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ANALYSIS OF THE IOT PLATFORMS BUSINESS MODELS

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Abstract

In the last decade the world of manufacturing firms is completely changed thanks to the use of new technologies. Internet of Things (IoT) is one of these technologies that not only has the potential to impact how we live, but also how the businesses are being ran. Innovative companies are adopting IoT strategies and technologies to reengineer their products and services and redefine their relationships with customers, employees and partners.

The IoT market is exploding at a significant pace as consumers, businesses, and governments are recognizing the benefits of connecting devices to the Internet.

The purpose of this thesis is to explore in depth the different business model utilized by different companies, with no distinction of specific industry. Moreover, this thesis aims to study the IoT platforms business models and to understand how these platforms change the market competition by leveraging the IoT technologies. In order to reach this aim a structured literature review will be performed. Then, analysing different companies by using the business model canvas approach, three business scenarios will be identified and defined, as follows: servitisation, lean and world manufacturing and, digital platforms for manufacturing. Finally, it will be applied a mathematical model in order to discuss whether and how an IoT investment can give advantage to a manufacturing firm.

Key words: Internet of Things; Business Models; Servitisation; Lean and World class Manufacturing; Digital platforms for manufacturing.

JEL Classification System: O33

Index

Index of Figures

Index of Tables

List of Abbreviations

API – Application Programming Interface

AWS – Amazon Web Service

B2B – Business to Business

B2C – Business to Consumer

BPS – Bosch Production System

BR – Best Responses

CEM – Capital Equipment Manufacturing

CIP – Continuous Improvement Process

CR – Customer relationship

CS – Customer Segment

GCP – Google Cloud Platform

GE – General Electric

H&S – Health and Safety

IaaS – Infrastructure as a Service

IIoT – Industrial Internet of Things

IoT – Internet of Things

IT – Information Technology

JIT – Just-in-time

M2M – Machine-to-Machine

MA – Microsoft Azure

PaaS – Platform as a service

R&D – Research and Development

RBV – Resource-Based view

RFID – Radio-frequency identification

SaaS – Software as a Service

SDK – Software Development Kits

TPS – Toyota Production System

VP – Value Proposition

WSN – Wireless Sensor Network

CHAPTER 1. INTRODUCTION

1.1. Context

Today, more than two billion people are using Internet to search information, to communicate, to use social network, to send and receive the e-mails and to do a lot more activities (Mehta et al., 2018). In the last decade Internet is moving to a higher level, where smart devices will be connected each other in order to deliver valuable information and service. In this scenario, the concept of Internet will diminish, giving rise to the, so called, Internet of Things (IoT) (Zheng et al., 2011). The IoT concept came into existence in 1998 and the term IoT was introduced by Kevin Ashton in 1999 (Ashton, 2009).

It is forecasted that the connected devices across all technologies will reach the number of 20.6 billion in 2020 (Gartner report, 2017). IoT can be utilized in several ways and it is widely used in manufacturing. IoT sensors allow to gather a huge amount of data enabling the transformation from a traditional manufacturing system into modern digitalized ones (Mourtzis et al., 2016).

1.2. Research Motivation and Objectives

The IoT investments in manufacturing in 2016 were about $178 billion, while the global IoT spending it is forecasted to reach $1.29 trillion in 2020 (IDC report, 2017).

IoT has spread a lot in the last years so there is a lack in the literature, in particular there are not studies about the analysis of the IoT manufacturing firms business models. Since the IoT technology is a disruptive innovation that will change the business, it is fundamental to understand how the companies have to adapt themselves and change their business model.

The aim of this thesis is to explore in depth the different business model utilized by different companies, with no distinction of specific industry. Moreover, the purpose of this thesis is to study the IoT platforms business models and to understand how these platforms change the market competition by leveraging the IoT technologies.

1.3. Research Questions

In order to achieve the objectives of this thesis the following research questions will be explored:

- Which are the main business models utilized in the IoT industry and how do they operate with the IoT platforms to allow to the firms to get competitive advantage?
- What are the effects of the IoT platforms on the market competition and what are the main business parameters that affect it?

1.4. Research Methodology

To achieve the aim of the thesis a structured literature review will be conducted in the chapter 2 to understand which is the state-of-the-art about IoT platforms and, in particular, the business model of IoT platform. Since the literature review highlights the existence of three main business scenarios concerning the application of industrial analytics, it has been decided to investigate about the business models of the companies operating in these business scenarios in order to give a contribute to the literature. Using secondary data collected from business journals, reports, company information available on internet, business magazines and business books it was possible to describe the business model of the companies, using the canvas model, as described in chapter 3, it will be performed an analysis of four companies operating in the field of Servitisation, one company operating in the field of Lean and World Class Manufacturing and eight companies operating in the field of Digital platforms for Manufacturing. Furthermore it will be performed a cross-case analysis in order to compare the different scenarios. The business model canvas of the three business scenarios will be compared with other studies performed by researchers in order to see the similarities and differences among the business models.

Finally, the creation of a mathematic model will be performed, it will show a duopolistic competition where one firm uses IoT and the other does not use it, showing how the Nash equilibrium changes with the use of IoT.

CHAPTER 2. LITERATURE REVIEW

2.1. History of Internet of Things

The term “Internet of Things” was coined by Kevin Ashton in 1999 during his work at ProcterandGamble. Ashton, who was working in supply chain optimization, wanted to attract the attention of senior managers to a new exciting technology called RFID. Radio-frequency identification (RFID) uses electromagnetic fields to automatically identify and track tags attached to objects. The tags contain electronically-stored information, it brought to the concept of connected devices. Actually, the idea of connected devices existed before 1999, but no one gave a proper name to it; so, it was called “embedded internet” or “pervasive computing”. An interesting story about a device with “embedded internet” was about the worlds first IoT device (Vinik, 2015). In 1980, David Nichols, a graduate student in Carnegie Mellon Univesity’s computer science was in his office craving a soda, but his office was “relatively far” from the coke machine and considering the use of caffeine that the students are used to drink, he knew that the chances that the coke machine was empty were high, so he had the brilliant idea. With the help of two other students, Mike Kazar and Ivor Durham, and an engineer, John Zsarnay, he started to work to track the machine’s contents remotely. The machine had six columns of bottles, so they put an indicator light for the corresponding column and when someone purchased a Coke, a red indicator light for the corresponding column would flash for a few seconds before turning back off. When a column was empty, the light stayed on until the sodas were replaced. Zsarnay installed a board that sensed the status of each of the indicator lights. A line from the board ran to a gateway for the department’s main computer, which was connected to the ARPANET. Kazar wrote a program for the gateway that checked the status of each column’s light a few times per second. If a light transitioned from off to on but then went off again a few seconds later, it knew that a Coke had been purchased. If the light stayed on more than five seconds, it assumed the column was empty. When the light went back off, the program knew that two cold Cokes—which were always held in the machine in reserve—were now available for purchase, while the rest of the bottles were still warm. The program tracked how many minutes the bottles had been in the machine after restocking. After three hours, the bottles simply registered as “cold.” Finally, the group added code to the main computer’s finger program, which allowed anyone on a computer connected to the ARPANET, or anyone connected to Carnegie Mellon's local Ethernet, to access information about the machine. With a few simple keystrokes, they could find out if there were any Cokes in the machine, and, if so, which ones were cold. After a while, all the students started to check if there was cold coke before to go to the coke machine (Vinik, 2015).

This interesting story shows the power of IoT device, this is the reason about the exponential growth of IoT devices during the last years. It is forecasted that in 2020 there will be more than 50 billion devices using Internet of Things, as depicted in the figure 1.

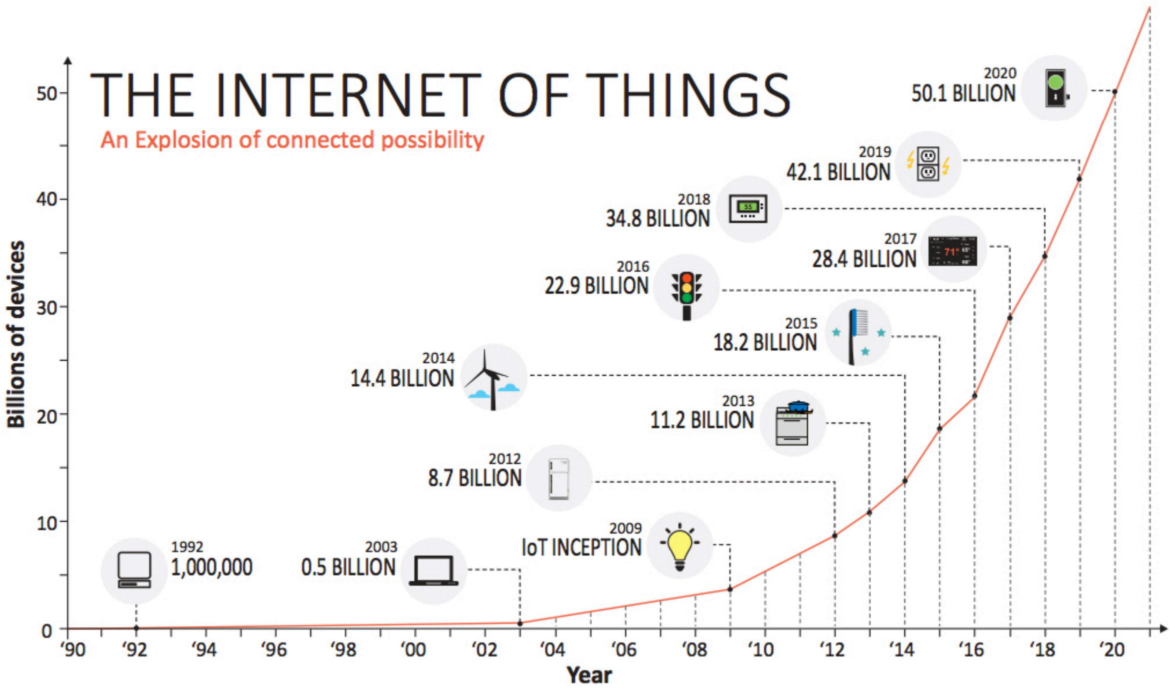

Figure 1 – Growth of IoT (Baker, 2017)

2.2. Applications of IoT

The use of IoT is spreading in many industries. Some applications are developed in the field of healthcare, logistics, inventory control, supply chain, transportation, security and privacy (vide figure 2).

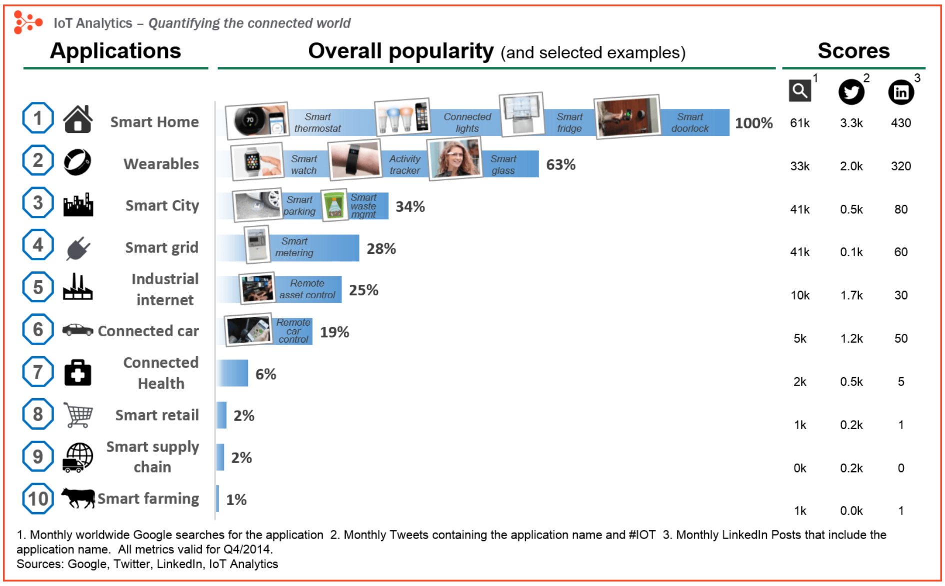

Figure 2 – Most popular IoT Applications (Kashyap, 2016)

IoT analytics make a research showing the overall popularity of IoT applications, they measured what people search for on Google, what people talk about on Twitter and what people write about on Linkedin. They gave a rating of 100% to the highest score and then they gave a percentage to the other applications that represents the relative ranking compared to the highest score. The most common IoT application is about:

- Smart Home: the IoT has the capability of making the homes smart by managing energy consumption, providing interaction among the home appliances, spotting emergencies, ensuring safety etc. The total amount of funding for Smart Home startups currently exceeds $2.5bn.
- Wereables: the main purpose of wearable devices is to collect data and information about the users through the sensors and software in order to extract essential insights about user. These devices are used in the field of fitness, health and entertainment requirements.
- Smart Cities: by installing sensors and using web applications, citizens can find free available parking slots across the city. It can be used to reduce the light consumption, lights can turn on, during the night, only when someone pass near them. The waste collection companies can know how full the containers are in real time without loosing time to collect empty bins.
- Smart grid: Nowadays the electricity demand is very volatile and difficult to forecast, the smart grid allows to gather data about the consumption of electricity introducing a two-way dialogue where electricity and information can be exchanged between

utilities and customers, in this way it is possible to create a more efficient, reliable, secure and cleaner system.

- Industrial Internet: According to General Electric the improvement industry productivity will generate $10 trillion to $15 trillion in GDP worldwide over next 15 years. Industrial Internet covers all the applications useful for the companies in order to ensure quality control and sustainability or for tracking goods, real time information exchange about inventory among suppliers and retailers.
- Connected cars: a connected car is a vehicle that uses onboard sensors and internet connectivity to optimize own operations, maintenance and comfort of passengers. It can bring add value to the firm using servitisation where the producers do not sell only the product but also the service associated to the product, in this case the service will be the maintenance since they can know earlier that the car needs maintenance and they can supply the service to the consumer.
- Connected Health: IoT in healthcare is aimed at empowering people to live healthier life by wearing connected devices. The collected data will help in personalized analysis of an individual's health and provide tailor made strategies to combat illness (Kashyap, 2016).
- Smart retail: IoT provides an opportunity to retailers to improve the in-store customer experience, allowing them to know where are the products that they are looking for and how much is the grocery that they are buying. Each user can also have an IoT application linked with their fridge that can be helpful to communicate them what they need to buy.
- Smart supply chain: IoT can save time and money to the companies connecting goods, assets and people in the supply chain. It can affect positively warehouse management, transportation and logistics. Some examples are sensors that optimize energy consumption, sensors that alert employees of potential dangers in the workplace or sensors that allow real time tracking of the packages.
- Smart farm: farmers are using meaningful insights from the data to yield better return on investment. Sensing for soil moisture and nutrients, controlling water usage for plant growth and determining custom fertilizer are some simple examples of how IoT can help in this field (Kashyap, 2016).

2.3. IoT Platforms

An IoT Platform is an application that connects everything involved in an IoT system. At the beginning, IoT platforms were used only as middleware (figure 3), in order to link the hardware and the application layers.

Figure 3 – IoT Platform (Kaaproject, 2019)

Nowadays, it has a variety of valuable features. IoT platforms can handle different hardware and software communication protocols, it can provide security and authentication for devices and users, it can collect, visualize and analyse the data that the sensors and devices gather, furthermore it can integrate all with other web services. An IoT platform can be used in the Business to Business (B2B) or in the Business to Consumer (B2C). The developers can take advantage of the set of ready-to-use features that IoT platform offers, since they greatly speed up development of applications for connected devices. For companies it can be really helpful in order to reduce the costs in the industrial, agriculture and transportation sectors, for example, through predictive maintenance or collecting sensor data for real-time production analytics.

An end-to-end IoT platform consists of eight important architectural building blocks (figure 4) (Scully, 2016).

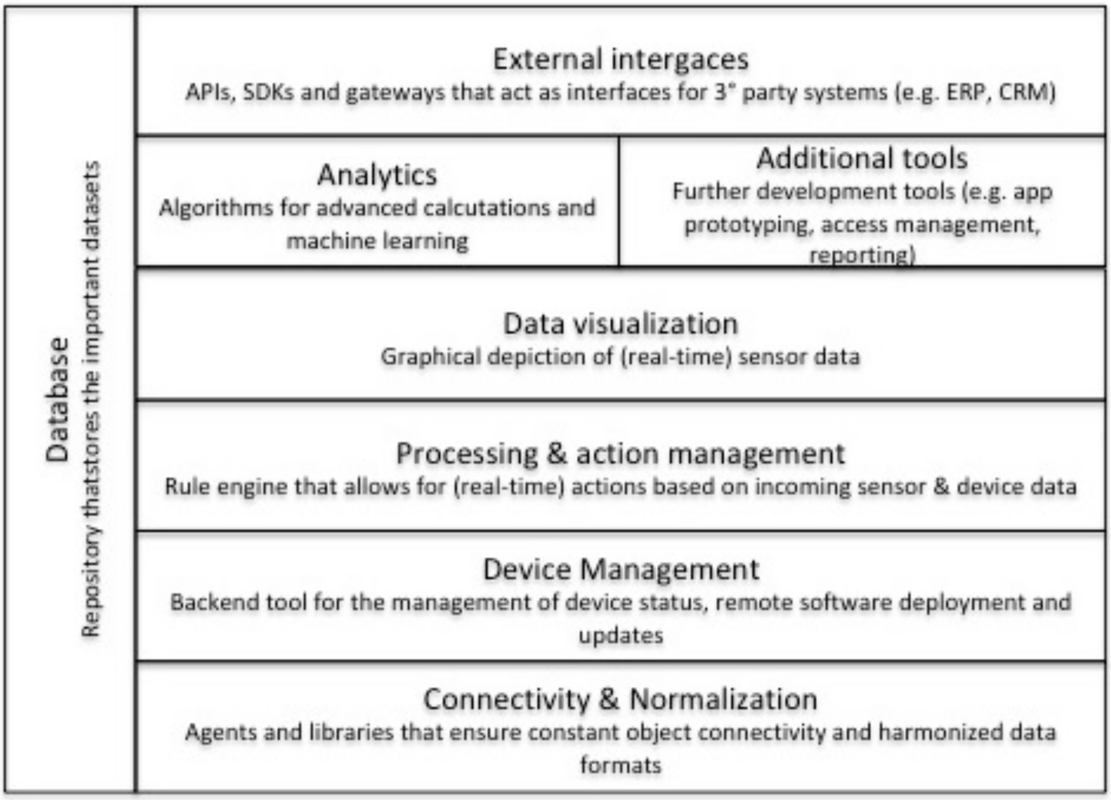

Figure 4 – IoT Platform components (IoT Analytics Report, 2015)

The first component is connectivity and normalization; which refers to the capability of the platform to gather different data into one "software" interface ensuring interaction with all devices.

The second component is device management; it ensures the connected objects are working properly and their software are up to date.

The third component is the database; it is necessary in order to storage the huge volume of data.

The fourth component is processing and action management; it is the process of the platform that allows to execute "smart" actions based on specific sensor data.

The fifth component is analytics; which performs a range of complex analysis from basic data clustering and deep machine learning to predictive analytics extracting the most value out of the IoT data-stream.

The sixth component is visualization; which allows to the platform to create graphs in order to show the patterns and trends to the users.

The seventh component is additional tools; the platform through this component can allow to the IoT developers to test the apps for visualizing, managing and controlling connected devices.

The eighth component is external interfaces: which allows to integrate with other IT system using application programming interfaces (API), software development kits (SDK), and gateways (Scully, 2016).

2.3.1. Different models of Cloud Service: IaaS, PaaS and SaaS

An IoT platform can supply three different models of cloud service (figure 5): Infrastructure as a Service (IaaS), a Platform as a Service (PaaS) or a Software as a Service (SaaS).

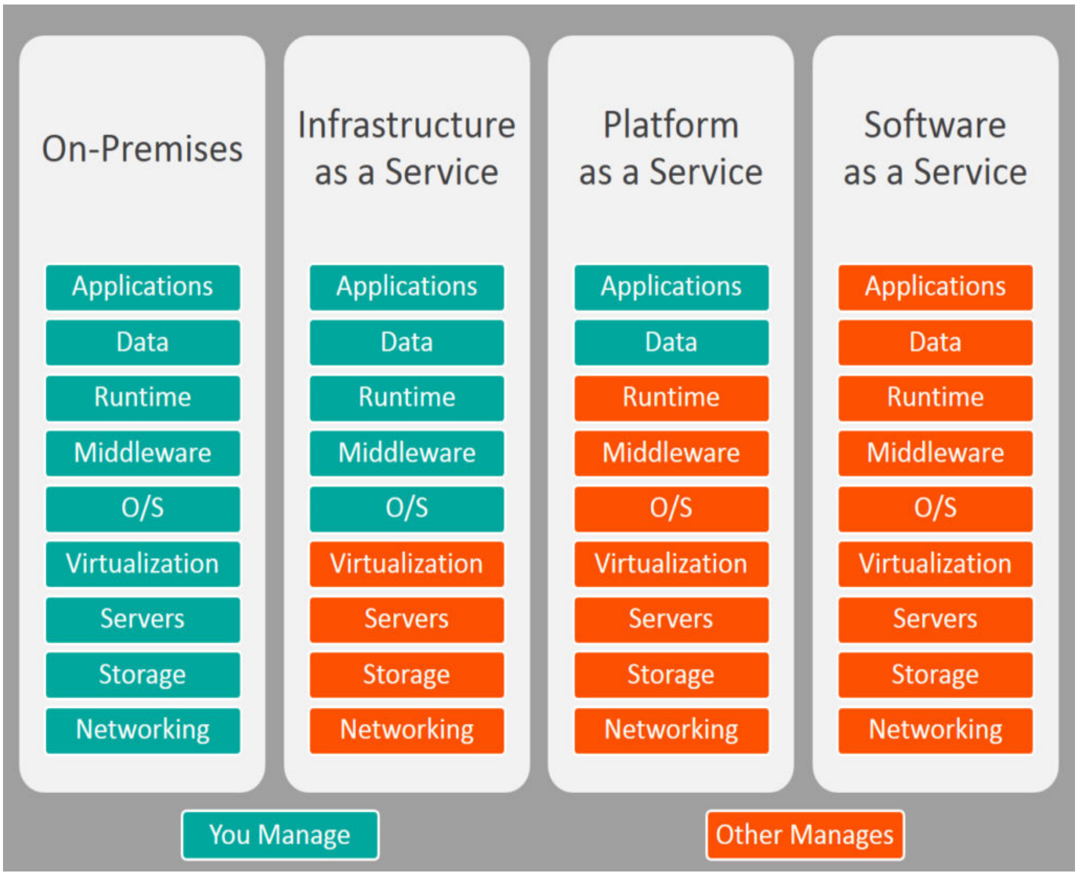

Figure 5 – Difference between PAAS, IAAS and SAAS (Watts, 2017)

The differences between them is in the separation of the responsibilities, and so in what the platform runs and what the user can manage.

IaaS is a model, which the user can utilize pre-configured hardware, provided via a virtualised interface, to manage an infrastructure in the cloud without care about the place on which the resources are located. It provides a virtualization platform by creating Virtual Machines that assist users in accomplishing their tasks within a reasonable time (Garg et al., 2014). IaaS clients are responsible for managing aspects such as applications, runtime, OSes, middleware, and data. However, providers of the IaaS manage the servers, hard drives, networking, virtualization, and storage. Some providers even offer more services outside of the virtualization layer, such as databases or message queuing. There are many advantages of choosing IaaS such as:

- It is the most flexible cloud computing model;
- Easily allows for automated deployment of storage, networking, servers, and processing power;
- Hardware can be purchased based on consumption;
- Gives clients complete control of their infrastructure;
- Resources can be purchased as-needed;
- It is highly scalable.

The characteristics of IaaS are:

- Resources are available as a service;
- The cost varies depending on consumption;
- Services are highly scalable;
- Typically includes multiple users on a single piece of hardware;
- Provides complete control of the infrastructure to organizations;
- Dynamic and flexible.

PaaS clouds offer services to automate the deployment and management of applications, relieving application owners of the complexity of managing the underlying infrastructure resources. PaaS systems are currently used to host diverse applications, ranging from high performance computations to web applications, storage services, video streaming and, more recently, data analytics workloads (Costache et al., 2017).
As it is shown in the picture 5 in PaaS, the user can manage applications and data and the platform that runs the other services.
The IoT Platform as PaaS allows to the developers to code, test and deploy their applications while the platform manage all the other tasks. There are numerous advantages for using PaaS:

- Makes the development and deployment of apps simple and cost-effective;

- Scalable;
- Highly available;
- Gives developers the ability to create customized apps without the headache of maintaining the software;
- Greatly reduces the amount of coding;
- Automates business policy;
- Allows easy migration to the hybrid model.

As concern the characteristics of PaaS, the main ones are:

- It is built on virtualization technology, meaning resources can easily be scaled up or down as your business changes;
- Provides a variety of services to assist with the development, testing, and deployment of apps;
- Numerous users can access the same development application;
- Web services and databases are integrated.

Software as a Service, also known as cloud application services, represents the most commonly utilized option for businesses in the cloud market. SaaS delivery can help organizations significantly reduce the cost of using software, because the resources for running SaaS applications are shared among tenants, end users or organizations (Cao et al., 2019). With SaaS, vendors manage all of the potential technical issues, such as data, middleware, servers, and storage, allowing businesses to streamline their maintenance and support. The main advantages of SaaS concern the reducing of time and money spent on tasks such as installing, managing and upgrading software. The characteristics of Saas are:

- Managed from a central location;
- Hosted on a remote server;
- Accessible over the internet;
- Users not responsible for hardware or software updates.

2.4. IoT Platforms

The following literature review gives to the reader an overview about the state-of-the-art of IoT Platforms.

Since the aim of the research is to analyse the IoT platforms, a structural research of the literature review of IoT platform is needed in order to successfully begin the work.

The utilization of platforms raised in the last years, due to the success of some companies like Uber or Airbnb, that have reached the success using Multi-sided platform business model.

Andrei Hagiu and Julian Wright (2015) have provided evidence that Multi-sided platforms (MSPs) are technologies, products or services that create value primarily by enabling direct interactions between two or more customer or participant groups.

MSPs are characterised by two key features:

- They enable direct interactions between two or more distinct sides;
- Each side is affiliated with the platform.

Actually, there is a misunderstanding in the literature, because it is common to confuse IoT platforms as a multi-sided business model. Andreas Hein (2018) gives us an accurate definition of IoT platform, he states that IoT platform act as intermediaries to connect different parties like companies, sensor manufacturers, and third-party developers within an ecosystem.

Therefore, the parties linked within an IoT platform can be also devices; while in the multi-sided platform business model they are always customers or companies.

Since there are many different definitions of IoT Platform, due to the different purposes and different ways of use, it was decided to create a structured literature review, in order to clarify the term of IoT Platform. This term was searched on Google Scholar and ten scientific papers were gathered. The different definitions of the authors were compared and some similarities were found so, it was possible to resume these different definitions in three main clusters that are:

- IoT Platform defined as bridge that connects different parties;
- IoT Platform as facilitator that satisfies different needs;
- IoT Platform as connector to supply different services.

Table 1 - IoT Platform (developed by the author)

IoT Platform as the middleware, i.e. a connecting bridge	**IoT Platform as facilitator for different needs**	**IoT Platform as connector to supply different services**
Jim Morrish (2013) The Machine to Machine (M2M)/IoT Application Platform provides the 'glue' that intermediates between application developers, M2M connected devices and a range of niche and specialised M2M platforms and wider enterprise IT systems".	Nakhuva and Champaneria (2015) IoT platform is a complete suite of services that facilitates services like development, deployment, maintenance, analytics as well as intelligent decision making capabilities to an IoT application.	Zdravković et al. (2016) Internet-of-Things (IoT) platform is a software that enables connecting the machines and devices and then acquisition, processing, transformation, organization and storing machine and sensor data.
IoT Analytics (2015) IoT platforms are defined as the central piece in the Internet of Things architecture that connect the real and the virtual worlds and enable communication between objects.	Köhler, Wörner, Wortmann (2014) Some platforms offer capabilities to develop and run applications on end user devices. Others provide functionality to develop and run embedded applications on "things". the platforms provide functionally to centrally coordinate and process execution.	Scully (2016) IoT platforms are crucial for creating scalable IoT applications, which connect things, systems and individuals, and they are necessary for almost any IoT business case.
Purushothaman, Pal, Misra,	Ray (2017)	

(2013) M2M service platform is needed to connect and collect information on various devices and to be able to manage them.	IoT Cloud Platform is a platform, offered by a service provider, that enables advanced services by inter-connecting physical and virtual things based on interoperable information and communication tech-nologies.	
Mineraud, Mazhelis, Su, Tarkoma (2016) IoT platform is defined as the middleware and the infrastructure that enables the end-users to interact with smart objects.		

In the first cluster, IoT Platform as a bridge that connects, Jim Morrish (2015) identifies the Machine-to-Machine (M2M) Platforms as the ‘glue’ that intermediates between developers and devices; in particular, he identifies the key areas in which a M2M/IoT Platform differs from the more ‘traditional’ M2M platform environment, these are:

- Carrier and communications integration. An IoT Platform must develop “meta-APIs” to allow IoT developers to integrate to multiple carriers using a single Application Programming Interface (API);
- Device Management. An IoT Platform must build a wide-ranging library of cross-industry drivers to control local devices;
- Application Development. An IoT Platform should offer sophisticated tools to create business rules and integrate to business processes;
- Application Management. An IoT Platform should offer both software and firmware updates;
- Operations Environment. An IoT Platform should take into account the process about the privacy for the user data;

- Scalability. An IoT Platform must be highly scalable, and able to handle huge volumes of: users, event volumes and backend processing events.

In the IoT Analytics (2015) report, IoT platform is seen as the central piece in the Internet of Things architecture that connect the real and the virtual worlds and enable communication between objects, in particular it consists of eight important architectural building blocks, as it was previously explained in a more deep way in the chapter 1.3 of this thesis.

The research of Purushothaman, Pal, Misra (2013) focuses the attention on the different users of IoT Platform, in particular they identify four different kind of users:

- End Users of IoT Application. They are the public that uses IoT devices developed by application developers;
- Application Developers. They are those who register themselves to the IoT platform and use the platform services to develop and deploy application;
- Sensor Providers. They are those who own and/or operate sensors and contribute sensor observations to the platform, either for their own private use or for use by others based on access control and privacy policies;
- Platform Administrators. They are those who use the services, APIs and tools provided by the platform to manage and monitor users, services and devices.

Mineraud, Mazhelis, Su, Tarkoma (2016) identify the IoT platform as the middleware and the infrastructure that enables the end-users to interact with smart objects. They focus their attention on the problem of data ownership on IoT Platform. The enormous volume of data that would be generated by the devices in the IoT mandates the data management to be at the core of IoT paradigm, and it amplifies the need to maintain a certain degree of privacy and security.

The second cluster is about IoT Platform as facilitator for different needs, indeed the platforms of Internet of Things can be helpful for different kind of services in various sectors.

Nakhuva and Champaneria (2015) state that an IoT application platform is a virtual solution, means it resides over cloud. Data is the entity that drives business intelligence and every device has something to talk with other device that is data. They highlight the importance of the Cloud in this business model; in fact the main purpose of IoT platform is the gathering of big data that the devices can share.

The work of Köhler, Wörner, Wortmann (2014) analyses about the functionality of IoT Platforms, in particular they classify them in two general types:

- Core functionality: libraries and code frameworks which can be leveraged for application development and execution;
- Cross functionality: tools for development as well as life cycle management, i.e. managing the platform at runtime.

In the interesting work of Ray (2017), he formulated a definition of IoT Cloud Platform as: "a platform offered by a service provider as a hosted service which facilitates the deployment of software applications without the cost and complexity of acquiring and managing the underlying hardware and software layers to hinder a model designed to facilitate the information society, enabling advanced services by inter-connecting (physical and virtual) things based on, existing and evolving, interoperable information and communication tech- nologies through ennoblement of ubiquitous, convenient, on- demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applica- tions, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction that leverage the need and heterogeneous connectivity issues of the user centric things in well defined fashion". The third cluster is about IoT Platform as connector to supply different services. Zdravković et al. (2016*)* define IoT platform as a software that enables connecting the machines and devices and then acquisition, processing, transformation, organization and storing machine and sensor data. They identify the following categories on IoT platforms:

- Domain-specific platforms are the IoT platforms that focus on specific scenarios like smart irrigation or home automation;
- Technology-specific platforms are the platforms which take into account only specific set of devices;
- M2M connectivity providers offer "connectivity as a service" as a core service, with only a few other features, mostly related to data analytics;
- Full scale generic IoT middlewares provide full range of connectivity services, but they also facilitate the application development, based on data collected by the devices and transformed by analytical tools.

Scully (2016) identifies 4 types of IoT platforms:

- M2M platforms: These platforms focus mainly on the connectivity of connected IoT devices via telecommunication networks but rarely on the processing and enrichment of different sets of sensor data;
- IaaS backends: Infrastructure-as-a-service backends provide hosting space and processing power for applications and services. These backends used to be optimized for desktop and mobile applications but IoT is now also in focus;
- Hardware-specific software platforms: Some companies that sell connected devices have built their own proprietary software backend. These kind of platform differ from the others since are not open to anyone else on the market;
- Consumer/Enterprise software extensions: Existing enterprise software packages and operating systems such as Microsoft Windows 10 are increasingly allowing the integration of IoT devices.

2.5. IoT Platform in manufacturing

The focus of the thesis will be about the impact of IoT in manufacturing. There are different advantages IoT will bring to the manufacture. One of the greatest benefits of the Industrial IoT concerns the power of prediction, it can extraordinarily improve operating efficiencies. The IIoT can also help a manufacturer predict when a machine will likely breakdown or enter a dangerous operating condition before it ever happens (Schmid, 2018). Jaehyeon J., Mi-Seon K., Jae-Hyeon A. (2016: 889*)* state that *"Manufacturers can identify hardware or software problems preemptively and can optimize engineering processes"*.

Predictive analytics to anticipate failures can bring to an important and profitable business scenario called servitisation.

Many traditionally product-centered companies are realizing revenue opportunities offered by developing an ongoing, service-oriented relationship with customers, for example organizing a customer relationship on the basis of a service contract whereby the customer is paying for a negotiated business outcome rather than a piece of equipment (Sam Lucero, 2016).

2.5.1 Servitisation

Producers are developing their strategy to sell bundles of services supporting the physical product. By including IoT devices in their products, manufacturers can collect new data about the product and the use the customer is doing of it. Servitisation is a widespread phenomenon that allows manufacturers to create greater value for customers. Many technologies are utilized for servitisation purpose, the ones identified by Capital Equipment Manufacturing (CEM) experts are:

- Predictive analytics to anticipate failures;
- Communications between smart objects to solve problems remotely;
- Customization of the product/service;
- Technology solutions to improve maintenance techniques.

While the five key drivers from the industrial perspective of the CEMs are:

- Generating new revenue streams;
- Improving maintenance efficiency and effectiveness;
- Improving product performance;
- Increasing data gathering (volume, quality, data types etc.);
- Increasing/improving access to information.

Organisations need to align their products, technologies, operations and supply chain to provide a new service. This takes time and so it is therefore essential to identify the right technologies, and incorporate these early in the service design process, in order to progress towards the provision of more advanced services (Dinges et al., 2015).

The research of Riahi A., Natalizio E., Challal Y., Chtourou Z. (2017) agreed about the improvement of productivity that IoT Platform for smart manufacturing can bring and they highlight the security challenges that this innovation can bring. These challenges concern:

- **Privacy**: In IoT, it is essential to achieve privacy requirements due to the omnipresence of intelligent objects;
- **Trust**: IoT devices may give various information to the users. As Riahi et al., (2017: 122*)* state "*This reflects the necessity of trusting the involved devices to make the right assessment, and highlights the interaction between entities by trusting what*

they report and acting accordingly. Then, establishing and managing trust in a huge number of objects in heterogeneous and large-scaled environments is a considerable challenge for researchers and manufacturers";

- **Identification/access control**: It is necessary to establish connection among entities, using their identifiers;
- **Reliability**: It analyses the possibility of non-failure of the system operation. In IoT, it can be considered as handling addresses for entities, managing data over network and effective use of devices in various applications;
- **Safety**: It concerns the protection of the persons and objects during the execution. The software embedded into objects can be the cause of random errors that could create disastrous consequences;
- **Auto-immunity**: It concerns the remote control of devices. It is fundamental to improve IoT system immunity to avoid that electromagnetic interferences could create problems in the communication;
- **Responsibility**: It concerns the decision that a smart device can take. For example, a smart refrigerator can be able to know which aliment miss and automatically order the product, so if there is a dysfunction, it is important to attribute the responsibility to the right entity in order to take reactions.

As regards the advantages of IoT in Manufacturing, a crucial role is played by Big Data, the process of evaluating a large volume of various datasets to discover patterns, correlations, market trends and other useful information that can help organizations to make more informed decisions (Zhong et al., 2017). Big Data analytics constitute the basis for the modern scope of mass customization, which implies the fulfilling of the needs of individualized customer markets (Tien, 2012). In order to collect all these data, the Wireless Sensor Network (WSN) is utilized, it consists of a large number of wireless capable sensor devices working together to reach the common goal (Yingshu, 2008).

The use of WSN and IoT can overcome existing barriers such as large capital investment, physical and logical connectivity. The benefits of such practices will not only benefits manufacturers with a reduced cost and ensured quality from the economic perspective, but also a reduction in energy consumption and the associated environmental impact (Wen and Sami, 2017).

Big Data exploitation in manufacturing can decrease product development and assembly costs by up to 50% and can cause a 7% reduction in working capital (McKinsey Report, 2011).

Big data, analytics and sharing data and inside along the value chain can improve the performance of lean and world class production, e.g. reducing the impact of bullwhip effect. Integrating both the spheres of lean manufacturing and Industry 4.0 is an important research field to be extensively explored.

2.5.2 Lean and World Class Manufacturing

Lean Manufacturing was introduced by Womack et al., (1990) to describe the Toyota Production System (TPS), the approach developed by Toyota in order to organize better manufacturing and logistic reducing waste.

Lean manufacturing can be described as a production method comprising a variety of industrial practices. The central thrust of lean manufacturing is to create a streamlined flow of processes to create the finished products at the required pace of customers with little or no waste (Shah and Ward, 2003). In the work of Shah and Ward, ten factors of lean manufacturing are identified. Internet of things can be the key to improve these factors of the lean manufacturing:

- *Supplier feedback:* Critics and performances of products and services received from customers must be periodically communicated back to suppliers, for effective transfer of information. Internet of things provides the necessary tools to achieve immediate and automatic feedback to suppliers, to overcome bureaucracies and inadequate communication channels;
- *Just-in-time (JIT) delivery by suppliers*: Only required quantity of products to be delivered by suppliers at the specified time when customers require them. IoT is equipped with different integrated devices for communication, which manage information about goods transported. Every item already stored with a delivery note, would be tracked wirelessly about its origin, destination as well as the current status. Tagging every item ensures sending of right products to the correct destinations and reduction of lead times of distribution. This ensures not only timely delivery of the items, but also optimisation of the travel routes and reliability in logistics. A supplier is empowered to comment when exactly his goods would reach the customer,

thereby enhancing credibility and adding value to customers (Bose and Pal, 2005; Caballero-Gil et al., 2013);

- *Supplier development:* Suppliers to be developed along with the manufacturer, to avoid inconsistency or mismatch in competence levels (Tepeš et al., 2015). Technological networks are established between different cooperating partners. These networks assist in the sharing of intangible assets such as research and knowledge in the form of data and information, as well as tangible resources such as machines, equipment and human experts. These resources are part of different organisations but act towards achieving a common goal. Such virtual organisations benefit the supplier firms in different aspects with not just the business model of outsourcing, but more synergetic cooperation from product development until production and sales. In this environment, the emphasis is heavy on information management for development of suppliers and to become on par with manufacturer;
- *Customer involvement:* Customers are the prime drivers of a business, their needs and expectations should be given high priority (Cannata et al., 2008). Through intelligent systems in manufacturing, the start of freeze period, i.e. the period at which manufacturing parameters are frozen and cannot be changed, can be elongated until the point where unchangeable parameters are incorporated into the product. This is achieved quite effortlessly by the integration of different systems such as manufacturing execution system, B2C applications, etc. This provides a system for customers to be kept informed about the actual production stage and expected completion of the order;
- *Pull production:* An initiation of need from the successor through kanban should enable the flow of production from the predecessor, signified as JIT production.
  Kanban is one of the best methods of implementing pull production, in which a successive station generates kanban cards to initiate operation for a particular station. By using information and communication technologies, an e-kanban system recognises missing and empty bins automatically via sensors and triggers replenishment. The charging level of the bin also can be monitored and data can be transmitted wirelessly to an inventory control system in real time. As long as real inventory and value in manufacturing execution system matches, faults in production control can be avoided due to lost kanban (Kolberg and Zühlke, 2015);

- *Continuous flow:* A streamlined flow of products without large halts should be established across the factory. Industry 4.0-solutions employing RFID technology help to eliminate errors associated with inventory by real-time exact tracking of inventory. An error-free inventory status aids maintaining a low inventory level and timely ordering of goods (Raki, 2014);
- *Setup time reduction:* Time required to adapt resources for variations in products should be maintained as least as possible (Brettel et al., 2014). With Industry 4.0-technologies, plug and play and distributed systems are equipped with self-optimising and machine learning behaviour, which enable firms to adapt machines according to products and produce small batch sizes. The operations to be performed on a part are initially loaded into the part through RFID tags. As the part reaches its respective machine, it directly communicates with the machine through RFID receivers. This results in quicker changeover of machine parameters according to the instructions read from the part;
- *Total productive/preventive maintenance:* Failure of machines and equipment should be avoided by effective periodical maintenance procedures. In case of failure low rectification time is to be maintained (Lee, Kao, Yang, 2014). With more advanced analytics and big data environment, machines are equipped to be self-aware and self-maintained. Such machines assess their own health and degradation and utilise data from other machines to avoid potential maintenance issues. The ability to anticipate potential breakdown and identify root cause needs to be developed in the control systems;
- *Statistical process control:* Quality of products is of prime importance, no defect should get percolated from a process to a subsequent one. In the scenario of Industry 4.0, smart products come with details about the operations to be done on them. The sequence of operations to be performed on a product is already loaded onto the carrier of that product. This information is already passed on to the machine for automated operations, and shown with better visualisation interfaces for manual operations. Improved man-machine interfaces also present information in a more appealing manner, and avoid possibility of making mistakes in the production processes (Schuh et al., 2015);
- *Employee involvement:* With adequate motivation and entitlement, employees are to be empowered for an overall contribution towards the firm. In the work environment

of Industry 4.0, production workers provide immediate feedback of production conditions via real time data through their own smart phones and tablets. Everyone is equipped with a smart handheld device, which is integrated with the company's network. This presents an extremely comfortable environment for employees to record their concerns and feedback right at the workplace (Schuh et al., 2015).

From this analysis it has been highlighted a positive correlation between lean manufacturing and Internet of Things. By implementing Industry 4.0, besides the stated benefits of making the factory smart, financial benefits would be realised as well due to the reduction or elimination of redundant wastes (Sandres et al., 2016).

2.5.3 Digital Platforms for Manufacturing

Suppliers such as GE (Predix) or Siemens (MindSphere) are opening themselves to new business models that are quite close to those of Web giants such as Google or Facebook, strongly based on Big Data and Analytics.

Digital manufacturing platforms offer different services to support manufacturing. These services are associated to collecting, storing, processing and delivering data. Various activities can be performed through digital manufacturing platforms such as:

- Engineering of manufacturing;
- Monitoring of manufacturing processes;
- Data analytics through advanced automatic and human data science technics/technologies;
- Manufacturing control involving an interaction among different agents, including machine-to-machine communication and the introduction of self-learning capabilities;
- Simulation of manufacturing processes;
- Assistance to factory workers and engineers, including augmented reality;
- Planning of manufacturing, predictive and automated maintenance, etc.;
- Digital Integration of value chains (e.g. order-centered production);
- Interoperability of multi-sided loosely coupled processes and flexible production systems.

Cloud plays an essential role in digital platforms since it allows to gather the data that could be analysed from the platform and used for different purpose, such as predictive maintenance or customization of the products. Digital platforms are characterized by a multi-sided ecosystem of service providers, platform providers and manufacturing companies. The platforms focus on a open-source provision of the digital services through appropriate marketplaces. Three main roles can be distinguished:

- Community role: in digital platforms the third-party producers create value and they are a key source of value for the platform itself;
- Infrastructure role: the platforms allow users and partners to build applications and create value on top of this infrastructure. This brings to positive network externalities because more developers working on the platform create more applications; more applications make the platform's offering more valuable, and results into more customers using the platform; more customers using the platform attracts more developers;
- Data role: the data gathered from the devices are a big source of value for the platform, since they are useful to different purposes from the manufacture firms.

CHAPTER 3. CONCEPTUAL FRAMEWORK

The term "Business Model" has spread in the last years becoming popular, but in the academic literature there are different definitions. In this paragraph, it will be analysed the different definition of business model in order to understand what is and how it can be important for IoT platforms.

A business model is a process that convert innovation into value (Chesbrough and Rosenbloom, 2002), it is a statement of how a firm will make money and sustain its profit stream over time (Stewart and Zhao, 2000).

Baker, Addams and Davis (1993) stated that the business model is the written detailed document of the firm's strategic planning. Osterwalder and Pigneur (2010) state that most studies fail to clearly distinguish business model from organizational constructs such as strategy.

Business models can be linked to resource acquisition and allocation (Garnsey et al., 2008), following the Resource-Based view (RBV) theory. The resource-based view approach is a managerial framework used to determine the strategic resources that a firm can use in order to gain competitive advantage. RBV explains that firms are different because they possess heterogeneous resources meaning that firms can have different strategies because they have different resources. The RBV focuses managerial attention on the firm's internal resources in an effort to identify those assets, capabilities and competencies with the potential to deliver competitive advantages, in particular the resources able to do that are the VRIN one: Valuable, Rare, Inimitable and Not Substitutable (Barney, 1991).

Hamel (1999) suggests that firms must acquire resources concomitantly to the implementation of new business models.

Eden and Ackermann (2000) define the business model as the dynamic capability that links the firm's distinctive competencies to organizational aspirations and outcomes.

Despite these differences about the definitions of business model, it appears that the most researchers link business model with three main topics, such as value, strategy and resources.

Many authors assert that the business model of a company can be divided into different components (Osterwalder and Pigneur, 2010). The most popular business model framework divided into different components is the Business Model Canvas, introduced by Alexander Osterwalder and Yves Pigneur.

According to the Canvas approach, depicted in the figure 6, the business model is divided into 9 building blocks that show the logic of how a company can make money. The 9 building blocks concern the 4 main area of business:

- Customer;
- Offer;
- Infrastructure;
- Financial viability.

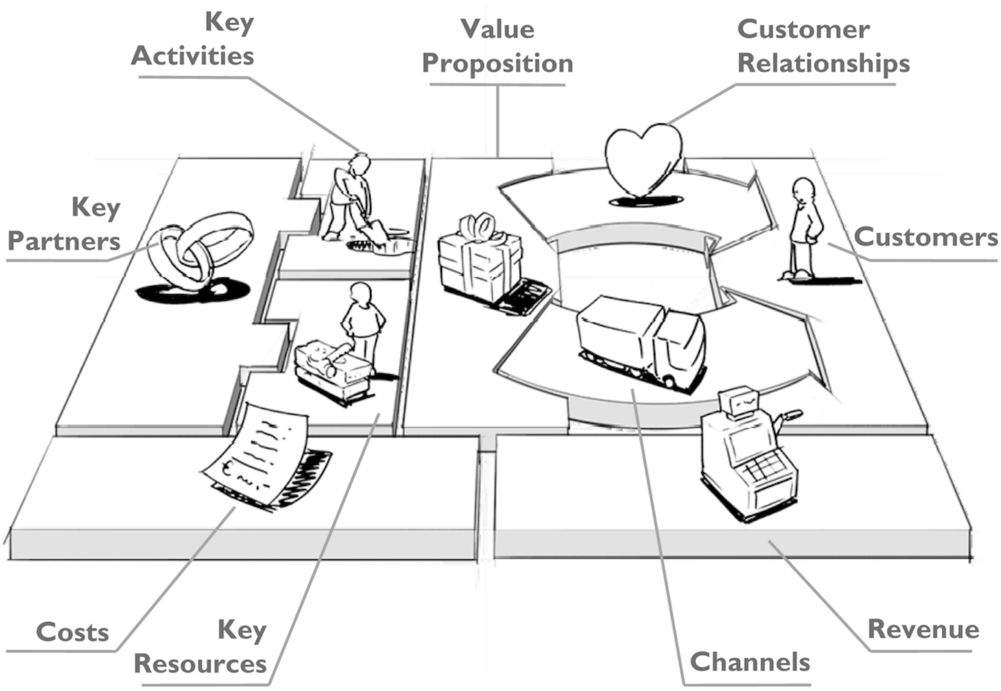

Figure 6 – Business Model Canvas (Osterwalder, 2010)

The business model Canvas has the following nine blocks:

1. Customer Segment: it identifies for whom the organisation is creating value and who are the most important customers;
2. Value Proposition: it explains what value the company delivers to the customer, which one of the customer's problems the company is helping to solve, what bundles of products and services the company is offering to the customer segment and which customers needs the company is satisfying;

3. Channels: it describes through which channels the Customer Segments want to be reached, how the company is reaching them, how the Channels are integrated, which ones work best and which ones are most-cost efficient;
4. Customer Relationships: it clarifies the kind of relationships the customers expect to establish or maintain, which one has been established, how costly it is and how are they integrated with the rest of the business model;
5. Revenue Streams: it determines for what value the customers are willing to pay, for what they currently pay and how much each revenue stream contribute to the overall revenue;
6. Key Resource: it analyses what kind of resources the value proposition requires, what kind of resources the distribution channels requires and what kind of resource the custmer relationship requires;
7. Key Activities: it defines what kind of key activities the value proposition requires, what kind of key activities the distribution channels requires, what kind of key activities customer relationship requires;
8. Key Partnership: it illustrates what are the key partners and who are the key suppliers;
9. Cost Structure: it shows what are the most important costs inherent in the business model.

The nine blocks are linked explaining together the general business of the company, for example, the components about the key resources are the resources necessary in order to create the value proposition.

CHAPTER 4. APPLICATION OF THE BUSINESS MODEL CANVAS TO IOT PLATFORMS

In this chapter, an analysis of different business models of IoT platforms through the Business Model Canvas will be carried out. Since the literature review analysis of the previous chapter, about the impact of IoT platform in manufacturing, highlights the existence of three main business scenarios concerning the application of industrial analytics, it has been decided to investigate about the business models of the company operating in these business scenarios in order to give a contribute to the literature. Therefore, in this chapter, it will be performed an analysis of four companies operating in the field of Servitisation, one company operating in the field of Lean and World Class Manufacturing and eight companies operating in the field of Digital platforms for Manufacturing.

4.1 Servitisation

For the field of Servitisation it will be analysed Rolls Royce Total Care, leader in the industry of Aviation, FitBit, leader in the wereables, Nest, leader in the smart home industry and Tesla, leader in the automotive industry.

4.1.1. Rolls Royce Total Care

Rolls Royce is one of the main examples of Servitisation in Industrial Internet of Things (IIoT). IIoT is a concept based on the same principles as the IoT, but for the connection of proper machineries. IIoT is primarily communication between machines (M2M) and autonomous action based on the information exchanged each other. IIoT allows the network system of the company to work with other systems to provide information, e.g. about any problems on the state of the equipment and so on.

Rolls Royce exploited the opportunity coming from IoT to increase the performance of its products, from jet engines and helicopter blades to power generation systems and marine turbines (Smith, 2013).
Using IoT technology it is possible to gather, store and process data quickly to minimize manufacturing and supply chain inefficiencies, while real time data analysis allows Rolls Royce to offer consultancy services that provide corporate insights that were previously impossible (Choudhury and Mortleman, 2018).
Business model of Rolls Royce has been analysed through the canvas showed in the figure 7.
Rolls Royce, selling the product to the aviation companies, sells the service as well and the main revenue of Rolls Royce comes from the service itself since the maintenance is very important in this kind of business. The premium service sold by Rolls Royce is called Total Care. Rolls Royce, through this service, assures maintenance based upon predictability and reliability. The myriads of sensors in each Rolls Royce engine track everything from fuel flow, pressure and temperature to the aircraft's altitude, speed and the air temperature, with data instantly feedback to operational centers. Hence, the company's data center, not being used to this kind of specific resource based knowledge, is asked to control data from 4,500 in-service engines at a time. All these data need to be gathered, analysed and they generate high value for the customers because it reduces the need to manufacture new parts and speed up the time it takes to repair an engine. At the same time Rolls Royce benefits from it, either in terms of service supplied or improving the service and improving the engines that they produce. For this reason the data are considered a key resource of Rolls Royce Total Care and the data analytics a key activity (Samuels, 2018).
In the Customer relationship block it is possible to observe a co-creation value process since both parties enjoy from the analysed data. It allows bigger returns on optimization, maximization of value and cost reduction, that are key elements of the value proposition of Rolls Royce Total Care.
Furthermore, thanks to the accurate maintenance, the life cycle of an engine increases and keeping engines flying for longer means a lower demand for new products. The biggest and main innovation in the value proposition of Total Care is the fact that it aligns the objectives of clients and supplier because the clients can utilize the engine for longer time and the supplier can increase the profit through the maintenance.

A key strategy of Rolls Royce concerns the high switching cost that the customers have if they want to move to another supplier, since the engine produced by Rolls Royce is very costly to ask maintenance to another supplier; so, in this way the long term assistance is protected.
The main driving factors are related to costs and performances, in which engines efficiencies play the critical role to customer’s operations and their complexity and safety-critical nature makes maintenance and repair costly and time consuming. Whether an engine becomes unusable or out-of-service it can have a significant impact in terms of disruption to flights, resulting in loss, decreasing revenue and reputational damage for business customers.
Another great success is the revolutionary idea to opt for a usage-based pricing model in the market of airplane engines. In fact, Total Care is charged on a fixed rate per flying hour basis, so a monetizing way to reward both parties for engines that performs well. This rewards reliability, an extremely valued factor for customers of these kind of heavy assets.
The Rolls Royce IoT implementation is a disruptive business model, it is extraordinarily succesful and it changed totally the way in which a very costly product, like an engine, is sold.

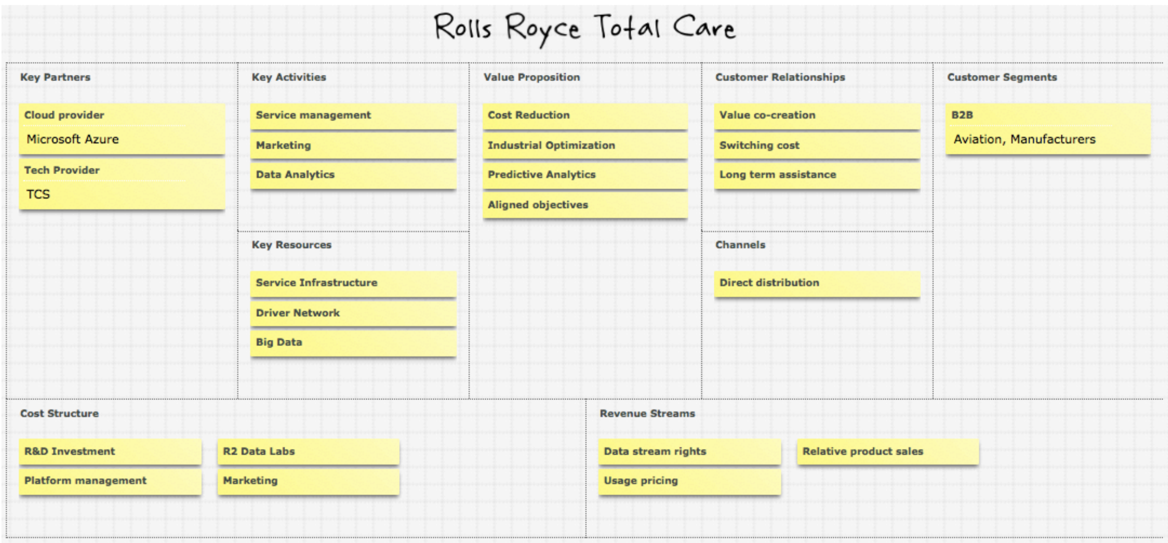

Figure 7 - Rolls Royce Canvas (developed by the author)

4.1.2. FitBit

FitBit is a very interesting example of IoT Applications in the sector of healtcare. Fitbit is a physical activity tracker created to help the people to live better, becoming more active, eating a more well-rounded diet and sleeping better. Fitbit was introduced in 2008 by Eric Friedman and James Park in San Francisco.

In the figure 8 it is shown the business model canvas of Fitbit. The value proposition of Fitbit is the possibility to improve the life of the customers using the latest technologies on healthcare sector. The devices are easy to use and satisfy all the needs of a customer interested in healthy lifestyle. Fitbit has been a disruption in the market and the success of Fitbit is due to two main factors, as follows: the increasing number of people interested in the analysis of their own health data and the rising of obesity (Taal and Jalakas, 2016).

The customer segments of FitBit include health-conscious and active individuals belonging to every age-group. Moreover, companies who take care about the customers' health belong to the customer segments of FitBit. The wide range of customers affiliated with the smart trackers has allowed to build an actual community, the latter has become an integrated part of the offer since users are able to communicate with other FitBit users through the community where customers can exchange advices, solutions and opinions regarding the various aspects of the devices/services. There is a co-creation of services because third-party developers can create health and fitness apps that interact with their platform and this helps Fitbit to grow. About the key channels, FitBit sells the product mostly through e-commerce, even if FitBit has contracts with retail stores. In order to reach the customers FitBit uses the app store, where it is possible to download the application and see all the analysis the customers need, and the social media, mainly used to advertise the product (Porter and Heppelmann, 2014).

In order to supply the service to the customers, Fitbit performs some key activities. It updates often the platform that needs to analyse the data, deliver useful charts and build the community where the consumers can interact. The R&D is also a key activity of FitBit since the company knows that in order to maintain the advantage from the competitors has to innovate the product and deliver always the latest technologies to the customers. The innovation comes from the engineers of Fitbit, that are a key resource.

FitBit creates successful health plans such as Anthem and Humana, thanks to the collaboration with some companies as Staywell and Virgin Pulse. Partners of Fitbit are also the retailers where it is possible to buy the wereables. The research faculties collaborated with FitBit in order to study how the device can improve the life of the people.

Considering the cost structure, the main cost of FitBit concerns the product costs, including cost of manufacturing, production, shipping and handling costs, warranty replacement costs, packaging, warehousing cost and employees cost. Other important costs are related to the R&D investments and to the advertising.

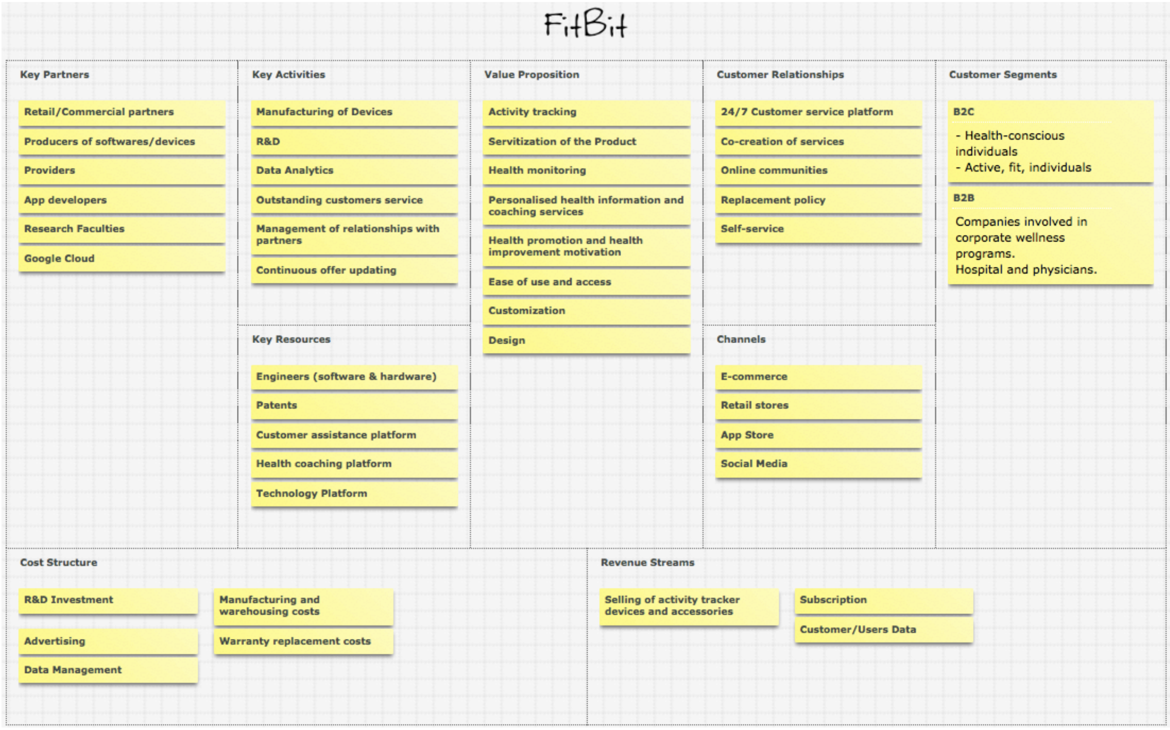

Figure 8 - FitBit canvas (developed by the author)

4.1.3. Nest

Nest is one of the main example of IoT application in the field of Smart Home. Nest was founded in 2010 by two former Apple engineers, Tony Fadell and Matt Rogers.

Nest technologies enable intelligent control of its devices in order to create a smart home ecosystem and to make home comfortable (Zdravković et al., 2016). The thermostat is the core business for Nest, thanks to the IoT technology, it can learn automatically from the user's behaviour and optimize heating and cooling of homes based on a machine learning algorithm. It helps to save money through efficient use and integrate home safety and security features (Turber and Smiela, 2014). The customers are both in B2C and B2B, the companies using Nest are mostly energy providers or governments interested in reducing energy costs and increasing efficiency or insurance companies. The individuals are customers seeking for smart home solutions.

As it is shown in the figure 9, the customers are assisted through an online installation support. It is possible to buy the product in the retailers or online. The customers are also reached through the social media in order to advertise the product.

Nest is now making important steps to move from providing smart products itself to become a facilitator of smart homes. Creating the platform Works with Nest, they formulated a program that allows third party devices to communicate with Nest products. The data gathered from the users are a key resource for Nest because they allow Nest to improve the service (Tai et al., 2018).

The key activities concern the software development, the maintenance and the management of the partnership with smart home device producers. The main partnerships are done with insurance providers to help customers to get discount on their home insurance and with energy providers.

The costs concern mainly the production of the devices and the management of the data. The revenue comes from the sales of the product and the additional services. The company is moving from being just a manufacturer to become an actual service provider. In fact, in addition to selling devices, Nest benefits from the signing up for subscriptions for additional services like Nest Aware, which is a paid subscription that enhances the performance of Nest Cam with additional features and services.

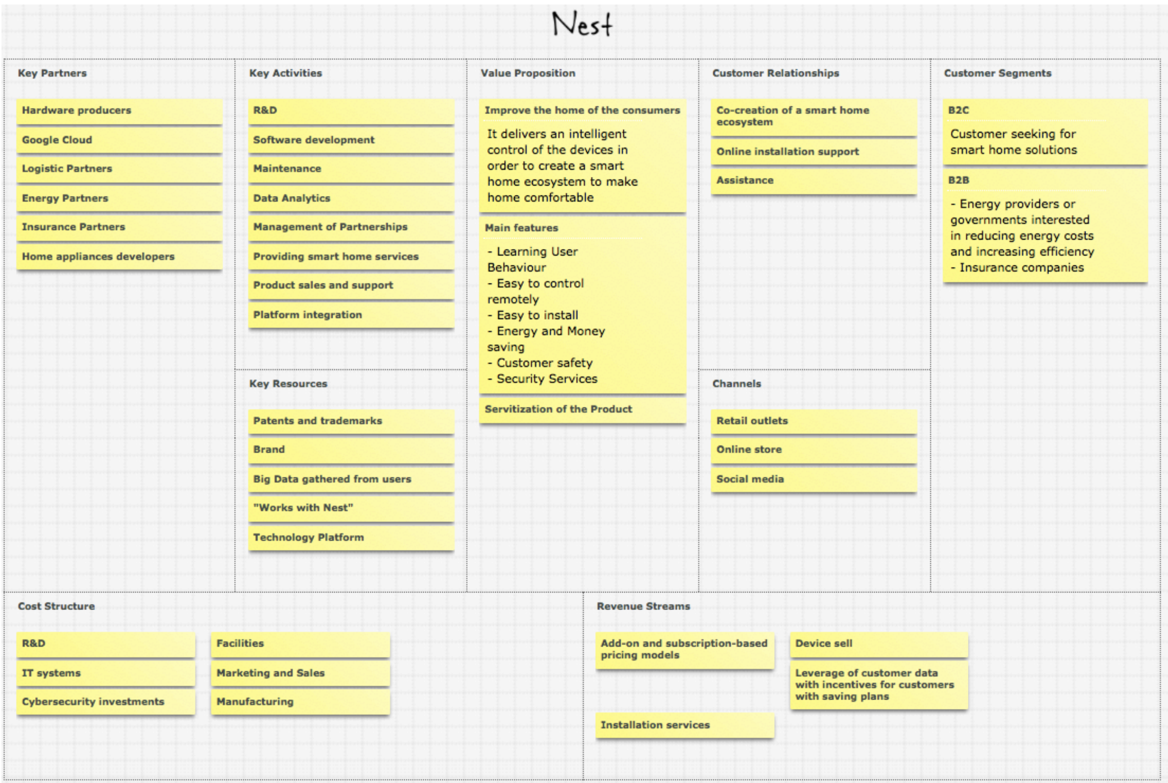

Figure 9 – Nest Canvas (developed by the author)

4.1.4. Tesla

The main example of IoT Application in the automotive sector is, doubtless, Tesla Motor. Tesla changed totally the way a car is thought, the car is no longer a mere means of transport but it is an experience that can change continually offering, day by day, new features. The Tesla's car are connected with IoT technology allowing to deliver a wide series of benefits to the consumers. Tesla's cars have an internal monitoring system that checks in real time the conditions of the vehicle. When the monitoring systems detects that a Tesla vehicle is due for repairs, the car either autonomously calls for a remote repair via software or sends a notification to the customer with an invitation to request that a Tesla employee delivers it to the Tesla facility. Through the smartphone application the consumers can control some functions such as charging, air conditioning. Periodically the firm transmits software upgrades to the car, in this way the customer feels, after every update, to have a "new" product. Therefore, the customers do not buy only the product anymore, they buy the service associated to the product. In order to maintain the high quality Tesla has chosen a highly integrated approach for its business: from manufacturing, where the company operates as an original equipment manufacturer, to commercializing its products, by selling its cars directly to consumers rather than through a traditional dealer network (Porter and Heppelmann, 2014).

The customer segments (vide figure 10) are represented, mainly, by individuals looking for high performance electric car or eco-friendly professionals and owners of smart home appliances thanks to the partnership with EVE platform that connect the car with more than 300 products.

The Key partners are the suppliers such as AGC automotive and fisher dynamics, and also local governments, needed to incentivize the use of electric car, and the IoT platform providers.

The Key activities concern the manufacture, the management of the charge stations, the design, the software development of the applications and the IoT sensors. The After-sale service is also a key activity.

The revenue comes not only from the direct sale but also from the premium subscription that the customers can choose in order to have additional features about the maintenance and upgrade of the car using the IoT sensors.

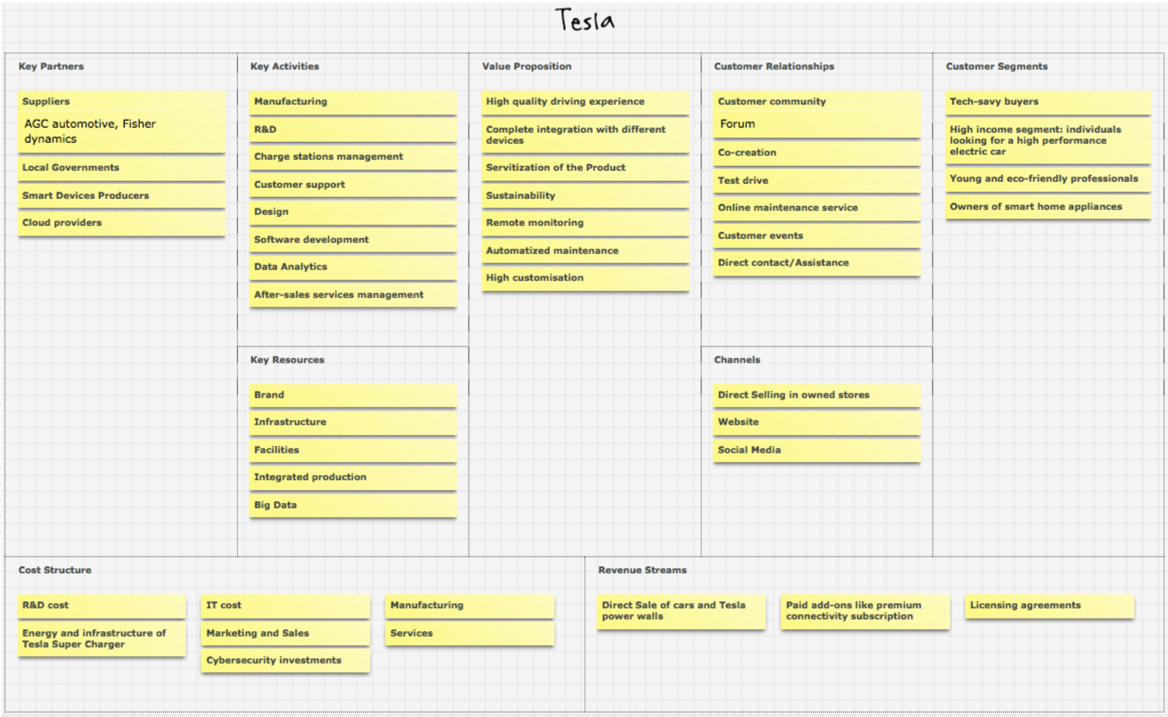

Figure 10 – Tesla Canvas (developed by the author)

4.2. Lean and World Class Manufacturing

For the field of Lean and World Class Manufacturing it will be analysed the example of Bosch IoT Suite.

4.2.1 Bosch IoT Suite

Bosch IoT Suite is an open IoT Platform that help companies to create, implement and maintain IoT applications in a fast, easy and secure way.
The value proposition, represented in the business model canvas in the figure 11, that Bosch IoT Suite offers is a Platform as a Service to provide functionality to manage devices, machines and gateway, to provide secure access management, to execute software rollout processes, to connect third-party systems and devices and to analyse data (Bilgeri et al., 2015). The business model is a two-sided platform among companies of different industries such as manufacturing, energy, social, infrastructure and logistic and product manufacturers. It brings to a value co-creation process between the parties since the product manufacturers are incentivised to develop innovative IoT application in order to sell them to the business

customers. The channels are Internet and IoT devices. The key activities performed by Bosch concern all the tasks needed to maintain the platform and the activities of data analysis and after-sale service. Bosch cooperates with some cloud service providers such as Amazon, IBM and SAP, in this way it offers an high scalability to the customers. Bosch make different partnership investing in the R&D department, for example they work with Tesla on autonomous cars and with Amazon to improve the smart-home and Alexa, the personal assistant. The key resources are the Bosch IoT Cloud and all the data that Bosch can gather through the devices. The cost stucture concerns the Platform development and management and it is characterised by a cost saving strategy which improve with the increase of data volumes as knowledge-based economies of scale. Concerning the revenue streams, the price strategy is the “Freemium” one with usage based pricing model, so the platform can be used for free while all the additional services have a different cost.

The Bosch Model is a perfect example of Lean Manufacturing, where the aim is to minimize the waste without reducing the productivity. Bosch, taking as example the Toyota Production System, designed its own Lean Management reference model, the so-called Bosch Production System (BPS) which is applied worldwide in all the Bosch plants. The BPS represents an evolution of the TPS, as they added new concepts concerning safety and environmental protection, without modifying the main aim, the elimination of all source of “waste” in order to reduce cost and maintain quality and delivery time. BPS is also a philosophy, one of the main goal is to increase the involvement of the workers, through the personal responsibility, in this way each Bosch employee knows that with its own competencies can improve the firm performance. Indeed, if the Bosch employees find some problems, they are encouraged to stop and solve them. It brings to a Continuous Improvement Process (CIP) that offers the opportunity to all the firm division to improve the effectiveness. Some tasks performed by Bosch in order to rise the safety inside the plants are theYellow Line, the Lernstatt and the Safety Walk. As Gnoni and Andriulo (2013) explain “the Yellow Line event is an inspection visit carried out by man- agers in each plant unit once a week. The focus is to monitor about process quality and service levels and to define corrective actions if non-compliance data are verified”. General issues are after checked by the Health and Safety (H&S) department. The Lernstatt is a periodic meeting between employees of different divisions. The safety walk is the supervision of the members of the H&S department performed every day inside the plant in order to verify safety level and safe behaviours.

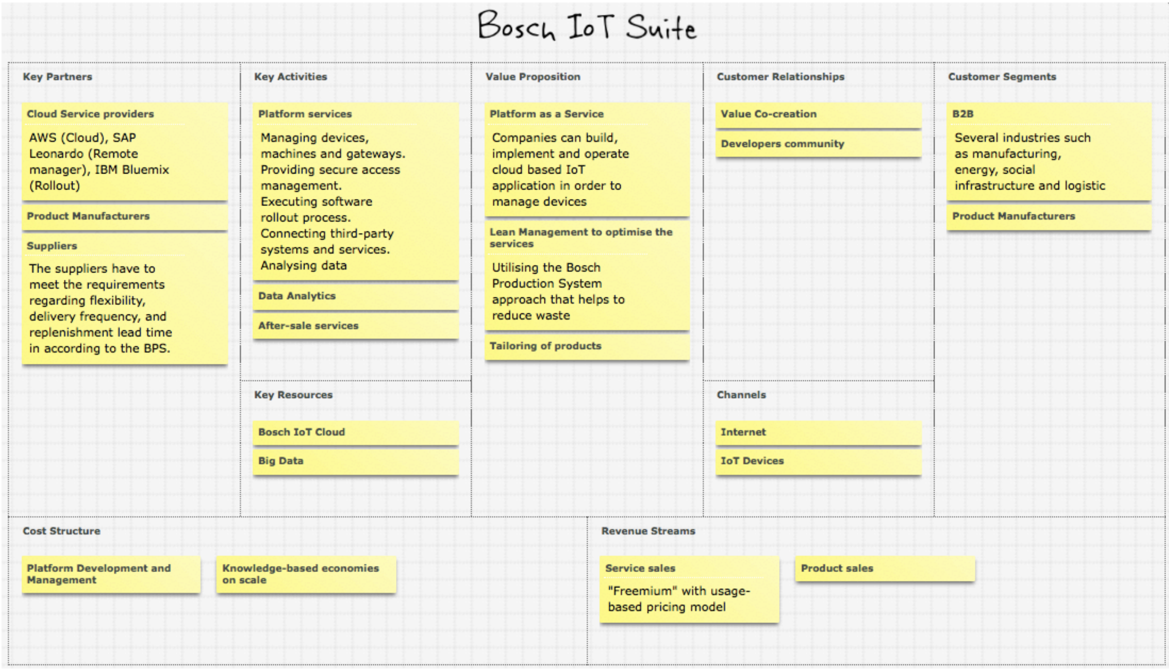

Figure 11 – Bosch Canvas (developed by the author)

4.3. Digital Platforms for Manufacturing

For the field of Digital Platforms for manufacturing it will be analysed Google Cloud Platform, Amazon Web Services, Microsoft Azure Cloud, ThingWorx, Toshiba Spinex, GE Predixe, Siemens Mindsphere and DataV.

4.3.1. Google Cloud Platform

Google Cloud Platform (GCP) is a service supplied by Google that provides different services including computing, data storage, data analytics and machine learning. In the figure 13, it is represented the Google Cloud Platform business model canvas.
The value proposition of GCP, represented in the busines model canvas in the figure 12, is that it can be used either as Platform as a Service or Infrastructure as a Service. It means that developers can code, test and deploy their applications with highly scalable and reliable infrastructure, furthermore it provides a robust computing infrastructure allowing to the users to configure and monitor the systems (Nakhuva and Champaneria, 2015).
The channels used to reach the customers to use the platform are Internet and IoT Devices. GCP builds a customer relationship giving support to the customer, if needed and ensuring the assurance of Google Cloud Security.

In order to supply the value proposition GCP utilizes key resources as: the know-how of the employees, especially the IT ones, and Google Cloud that allows to keep the huge amount of data that the users create inside the Cloud of Google. The key activity is about the maintenance of the platform, computing power and data storage facility. GCP have many key partners as RiptideIO, BigQuery, Firebase, PubSub, Telit Wireless Solutions, Connecting Arduino and Cassandra.

The cost structure concern about the development and management of the platform while the revenue comes from a strategy called "Pay as you use", indeed the customer does not have a fixed fee, he pays only when uses the product.

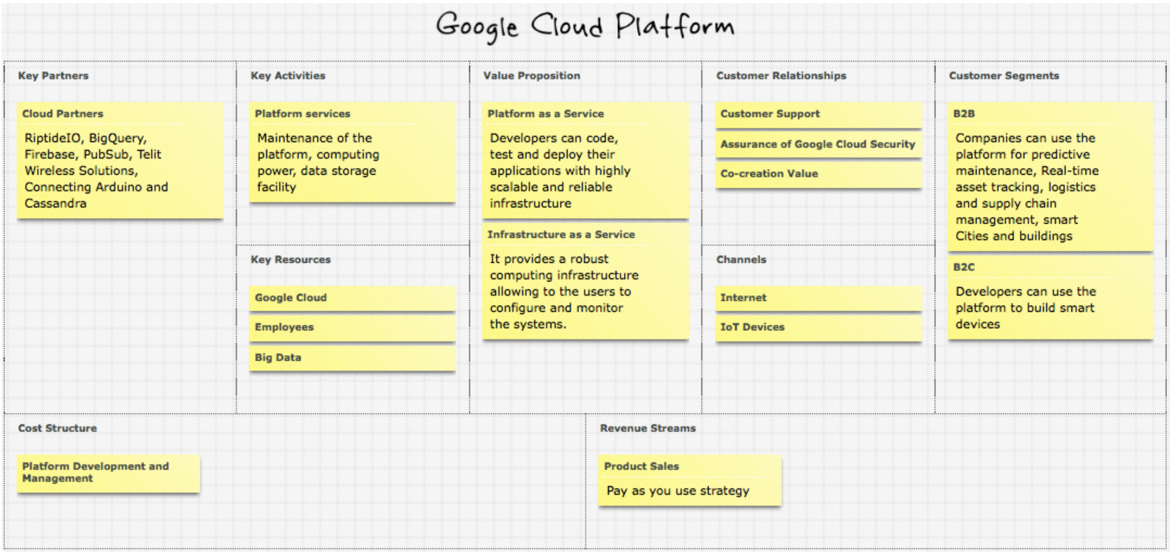

Figure 12 – Google Cloud Platform Canvas (developed by the author)

4.3.2. Amazon Web Service

Amazon Web Services (AWS) is an IoT platform that provides on-demand cloud computing platforms to individuals, companies and governments.

In the figure 13 is represented the Amazon Web Service business model canvas. AWS offers a PaaS solution as an ensemble of services for managing web and data analytics applications (Costache et al., 2017). The value proposition of AWS is about the variety of the services offered and about the security, essential element in this kind of business. The customers of AWS are both individuals and companies because it can be used by developers to code and to create IoT applications and by companies for multiple purposes. AWS offers a service of customers support. The channels used are Internet and the IoT devices. The key partners are mostly the servers, ActiveMq and Mosquitto, and the Cloud owned by Amazon itself using

Amazon Elastic Compute Cloud. The key resources used by Amazon to supply the service are the Cloud and the know-how of the IT employees. The cost concern mostly the platform management and the revenue comes from a strategy called “pay as you go”, but there are different pricing models that the customers can choose like tiered pricing, reserved istances and marketplace.

AWS owns a dominant 34% of all cloud of IaaS and PaaS, this allowed to Amazon to become leader in the market of the Cloud Platform with $25.65 billion of revenue, and notable customers like NASA and Netflix.

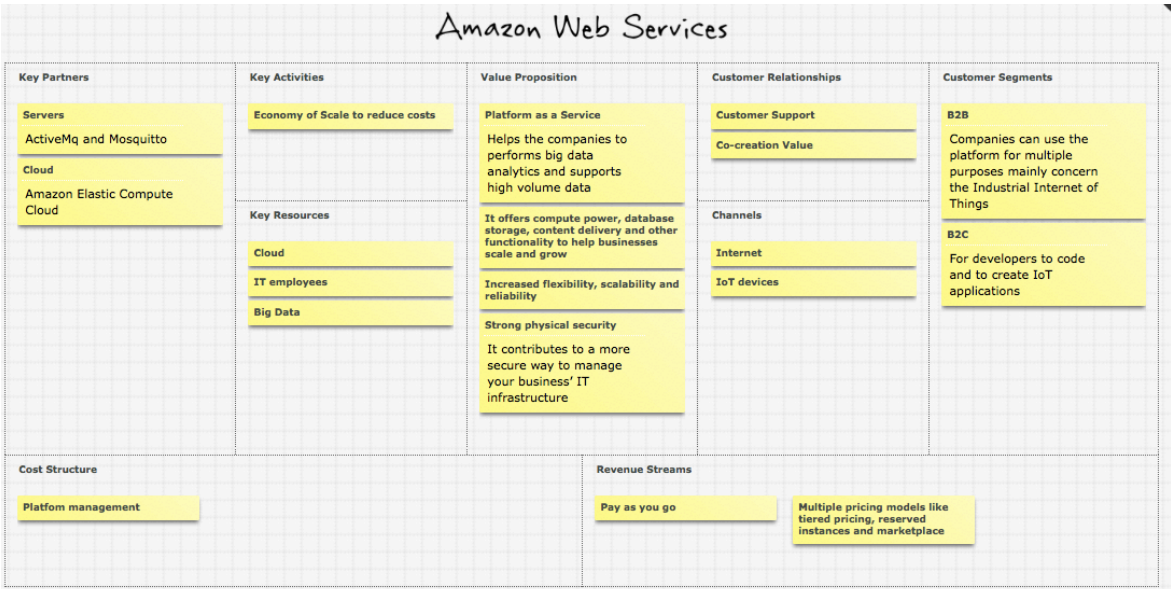

Figure 13 – Amazon Web Services Canvas (developed by the author)

4.3.3. Microsoft Azure Cloud

Microsoft Azure Cloud is a platform, offered by Microsoft, that helps companies for building, testing, deploying, and managing applications (Mineraud et al., 2016).

The value proposition, represented in the figure 14, is about the low cost and the reduction of the complexity. It provides Infrastructure as a Service allowing users to launch virtual machines, like Microsoft Windows or Linux (Michon et al., 2016).

It can be used by companies or individual customers. The channels to reach the customers are Internet and IoT devices. Microsoft Azure provides, in case of necessity, customer support. The key resources are the Cloud and the IT employees that work for the platform maintenance, this is a key activity together to the collection, process and analysis of data. The key partners are all the software needed to supply the service as Power BI, Office 365 and HD insight, Intelligent Systems Service, Microsoft Cloud Compute. The main cost is related to the platform development and management while the revenue comes from a strategy called "Pay-per-use", where the users pay only when uses the service (Costache et al., 2017).

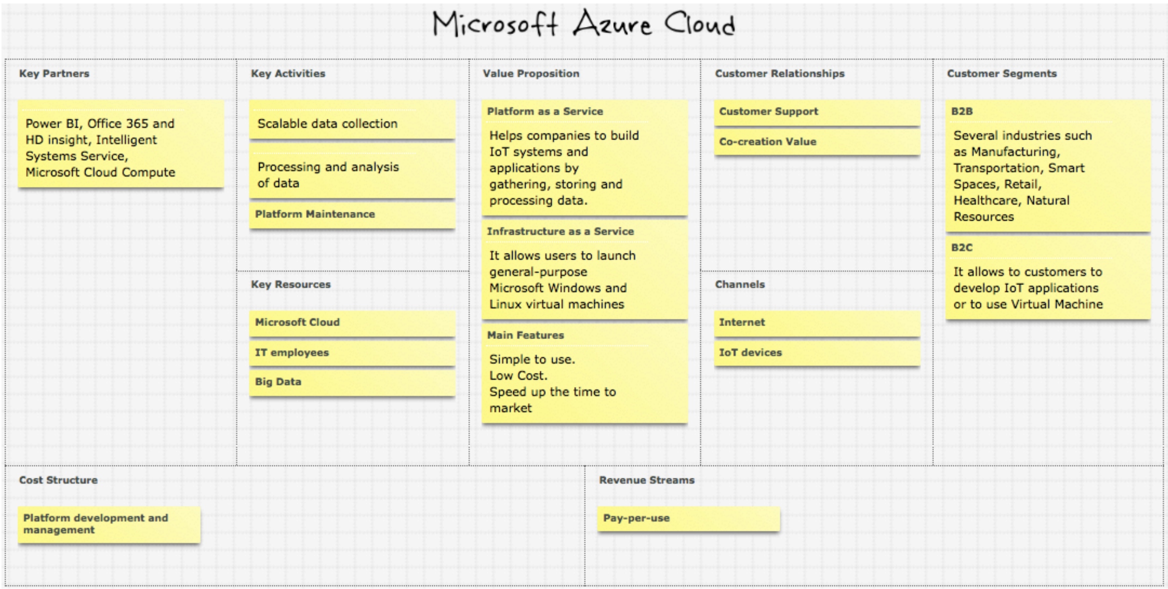

Figure 14 – Microsoft Azure Cloud Canvas (developed by the author)

4.3.4. ThingWorx

Thingworx is a platform, useful for the development of IoT devices.
The business model canvas of Thingworx is represented in the figure 15. The Value Proposition of ThingWorx is about the capability to offer an end-to-end experience to their customers, Thingworx can ensure connectivity to devices, applications and data sources of the company, it can build bettere IoT solutions that maximize the return on investment of the company, it can manage connected devices analysing the huge volume of data produced and create useful insights for the needs of the companies (Köhler et al., 2014).
Thingworx is addressed for the companies in many sectors like Smart Agriculture, Smart Cities, Smart Grid, Smart Water, Smart Buildings and Telematics. The channels used are Internet and IoT devices. It provides customers support for the companies. Thingworx can supply these services with the support of some partners like Oracle, Salesforce, Sap, IBM maximo and Cloud Services as Amazon Web Services Cloud (Nakhuva and Champaneria, 2015).

The key resources concern are IT employees that have to manage all the activities concern the maintenance and updating of the platform and the big data gathered by the platform. The key activity is to offer all these kind of services through the platform. The main costs are related the development and management of the platform. The revenue comes from the Pay as you go strategy which the customers pay only when they use the platform and the extra services that Thingworx offers like Support Service and Implementation Service.

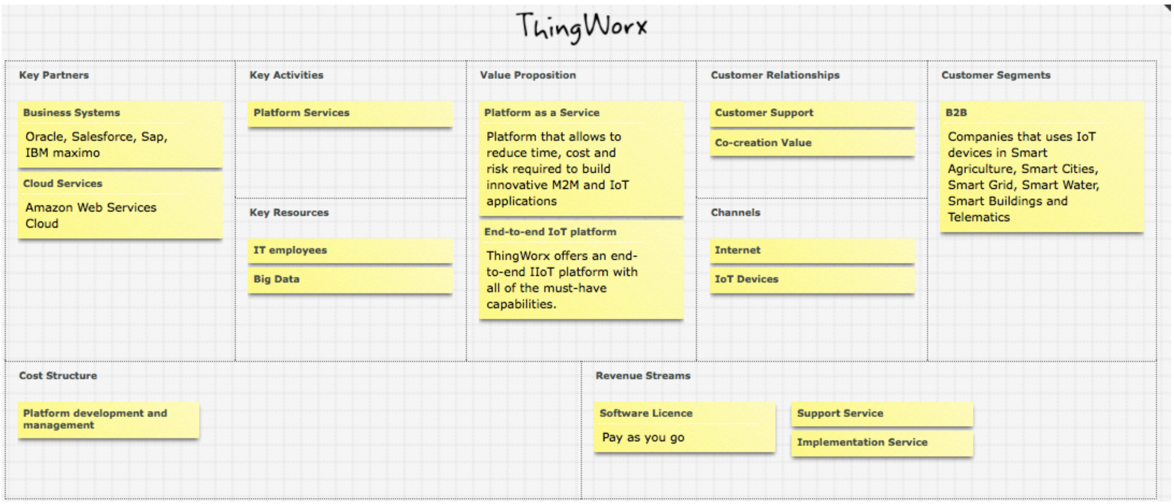

Figure 15 – ThingWorx Canvas (developed by the author)

4.3.5. Toshiba

Toshiba Spinex is an IoT platform that integrates a wide range of technologies that connect the equipment, infrastructures and facilities of a company to maximize the utilization of essential data and analytics by connecting information, business processes and Artificial Intelligence. Toshiba Spinex can accelerate the digital transformation of a company and deliver new insights, delivering business value.

The business model canvas it has been represented in the figure 16. Toshiba spinex is a plaform as a service, which offers services to enable innovation of processes toward optimization and automation. It is a two-side platform that connect business customer represented by companies in several industries such as manufacturing, energy, social, infrastructure and logistic and the product manufacturers that affiliate their products to the platform in order to offer to their customers the features of the platform and its services.

The key activities operated by SPINEX in order to deliver the service to the business customers are three: Edge computing, that performs data processing to improve time-to-action; Digital twin to reproduce operating status of things in real time for emulation and simulation of processes; Media intelligence which integrates speech and image recognition to recognize human interactions. Compared to other IoT platforms, SPINEX enables the IoT to not only connect equipment, devices, and products, but also the intentions and situations of users, dynamically optimizing processes and systems based on these conditions. The channels that Toshiba uses in order to reach the customers are represented by the Internet and IoT connected products (Hotta, 2017).

The key resources of Spinex concern mainly the know-how of Toshiba in the business fields of energy and other social infrastructure, semiconductors and electronic devices, combining this know-how with the IoT technologies help to solve the challenge of digitalization that the customers require. The cost concern the platform management and the revenue comes from the sales of products and services. Finally, in order to gather the many data the key partner are the cloud providers, while there are other partnership inside the area of R&D.

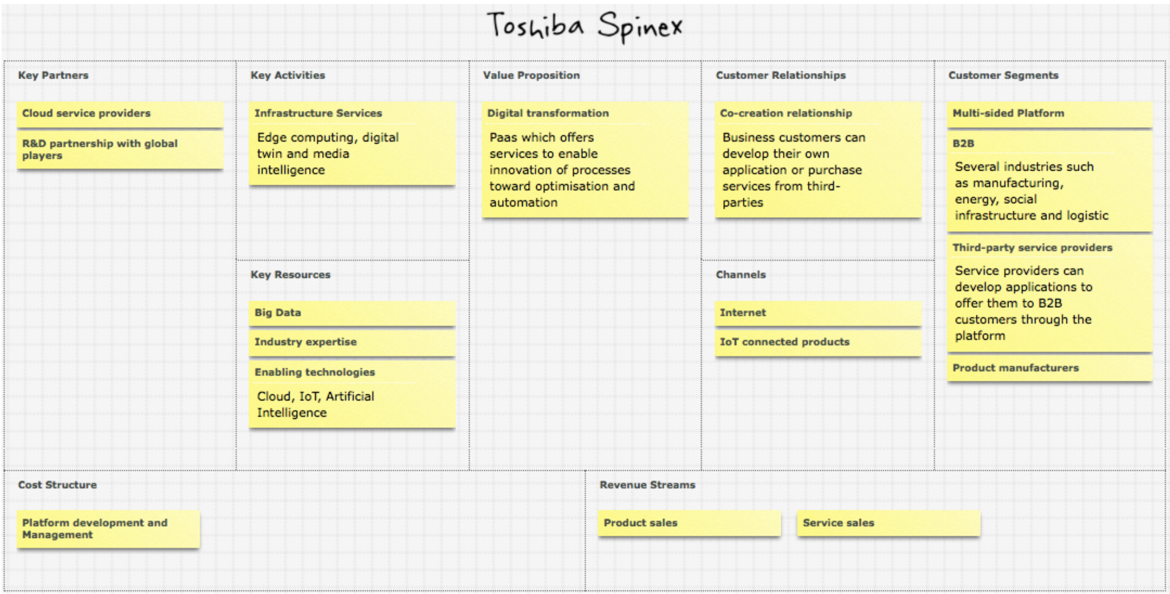

Figure 16 – Toshiba Canvas (developed by the author)

4.3.6. GE Predix

In the figure 17 it is represented the business model canvas of General Electric Predix. It is the software platform of General Electric (GE), it can be used for the collection and analysis of data from industrial machines. Predix is supplied as Platform as a Service to build, run and operate applications in order to help the way industrial companies monitor, manage and optimize their asset (Ju et al., 2016).

The value proposition of Predix is to give to to the customers, in particular the companies that operate in industrial sector the possibility to servitize the products towards digital transformation. Different activities are performed by GE to supply this service, the key activities concern the management of the platform, the data analysis and the after-sales service.

Even in this case the business model operates as multi-sided business model between the two Customer Segments of Third-Party providers and Business Customers, while the third side is represented by Product Manufacturers of assets integrable in the platform thanks to open communication standards. There is a value co-creation process since the customers can customize their service adding value to the platform by developing new applications. Big Data retrieved from devices result to be one of the main key resource. General Electric itself, in particular General Electric Aviation, utilizes data retrived from the engines of the planes to optimize the service. GE Aviation is in a dominant position for maintenance services of its engines, thanks to the performance-based pricing model "Power-by-the hour", which aligns objectives between the company and its customers: as customer pays only when the plane is flying, both GE and its customers want to minimize the amount of downtime for unscheduled maintenance. These aligned incentives stimulate GE to learn more about how to reduce unscheduled maintenance of its engines.

The process for gathering the huge amount of data can be done through the use of Cloud Service provider that are key partners together with the product manufacturers and third-party service providers. The cost concern the platform development and management and the revenue comes from the service sales and the product sales through a pay-per-use strategy.

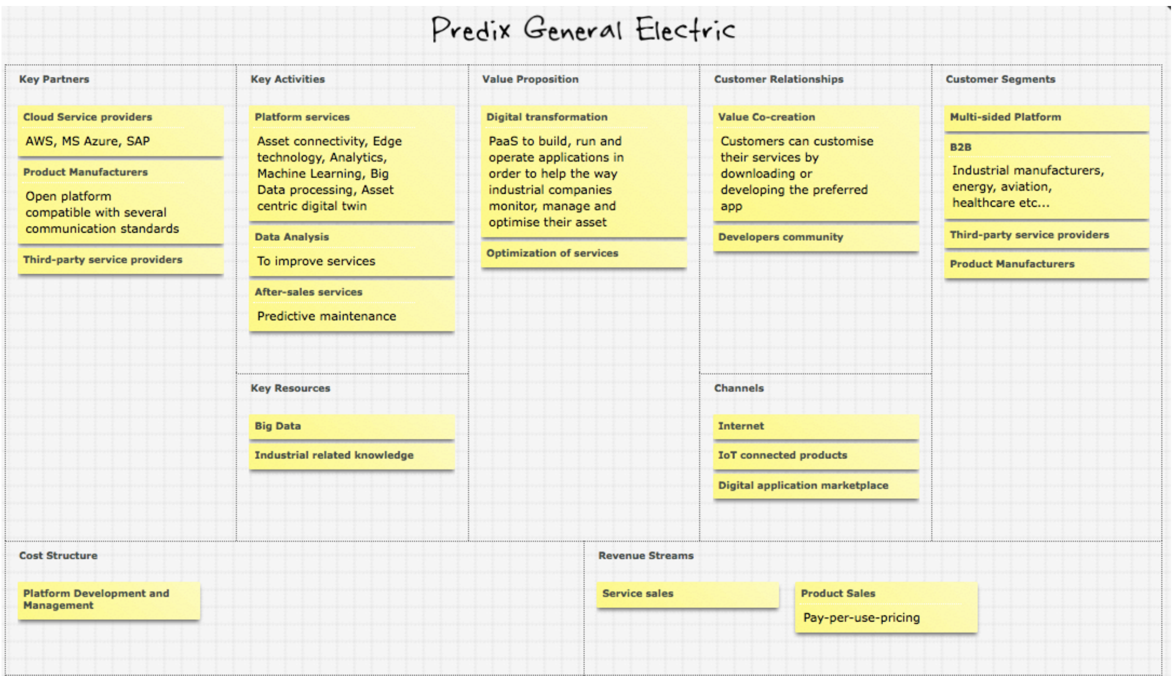

Figure 17 – GE Predix Canvas (developed by the author)

4.3.7. Siemes Mindsphere

In the figure 18 it is represented the Siemens Mindshere business model canvas. MindSphere is the cloud-based, open IoT operating system from Siemens that connects the products to the digital world. It stores operational data allowing the customers to make decision based on the valuable information gathered by the platform. The system is used in applications in the areas of predictive maintenance, energy data management, and resource optimization. The platform of Siemens is offered in the form of a PaaS, that enables customers to develop, run and manage their applications without the complexity of building their own infrastructures or managing complex software stacks.

The Value Proposition of Siemens Mindsphere is about the servitisation of products toward digital transformation, indeed the platform can gather a huge amount of data, using the cloud of the key partners as Amazon Web Service and Microsoft Azure Cloud, and deliver to the customers useful analysis. These analysis bring to the servitisation logic, after products are manufactured and sold, new features and functionality can be pushed to the customer on a regular basis by service providers. Customer behaviour can be tracked, and products can now be connected with other products, leading to new analytics and new services for more effective forecasting, process optimization, and customer service experiences (Report Siemens Mindsphere, 2017).

The pattern of this business model is the multi-sided platform business model, indeed Mindsphere connect three different kind of customer segments. On one side, third-party service providers utilize the platform to develop applications. On other side, the companies can use the platform to boost their productivity and improve their service, they can develop applications by themselves or buy applications from the Third-Party service providers. In this way, the customer relationships is build through the value creation process, the customers developing new applications that better fits the needs of their business increase the value of the platform.

The third side of the platform is represented by Product Manufacturers that are integrable on the platform and utilized by the business customers. Product Manufacturers are core in the IoT ecosystem, since they provide for the acquisition of the platform distribution channels, i.e. connected assets.

The purchase of the applications from the third-party service provides takes place in the digital application marketplace, that together with Internet and IoT devices are the Channels used by Mindsphere to reach the different customers.

The Key Activities of Mindsphere are all the activities involved to manage the Platform as Data processing, security connectivity management. An important activity is Data Analysis that allow Mindsphere to deliver to the customers all the data he needs to servitize the products and optimize the service. Consequently, big data gathered from devices are a Key Resource for the success of the Business Model. Other resource is considered to be the industry-related knowledge.

Key partners are the Product Manufacturers, the Third-party service providers and the, above mentioned, Cloud provider. Customers can run Mindsphere applications on their preferred cloud infrastructure, including Amazon Web Services, Microsoft Azure, SAP Cloud Platform and Atos Canopy. With the cloud managed infrastructure, companies
take affordable advantage of the infinitely scalable computing capacity: the platform can automatically scale to required data volumes and the numbers of connected assets and users. The costs, mainly, concern the platform development and management while the revenue comes from a Pay-per-use pricing applied during the service sales and the product sales.

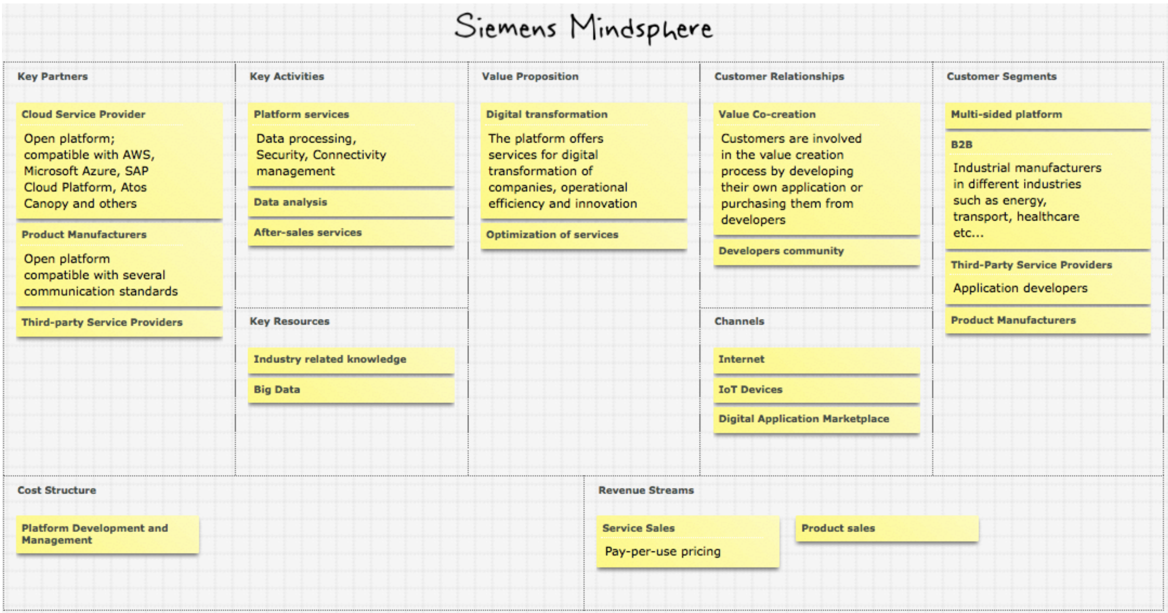

Figure 18 – Siemens Mindsphere Canvas (developed by the author)

4.3.8. DataV

DataV platform is an IoT software solution supplied by Bsquare Corporation, an IoT provider, technology distributor and system integrator. DataV accomplishes different needs of the customers, that are mainly companies of different industries. In the figure 19 it is represented the DataV business model canvas. The Value Proposition of DataV is the offer of an end-to-end experience. According to the study of Schwadererj (2016), it can be supplied through three main services of the platform:

1. **Device IoT Enablement**

   DataV helps the customer to enable the IoT device, connecting all the sensors. Connecting ‘things’ is the obvious first step to undertake, even though it could evident, this first link already provides mole of data as well as intelligence at the device level, which is key for distributing information upstream. The power of the IoT connection resides in the modular flexibility it offers, since the components are architected to be malleably moved between remote cloud environments and on-premises.

2. **Real-time Data**

   DataV offers the possibility to gather real-time data. The collaboration announced between Bsquare and Amazon Web Service is crucial for this need, in order to improve the amount of data gathered using the Cloud of Amazon and to satisfy the increasing demand of Industrial IoT. "By leveraging AWS IoT services, Bsquare's DataV suite can help customers accelerate time-to-value versus customizing solutions in-house," said Joshua Hofmann, Director, AWS Partner Ecosystem, Amazon Web Services, Inc. "We look forward to working with Bsquare to help our customers achieve additional IoT success at a faster pace."

3. **Data Analytics and Prediction**

   DataV delivers augmented analytics and resultant forecasts based on the data gathered by the sensors. It helps to increase the value delivered to the customer, giving succesfull insights based on data information.

The customer relationship is created through a long term dedicated assistance, DataV follow the customers during all the process of digitalization from the enabling of the IoT devices to the data analytics and prediction.

The partner building block is one of the most important for Bsquare, it highlights the effort that the company has put over the years in order to gain such a contradistinctive business advantage on the competitors. Bsquare collaborates with world-class cloud providers, such as Google, Amazon Web Service, Microsoft Azure (MA), Intel and Adobe, allowing the customers to choose the best platform to respond their needs. DataV offers products and systems integration capabilities on these cloud platforms that ease the journey for enterprises contemplating broader adoption of IoT technologies in order to achieve desired business outcomes. These collaborations are the strenght of the platform, they bring to a very customized service.

Since it is very difficult to provide an end-to-end IoT solution on their own, Bsquare collaborates with Solution Providers to combine use case and industry specific expertise.

Another important side not to underrate is for sure the existence of high switching costs related to the service level engagement, when a customer stores all his data in a proprietary format it might be quite harsh for him to switch to a substitute data storage provider. This is fundamental for Bsquare in order to maintain the installed base of consumers.

About the channels, Internet offers a low-cost channel to target a wide consumer base.

Another interesting side worth of attention is the revenue stream. Having rights and ownership to manipulate sensible data allows Bsquare to gain an important and non-indifferent industry related knowledge and asset; which in turn could hopefully come back in handy in exploitation of further economies of scale and scope.

While the main costs concern the R&D investment, the platform management and the security.

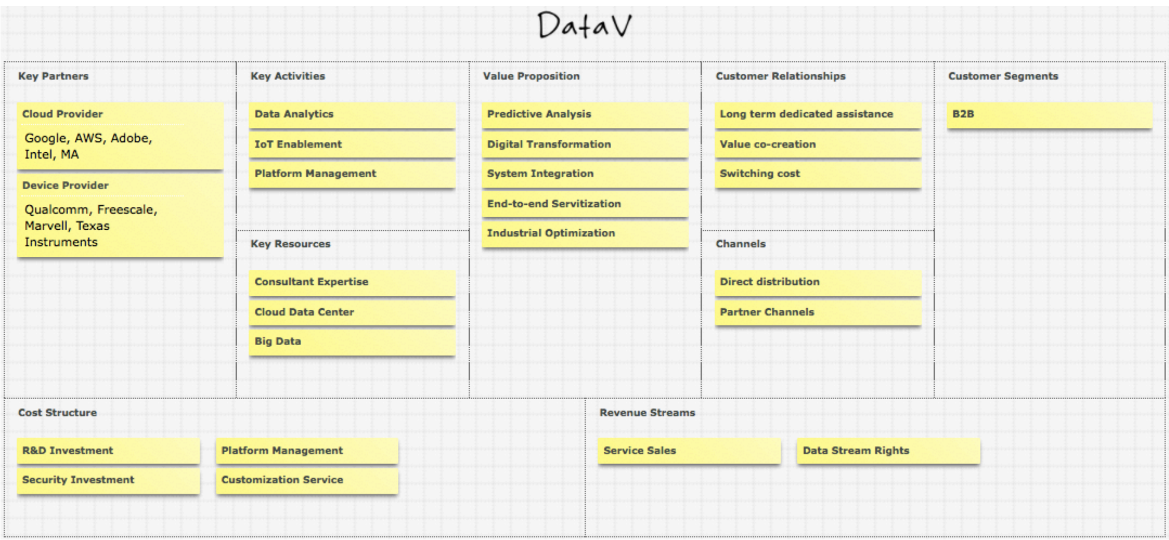

Figure 19 – DataV Canvas (developed by the author)

4.4 IoT Business Models Summary

The analysis of the business models of different IoT Platforms allows to define three different examples of Business Model in the three different fields already analysed.

4.4.1. IoT Servitisation

In the figure 20 it is represented an example of business model canvas for a company operating in the IoT Servitisation.
Servitisation is a process that involves manufacturing firms that are able to provide services and solutions in addition to the traditional product. So, the Value Proposition lies on the selling of the product as a service. It includes the maintenance, the possibility to prevent failures, the possibility to remotely control the product through the application. Servitisation allows the manufacturer to highly customize the product, since each consumer can add different services to their product. The cost reduction is another pillar of the servitisation process, it mainly comes from the maintenance. Using the IoT sensor is much easier to locate the problem of the product and to anticipate big failures, so it allows to reduce costs. The customers interested to the servitisation of the product are companies interested in the data produced by the users and consumers interested in the product and the additional features related with the service added to the product. There is a co-creation value process because the consumers gathering the data improve the services that the company can offer to them and, at the same time, they enjoy the high customization offered by the firm that comes from it. The channels are different, depends on the kind of product sold. The main channels are E-commerce, retail stores and direct sales. An example of e-commerce are the FitBit wereables while Rolls Royce sells through direct sales. The key activities concern the data analytics and the manufacturing and production. The key resource concern the management of big data. The main partners are the cloud providers, without them would be impossible to gather all the data produced by the users, and the app developers. The main costs are related to the manufacturing and warehousing cost, data management cost, R&D investment, helpful to fight the high competition and cybersecurity, useful to maintain the privacy of the consumers. As regard the revenue streams, they come from the direct sell of the product, but mainly from the subscription to join the additional services.

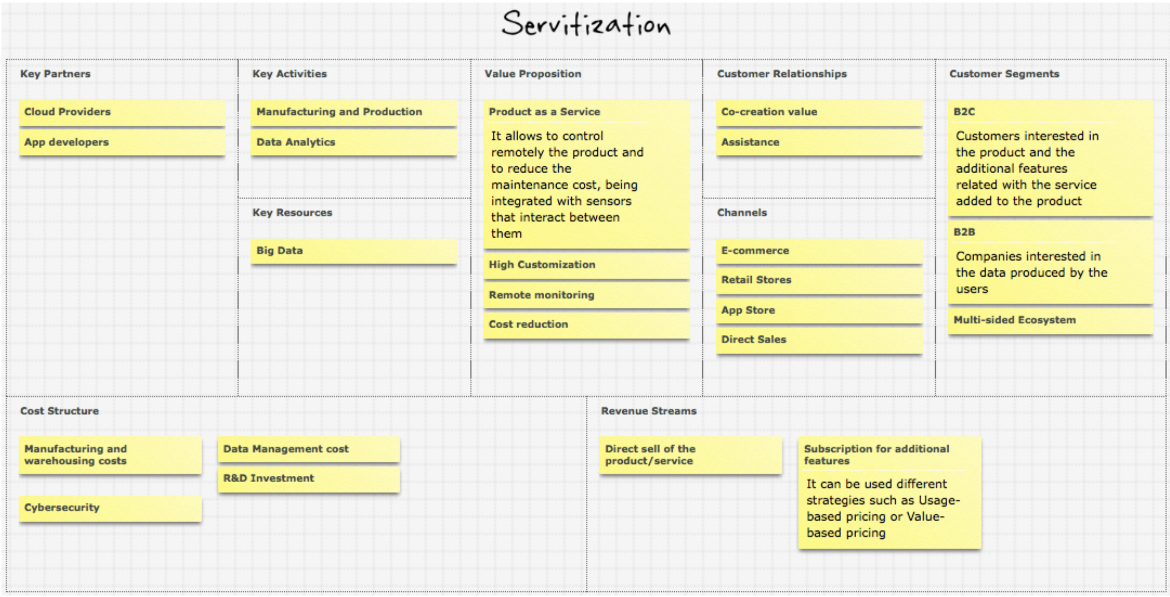

Figure 20 – IoT Servitisation Canvas (developed by the author)

4.4.2. IoT Lean and World Class Manufacture

In the figure 21 it is represented an example of business model canvas for a company operating in the IoT Lean and world class manufacturing. The main objective of the companies operate in the Lean Manufacturing is to reduce all kinds of waste, following the philosophy of Toyota Production System, maintaning high standard of quality and short delivery times. It is offered as Platform as a Service, it helps companies to build IoT systems and applications by gathering, storing and processing data. The customers are companies operate in several industries such as manufacturing, energy, social infrastructure and logistic. Product Manufacturers and developers are also customers, they use the IoT platform in order to create the product or the application and sell it to the companies. There is, even in this case, a value co-creation process between the customers and the company proprietary of the platform. The channels to reach the customers are, as usual, Internet and IoT devices. The Big Data gathered from the devices is the key resource. The huge amount of data can be gathered thanks to the Cloud Providers, it is fundamental to create a good relationship with Cloud partner to supply this kind of service. In order to assure the Lean Management, the suppliers have to meet the requirements regarding flexibility, delivery frequency, and replenishment lead time. The key activities concern the data analytics and the platform management, that is the reason of the main cost of the IoT platform. While the revenue comes from the sells of the product and the service.

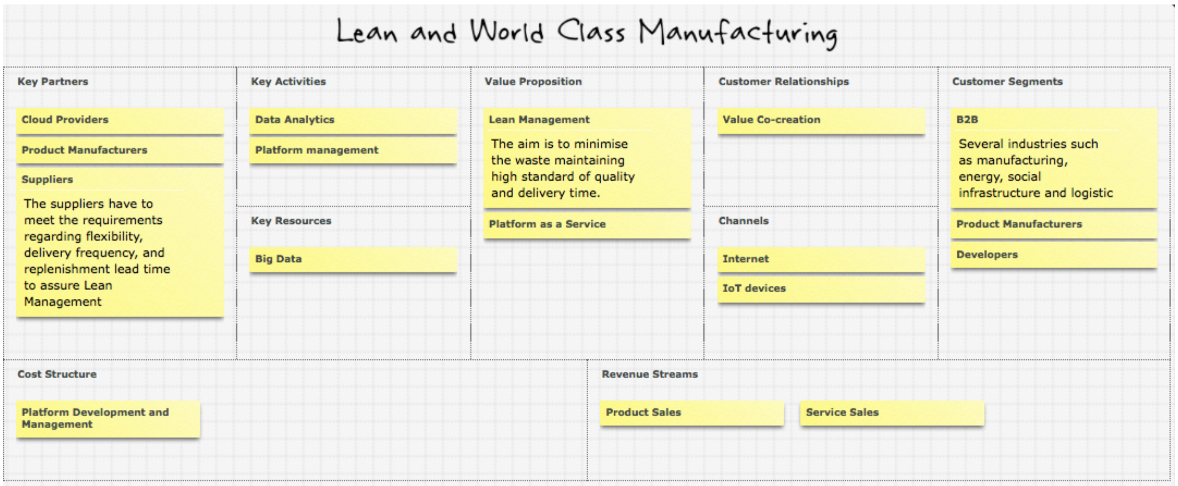

Figure 21 - IoT Lean and World Class Manufacture (developed by the author)

4.4.3. IoT Digital Platforms for Manufacturing

In the figure 22, it is represented an example of business model canvas for a company operating in the IoT Digital Platforms for Manufacturing. The most common IoT platform concern the digitalization of the product. What they offer is an end-to-end platform as a service (figure 22), allowing the customers to reduce time, cost and risk required to build innovative M2M and IoT applications. A company can use this kind of platform to servitize their products. The customers can be also developers that want to use the platform to create applications inside the platform and sell them to the companies. There is a value co-creation process since the customers can customize their service adding value to the platform by developing new applications. It is provided a customer assistance to help the customer to use the main services of the platform. The channels generally used are Internet and IoT devices. The Cloud providers are one of the main partner since they allow the company to analyse the data retrieved from the platform. The other partners are the product manufacturers and third-party service providers. The main costs concern the infrastructure and the platform development and management. There are different price strategy that the companies offer this kind of platform can develop, the main ones are the pay-per-use and pay-as-you-go where the customers pays only when it uses the platform, so it can be convenient even for the consumers that do not use the platform everyday.

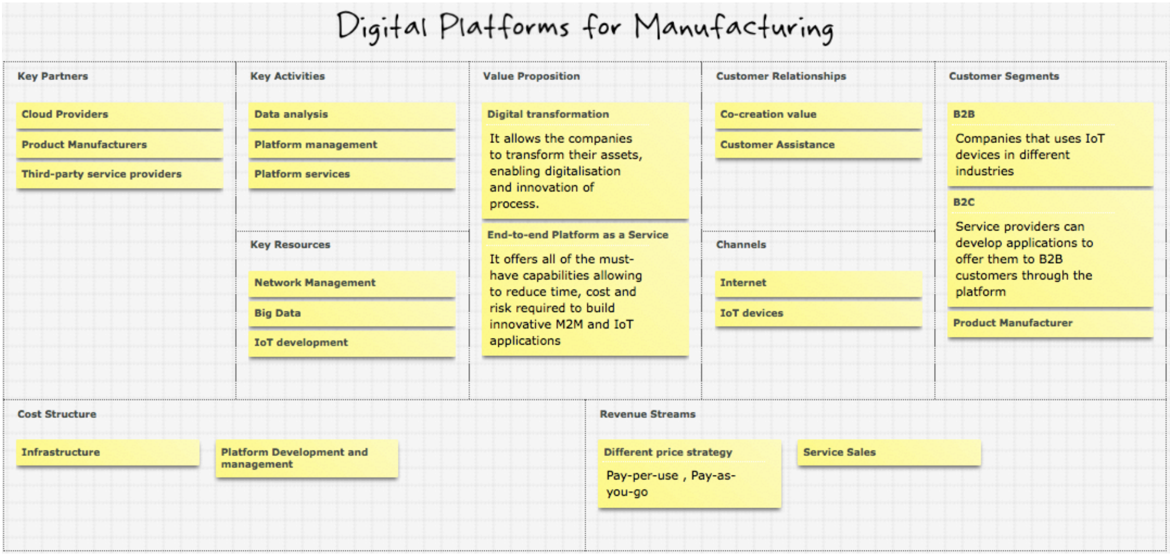

Figura 22 - IoT Digital Platforms for Manufacturing (developed by the author)

CHAPTER 4. DISCUSSION

4.1 Discussion about results

In order to give a better contribute to the literature in this section the results of the previous chapter will be compared with other studies (table 2).
The key elements of the business model canvas are showed in the table 2. Infrastructure and offer are considered to be from the literature analysis the main element for business model canvas (Jaehyeon et al., 2016).
In the survey of Dijkman et al. (2015), 103 companies answered to a survey about IoT application business model, the key partners identified by them contain, mostly, hardware producers, software developers and data interpretation. It is possible to note that Cloud Providers are not mentioned in the key partner block of the other studies, it means that the companies analysed have a cloud in-company in order to store all the infotrmation gathered by the sensors while the companies analysed in this thesis use Cloud of other companies, so they utilize an outsourcing strategy.
The work of Sun et al. (2012) focuses on the analysis of IoT business model examining a case study of smart logistic that illustrates how a business model for IoT can be developed. In smart logistic application, data processing center and transport fleet are the key resources. In the key activities block, the main factor consists of product development and implementation and it is interpreted as research, development and engineering (Dijkman et al., 2015).
The work of Qin et al. (2015) focuses in the analysis of IoT business model of telecom operators, the value proposition lies on the sharing of the information, users communicate and share information to achieve efficient and win-win cooperation.
Value is co-created by all members of the ecosystem, and so by customers (Turber and Smiela, 2014). The importance of the value co-creation it has been identified in all the business models analysed in the previous chapter. The customer segment and the channels identified in the other studies are the same the ones identified in this thesis, respectively individuals, companies and internet, IoT devices.
In the financial perspectives, the cost of infrastructure and staff are the most important costs in the smart logistics (Sun et al., 2012). Businesses should extend from cost reduction

models to exploring revenue models, such as additional revenues from the data being generated (Dijkman et al., 2015).

The main revenue comes from subscription fees and usage fees as identified in the servitisation and Digital Platforms for Manufacturing business models.

Table 2 – Components in IoT Business Models (developed by the author)

Main Perspectives	**Components (Building blocks)**	**Servitisation**	**Digital Platforms for Manufacturing**	**Lean and World Class Manufacturing**	**Key Elements (Other studies)**
Infrastructure	Key partner	Cloud Providers, App developers	Cloud Providers, Product Manufacturers, Third-party service providers	Cloud Providers, Product Manufacturer, Suppliers	Software Developer, Data Analyst, Device Manufacturer
	Key resources	Big Data	Network Management, Big Data, IoT development	Big Data	Software, Information, Customer Resource
	Key activities	Manufacturing and production, Data analytics	Data analysis, Platform management, Platform services	Data Analytics, Platform Management	Product Development, Platform Development, Partner Management, Platform and Resource Integration Ability
Offer	Value proposition	Product as a service, High Customization, Remote Monitoring, Cost Reduction	Digital Transformation, End-to-end Platform as a Service	Lean Management, Platform as a Service	Convenience, Performance, Customization, Share
Customer	Customer relationship	Co-creation Value, Assistance	Co-creation value, Customer Assistance	Value Co-creation	Co-creation, Self-service Communication, Fast Feedback
	Customer segments	B2C, B2B, Multi-sided Ecosystem	B2B, B2C, Product Manufacturers	B2B, Product manufacturers, developers	Mobile Users, Companies
	Channel	E-commerce, Retail Stores, App Store, Direct Sales	Internet, IoT devices	Internet IoT Devices	Internet, Mobile
Financials	Cost structure	Manufacturing and warehousing costs, Data Management, R&D investment, cybersecurity	Infrastructure, Platform development and management	Platform development and management	IT Cost, Infrastructure

	Revenue structure	Direct sell, Subscription for additional features	Pay-per-use, Pay-as-you-go, service sales	Product Sales, Service Sales	Subscription Fees, Usage Fee

4.2 Competitive Model

The analysis of the IoT Platform business model canvas showed that a firm, to get success in this industry, needs to have an innovative and coherent business model. The innovation in the IoT context is crucial, since IoT is a technology that is spreading quickly year by year. Timing assumes an important role in this panorama because who first innovates can increase its profit. It could be considered as a preemption game because a company that creates a new IoT product has to take care about the competitors that may preempt it by developing and patenting a similar product, and thus deprive it of the fruit of his efforts (Bobtcheff and Mariotti, 2012).

In order to show how an IoT investment can be profitable for a firm the following competitive model has been carried out.

The model chosen concerns the Bertrand Competition, where two companies (player_1 and player_2) competing on price (p_1, p_2). In particular, it is possible to assume that the firms sell differentiated products and they have the same cost structure, represented by c_1 and c_2, and only player_1 invest on IoT platform (I^2). Q_1 and Q_2 represent, respectively, the quantity demanded of player_1 and player_2. The objective of the model is to compare the profits of the firms and show if there is an increase of the profit for the firm that invests in IoT.

The parameters that represent the strategic effect of the investment are represented by $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$, they can assume a value between 0 and 1, so it is valued the following condition: $0 \leq \alpha, \beta \leq 1$. α will represent the servitisation coefficient. The customers will not buy only the product anymore, they will buy the service associated to the product. They will have a high willingness to pay due to the different features that the IoT product will offer. This investment will modify the curve demand of the two players.

β represents the retention of customers, triggered by the improvement of products features. This investment will have an impact on the elasticity of the demand of the player_1.

The firms have the following demand functions, where A represents the vertical intercept, b the slope and e represents the crossed elasticity:

$$Q_1(p_1, p_2) = A - bp_1 + (e + \beta I)p_2 + \alpha I \quad (1)$$

$$Q_2(p_1, p_2) = A - bp_2 + ep_1 - \alpha I \quad (2)$$

And the profits are:

$$\pi_1 = p_1 q_1 - c_1 q_1 - I^2 \quad (3)$$

$$\pi_2 = p_2 q_2 - c_2 q_2 \quad (4)$$

4.2.1 Model without investment ($\alpha = 0$ and $\beta = 0$)

First of all, it is showed the situation where the firms do not invest on IoT technology ($\alpha = 0$ and $\beta = 0$) assuming that they have a symmetric demand represented by Q1 and Q2 that depend on prices, P1 and P2, so the demand is characterized by elasticity. Since the cost structure is supposed to be equal for the two players, it is possible to assume that c1 = c2 = 0.

$$Q_1(P_1, P_2) = A - bP_1 + eP_2 \quad (5)$$

$$Q_2(P_1, P_2) = A - bP_2 + eP_1 \quad (6)$$

Best Response Player 1:

$$P_1 = \frac{A + ep_2}{2b} \quad (7)$$

Best Response Player 2:

$$P_2 = \frac{A + ep_1}{2b} \quad (8)$$

In order to solve the game, it is required to find the Nash Equilibrium, the strategic profile where each player's strategy is a best response to the strategies of all the other players, so no player has an interest to deviate from it, as by deflecting it could only get worse his situation. In this case, the Price Nash Equilibrium is when P1 and P2 are equals, so the profits will be the same too.

$$P_1^{NE} = P_2^{NE} = \frac{A}{2b-e} \tag{9}$$

$$\pi_1 = \pi_2 = \left(\frac{A}{2b-e}\right)^2 b \tag{10}$$

4.2.2 Model with investment: Servitisation effect ($\alpha \neq 0$ and $\beta = 0$)

Now, having proved that if no one invest the companies will have the same profit let's see what changes assuming that the game is divided in two stages, in this way:

I. In the first period, one of the companies can make an investment, I^2, in order to increase his market share. The strategic choice concerns the investment in IoT technology and the objective of this investment is to increase the consumer's willingness to pay by leveraging the servitisation strategy;
II. In the second period, the two players make tactical choice. In this game the competition will follow the Bertrand model, so the companies will compete on price.

The companies have a symmetric demand represented by Q1 and Q2 that depends on prices, P1 and P2, so the demand is characterized by elasticity. Since the cost structure is equal, it is possible to assume that $c1 = c2 = 0$. The coefficient $\boldsymbol{\alpha}$, introduced in the previous paragraph, and the investment will affect the demand curves of the two players so the equation 5 will change in this way:

$$Q_1(P_1, P_2) = A - bP_1 + eP_2 + \alpha I \tag{11}$$

$$Q_2(P_1, P_2) = A - bP_2 + eP_1 - \alpha I \tag{12}$$

Best Response player$_1$:

$$P_1 = \frac{A + ep_2 + \alpha I}{2b} \tag{13}$$

Best Response player$_2$:

$$P_2 = \frac{A + ep_1 - \alpha I}{2b} \tag{14}$$

$$P_1^{NE} = \frac{A}{2b-e} + \frac{\alpha I}{2b+e} \tag{15}$$

$$P_2^{NE} = \frac{A}{2b-e} - \frac{\alpha I}{2b+e} \tag{16}$$

Calculating the Nash Equilibrium, it is possible to note that the price of the firm 1, that invested on IoT technology, is increased, while the equilibrium price of the firm 2 is decreased, as showed in the figure 23. This is mainly because, after the investment, the consumers are willing to pay a surplus to buy the product/service from the firm 1.

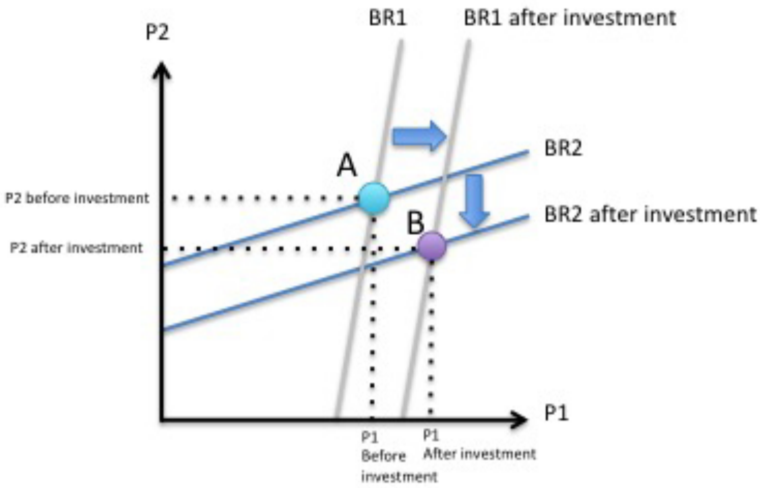

Figure 23 – Model 1: Best Responses. Developed by the author

In the figure 24 it is shown the shift of the best responses (BR) of the firms. BR1 and BR2 are the best responses of the model without the investment, after the investment the best response of the Player 1 shifts toward right while the best response of the Player 2 shifts down, it means that the Nash Equilibrium will shift from the point A to the point B. The price of the firm 1 will increase while the price of the firm two will decrease, so the profit of the firm 1 will be higher than the profit of the firm two.

Profits:

$$\pi_1 = \left(\frac{A}{2b-e} + \frac{\alpha I}{2b+e}\right)^2 b - I^2 \tag{17}$$

$$\pi_2 = \left(\frac{A}{2b-e} - \frac{\alpha I}{2b+e}\right)^2 b \tag{18}$$

It is possible to observe that if α is equal to 0, the profit of the player 2 will be the same as the equation 10, the one with the model without the investment. While if α is equal to 1, the profit of the player 2 decreases. Doing the derivative $\frac{d\pi_1}{dI} = 0$, it is possible to find the optimal investment of player 1.

This simple mathematical model proved that an investment in Internet of Things, focusing on the servitisation effect, could bring to an increasing of company's profit.

According to the framework of Funderberg and Tirole (1984), this investment can be seen as Puppy Dog, indeed the competition will become fiercer after the investment.

4.2.3 Model with investment: Customer retention effect ($\alpha = 0$ and $\beta \neq 0$)

In this second case the parameter that represents the strategic effect of the investment is represented by β, in particular it represents the retention of customers, triggered by the improvement of products features. The effect depends on the amount of the investment and the parameter β. The investment will have an impact on the elasticity of the demand of the player_1, as it is showed in the following demand function:

$$Q_1(p_1, p_2) = A - bp_1 + (e + \beta I)p_2 \tag{19}$$

$$Q_2(p_1, p_2) = A - bp_2 + ep_1 \tag{20}$$

As in the previous models, the cost structure is equal, so it is possible to assume that $c1 = c2 = 0$.

The best responses of player_1 and player_2 are represented:

$$P_1 = \frac{A + ep_2 + \beta Ip_2}{2b} \tag{21}$$

$$P_2 = \frac{A + ep_1}{2b} \tag{22}$$

In order to solve the game, the Nash Equilibrium has been found and represented:

$$P_1^{NE} = \frac{A(2b+e)+e\beta I}{(2b-e)(2b+e)-e\beta I} \tag{23}$$

$$P_2^{NE} = \frac{A(2b+e)}{(2b-e)(2b+e)-e\beta I} \tag{24}$$

Looking at the figure 24, it is possible to observe a shift in the best response of the player 1 due to the change on the elasticity. It brings to higher equilibrium price for both the players, but the increasing on the price 1 is higher than the increasing of the price 2. In this way the profits of player 1 and player 2 will increase, but the profit of player 1 will increase more than the profit of the player 2.

The reason of the change on the equilibrium price is that the investment in IoT technology affected the elasticity, so the customers are willing to pay more for the product of the firm 1. The profit of firm 1 will be:

$$\pi_1 = \left(\frac{A(2b+e)}{(2b+e)(2b-e)-e\beta I}\right)^2 b + \left(\frac{\beta I}{(2b+e)(2b-e)-e\beta I}\right)^2 (2eAb - e^2 b) - I^2 \tag{25}$$

$$\pi_2 = \left(\frac{A(2b+e)}{(2b+e)(2b-e)-e\beta I}\right)^2 b + \frac{\beta I(e^2-eA)}{((2b+e)(2b-e)-e\beta I)^2} \tag{26}$$

As it was expected from the graph of the best responses (figure 24) both the profits are increased after the investment, even if the profit 1 is increased more than the profit two.

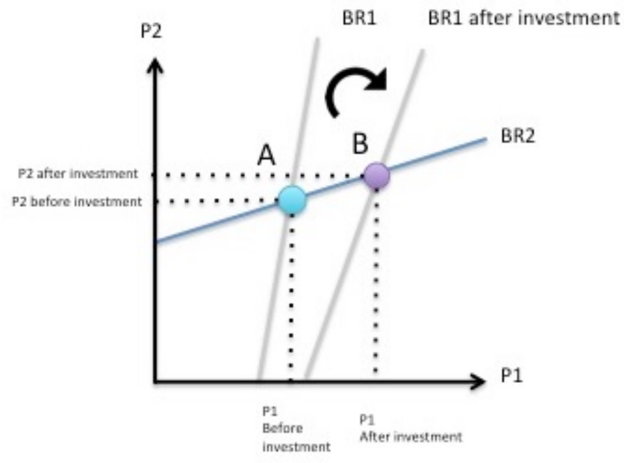

Figure 24 – Model 2: Best Responses. Developed by the author

The increasement of the profit depends on the coefficient β and the investment I, if β is equal to 0 the profit will be the same as the one of equation 10, the model without investment. While if β is equal to 1 the profit of the player two will increase, so according to the framework of Funderberg and Tirole (1984), this investment can be seen as Fat Cat, indeed the competition will become softer after the investment.

Doing the derivative $\frac{d\pi_1}{dI} = 0$ it is possible to find which is the optimal investment of player 1. This simple mathematical model proved that an investment in Internet of Things, focusing on the customer retention effect, could bring to an increasing of company's profit.

CHAPTER 5. CONCLUSIONS

This thesis presents empirical research through the study of different companies from different sources that leads to three frameworks for business models for Internet of Things platforms. Initially it has been conducted a structured literature review of the state-of-the-art of IoT Platform and IoT Platform business model then 13 business model canvas have been developed using secondary data, as the main information of the companies, available in their annual report, and scientific papers. From the literature review and from the business model canvas of these companies it has been possible to identify three archetypes of business model in IoT Platform: Servitisation, Lean and World Class Manufacturing and Digital Platform for Manufacturing. It has been carried out a comparison between these archetypes and other IoT Platform business model canvas developed by other reaserchers which some differences among the business models are highlighted. Finally, a mathematical model has been created in order to show the competitive advantage that a firm exploiting the IoT Platform can obtain.

5.1 Consideration about the results

This thesis suggested that manufacturing companies should invest in Internet of things technology in order to stay competitive. From the analysis of the literature review three different business scenarios have been identified: servitisation, lean and world class manufacturing and digital platform for manufacturing. Therefore, it has been possible to analyse different companies for each business scenario utilizing the canvas approach. This research showed different approaches that companies, using IoT technology, can have and it gave an example of business models in IoT that companies of different industries can follow. The business model canvas of the three business scenarios have been created and they have been compared with the business model canvas of other studies. In this way it has been possible to identify the differences among the study and the companies analysed.
Furthermore, the thesis concluded that a company investing in IoT can gain a competitive advantage and for this reason it might be anticipated that in the next future the majority of the companies in the manufacturing sector will use IoT technologies to reduce costs and increase efficiency and quality of service.

5.2 Answers to the research question

Which are the main business models utilized in the IoT industry and how do they operate with the IoT platforms to allow to the firms to get competitive advantage?

From the analysis of different business model canvas of companies that operate in different industries using IoT technology it has been possible to find some similarities and some differences among them.
From the analysis of the literature review arise three approaches that the firms can exploit utilizing IoT technology.
The companies can focus on servitisation aspect, delivering not only the product but the service associated to the product. It brings many benefits in terms of revenue, customer retention and customer satisfaction.
IoT can also bring the companies to focus on lean manufacturing, utilizing the IoT technology to increase the efficiency and reduce the waste and the costs.
Some innovative companies can focus on the delivery of digital platforms allowing other companies or developers to utilize the platform to build, test, deploy and manage IoT applications.
It is possible to identify three key factors that are essentials to get success in IoT industry: open innovation, value co-creation and positive network externalities.
In this complex and competitive industry, open innovation is crucial to improve the efficiency of the company. So, the key partners assume a very important role, indeed they are fundamental to improve the services supplied to the customers. Open innovation is the process in which the companies exchange tangible and intangible assets with other companies, in order to create a collaborative environment and improve each other.
One of the main benefits of Internet of Things is the possibiliy to gather big data; in this context a collaboration with cloud partners becomes very important. For this reason in all the business model canvas analysed there is a Cloud partner such as Amazon Web Cloud, Google Cloud etc…
Another key partner are the third-party providers, they develop applications within the platform allowing the company to increase the services supplied. In this way there is a value co-creation since the developers gain from the use of their application by the customers and the company can supply more services without extra cost. It also creates positive network

externalities because more developers working on the platform create more applications; more applications make the platform's offering more valuable and results into more customers using the platform.
The manufacturing industry has been totally changed from the advent of Internet of Things. The linear manufacturing supply chains became dynamic and interconnected systems. The factories are more efficient and safer and allow to reduce considerably the costs. One of the main changes is the increasing of the life cycle of the machineries. Using predictive maintenance it is possible to act before that a damage in the machinary happens and this avoids repairing costs. From the example of Rolls Royce it has been highlighted the importance of predictive maintenance in the servitisation approach. Rolls Royce delivers high quality to their customers and exploiting high switching cost they can avoid that the consumers change supplier; indeed if they want to move to another supplier, since the engine is produced by Rolls Royce and the data gathered by the sensors are owned by Rolls Royce is very costly to ask maintenance to another supplier; so, in this way the long term assistance is protected and it brings in high customer retention.

What are the effects of the IoT platforms on the market competition and what are the main business parameters that affect it?

In this thesis, a mathematic model analysing the business parameters that affect the competition was applied. Two business parameters have been identified: Servitisation and Customer retention. The first mathematical model showed how the servitisation can affect the market competition. It has been highlighted that an investment on servitisation effect using IoT technology allows to increase the profit and to win the competition since the customers will have higher willingness to pay due to the different features that the company can offer. In the Tesla business model is possible to observe this effect. Actually the Tesla customers do not buy only the product, they buy the service related to the product, indeed Tesla transmits software upgrades to the car, in this way the customer feels after every update to have a "new" product.
The second mathematical model showed how the customer retention effect can affect the market competition. Even in this way the investment will bring benefit to the company increasing the profit. This effect can assume an important role in the Digital Platform for Manufacturing Business Model, indeed there are many companies that operate in this sector

and so it is very important to invest in order to maintain the installed base of consumers offering new features. In a world where the innovation moves very fast it is fundamental for the companies to invest in reaserch and development in order to stay update. Investing in the new technologies, as Internet of Things, is the only way to stay competitive and satisfy the new needs of the consumers of tomorrow.

5.3 Relevance and contributions

The findings of the thesis may have a positive impact to the society considering that IoT technology will become more popular in the next years. The thesis helps to fill the literature gap concerning IoT business models and it can be helpful as starting point for future research in this argument. It can help managers of innovative companies to improve their business model or to create a new IoT platform business model choosing as model one of the archetypes analysed in the previous chapters. The comparison between the three business scenarios identified in this study and the business model canvas developed by other researchers is relevant for future work because it highlights the similarities and differences among them.

5.4 Limitations and recommendations

Even if the thesis yelds insightful results for IoT business models, the findings of this study have to be seen in light of some limitations.
The main ones concern: the relative low number of companies analysed, the possibility to identify other important archetypes, the limited number of scientific papers available about IoT Platform business model.
In the thesis, 13 companies have been analysed through the canvas approach, even if these companies are different among them and they operate in different industries, a recommendation for further works is to analyse more companies. In this way, it could be possible to discover other business scenarios and it would allow to analyse them with statistical tools in order to understand what business model is more utilized and more suitable and what is the main canvas block for the companies. Increasing the number of observations it would be also possible to discover if there are companies that utilize more than one archetype. The secondary data allow to gather more data in less time but they are not always specific for the purpose of the study so a reccomendation for future works could be to use primary data. A survey to the companies operating in the IoT industry would be

helpful in order to confirm the results of this thesis or to improve it comparing the answers to the survery with the results of this thesis. The majority of the scientific papers focuses on the advantages of the IoT applications, so there is a limited number of scientific papers about IoT Platform business model, it brings to a lack in the literature, therefore a recommendation for future studies is to investigate in this area in order to give a contribution to the companies that want to arise in this industry.

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