its developers it is not still fully achieved and understood. The main aspects of both case studies involved in our research are related to activities fulfilled for the adoption of Open IoT. The public company relies on collaborations and open source support and funding in order to succeed in its projects, and the private company has initiated a start-up and many small community groups for attracting the attention of not only consumers or customers, but also developers and contributors. Measuring and reporting data is not enough anymore, the huge amount of data that cannot be interconnected and processed does not have the same level of value. Therefore, Open IoT has the necessary relative advantage in order to be further investigated and potentially adopted by companies.

• Compatibility

IoT adoption will increase its variety in terms of strategies applied by companies in this process. There are many technologies, platforms and businesses, which will interconnect and try to build a standard for its broad application in the industry. All these approaches will have the same aim – to become a standard used in the market by companies. The increase in number of software and hardware used during this adoption will constraint the adoption of IoT in a more open way. This is one of the issues that occurred in both cases, the limitations caused by the existing vertical silos in the IoT segment.

In the Nestle case (2018), it has been seen similar concern related to the fragmentation of markets, and in order to benefit from the current situation the company applied a strategy to provide supplements to medicine, instead of competing in the pharmaceutical market this led to collaboration with this companies in the segment, and also provide another and better solution to the customer.

Some of the technologies and devices used for the adoption of IoT and its standardization will become unnecessary or useless in the next few years, therefore it is important to define
a proper strategy for the company in order to keep up with this transformation flow. It is important to realize the short-life performance of IoT appliances in comparison with the generic computing technologies, which can be utilized for much longer periods of time. The functionality and the purpose of the product is what will shape the approach of the user or the customer to the service or product provided.

- **Complexity**

In terms of structure, there are several factors that would influence the path for innovation activities. Such as with the automotive business supplier, the more complex, big and differentiated in terms of products and services’ range provided by the organization, it is easier to cross boundaries and higher number of sources to be used in order to explicit high possibilities for generating ideas. On the other hand, with increase in size and complexity of the business, it emerges the fragmentation and the bureaucratic structure that constrain the adoption of innovations (Van de Ven, 1991). This is also the case with IoT adoption, as the size of the market is increased and gets fragmented; it is more difficult to achieve an efficient and reliable integration of its applications.

Through those two IoT project cases it has been observed that the adoption process of the innovation is becoming too complex to manage because of the fragmented nature of the IoT and its applicability in such broad context. Even after the decision for adoption, the mainstream of IoT is diverged into multiple paths of activities. Some if appears to be the devices used, which record huge amount of data that needs highly complex algorithms in order to be utilized efficiently, and others are the connectivity boundaries between the devices and how they differ according to the environment they have been implemented. Much of this complexity is coming from the expectations of achieving too much too soon, and therefore aiming to maintain so many activities in many aspects without having the necessary capabilities in these terms. Such as in Case 1, during discussion with Bengt Ahlgren about Green IoT project, similar approach was followed:

The main challenge was that it was more difficult than anticipated to actually mount sensors outdoors in the street. (...), and one of the hard issues was getting power. (...) We needed the support from Vatenfall, they provide electricity and maintenance for the street lights in Uppsala. At the end we borrowed electricity from the street lights, and this had the complexity that there is no power when the street lights are not on, so we had to add batteries at a quite late stage in the design of the sensors that were mounted.

The different levels of novelty in innovations need to be treated differently, and not all organizations may be suited for all types of innovations. Such as, organizations that place more value on individuals have more potential to take part in developments made in relevance with radical innovations, and the more collectivist is the organization’s approach is much better to adopt an incremental innovation (Van de Ven, 1991). However, disruptive innovations somehow affect both type of innovations and require attention by any type of organization. As an emerging disruptive innovation, IoT has the potential of disrupting everything and by being quite technically complex in its nature; its stages of the adoption
process may vary and be more disorderly compared to other disruptive technologies. The IoT has not only the potential of disrupting wireless sensors network, but also the potential of shifting the consumer data ownership from firms and organizations that provide cloud services to their wireless personal area network (WPAN) for privacy and data ownership (Amyx, 2019).

6.2.2. Organizational factors

- Top management support

Leaders and managers are very important in the adoption of innovations and ideals inside organization's structure (Rogers, 1983). Their attitude depending on the level openness for adopting new and innovative solutions may have high impact over the rate of adoption. Further on, this is supported by Project Leader B in Case 2:

Top management should be able to clearly identify the allocation of IoT in company’s core strategy. Our company, for example, has decided to adapt all of its products to IoT in the near future. All employees also need to be trained regarding the relevant and required topics. Switching to such technologies may also require the change of companies’ cultures and posture.

While similar decisions and implications take less time on private organizations this is not the case with the public organizations. Receiving the necessary feedback when it is required and getting the needed support is vital for implementing the ideas of the top management. In difference with private enterprises, public organizations face bigger challenges during the adoption phase of the project, as it can be seen by the thoughts of the project leader in Case 1:

There is always a difference, especially when it comes to small companies. (...) The smaller the organization the easier it is to get a quick feedback. With the public sectors, sometimes it can be difficult to get a decision, but Uppsala Kommun was so engaged and committed to this project that it worked out very nicely. To sort out the issues with the mounting took a very long time because several different departments at Uppsala Kommun were involved in that.

Given the description by Christensen (1997), companies must build on potential solutions in order to succeed in the management of disruptive innovations. The key factors lie upon the proper division of the entrepreneurial units that must be segmented into independent small units for keeping up with the dynamism of the target market and its dimensions. If managers have the abilities to do this distribution, this would generate efficient solutions. However, this is not always the case, as mentioned by Project Leader A in Case 2:

One of the main reasons, regarding the companies that are not being able to implement IoT applications, is that the senior management does not have enough knowledge and experience in this aspect. Another reason is that companies didn’t reach out the necessary maturity level in this regard. Looked through regional perspective, companies in Turkey have many other technological investments to make before funding similar implications.
Disruptive technologies usually require new set of skills in order to respond to the changes and transform the business model by accommodating the value generating activities into already established technologies in the companies. Managers must possess the mindset of allocating the necessary technologies by embracing an entrepreneurial behavior and analyzing the current business status beyond the accepted traditional behavior. The aim must be generating new approaches for capturing value through new business models (Schiavi & Behr, 2018).

As the heads of their respective units, it is clear that the top management have a key role in consolidating the connection between units, which leads to a more efficient and responsive organization as a whole (Rogers, 1983). On the other hand, in some cases this could be opposite results and managers may become an obstacle, which is one of the statements of Project Leader C in Case 2:

There were limitations from managerial side – taking decisions about the investments, work distribution, and regarding the necessary changes to be made.

Even if there is no any disruption or shift occurring in the market, the level of accumulation of experience and scientific knowledge activates the invention of new developments and innovation in the field of research and development of companies. At this stage, most of decisions are taken by project leaders that first follow the trace of potential developments and improvements that might lead to innovations. Such as, the leader or the manager can be the disruption element by allocating resources from old technologies into new potential innovations (Schiavi & Behr, 2018).

• **Organization size**

IoT as a technological innovation is a valuable resource that is upon facing up bigger shifts in recent future. These changes will have high impact over business development costs, quality standards and in terms of legal aspects (environmental, social, individual and etc.) There are many challenges to be faced on the way, and especially if this will bring forward a new way of strategic thinking for achieving sustainability. The IoT tools and applications will further require higher rates of adaption and better management of the operational systems of the business models. At the same time, the necessity to transform the systemic infrastructure of organizations will appear together with the increase in generated number of innovations.

The size of organizations has a direct association with the resources provided, especially in terms of taking the initiatives to adapt to the innovative changes related to the IoT. Firms are following different ways in the adoption of the IoT with relevance to the resources that they have in hand, employees’ competences, size of company, or position in the market. As it was mentioned by Project Leader A in Case 2:

However, each change also comes up with some losses. It is important to plan well what will be the wins and losses in the long term. Other companies and competitors, of course, continue their work on this topic. However, while some of them have the aim to be the first
movers, others may want to take their steps more confidently and slowly in this process. It is important to estimate what you've gained in the process and what you've lost, and that's the point where companies will need consultancies.

While the size has a positive input to be considered during this process, it is not the basic requirement for advancing in the field. The knowledge exchange and the strategy of the company are the main factors that will affect the adoption process of the IoT.

- **Interconnectedness**

The GreenIoT project depicted in Case 1 had a diverse set of stakeholders in its ranks, and each had its own distinct contribution and roles throughout the project, as well as different results and experiences that they aimed to receive from it. Ahlgren provided us with a comprehensive breakdown of the stakeholders contributing to the project and their interests from it:

We had our end-customer, the Uppsala Kommun as part of the project, and we also had equipment vendors, software companies, and also us the academic partners. (...) We had two sensing system developer companies, SenseAir and Upwis, and they contributed with ideas and technology for the air quality sending part. They wanted to understand the business of selling that kind of equipment to the public sector, which is quite complex because you [public sector customer] need to do a public announcement and procurement. (...) SenseAir provided some of their sensors which were integrated into the Upwis sensor platform. (...) One interest from their side was to extend their business to outdoor sensing, they have previously mostly dealt with [air quality sensing] indoors. (...) IBM was interested in the data collection, computation and analysis parts of the project, and they were also quite into business development, how do you create new business out of open data. (...) Ericsson [Research] was interested in new applications that can benefit from mobile systems and mobile communications. (...) We did not do so much directly involving Ericsson's mobile systems, but they are also interested in more future-oriented network architectures that were investigated to some extent in this project, based on information-centric networks. (...) 4Dialog was more [interested] into visualization using what they call a 4D system, which is basically a 3D visualization logic reality, with the possibility to simulate time [the 4th dimension].

While other projects or development processes might not have as many stakeholders involved, this case still helps demonstrate how organizations with different competences can collaborate and work together to develop solutions that benefit all parties involved, as well as learning experiences. This case also shows how IoT solutions are technologically multifaceted in a sense that they require knowledge and competences from different areas of both software and hardware. Since organizations might not have all capabilities required to develop and deploy IoT products all by themselves, a strategy to be considered would be to collaborate with other organizations whose competences complement their own. The same conclusion is reached out in the second case project, in which Project Leader A comments about the necessity to involve external stakeholders and even their partners for maintaining an efficient collaboration with them:
Of course there are business partners involved, it is impossible to realize this process alone. By collaboration with this automotive brand, we also work with the equipment manufacturers of the brand; the process is managed and coordinated by PLC system software developers, such as: UIB, BOSAB, TUSİAD, and etc.

Not only does the innovation have to be redefined to better fit the organization’s environment, but the organization itself also needs to adapt to the innovation. Changes in structure, processes and others might have to be made to better accommodate innovations (Rogers, 1983). Although the automotive business supplier that was involved in the second case has one of the biggest influences on the market currently, still there is a similar tendency followed by its departments and managers, which was proved in Project Leader B wording:

Smart buildings have the potential to enhance the activities that will shift the competition forces between different firms. We’re aiming of opening up new avenues that will bring differentiation not only for the consumer, but also for company’s business model. For the purpose, our aim is to develop new value-added services for developers, consumers, external organizations and even our competitors by involving them in the process of Open IoT adoption. This approach will enable many organizations to bring their products, services and whatever input into the development scheme.

Rogers (1983), also acknowledges that an organization’s openness towards outer systems positively impacts the organization’s innovativeness (Figure 8). While our understanding of outer systems includes players such as suppliers, competitors, regulating entities, and customers, Rogers seems to not include the customers in the group of outer systems that innovative organizations ought to have a high level of interconnectedness with. As what Ahlgren in Case 1 argues about:

We had two sensing system developer companies, SenseAir and Upwis, and they contributed with ideas and technology for the air quality sending part. They wanted to understand the business of selling that kind of equipment to the public sector, which is quite complex because you need to do a public announcement and procurement.

Rogers’ statement is that organizations with open systems have built high level of interconnectedness with neighboring systems, by possessing an internal structure which enables the exchange of information internally and externally.

- **Slack of resources**

While it’s true that small organizations have advantages in starting up a new business and have quicker advancements in the market, larger organizations have much more resources and skill-set that is more advantageous in longer periods of time. This is exactly what was stated by Ahlgren in Case 1:

Small companies are very specialized to a certain thing, and they don’t have the capacity to engage in other things.

The implementation time may differ, which can provide beneficiaries or not, but sustaining the activities related to IoT and remaining flexible at the same time does not seem conductive while applying the IoT when its disruptive structure is considered. The critical factors influencing successful implementation of IoT without being disrupted in the market are as
following: maintaining the flexibility of the organization, providing the necessary resources to advance in the field, having access to technological tools and competences, and giving importance to members’ views participating in the process of implementation (Van de Ven, 1991).

- **Technological knowledge**

The involvement of many departments complicated solving the issue that was faced during the deployment of the project. On the other hand what is stated in second case’s interview is totally different:

> The difficulties are usually due to the incomplete understanding of the processes and the lack of technical skills or time / capacity of the participants. It is important that not only the company that provides the services is involved in the implementation process, but also all stakeholders participate in such projects. Therefore, it is important to involve the participants in the process and choose the right people for it. The support and follow up of top management for realizing this project is one of the key points to achieve success.

According to this input, the difficulties come from participants’ lack of qualification and training. It must be mentioned that it is vital to choose the right people for the purpose and similar disposition of employees within the management team, who make the final decisions. Additionally, in terms of what Rogers (1983) has indicated, a higher rate of interconnectedness means that different units communicate better, making the flow of new ideas and innovative thinking faster and more fluid, which translates into higher organizational innovativeness.

### 6.2.3. Environmental factors

- **Competitive pressure**

Larger companies with organizational slack may have advantageous competitive position in the market by targeting the specific customer preferences. In recent years, technological innovations and the disruptive potentials of IoT have changed not only the market segmentation, but also customers’ expectations. Purchasing more personalized products and services that are delivered faster are the main output of this change. It could be seen that this is leading to increase competitive pressure, especially because of the changes happening over business models, and companies are faced with the challenge of sustaining continuous innovativeness in order to keep their competitive advantage.

The powers of stakeholders are enforced to shift, and new partnerships are not necessity but obligation for maintaining company’s competitive advantage in the segment. Also, the competitive forces in the market are forced to transform and this new landscape becomes the main factor reshaping the industry structure that can be also seen in Porter’s five forces model (Khoja, 2016). Each company that has a leading position in the market finds a way to be part of this landscape, as it was discussed by Project Leader A in Case 2:

> So many companies want to do something and act while this wave called IoT is still in its beginning, for this purpose everyone jumps into it and finds potential opportunities for
allocating budget into IoT activities. Top management is also trying to follow up closely what has been doing in other factories and benchmarking its performance. Everybody and every institution somehow want to be involved in this process.

And in the same way by Project Leader C in Case 2:

Certainly, everyone is trying to do something; some use their own internal resources while others like our company try to improve this process by cooperating with other businesses and organizations.

In a similar way it has been stated by Christensen: "Within a value network, each firm’s competitive strategy, and particularly its past choices of markets, determines its perceptions of the economic value of a new technology" (1997).

- **Expectation of market trends**

One of the main factors of startups for delivering innovative solutions to consumers in the IoT market is about having better technologies in their disposition than most incumbents. The enterprises are defying this principle with examples such as Azure IoT Suite, Bosch IoT Suite, IBM IoT Foundation and etc. that have delivered the most innovative solutions to the market. And this has become more evident in the recent years, which can be noted from the interview done with the Project Leader of Case 1:

IBM was interested in the data collection, computation and analysis parts of the project, and they were also quite into business development, how do you create new business out of open data.

Similar approach and output can be extracted from Case 2, in which the Project Leader A made the following statement:

One of our sub-projects related to Open IoT deployment was initialized through the digitalization services provided for an automotive brand outside of our company and through the realization of the implementation process in the production area. Initially, the project began with providing digital transformation consultancy services that was followed by the implementation of the project processes on the customer side (automotive brand).

Companies show incline towards partnerships with their consumers and in future this is expected to go further and initiate collaborations with competitors in the same way. That's how incumbents will hold their ground in this environment. Additionally, big enterprises have the necessary set of skills and capabilities that is difficult to be simulated by the IoT startups. Especially, in terms of giving the necessary importance to customers’ expectations in order to gain competitive advantage in the market as it was supported by Ahlgren during the interview:

From a customer perspective I think it is important to understand [vendor lock-in], because from a vendor perspective, they might be happy to deliver a locked in system, so they can keep their customers. In the end those vendors also need to understand that if they provide an open system the market might become much larger for everybody.

Mainly, many of the initial stages during this process are not intentionally directed towards adopting an innovation. As it can be seen in our case studies’ findings, most of the time
organizations are forced to adapt to the changes happening in the market in order to maintain their position in the industry or in order to gain competitive advantage among competitors. Some time, the government is the one who enforces these changes by enacting new regulations or by making investments or funding it may encourage such implementations.

6.3. IoT Innovation Adoption Process – DOI theory

Innovations are not initiated or implemented within companies’ business structures just by decision taken from a single individual or entrepreneur. As it was observed through the case studies of our research, there is a process of adoption for similar innovation as IoT, and it takes long time and a lot of effort to maintain and sustain good rate of adoption.

6.3.1. Evaluation

In the initial phase, we will analyze our findings according to the proceedings that each organization takes upon to for integrating IoT solutions into their businesses. For the purpose, private and public organization’s case studies and the data gathered from the interviews will be contributing to our research. The chosen innovation adoption mainly has the aim to approach an existing or occurring issue appearing on the market. Some events, such as shifts on customers’ needs or expectations, evolution of technology, sustainability issues, and governmental regulations, might be defined as the key triggers for evaluating the necessity or the applicability of this innovation. Considering IoT, we see that there are triggers that disrupt the technological market and companies in the field are impelled to look for solutions to overcome the issues related to IoT, such as, security and privacy concerns, data integrity, connectivity and mobility issues, and sustainability threats. Those are the issues found to be concerning private and public organizations, which also are the factors influencing the requirement for IoT adoption in firms. Project Leader B in Case 2 mentioned that the connectivity and mobility aspects are what directed them to evaluate the IoT adoption:

Connecting all devices and external components that will exchange information in one single platform is what will bring a solution of the connectivity issues existing in the field. However, the existence of vertical-silos that build boundaries for excluding competitors and businesses from their services, it is not giving us any permanent solution to the current issue on connectivity. This is one of the reasons why we had to focus on developing a new strategy or innovation in our business model, so we could find a way to keep our roles in the future evolution of the technology market.

We see similar concerns, as the ones mentioned above, from the side of Project Leader A in Case 2, which is followed by a discussion about the current advancements in the market and their potential implications as a solution regarding the security and privacy concerns:

One of the biggest issues in this concern is about the security concept that enterprises face, and the second one is the privacy challenge. Of course, there are already many things have been done to face and overcome these challenges. The government plays an important role as well, especially in terms of securing IoT. There are applications developed for detecting
security bridges where the aim is to develop a standardized model that will recognize common patterns and improve its identification system by automation.

Van de Ven, in his book “People and Technology in the Workplace” has the following statement saying: “Technology-push and demand-pull events”, which means that the factor influencing company’s decision is often leading towards courses of action that somehow intersect with totally different actions of others (Van de Ven, 1991). For an example, IoT is a new technological wave that pushes the limits of the current standard of the market, and customers’ demand on mobility and connectivity in their lives brings up new opportunities and access to new potential resources. Therefore, companies are enforced to exploit these occasions and take interdependent collective actions while evaluating the adoption of innovation in their businesses (Van de Ven, 1991).

When discussing with Project Leader C in Case 2, there was another threat that led to initiation of a sustainability project and evaluation of IoT platform adoption:

One of the projects initiated in the field was about the reduction of energy costs through improved energy efficiency in the production area by developing an energy monitoring system, which was managed through an IoT platform for monitoring the changes occurring in energy consumption and for defining the factors that have the highest effect on this consumption. (...) Through analyzing the collected data it was possible to identify and explain excessive energy use, detect instances when consumption is unexpectedly higher or lower than would usually have been the case, visualize energy consumption trends (based on date, time, duration, component, operation, process and etc.), and diagnose areas that waste energy.

It could be seen that there are some factors to be considered while evaluating the adoption of innovation, such as the IoT that led to further developments and improvements in organizational level. Some of those factors have shown their results, such as improvements made in divisional level, which are handled in short-term periods that are also having contribution to bigger on-going changes. During this stage of the process there are many drivers to be considered. The evaluation may result in identifying future opportunities or it may trigger the recognition for bigger changes and new innovations in the business.

6.3.2. Adoption

The second phase of the model of organizational innovation process is the implementation stage, which will be consisting of the processes that organization follows during the IoT implementation. During the process of IoT adoption, the company and the organization that we conducted our study upon had built up long-term strategic time horizons with high degree of involvement and commitment from the top management and the project leaders. It was noted that organizations are willing and making significant investments on IoT technologies, partnerships and their employees. While those aspects are hard to assess, combined all together they generate the fundamental unit of an organizational setting that enables the adoption of IoT applications and applies company’s strategic vision starting from the smallest units and reshaping the big picture.
After initiating the use of IoT in company’s activities, employees get better picture of how actually the innovation works and better understanding of its attributes. However, this is not enough in order to ensure innovative behavior from employees’ side and there is a necessity on providing the conditions that will enable the faster adoption of IoT related applications in the business structure. In shorter terms, people have tendency to show the capability and potential of being creative and innovative, but the company must also provide the necessary environment for enabling the motivation of individuals (Van de Ven, 1991).

The importance of the presence of different resources for enabling IoT applications must not be underestimated, which was discussed similarly with Project Leader B in Case 2. Here, it could be seen that for companies in order to be defined as innovative must have the potential of investing in different resources of innovation:

The main characteristics of companies that are ought to have to be innovative are: having awareness of the IT infrastructure, understanding of the existence and importance of data, the perception of the significance and meaning of the potentially useful data, the amount of resources allocated to manpower and budget for new technologies, and adapt to the shifts transforming the existing process resources into new systems.

Organizations looking to make the most of IoT technologies ought to invest in harvesting and tightening connections with the customer in order get the most value from it. In this scenario, investing in the after-sales function becomes a sound strategy (Hide, et al., 2019). By having a direct connection to the customer, optimizing the operations of this function directly translates into optimizing the vendor-customer relationship. Due to its continuous and open-ended nature, one can even see some sort of synergy in this vendor-customer relationship, where on one side the vendor receives valuable insight on the usage and customer experience of the product that will help it is optimization, and on the other side the customer is provided with comprehensive customer support through maintenance and consulting, as well as with a personalized product that better suits its needs.

Inter-divisional communication in the organization between departments and among employees with different knowledge background and dissimilar viewpoints may influence the creativeness and innovativeness of people, where the adopted innovation gain pace in its adoption rate according to the organization’s environment and specific circumstances to better suit company’s interests. As Project Leader C stated in his interview in the second case:

IoT (IoT) platform is an environment that gives the possibility to process the information flow from different technologies: sensors, cameras, automobiles, traffic lights, smartphones, and also from cloud platforms with the purpose of combining those two sides for building up new services and applications. (...) By 2020 it is expected that more than 50% of all enterprises will be adopting IoT, and simultaneously IoT applications in the business environment will generate double compared to consumer IoT applications. Most organizations think that there are many IoT opportunities, but they are aware of the challenges that will be encountered on the way of adoption.
The adoption process of IoT is already happening, and firms are part of trying to find the best solution to fit their businesses in this flow. However, despite the importance reflected upon the disruptive technologies and innovations that are appearing every other second on the market, there is another vital point considering the level of significance given to business models. The only successful approach in adapting disruptive technologies and innovations is when they are used in combination with the existing business model while it is being restructured (Johnson, et al., 2008). That’s how the business infrastructure is examined by putting into contrast the already fixed model and the new one that must be established for disruptive technology, such as IoT (Christensen & Raynor, 2013) discussed with Project Leader A in Case 2:

The IoT business has the potential to become a new standard and its attributes will evolve in its activities to an extent that it will be providing new strategic business models, offering services for process improvements, models of reducing inefficiencies in various processes and many others.

However, it might result in totally opposite outcome, because not all organizations own the same capabilities.

It is also important for companies to have adequate information infrastructure. There are companies that are far from being able to deploy IoT.

Resources provided by governmental side are also another supporting tool for adoption of IoT in firms’ strategic models by contributing into sustainable projects or technological developments in the field, the government have high level of influence over this process:

The government has an effect in these IoT and technological projects. Also, it may provide capital and investment funding. These supports are generally available and used for energy saving projects.

6.3.3. Routinization

As IoT gets more usage in the field and within organizations, it will lose its disruptive potentials, and it will be routinized by being involved through regularly in companies' processes and the way how they actually operate. According to Porter, the new third wave of ITs, the IoT will lead to advancements in productivity levels. The current developments in the field will transform not only the value chain and its activities, but also will be generating new operations in terms of products and services’ data analysis (Porter & Heppelmann, 2014). That’s why IoT is expected to change the competitive landscape much more drastically when it is compared to the Internet. In the second case, Project Leader B shared a similar standpoint regarding the expected changes and how this will standardize not only companies’ culture but also people’s daily lives:

Since IoT technologies increase productivity in production, now we can buy products at a cheaper price. In fact, since we will benefit from all the utilities of IoT as a community, we can also describe the individual benefits as a social benefit. In addition, the cities we live in will become smarter. Many services such as traffic, energy, waste and public transport can be planned and managed more effectively. We shouldn’t ignore them either.
There are similar expectations of the project leaders and managers in enterprises, as it was mentioned by Project Leader A in the second case:

Even the connection of mobile phones to the Internet have revolutionized our daily lives in such sharp way, so in case that those objects are able to connect to all things that we use daily, it will make everyone’s life much easier and simpler. At the same time, all the devices connected to the Internet without even having complicated hardware will be able to carry out more complex algorithms through the servers to which they are connected.

This brings up opportunities to enhance the value proposition beyond products by using the exchange and processing of data flows in order to offer new services. The enhancement in the capabilities of smart and connected products and services is expected to decrease the rivalry between companies and improve the IoT performance in the market (Khoja, 2016).

Project leader B states that this rapid shift will transform the businesses of many firms and expand value-based services by increasing the opportunities in the industry:

The core aspect while switching from manufacturer of products into a provider of services is maintaining an efficient balance between strategic and operational characteristics of the shift. The increase in digitalization of products that companies manufacture have had also led to expansion of the allocation of more services in the industry. That’s why many companies have broadened their practices in the IoT field.

It can be seen that cloud technologies are giving more potential opportunities to increase the competitive advantages of firms by creating value to the consumer, which is not based upon the complexity of technologies but on the operational characteristics.

Porter and Heppelmann (2014) argue that the digitalization in industries indicate the need for identifying the required technological skills and abilities through company’s processes and its value chain. For the purpose, the company must define its capabilities and make developments in the right direction. Some of the functional definitions of departments have the possibility to switch in future, such as IT activities to be directed from maintenance to focusing on cloud-based projects by providing the opportunity of speeding up the process of launching applications that won’t be requiring longer times for setup or installations (Nagy, et al., 2018).

On the other hand, digitalization by being part of people’s daily lives and organizations’ structure is also providing an initiative of routinizing the way how data is managed. In addition, the IoT is also enabling new players and their involvement to this process. For example, web-based applications that pair up businesses with providers of IoT services. However, for the purpose there is a requirement of having open-source and standardize system for including different levels of businesses and enable their interoperability, which is further discussed with Ahlgren in his interview in Case 1:

There is a long necessity to have open and standardized systems and interfaces. (...) There are several levels. You might need to able to attach sensors from different vendors, so that interface needs to be standardized. It is not only the physical radio interface, it is also the data format used for the data that the sensors produce, which is called semantic
interoperability. (...) Interoperability from a technical standpoint is pretty straightforward, it is just agreeing on what technology to use. But then it is more about business and politics – to decide to use open standards, and to decide which standard to use. The most difficult issues are in the non-technical area, when it comes to applying open and standardized technology.

The standardized behavior, organizational rules and employees’ occupational roles are managed by companies and usually this approach is discouraging members from adapting to innovative changes. The first stage is initiated through the acceptance of innovation into organization’s structure, which brings the advantage of easily adopting the procedures of IoT and implementing them into the existing business model in the later stages. Therefore, the importance of standardization must not be neglected. It is an approach that is being used for controlling and managing information flows in order to reduce the inefficiencies in the process. However, determining a standardized behavior while deploying applications with disruptive potentials, such as the IoT innovation, is neither easy nor simple thing to do. In Case 2, Project Leader A mentioned sometimes the knowledge that employees have is not enough for the routinization of similar technologies:

Another challenge is to determine a proper systematic approach to perform processes and to standardize the approach. (...) Besides production knowledge, IT and OT knowledge and experience have great importance for building up a standardized approach for adopting IoT activities.

In order to increase the speed of IoT adoption, there is necessity of providing universal, reliable and secure connection to IoT platforms. As Ahlgren mentioned, the necessity of attaching every type of sensor that is provided from different vendors (or capable of connecting any other device) to only one universal platform is the basic requirement in order to fulfill the first phase of the deployment. Secondly, vendors must agree upon having the same technical standards that support interoperability, which however it doesn’t look that achievable for now. On the other hand, customers’ expectations are changing towards opposite direction, every user have personalized needs that are affecting the market shape and enforcing vendors towards collaboration with business partners or even competitors. This is how in future, companies will be forced to change their standpoints and transform their business strategies accordingly. In the next stage, in order to achieve the necessary standardization and enhance interoperability, the governments and other regulators will have the task to build new frameworks for securing the software rights of the vendors, enable an efficient connection between customers and their requirements, provide secure system for transactions including digital financial services and ensure consumer protection in terms of data privacy issues and cyber-security.

Therefore, it could be said that directing the workforce in right direction and maintaining a good and solid planning for managing the change in the environment is one of the most important factors influencing the adoption of open source IoT applications into business models’ infrastructure and its standardization over company’s strategy.
6.4. Summary of Key Findings

The below summary gives further detailed information about the key findings related to the key requirements and challenges identified during the research regarding public and private organizations.

<table>
<thead>
<tr>
<th>Key Requirements</th>
<th>Challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Public</strong></td>
<td></td>
</tr>
<tr>
<td>✓ Good knowledge and information exchange</td>
<td>✓ Connectivity &amp; mobility concerns – vertical silos</td>
</tr>
<tr>
<td>✓ Technological capabilities &amp; resources</td>
<td>✓ Governmental approach – supportive policies</td>
</tr>
<tr>
<td>✓ Business partnerships</td>
<td>✓ Security and privacy concerns</td>
</tr>
<tr>
<td>x Social needs</td>
<td>x Difficult to find the necessary funding &amp; resources</td>
</tr>
<tr>
<td><strong>Private</strong></td>
<td></td>
</tr>
<tr>
<td>✓ Good knowledge and information exchange</td>
<td>✓ Connectivity &amp; mobility concerns – vertical silos</td>
</tr>
<tr>
<td>✓ Technological capabilities &amp; resources</td>
<td>✓ Governmental approach – open system</td>
</tr>
<tr>
<td>✓ Business partnerships</td>
<td>✓ Security and privacy concerns</td>
</tr>
<tr>
<td>x Consumer needs</td>
<td>x Re-structuring of relevant business strategy</td>
</tr>
<tr>
<td></td>
<td>x Forecasting market shifts &amp; having rapid response</td>
</tr>
<tr>
<td></td>
<td>x Seize through potential business opportunities</td>
</tr>
</tbody>
</table>

The below summary is giving general overview of the adoption process and the differences and commonalities regarding the activities followed during the projects’ applications of public and private companies.

<table>
<thead>
<tr>
<th>Evaluation</th>
<th>Adoption</th>
<th>Routinization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public</td>
<td></td>
<td></td>
</tr>
<tr>
<td>▪ According to social necessities and requirements</td>
<td>▪ Applied business strategy acc. to users relationships – continuous, open-ended feedback</td>
<td>▪ It is expected to change the competitive landscape drastically</td>
</tr>
<tr>
<td>▪ Governmental influence</td>
<td>▪ Increased rate of adoption – efficient management of good inter-divisional</td>
<td>▪ Decreased rivalry between</td>
</tr>
<tr>
<td></td>
<td>personalized products</td>
<td>communication within the organization</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>
| **Private** | ▪ Investing in different resources of innovation  
▪ The resources, support, encouraging regulations by governmental side | ▪ Business strategy – standardized model adoption;  
- Smaller projects → Bigger changes  
- Specific strategic approach – 3S Business strategy  
- Align disruptive potentials with company’s interests | ▪ Right distribution of resources and maintaining a solid plan of the IoT adoption |

A summary is given below considering the industry design principles that are shaping the future of IoT, in which some have incremental impact and others are more reshaping or disruptive. However, no matter how the IoT market is being reshaped, the necessity for capturing value remains vital. Therefore, companies will have the necessity to follow the principles in a way that will bring advantages in terms of strategic differentiation, process flow management, and value network in order to achieve long-term success.

### Interoperability
The existing vertical silos in the industry, and also the auto-supplier in the case study is also one of them, are what present a boundary for efficiently managed interoperability. The main reason for is that IoT has complex and fragmented nature. While these points are restrictions connected to the factor, it has high potentials when it’s efficiently applied.

### Virtualization
Embedded virtualization is the key concept for efficient IoT adoption. In order to achieve flexibility, security and safety through virtualization, IoT must take into consideration those factors related to the aspect.

### Decentralization
In order to gain interoperability, decentralization of IoT is a must. In a world, where the information will be reachable freely and will be processed safely, people’s lives will become more convenient. The automation of services through IoT is one expected outcome in successful decentralization of IoT activities.

### Real-time capability
The information is the most vital aspect when considering real-time capability of the IoT. Nor services neither the features of the product will create value if there is no data to be used for modifying future activities. These modifications are creating new information flows that create the learning process; the artificial intelligence. The continuous loop of this flow is the key for the principle.

### Service orientation
The relationship between product – performance measures is what defines the boundaries of the value network according to Christensen (1997). In IoT, the interoperability and information process flow are the most important performance measures. What customers value is related to these factors, such as easy to use application that will maintain daily activities efficiently could be the key aspect for users.

### Modularity
The IoT adoption in businesses needs a strategy that will suit the requirements of not only one single system. Usually firms apply value network that is not allowing them to switch between different structures in order to address various needs of customers. The necessity for open source platform becomes mandatory in this regard. This is the key that will ensure the adaptation to rapid market shifts.
7. Discussion

In this section, the research questions of this study will be further elaborated by aiming to provide a general output regarding the discussions that were followed throughout the paper. The answers given through those questions is what will put light on the focus of the research, and potentially open new areas for investigation. For this purpose, three essential questions are addressed below.

7.1. Research question 1

- How the adoption of IoT is being managed in the case studies involved in this research?

From the studies we have studied, it can be seen that adopting IoT internally by organizations is a meticulous process with different phases, which is following an innovation adoption process.

Organizational adoption has various processes as pointed out by Rogers (1995), there are two stages; the initiation stage gives the starting point for identifying the needs or issues that the organizations is being facing and through its analysis to follow up a path for improvement, and the implementation stage involves all proceedings to be considered after the decision for adoption is being taken by the organization.

Therefore, starting with the process of identifying a need(s) or an issue(s) to be solved, and searching for a solution that better suits the organization’s best interests is the exit point of this research. Having decided that adopting IoT technologies is the best way to proceed in solving the identified issue(s), the organization embarks on a journey to accommodate the solution by implementing the chosen aspects of IoT technologies into their business strategy, thus beginning the implementation phase of the process. At the core of this adoption phase is the restructuring stage, where both adopted the technology and organizations’ structure are susceptible to be reinvented and restructured respectively in order to optimize performance and create the most value.

As mentioned in the literature review and interviews from the empirical cases examined in the analysis section, considering the characteristics of IoT solutions, there is an increased interest for companies to invest in data generation and open-ended customer relationships. Interconnectedness and continuous data generation is perhaps the most important feature enabled by the nature of IoT technologies and devices. Organizations adopting IoT are investing and creating networks and ecosystems by connecting devices and external components that exchange information between them and generate valuable information that can be used to improve operations and internal processes. In that regard, there is also an increased investment in software development, with organizations increasingly hiring more staff that has the skillset to handle all the data generated and developing solutions from it. Another point of emphasis in the organizations’ strategies concerning the adoption of IoT is the role of the customer as a variable for optimizing operations. Being able to acquire
feedback from the customer provides various insights for the organization. As a result, organizations adopting IoT have created a system that facilitates continuous interaction with customers, making it an open-ended relationship that ends up benefitting both parties involved.

When it comes to diffusing IoT in their businesses, organizations are making efforts in two fronts: creating a single general mindset where every employee sharing the same mindset regarding the organization’s goal, and also providing the employees with the right resources and infrastructures to fully harvest the potential of IoT. Based on the knowledge shared by the project leaders in Case 2, it could be seen that leaders and managers are very important in diffusion of innovations and ideals inside organization’s structure. As organization-wide changes need to happen in different units of the whole structure, it is important that there is a high degree of cross-functional collaboration. Being the heads of their respective units, managers have a key role in consolidating the connection between units, which leads to a more efficient and responsive organization as a whole.

Following the successful implementation and diffusion of IoT, the adoption process is then finalized when the technologies/solutions adopted start losing their disruptive identity, and become a routine within the organization’s structure and operations. Such event happens overtime, and requires redirecting the workforce in the right direction and maintaining a good and solid planning for managing the changes in the environment.

7.2. Research question 2

- **What are the potential key enablers and main challenges influencing the IoT adoption process for organizations?**

As a conclusion of this study, potential key enablers while adopting disruptive technologies, such as the IoT are observed to be the level of system openness towards innovative changes, the flexibility and resources of the company to respond to the shifts and the capability to maintain an efficient interoperable environment.

In order to get comprehensive view of the IoT adoption characteristics and evaluate individuals' contribution, this study combined the TOE framework (Tornatzky & Fleischer, 1990) and the DOI theory (Rogers, 1995). The TOE framework gave us an output from organization-level perspective, and served as a tool to identify the main key factors that were further allocated within the technological, organizational, and environmental aspects. On the other hand, the DOI theory was used to evaluate how the IoT integration will be placed into a standard within the organization. Diffusion is described by Rogers (1995, p. 409) as: “the process by which an innovation is communicated through certain channels over time among the members of a social system”. The study analyzed the behavior and influence of individuals over this process over time.

To begin with, the current market is fundamentally influenced by the activities of digitalization in the industry. This by all means will lead to higher rates of adoption in terms
of IoT applications and tools into the current business models of companies, which will shape the systematic infrastructure of organizations. Within private organizations this will generate a necessity towards adopting a strategy that involves collaboration with business partners and even competitors in the industry in order to harvest the IoT opportunities in its full potential, in public organizations it will not be approached any differently, and they will also require good communication and knowledge exchange with businesses that have better technical background in this regard.

Looking into the organizational decisions taken by organizations, it is important to make a distinction between the adoption of specific innovation as it is defined by Rogers (1995) and the adoption of specific aspects or variables that are part of the innovation as it was described in the TOE framework of Tornatzky and Fleischer (1990), some characteristics were concluded to be essential while adopting IoT application. Especially the key factors or requirements in order to achieve a successful implementation of open source IoT activities were classified as: obtaining high level of expertise, providing technological advancements and sustaining continuous exchange of knowledge through the improvement of inter-divisional coordination. Those aspects are also considered as main resources or the backbone of the IoT infrastructure. They are obligatory in order to initiate beneficial activities in the field, because otherwise the connectivity or the mobility between the surrounding environments with the cloud computing services would have not been a possibility.

One more significant requirement that was reported during our case studies was the involvement of the end-consumer into the process of adoption. The characteristics of IoT have focus on providing more personalized services, which result in having the necessity of improving the relationships with users or customers by providing continuous and open-ended interaction and use cloud computing for data collection and process improvement. For the purpose, making investments in the field of customer relations and after-sales services becomes an important asset to the business.

Following the key requirements specified above, the key challenges are faced in similar areas during the diffusion of IoT. To begin with, in order to fulfill the requirements for enhancing efficient interoperability between developers and IoT platforms, the challenges in relevance with the existing verticals silos in the industry must be overcome. For the purpose, organizations need to realize the high necessity of adopting an innovative strategy and acquiring an open system. Therefore, another challenge appears to be the process of re-structuring strategies that are being adopted by companies in order to deploy IoT or Open IoT activities. The main influencer that complicates this process is the fragmented structure of IoT, which means that the adopted business model approach usually provides only one solution by focusing on individual segments of the value chain.

Another challenge and a requirement for achieving connectivity and mobility in the field of IoT it will always remain the governmental approach to the topic. There is a huge necessity
regarding the development of regulatory frameworks that will manage and maintain this transition process in a more reliable way. Potentially, the government is the one that may provide funding and investments in the industry and improves the level of information exchange by providing equal opportunities to organizations. Not only economic conditions may be further improved, but also supportive policies can be introduced for the purpose.

Another topic that was discussed and it involves activities that are already initiated by the governments are the security and privacy issues, which are the main challenges to be faced during the process of Open IoT adoption. The developments of software solutions for preventing security bridges and ensuring the privacy of users are still on-going and are managed not only by enterprises, but also by governments. However, the development of a standardized model that will be able to detect and secure the confidentiality of data flows, and also improve its identification process by automatized learning is not still possible. That’s why this challenge will possibly remain unresolved for a long time in the future.

7.3. Research question 3

- Why Open IoT ecosystem is the future of IoT technologies?

_The rate of adopting digital services in businesses’ core structures is gaining pace, and the integration of Open IoT into companies’ strategies is what will give advantage to enterprises in the future transformation of the market._

While there are many organizations in the industry that are not willing to acknowledge the importance of Open IoT adoption, it is clear that IoT diffusion is gaining pace by wireless connectivity and technology advancements. During our case studies, it was reported that organizations, which have already been in the market and have the necessary processing capabilities continue on making investments in order to broaden their range of IoT services and products. On the other hand, eventually smaller companies will be involved in the field by aiming to disrupt the market and provide smaller business solutions. This will result in widening customer needs, providing a ground for developing newer solutions and markets, and lead to an extensive growth in the IoT activities.

In order to avoid vendor lock-in and single manufacturer dependence, customer needs will reshape the industry structure. Organizations will be mostly enforced to adopt Open IoT platforms in order to not lose their competitive advantage positioning in the market. The main reason of this tendency is the interoperability aspect, providing a better connection and communication between all the devices provided in the market by different vendors. This is how even communities will be inter-connected and exchanging information, but consumers will adopt IoT into their daily lives if this is what will ease and really improve their lives. Open source IoT is the term that will further expand the commercial and economic benefits of IoT that are being used as a free source by companies.

It is a common understanding that the IoT will shape the future of enterprises. However, adapting to the changes occurring in the market is becoming more complex every other day,
and IoT is constantly transforming technology that needs flexibility, which can be provided only by open source developments. Therefore, the nature of Open IoT is what will provide the durability of companies’ services and products, and greater adaptability in the long term. This is how organizations will be able to maintain a continuous organizational innovativeness. Different types of companies have initiated some phase of developments in the field, which no matter the size or involvement rate are contributing to the advancement of the industry. While improvements made internally and in sub-divisional level are having beneficiaries in the short-term processes, the awareness of the need for bigger innovations is recognized. Open IoT ecosystem is creating shared value, which in future will lead to industry-wide growth and integrity between today’s businesses.
8. Conclusions

Two cases have been built and analyzed in this paper, which results were summed up in this section and the interpretations were pointed out in more generalized statements. Research’s main findings and contributions were presented in overall arguments. In addition, future research recommendations were briefly discussed.

8.1. General conclusions

In this study, existing IoT literature was thoroughly discussed and different methodologies were analyzed, which outcome combined the TOE framework (Tornatzky & Fleischer, 1990) and DOI theory (Rogers, 1995) as a basis model for analysis of the case studies. The main purpose was to further understand and get an overview of the extensive elements of environmental and organizational contexts aside from technological diffusion perspective of IoT. In this paper, by understanding the existing literature interpretations and utilizing them for the generation of empirical findings, a general overview is given regarding applied solutions in the IoT market. Company sizes and their industry types are also considered as control variables that are used as a basis for follow-up research and give more detailed understanding of other potential variables that may influence the IoT adoption process.

The research finding contributed to our study with required information for identifying the key enablers of successful IoT integration as technological innovation. Throughout those findings, it has been seen that there were instances where the theory does not correspond to the experience in reality about how today innovations behave in certain circumstances. While Rogers acknowledges the influence of the customer/adopter in the diffusion of an innovation, he failed to acknowledge their influence to the process of integration. From what it can be seen in his work, the development of innovations is followed as a linear process that ends after their deployment to the markets. However, nowadays products, especially non-physical ones, are constantly changing and evolving even after they are first deployed (updates, new versions, etc.), thus the development process of many products and innovations in the present is continuous, which is also derived from the findings of the case studies. Organizations do not invest into specific project to achieve or obtain some monetary value, but the investments made are focusing on future returns. The results from the study show that even after integration and eventual adoption, the organization developing the innovation has the possibility to receive feedback coming from the adopter regarding the innovation’s performance, efficiency, and effectiveness, and also feedback in terms of product/service usability, and overall satisfaction. This feedback can then be used by the developer to further build the innovation and improve it. With this type of insight coming from the adopter of the innovation and the utility it can have for developers, not only can one conclude that the development process of an innovation can be continuous and not necessarily ending on deployment, it can also be concluded that customer/adopter also has an influence on the development process of innovations.
The infrastructure of business is being reshaped according to the leading market shifts in the industry and upon the necessity for creating innovation in order to reassure company’s constant position. For this reason, findings show that companies have continuous aim of launching new products and services, which has become one of the main concerns for project leaders and managers, too (Schiavi & Behr, 2018), as it can been seen within the results of this study. Therefore maintaining a continuous improvement for organizations within the IoT field appears to be a key factor for efficient innovation management. This is also the key element for gaining competitive advantage amongst others involved in the industry and keeping on a sustainable development by highlighting your difference in the business environment.

If companies are capable of defining the potential threats of new technologies that are being introduced in the market and understanding their future opportunities, they will be capable of processing the substantial information that will be applied into their products and services, set of skills, the profit and value network transformation (Sainio, 2004). As earlier is the reaction of the companies as faster will be response towards the imminent dangers of the rapid changes happening in the market. This is how the applied theories in this paper gain importance when related to disruptive technologies and innovations, which dictate the norms for generating a new business model and being able to identify the characteristics of these aspects (Sainio, 2004).

It is clear to oversee the future beneficiaries of IoT, and its interaction with people’s lives. Many product and service providers are adopting IoT activities in order to save costs, improve manufacturing processes, enhance efficiency in their businesses, reduce failures, optimize their utilization of resources, and for many other reasons related to increasing their profits. The increase in business efficiency is also the key for increased customer satisfaction, and creating value through more reliable and less time consuming services is what will bring the success in organizations. As the IoT is exponentially developing, the opportunities provided for organizations will be continuously increasing as well. Enabling IoT will require a specific strategy in order for enterprises to succeed in this process. As it was highlighted through the paper, IoT has different layers in its infrastructure, starting from frameworks to network connections each one of them is represented in different maturity level. Therefore, companies or organizations deploying IoT applications are aiming to apply their activities by pairing up their business models with the right system. How much of this potential will be utilized by companies will determine the efficiency of the IoT adoption. This is the context, in which this study brings the most value – providing a detailed analysis on how organizations react to new applications and how they become compatible with the already existing system or structure of the company.
8.2. Future research

- **More extensive research regarding policy makers and regulating entities**

  IoT is regarded as a technological innovation that will play a role in various different environments in today’s society. A useful topic that requires extensive research in the future would be to assess the role of regulating entities and policy makers in the diffusion and adoption of IoT. The concerns of this innovation associated with the users’ privacy and security, as well as the implementation of IoT in public services and other branches of society, require a certain action from regulating entities that must do so having the best interests of the whole society in mind.

- **Further explore interoperability issues at organizational level**

  While not explored at a desired level in this study, the topic of interoperability between IoT devices and services is pivotal in the future development of IoT solutions for all different types of adopters and environments where IoT is expected to be present. Thus, further researching on this topic will provide much needed knowledge on an issue that is central in IoT technologies. Based on Ahlgren’s remarks about how a lot of the issues revolving interoperability can be more related to how organizations fail to agree on using the same standards, instead of being related to complex technical issues, it would also be an interesting practice to research about organizations interaction between each other when discussing which standards to use at an industry-wide level.
References


Gravina, R. et al., 2018. *Integration, Interconnection, and Interoperability of IoT Systems*. Cham, Switzerland: Springer International Publishing AG.


Appendix

Questions for project leaders employed in private or public organizations

Interviewee Profile
1. Provide us with a brief background of who you are, and what you do
   - Education
   - Occupation
   - Area of interest and research

About the project
1. How did it start
2. What is the aim of the project
3. What are the different stakeholders involved
4. What challenges were faced
5. How was the involvement with other entities (private vs. governmental / public)
6. How would you describe user reception/usage (adoption)

Technology context
1. What are the attributes/benefits associated with Open IoT (in terms of Individuals, Organizations, Society)
2. What are the risks associated with Open IoT (Security, privacy, access)
3. What complementary technologies are necessary to support Open IoT systems
4. IoT vs. Open IoT (Key differences, Motivations for Open IoT)
5. Operation difficulties (Interoperability issues, Stability)

Organizational context
1. What are motivations for organizations to adopt Open IoT
2. What are the barriers for organizations to adopt Open IoT
3. Describe the implementation process of such technologies
4. What characteristics (profile) companies ought to have to be innovative
5. What adjustments need to be made to accommodate such technologies
   - What infrastructures need to be developed
   - What new (human) competencies does the organization need

Environment context
1. How do competitors and other organizations influence the spread/adoptions behavior
2. What is the role of governmental entities
   - As an enabler: funding, diffusion agent
   - As a regulating entity: Legislations, standards, regulations
3. How do customers influence the adoption process
   - Benefits, expectations, requirements