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ROLE OF OPENNESS IN TERMS OF SWITCHING COSTS FOR THE INDUSTRIAL INTERNET PLATFORM END-USERS

Master of Science thesis

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ABSTRACT

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Industrial Internet is one of the novel paradigms in the recent years, it has many implications in both practical and literature reviews for almost all the industry sectors. Industrial Internet is a broad subject and many concepts are related to it such as Industry 4.0, CPS, smart manufacturing or IoT. One of the most talked topics related to Industrial Internet are platforms. They are a revolution in the way companies communicate, partner, share and create value.

The purpose of the thesis is to develop a better understanding of the role of openness, which is a fundamental characteristic of the II-platforms in which the degree of participation of end-users, app developers and platform owners varies depending on the degree of openness. The impact of selecting a platform based on its openness is crucial for a company's long-term strategy.

This thesis concentrates on the risks and downsides of openness. The thesis focuses on the risks given that there is already an extensive research in the benefits that platforms provide. These downsides are evaluated in terms of switching costs through two interviews that provide an overview of the role of openness and its effects on the end-user.

The results show that openness plays an important role in the decision-making process. Companies are eager to know methods to evaluate its impacts and switching costs is an excellent tool well-known by companies. In addition, depending on the business openness influences positively or negatively or both, but it definitively has an impact in the long-term.

PREFACE

This thesis explores the role of openness in terms of switching costs for the II-platform end-users and the impact it has on their businesses.

I would like to thank in the first place my tutor Prof. Hannu Kärkkäinen for giving me the opportunity to work in this multi-cultural department and this revolutionary research topic, giving me full confidence during all the development of the Master thesis and show me how amazing Finnish people are. Secondly, I would like to thank Karan Menon for all his support and guidance through the whole research process, for transferring me his broad knowledge and his passion on the topic. Finally, I would like to mention my family and friends for allowing me to have had this experience and all their continuous support during this whole year.

Madrid, 29.06.17

Pilar Aldama Marín

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LIST OF ABBREVIATIONS

AC	Automation Company
ADFS	Active Directory Federation Services
AWS	Amazon Web Services
CPPS	Cyber-Physical Production System
CPU	Central Processing Unit
IBM	International Business Machines
GE	General Electrics
HMI	Human Machine Interface
ICT	Information and Communication Technology
II	Industrial Internet
IIoT	Industrial Internet of Things
IoT	Internet of Things
KPI	Key Performance Indicator
MB	Machine Builder
MP	Microsoft Project
OS	Operation System
PC	Personal Computer
PLC	Product Life Cycle
RFIF	Radio Frequency Identification
R&D	Resource and Development
SC	Switching costs
SDK	Software Development Kit
SME	Small and Medium Enterprise
WBS	Work Breakdown Structure

1. INTRODUCTION

1.1 RESEARCH BACKGROUND

The Internet was a revolution in the communications and computer world; its adoption started in the middle 90s and continued to evolve to this day (Leiner et al., 2009). The last evolution state of the Internet is the Internet of things which means that virtually all the physical things in the world can turn into a computer connected to the Internet (Fleisch and others, 2010).

The IoT has different applications on enterprise level such as monitoring and control, big data and business analytics and information sharing and collaboration (Mack and Veil, 2017). However; the IoT is recently applied to the Industry and it is referred as Industrial IoT or Industrial Internet.

General Electrics (GE) was the first to introduce the concept of Industrial Internet in 2012 and represents a significant business transformation. II is a solution-oriented strategy which allows companies to be competitive in the market through the deployment of new capabilities, strategies and processes (Agarwal and Brem, 2015).

Nowadays, there is a recent interest on platforms and each time there is more and more research on the subject. Platforms have evolved from product platforms in 1997 to MSP in 2015. Industry platforms appeared in 2002 and was first researched by Gawer and Cusumano (Mack and Veil, 2017). II-platforms are platforms that adhere to the definition of Industry platforms and Industrial Internet.

In addition, the II-platforms can have a different degree of openness. The first definition of openness was provided by (Eisenmann et al., 2008), the more open a platform is it is easier for the different actors to access and share data through the platform. The degree of II-platform openness vary based on these dimensions: the end-user side, the app developer side and the platform provider and platform sponsor side.

There is much literature related to platform openness written from the platform and app developer side; however, there is a lot of research that is missing from the demand-side. In order to study the impacts that openness has on the platform end-user many methods can be used, for example a transaction cost approach is used in several commercial platforms (Hallikas et al., 2002; Henten and Windekilde, 2016). But in this case the switching costs will be used for its relevance in the long-term and usefulness in carrying out the empirical part.

This fact brings up a research gap related to II-platform openness, II-platforms end-users and switching costs and this is what the current study tries to address. Figure 1 shows the research gap:

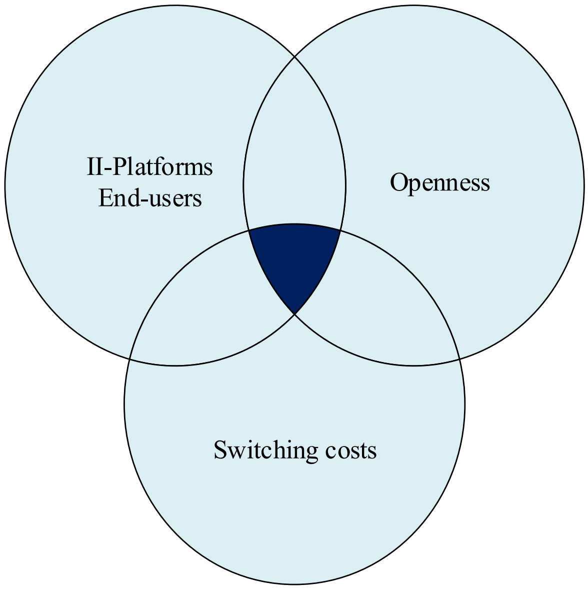

Figure 1: *Research gap this thesis addresses.*

1.2 RESEARCH QUESTIONS

Taking into consideration the research gap presented in the previous section (see Figure 1), it is possible to formalize the following primary ontological question of the thesis which is going to guide the research process:

> *What is the role of Openness in terms of switching costs for the Industrial Internet Platform end-users?*

The primary question has a too long scope that difficult the research. In order to facilitate and organize the work, some specific questions are created and will support the main question during the development of the thesis:

> *RQ 0 What is Industrial Internet (II, IoT, Smart factories, Industry 4.0., CPS (CPPS)?*
>
> *RQ 1 What are the II-Platforms?*
>
>> *RQ 1.1 What kinds of impacts do II-platforms carry towards platform users?*
>
> *RQ 2 What does openness mean for II-platform end-users?*

RQ 3 How can the impacts of II-platform openness for the II-platform end-user be identified?

RQ 4 What is the impact of II-platform openness to the II-platform end-user's business?

RQ 5 What are the impacts in terms of switching costs of II-Platform openness for an II-platform end-user?

The primary question comes from the research background explained in the section 1.1. The formulation of the research questions follows a logical thread; the first three questions are answered using the existing theory and the two last questions are answered using empirics and theory.

At the first place, there is a synthesis from theory of the basic concepts such as Industrial Internet and II-platforms (RQ 0 and RQ 1). Secondly, the impacts of the II-platforms are developed based on the empirical part and the theory (RQ 1.1). Once the main concepts are clear, II-platform openness is introduced in a theoretical way and from the end-user perspective through the empirics (RQ 2). The third research question (RQ 3) is the key for the two last questions which are the major research questions of the study (RQ 4 and RQ 5). These questions explain the impacts of openness to the II-platform end-user business, and specifically, the last question focuses on the impacts under the switching costs framework.

1.3 STRUCTURE OF THE THESIS

This section aims to present the overall structure of the thesis. At a general level, the structure can be divided into four different parts: introduction, literature review, empirical study and conclusions (see Figure 2).

The introduction is the first chapter of the thesis. It presents an overall overview of the topic and identifies the research gap, which serves as a base for the identification of the research questions.

The second part of the thesis is sub-divided into two chapters. Chapter 2 explains the II-platforms and its impacts towards platform users. Chapter 3 provides theory and the corresponding frameworks related to II-platform openness and its impacts on the end-user side.

The empirical study consists of two chapters. Chapter 4 explains the selected case study approach, as well as its development. Chapter 5 presents the results of the interviews of the empirical research.

Finally, the last part of the thesis is Chapter 6 which constitutes the discussion of the research questions and presents the conclusions of the whole study. It also includes an evaluation of the thesis, highlights the managerial implications and presents the limitations of the study and the topics for future research.

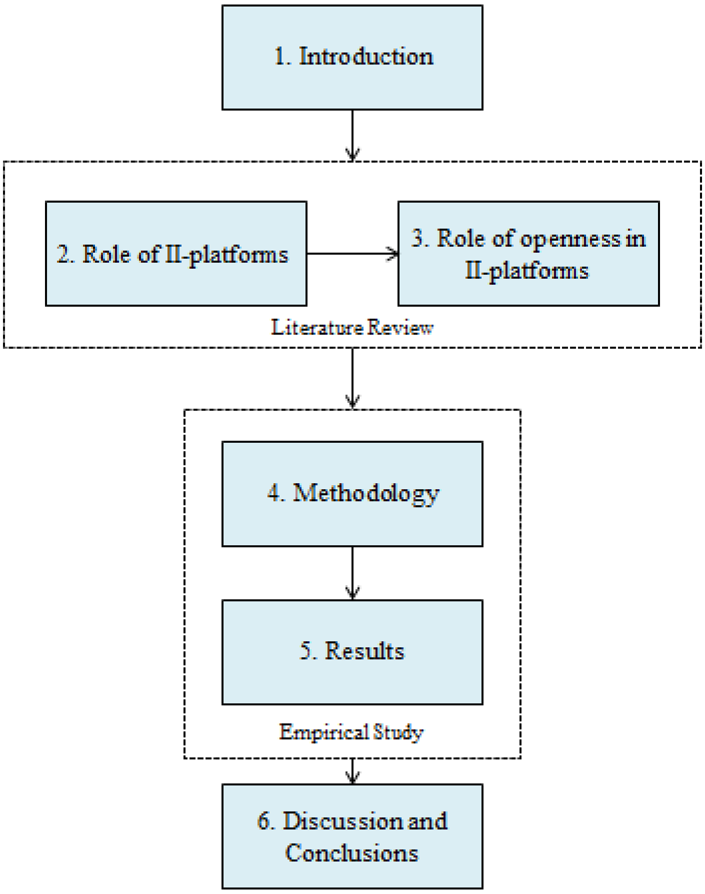

Figure 2: *Structure of the thesis.*

2. ROLE OF INDUSTRIAL INTERNET PLATFORMS

2.1 INDUSTRIAL INTERNET

In some of the most advanced industrial economies of the 21th century, there is a new wave that seeks to improve productivity and efficiency by incorporating the most recent advances in ICT. The adoption and development in ICT is creating enormous possibilities for manufacturing and production (Posada et al., 2015).

Industrial Internet of Things (IIoT) has become one of the most relevant industrial business concepts in recent years. There are many ways to refer to IIoT, GE was the first to introduce it as “Industrial Internet”, others such as Cisco called it “Internet of Everything”, and others termed it Internet 4.0 (Gilchrist, 2016).

The rise of Industrial Internet is due to the fusion of a first wave, the Industrial Revolution, together with a second, the Internet Revolution (Evans and Annunziata, 2012). GE describes the Industrial Internet as having three essential elements: intelligent machines, advanced analytics and people at work (see Figure 3) (Agarwal and Brem, 2015; Evans and Annunziata, 2012).

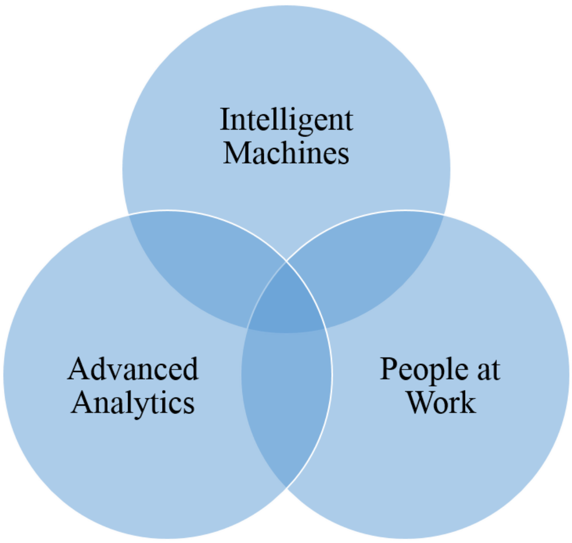

Figure 3: *Essential elements of Industrial Internet.*

- Intelligent machines: New ways of connecting the world of machines, facilities, fleets and networks with advanced sensors, controls and software applications.
- Advanced analytics: Combines the power of physics-based analytics, predictive algorithms, automation and deep domain expertise in material science, electrical engineering and other key disciplines required to understand how machines and larger systems operate.

- People at work: Connecting people, whether they be at work in industrial facilities, offices, hospitals or on the move, at any time to support more intelligent design, operations, maintenance as well as higher quality service and safety.

Industry is currently undergoing a transformation towards full digitalization and intelligentation of manufacturing processes (Erol et al., 2016). According to (Evans and Annunziata, 2012); intelligent devices, intelligent systems, and intelligent decisioning represent the fundamental ways in which the physical world can merge with the digital world (see Figure 4).

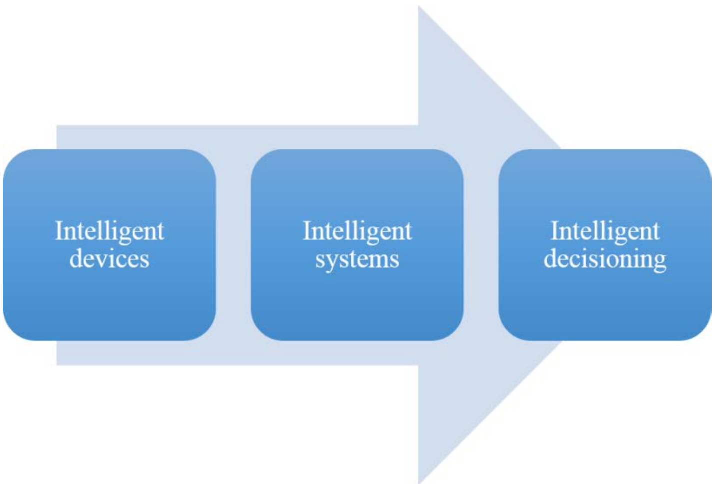

Figure 4: *Primary ways of digitalization of the industrial world.*

- Intelligent devices: Providing digital instrumentation to industrial machines is the first step in the Industrial Internet Revolution.
- Intelligent systems: It is the combination of machine instrumentation with software. Intelligent systems come in different forms such as network optimization, maintenance optimization, system recovery and learning.
- Intelligent decisioning: Enough information is gathered from intelligent devices and systems to facilitate data-driven learning.

Industrial Internet provides a method to transform operational business processes by incorporating sensors and advanced instrumentation in the machines which allows collecting high volumes of data. Then, the data can be harvested from those intelligent devices and networks, stored, analyzed and visualized using big data and analytics tools. Thus, the intelligent information can be used, for example, to improve machine performance and the efficiency of the systems and the networks between machines and systems. That information can also be shared across machines, networks, individuals or groups to facilitate intelligent collaboration and better decision making. (Agarwal and Brem, 2015; Evans and Annunziata, 2012; Gilchrist, 2016).

In conclusion, when these intelligent devices, systems and decision-making join together with the physical machines, facilities, fleets and networks; the total industrial economy will take advantage of an improved productivity, lower costs and reduced waste (Evans and Annunziata, 2012).

2.2 BASIC CONCEPTS RELATED TO INDUSTRIAL INTERNET

There are some concepts related to the Industrial Internet (e.g. IoT, Industry 4.0, CPS, CPPS, etc.) frequently repeated throughout the academic literature. In this subsection each term will be defined and the relationship between these concepts will be explained.

On one hand, in the publication "industrie 4.0 Working Group" published in April 2013 the authors named three key components of Industrie 4.0: IoT, CPS, and Smart Factories (Erol et al., 2016). On the other hand, (Hermann et al., 2016) explained that concepts such as the IoT, II, Cloud-based Manufacturing and Smart manufacturing are drivers of the Industry 4.0.

Industrial Internet, Industry 4.0 and CPS can be collectively defined as industrial systems that integrate computational and physical capabilities of machines in order to provide advanced analytics and interact with humans (Agarwal and Brem, 2015) (Hermann et al., 2016) (Lee et al., 2015) (Iansiti and Lakhani, 2014) (Evans and Annunziata, 2012).

In the Table 1 below, a proper definition is given for each concept related to II:

Table 1: *Different concepts related to Industrial Internet.*

Concept	Definition	References
Industrial Internet	The industrial Internet is a phenomenon that involves the merging of the digital world with the world of machines. It is the convergence of the global industrial systems such as machines, facilities, fleets and networks with the power of advanced computing, analytics, low-cost sensing, and new levels of connectivity provided by the Internet.	(Agarwal and Brem, 2015; Evans and Annunziata, 2012)
Industry 4.0	A collective term for technologies and concepts of value chain organization, focusing on the field of industrial manufacturing.	(Hermann et al., 2016; Mack and Veil, 2017)
Internet of Things (IoT)	A network in which CPS cooperate with each other through unique addressing schemas.	(Hermann et al., 2016; Mack and Veil, 2017)
Internet of Service (IoS)	It provides individual service providers the ability to offer their services over the Internet, where services can be flexibly combined into customer-specific value-added services that can be offered in various configurations, integrating them into the value chain activities of interorganizational networks.	(Hermann et al., 2016; Mack and Veil, 2017)
Cyber-	Next generation of embedded ICT systems where computa-	(Hermann et al.,

Physical Systems (CPS)	tion and networking are integrated with physical processes and they control and manage their dynamics and make them more efficient, reliable, adaptable, and secure.	2016; Mack and Veil, 2017)
Cyber-Physical Production Systems (CPPS)	CPPS is an applied version of CPS to the manufacturing area with various root technologies, and suggested technologies, such as context-adaptive and autonomous systems, that require research and development.	(Monostori, 2014)
Smart factory	A factory where CPS communicates over the IoT and assist people and machines in the execution of their tasks.	(Hermann et al., 2016; Mack and Veil, 2017)

Figure 5 stablishes a relationship between the previous concepts. Industrial Internet has wider focus on many application areas whilst Industry 4.0 and its emphasis on manufacturing and logistics processes can be understood as a subset of the Industrial Internet, which is expanded by a product life-cycle perspective (Hermann et al., 2016).

Industry 4.0 involves the technical integration of CPS into manufacturing and logistics and the use of the Internet of Things and Services in industrial processes. This will have implications for value creation, business models, downstream services and work organization. (Kagermann et al., 2013)

The heart of Industry 4.0 in conceptual terms is the Smart Factory and everything revolves around this central entity that makes up the business model. (Gilchrist, 2016). In the area of manufacturing, CPS and IoT are core technologies for realizing Smart Manufacturing. (Kang et al., 2016). By integrating the ideas of the IoT and CPS in their operations, “smart factories constitute a key feature of Industry 4.0” (Hermann et al., 2016).

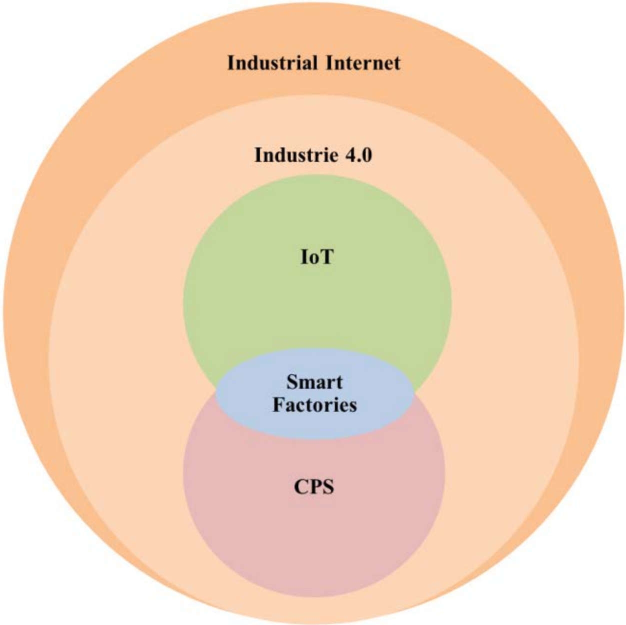

Figure 5: *Relationship between basic concepts related to Industrial Internet.*

2.2.1 Internet of Things and Internet of Services

Many researchers see IoT as a revolutionary topic. (Miorandi et al., 2012) defines it as a major trend shaping the development of technologies in the ICT sector; (Atzori et al., 2010) states it as a novel paradigm that has an increased relevance in the scenario of modern wireless and telecommunications. Internet of things means a world-wide network of interconnected objects uniquely addressable, based on standard communication protocols (Kang et al., 2016) (Hermann et al., 2016).

The IoT makes smart connected products which are objects that contain electronic components, software, and network connectivity that enables these objects to collect, process, and exchange data (Mack and Veil, 2017). These smart products are equipped with identifying, sensing, networking capabilities that will allow them to communicate with one another and with other devices and services over the Internet to accomplish some useful objective. IoT represents an evolution of existing technologies (such as RFID, sensor networks, machine-to-machine communication devices, etc.) in terms of the number and kinds of devices and the interconnection of networks of these devices across the Internet. IoT also refers to the ensemble of applications and services leveraging such technologies to open new business and market opportunities (Miorandi et al., 2012) (Whitmore et al., 2015).

The implementation of IoT has some challenges in the areas of data management, data mining, privacy, security, and coordination; which can also be opportunities for platform concepts solving problems in these areas in a more efficient way than companies (Mack and Veil, 2017).

2.2.2 Industry 4.0

The convergence of industrial production and information and communication technologies, called Industry 4.0, is one of the most discussed topics among researchers in the German-speaking area; Industrial Internet in the US. (Hermann et al., 2016) defines it as the integration of complex physical machinery and devices with networked sensors and software, used to predict, control and plan for better business and societal outcomes.

As shown in the Figure 6, the term Industry 4.0 is used for the next industrial revolution which has been preceded by three other industrial revolutions (Hermann et al., 2016):

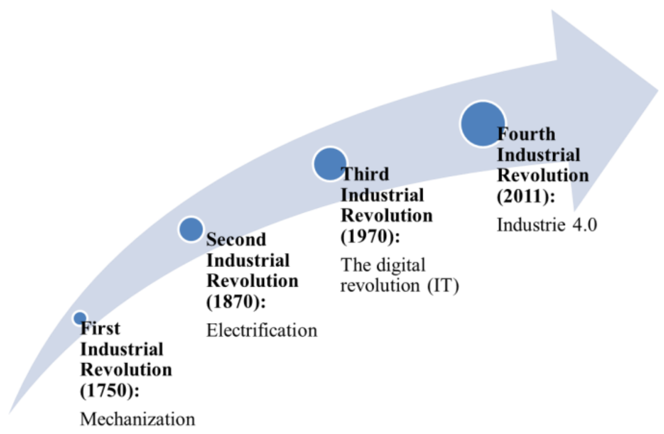

Figure 6: *Evolution of the Industrial Revolution.*

The future of Industry 4.0 is that industrial businesses will build global networks to connect their machinery, factories and warehousing facilities. These CPS will take the shape of smart factories, smart machines, smart storage facilities, and smart supply chains. This will improve the industrial processes and manufacturing, through engineering, material usage, supply chains and product lifecycle management (Gilchrist, 2016).

According to (Gilchrist, 2016), the main benefits of Industry 4.0 for SMEs are:

- Increased competitiveness of businesses, the systematic network integration of machines allows making an efficient use of the company´s available information resources (Stich et al., 2015).
- Increased productivity
- Increased revenue.
- Increased employment opportunities, enhanced human and IT resources management.
- Optimization of manufacturing processes, which shift from centrally controlled to decentralized production processes (Hermann et al., 2016).

- Development of exponential technologies.
- Delivery of better customer service.

2.2.3 Cyber-physical Systems and Cyber-physical Production Systems

CPS is central to the Industry 4.0, and many definitions are given by different researchers:

- CPS is defined as “transformative technologies for managing interconnected systems between its physical assets and computational capabilities” (Lee et al., 2015).
- CPS are “integration of computation and physical processes, usually with feedback loops where physical processes affect computations and vice versa” (Hermann et al., 2016).
- CPS can be generally characterized as “physical and engineered systems whose operations are monitored, controlled, coordinated and integrated by a computing and communicating core” (Monostori, 2015).

However; they all agree that CPS refers to the convergence of the physical and digital worlds. In the future businesses will stablish global networks that incorporate their machinery, warehousing systems and production facilities in the shape of CPS (Gilchrist, 2016).

In the manufacturing environment, CPS includes smart machines, smart data storage systems and smart factories that can exchange information with autonomy and intelligence, are able to decide and trigger actions, and can control each other independently (Posada et al., 2015). When CPS is applied to production and the manufacturing environment, it is called CPPS (Posada et al., 2015). CPPS consist of “autonomous and cooperative elements and sub-systems that are getting into connection with each other in situation dependent ways, on and across all levels of production, from processes through machines up to production and logistics networks” (Monostori, 2015).

In conclusion, Industry 4.0 requires the integration of CPS, IoT and IoS into the manufacturing and logistics environment. This will bring new ways of creating value and novel business models (Gilchrist, 2016; Hehenberger et al., 2016; Kagermann et al., 2013).

2.2.4 Smart manufacturing, smart factories and smart products

Smart manufacturing is the fourth revolution in the manufacturing industry, and it is “the collection of cutting-edge technologies that support effective and accurate engineering decision-making in real time through the introduction of various ICT technologies and the convergence with the existing manufacturing technologies" (Kang et al., 2016).

In industry 4.0 or Smart manufacturing, networked machines fully automate and optimize production enabling last-minute changes to production and deliver the ability to respond flexibly to disruptions and failures ((Kagermann et al., 2013; Porter and Heppelmann, 2015). The future of production as it is envisioned by Industry 4.0 id characterized by small decentralized and digitalized production networks, the nodes of such a network are so-called smart factories, which are connected to a larger value-chain network that fulfils a certain customer demand (Erol et al., 2016).

The smart factory is an optimization manufacturing solution related to automation (Kang et al., 2016) and it is defined as "a factory that context-aware assists people and machines in execution of their tasks. This is achieved by systems working in background. These systems accomplish their tasks based on information coming from physical and virtual world" (Hermann et al., 2016).

(McFarlane et al., 2003) defines an Intelligent Product or Smart Product as "a physical and information-based representation of a product" (Meyer et al., 2009). All smart, connected products share three core elements: physical components, smart components, and connectivity components (Porter and Heppelmann, 2014). Smart products are uniquely identifiable, may be located at all times and know their own history, status and alternative routes to achieving their target state (Kagermann et al., 2013), they include capabilities such as combination of monitoring data, remote control, optimization algorithms and autonomy (Porter and Heppelmann, 2015).

2.3 INDUSTRIAL INTERNET PLATFORM

In the recent years, more and more research has been done related to platforms; in spite of it, this area needs further research. It is a disruptive and quite young concept that hasn't yet a clear definition which depends on different entry points and theoretical backgrounds (Mack and Veil, 2017).

Platforms have more advantages than traditional pipelines because platforms have the capability to scale more efficiently, unlock new sources of value creation and supply, use data based tools to create network effects, enables new forms of consumer behaviour and quality control and leverage new capabilities to create entirely new business models (Choudary et al., 2016).

Platforms are continuously evolving and usually have more than one purpose. According to (Choudary et al., 2016) many industries are using platforms such as communication and networking, consumer goods, energy and heavy industry, health care, etc.. This master thesis will be focused on the manufacturing industry.

Platforms are divided into “internal” or company-specific platforms and “external” or industry-wide platforms. Industry platforms are defined as “products, services, or technologies developed by one or more firms, and which serve as foundations upon which a larger number of firms can build further complementary innovations and potentially generates network effects” (Gawer and Cusumano, 2014).

The definition of II-platform arises from the combination of the definitions of Industrial Internet and industry platform. The II-platforms can access data from different sensors, actuators, enterprise systems, social media and other novel data sources (Porter and Heppelmann, 2014) . This data is aggregated into a single database, which can be stored, either in dedicated in-house servers or with other third party cloud storage providers (Evans and Annunziata, 2012; Lee and Lee, 2015). The data via the platform can be used to monitor the condition of the machine without the physical presence of a technician, to predict the health condition of the machine through machine learning or to inform the technician about the need of the machine maintenance. In addition, the data can be used for analytics to create graphics with information that help decision makers (Menon et al., 2016).

GE, who was the first to introduce the term “Industrial Internet”, has also its II-platform, called Predix, on which all its physical equipment can easily operate across various sectors, from CT scanners to locomotives and from transformers to jet engines (Agarwal and Brem, 2015). Foer example, Predix is used to resolve traffic jams in real time and help workers to anticipate the assistance they will have to perform before arriving at the scene of the accident. In addition, applications are developed and the generated data is used to offer security, analytical or predictive maintenance solutions.

The II-platforms have some characteristics that generate a series of impacts on II-platform users; they will be commented on the next section of this chapter.

2.4 TYPE OF IMPACTS II-PLATFORMS CARRY TOWARDS PLATFORM USERS

II-platforms impact on the users of the platform, as two or more types of parties can affiliate and directly interact with mutual benefit while being partly controlled by the platform. The participation and interaction in the platform means the parties need to make platform-specific investments, which leads to lock-in, increasing the costs to switch easily.

In addition, a characteristic of platforms that will be explained in chapter 3 is that there is certain openness that creates a problem because there has to be a balance between control and competition versus cooperation. In a platform cooperation is vital; however, the companies should be able to create complements joining the ecosystem and at the same time make money from their investments (Gawer and Cusumano, 2014; Mack and

Veil, 2017). Another problem is the “chicken-and-egg problem” of how to encourage access to distinct groups of the platform, or how to share risks among members on an ecosystem (Gawer and Cusumano, 2014).

The most critical feature on an industry platform is the potential creation of network effects (Gawer and Cusumano, 2014). (Gawer and Cusumano, 2014) described it as “positive feedback loops that can grow at exponentially increasing rates as adoption of the platform and the number of complements rise”. (Choudary et al., 2016) states also that network effects refer to “the impact that the number of users of a platform has on the value created for each user”.

The network effects can be very powerful, especially when they are “direct” (sometimes called “same-side”) between the platform and the user of the complementary innovation. There are also “cross-side network effects,” sometimes referred to as “indirect network effects” and sometimes these are equally or even more powerful (Gawer and Cusumano, 2014; Hagiu, 2014).

Direct network effects are created by the impact of users from one side of the market on other users from the same side of the market. Indirect network effects arise when two or more sides of a market interact or transact with one another and benefit from the existence of a positive feedback loop (Amit and Zott, 2001; Gawer and Cusumano, 2014; Choudary et al., 2016), which means the value to customers on one side of a platform typically increases with the number of participating customers on another side (Hagiu, 2014).

In addition, these network effects may be positive or negative. Positive network effects refer to “the ability of a large, well-managed platform community to produce significant value for each user of the platform” and negative network effects refers to “the possibility that the growth in numbers of a poorly managed platform community can reduce the value produced for each user” (Choudary et al., 2016). Table 2 includes the kinds of network effects that exist in a multisided market.

Table 2: *Network effects in II-platforms.*

Kind of network effects	**Same-side network effects**	**Cross-side network effects**
Positive network effects	Positive benefits received by users when the number of users of the same kind increases (Choudary et al., 2016).	Users benefit from an increase in the number of participants on the other side of the market (Choudary et al., 2016).
Negative network effects	Downsides to the numbers growth on one side of a platform (Choudary et al., 2016).	Downsides to the numbers growth on the other side of a platform (Choudary et al., 2016).

In the case of II-platforms, end-users and application developers are each one in one side of the market. Same-side network effects are the impacts that end-users create on end-users or app developers create on app developers. Cross-side network effects are the impacts that end-users create on app developers or app developers create on end-users. At the same time, these direct and indirect network effects can be positive and negative (see Figure 7).

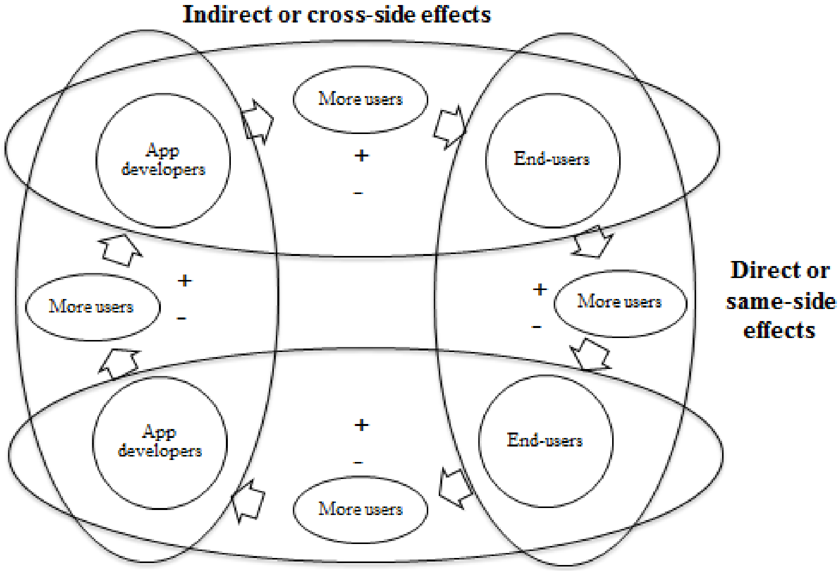

Figure 7: *Types of network effects in II-platforms.*

3. ROLE OF OPENNESS IN II-PLATFORMS

3.1 OPENNESS IN II-PLATFORMS

3.1.1 CONCEPT OF OPENNESS

As explained in section 2.4, a phenomenon that is attributed with platforms is that there is a certain openness in the platforms (Mack and Veil, 2017). According to Goeffrey Parker and Marshall Van Alstyne in collaboration with Thomas Eisenmann, “a platform is open to the extent that (1) no restrictions are placed on participation in its development, commercialization, or use, or (2) any restrictions-for example, requirements to conform with technical standards or pay licensing fees-are reasonable and non-discriminatory, that is, they are applied uniformly to all potential platform participants”.

A platform includes four types of participants (Eisenmann et al., 2008):

(i) Demand-side platform users or “end-users”,
(ii) Supply-side platform users or “application developers” who offer complements employed by end-users and the core platform,
(iii) Platform providers who serve as users’ primary point of contact with the platform and
(iv) Platform sponsors who exercise property rights and are responsible for determining who may participate in the platform and for developing in technology.

Each of these roles can be opened to encourage participation, or otherwise closed as shown in the Figure 8:

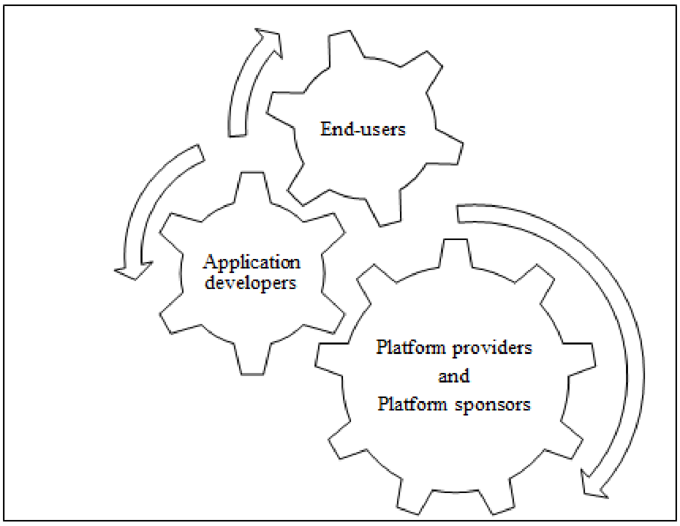

Figure 8: *Dimensions of openness in II-platforms.*

3.1.2 DIMENSIONS OF OPENNESS

Industrial companies need to choose the platform with an optimal level of openness that suits the requirements for all the different partners across the supply chain such as customers, suppliers, etc. Decisions related to the level of openness are critical, challenging and complex.

According to (Choudary et al., 2016) there are three degrees or dimensions of openness that platform managers need to consider when managing and designing the platform:

- User participation: The end-users can add content to the platform. The degree of openness can vary depending on three sub-dimensions: the access to information in the platform to build applications, the rules that allow the usage of platform, and the fee to get the access (license fee) (Gawer and Cusumano, 2014). In the Table 3 the different kinds of rules that govern the platform are described:

Table 3: *Types of rules governing the II-platform.*

Types of rules governing the II-platform	Characteristics
Platform rules	• Provider rules: Principle of transparency that encourages members to share the insights or any others behaviours or pricing policies to avoid the appearance of a monopoly (Choudary et al., 2016). • Sponsor rules: Standards that ensure compatibility among different components (Eisenmann et al., 2008).
Participant rules	• Rules that help to coordinate the participants' activities (Eisenmann et al., 2008). • Protocols that govern information exchange (Eisenmann et al., 2008). • Contracts that specify terms of trade and the rights and responsibilities of network participants (Eisenmann et al., 2008). • Security rules that penalize the violation of privacy rights and intellectual property and guarantee confidentiality (Choudary et al., 2016). • Quality control rules that inspect what is developed/shared and the quality content (sufficient information and transparency) (Choudary et al., 2016). • Tools and systems that serve to mitigate the effects of risk (For e.g. legal sanctions to bad participants or reward to good participants) (Choudary et al., 2016)
Stakeholder behaviour rules	• Policies that constrain user behaviour (Eisenmann et al., 2008) (For e.g. Developers have to submit all code for review)

- Developer participation: Developers create additional value for users making applications over the platform using the data and information from the platform (Eisenmann, 2008; Gawer and Cusumano, 2014). There are three kind of groups that add value to the interactions on a platform:
    - Core developers: They create the core platform functions and are responsible for the basic platform capabilities that provide value to platform participants through tools and rules. They are employed by the platform manager company.
    - Extension developers: They add features and value to the platform and enhance its functionality. They are usually third parties, not employees by the platform manager company.
    - Data aggregators: They gather data from different sources about platform users and resell it to other companies for purposes such as advertising. They can match platform users with producers that supply valuable products or services for them. They analyse customer's behaviours and anticipate future needs and purchasing abilities.
- Managers (providers) and sponsor participation: The platform manager organizes and controls end-users relationships as well as the outside developers' interactions; they influence the daily operations of the platform. The platform sponsor controls the overall architecture of the platform, the intellectual property and the allocation of other rights; which gives legal and economic control over the platform and a larger measure of power over its long term strategy. The four models that exist depending on the participation of providers and sponsors are (see Figure 9):
    - Proprietary model: The platform has only one provider managing the platform and serving the users and one sponsor controlling the platform.
    - Licensing model: The platform has many providers managing the platform and serving the users and one sponsor controlling the platform.
    - Joint venture model: The platform has one provider managing the platform and serving the users and many sponsors controlling the platform.
    - Shared model: The platform has many providers managing the platform and serving the users and many sponsors controlling the platform.

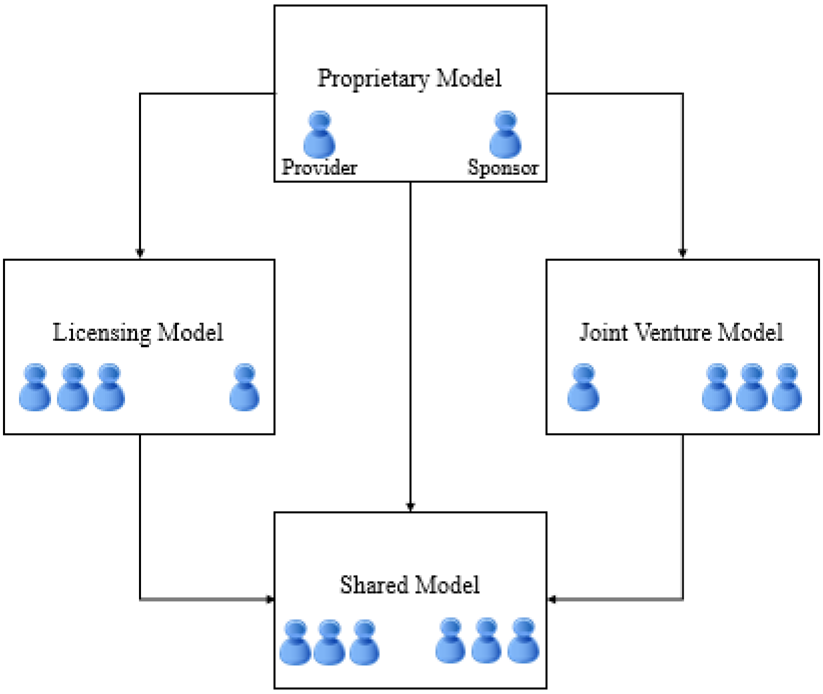

Figure 9: *II-platform models.*

(Menon et al., 2016) used this information to create the framework of openness, which contains the dimensions and sub-dimensions of openness. The more open the platform is in these three dimensions, the more easily it is for the different parties to access and share the relevant data through the platform. According to (Eisenmann et al., 2008) the demand-side user is completely open when any organization or individual can use the platform. The supply-side user is completely open when any party can offer a platform compatible software application. The platform provider side is completely open when any party can bundle the platform OS with server or personal computer hardware and the platform sponsor side is completely open when any party can contribute improvements to the platform OS. The Table 4 presents the meaning of each dimension in terms of openness:

Table 4: *Meaning of the dimensions of openness in terms of openness.*

Openness criteria	Detailed criteria	Meaning in terms of openness	References
Demand-Side User (End User)	**Access to information** (open standards)	Increasing the openness of access to information means the user can access more information on interfaces or make greater use of its capabilities through more open standards which means more interoperability.	(Gawer and Cusumano, 2014)
	Cost of Access (as in patent or licensing fees)	Increasing the openness of cost of access means reducing the price end-users have to pay to access the information. If the cost of access is fully open, the cost of access is free. If the cost of access is close, the users have to pay a fee.	(Gawer and Cusumano, 2014)

	Control in terms of rules to use the platform (governance)	Increasing the openness of control in terms of rules to use the platform means that the rules governing use of the platform give greater power to the users to regulate the access (who is allowed to join?) and the interactions (what are the various sides allow to do?). Open governance allows players other than the owner to shape the rules of trade and reward sharing on the platform.	(Gawer and Cusumano, 2014; Mack and Veil, 2017)
Supply-Side User (Application developer)	**Core Developers**	Increasing the openness of core developers means core developers can access to more customer data and information and develop more sophisticated applications for users providing better tailor made solutions.	(Choudary et al., 2016)
	Extension Developers (3rd Party)	Increasing the openness of extension developers means extension developers can access to more data and information and add more features (applications) and value to enhance the functionality of the platform.	(Choudary et al., 2016)
	Data Aggregators	Increasing the openness of data aggregators means data aggregators can access to more data and information and merge similar data from various industries creating high insights and even resell it to the companies.	(Choudary et al., 2016)
Platforms Provider and Sponsor related openness	**Proprietary Model**	Opening a proprietary model means moving towards a Licensing, Joint venture or Shared model by increasing the partnership. Proprietary model is the closest model.	(Eisenmann et al., 2008)
	Licensing model	Opening a Licensing model means moving towards a Shared Model by increasing the number of sponsors.	(Eisenmann et al., 2008)
	Joint Venture Model	Opening a Joint Venture model means moving towards a Shared Model by increasing the number of providers.	(Eisenmann et al., 2008)
	Shared Model	Shared model is the most open model.	(Eisenmann et al., 2008)

3.2 IMPACTS OF II-PLATFORM OPENNESS ON THE END-USER SIDE

In the previous section 4.1.2, it was explained that decisions related to the right level of openness are challenging because it affects usage, developer participation, monetization and regulation. If it is too close, it means there are rules that discourage participation and innovation or there are excessive fees to end-users. If it is too open, the system becomes very fragmented and it is difficult to control the intellectual property and to monetize. Also, it is more difficult to maintain a high quality at the same time the accessibility to all the participants is guaranteed (Choudary et al., 2016).

However, in general openness has a lot of benefits. It fosters the adoption of the platform because of the positive network effects. In addition, openness stimulates the creation of features and goods that meet the users' needs, reduces user's switching costs and lock-in and increases competition in the platform provider side (Eisenmann et al., 2008).

The methodology followed in order to identify the impacts that II-platform openness has on end-users is the next one:

(i) Identification of the general impacts, which includes benefits and downsides, of each sub-dimension of openness.
(ii) Identification of the main impacts within the overall impacts.
(iii) Identification of the relationship between the main impacts.

3.2.1 GENERAL IMPACTS

This section aims to study what kind of impacts appear when the different dimensions of openness are opened and directly affect the II-platform end-user. The Table 5, Table 6 and Table 7 contain the main impacts for each side (demand-side, supply-side, platform provider and sponsor side) in order to facilitate the understanding. After, the main ideas are developed below each table.

Table 5: *Impacts that the openness of the demand-side creates on the end-user.*

Openness criteria	Detailed criteria	Type of impact	Impacts on end-user
Demand-Side User (End User)	Access to information	Benefits	• The access of information facilitates the creation and provision of as much high quality content as possible, so end users can develop better applications or create higher insights (Choudary et al., 2016).
		Downsides	• Sharing on a mass-scale can create problems of security. • If the information doesn't have the right quality and quantity, then it is not possible to create quality content, nor insights. • Risk of failing in innovation due to more transaction costs.
	Cost of Access	Benefits	• "More open" means less investment and "more close" mean higher quality control and security.
		Downsides	• If it is close, end-users have to invest a big amount of money (special problem for SME's

			companies). Also, there are other costs related such as training costs (Gebregiorgis and Altmann, 2015).
	Control in terms of rules to use the platform	**Benefits**	• If it is open, end users have the power to decide about who can participate and how to use the platform, they "own" the platform.
		Down-sides	• If it is close, the platform fix the rules and the end-user lose power.

Opening the "access to information" implies that there are more open standards and more information (information about suppliers, designers, customers, etc.) is shared which is positive; however, sharing confidential information is risky. (Hallikas et al., 2002) explains that network cooperation is risky and increases transaction costs but not sharing information creates even more transaction costs and uncertainty.

If there is a huge amount of information but the information accessed is not accurate, complete or delivered on time; or the ease of operation (easy to aggregate, combine or manipulate to meet needs) is low then it is a downside. In addition, if there is too much information it is difficult or impossible for customers and providers to find the best match (Choudary et al., 2016). This explains the importance of having the right quantity and quality of information in the right moment at the right place.

"Cost of access" sometimes is preferable to be close which means that the access to information is sufficiently restricted and protected against unauthorized access and at the same time it is a guarantee that customers have enhanced access to data and information (Choudary et al., 2016).

But making a platform-specific investment is very risky, that's why some platforms provide a test period which allows the users to try the platform first. Also, the risk of no participation of partners or low effectiveness of partners has to be taken into account before making the investment.

It is important to understand that some costs such as training and learning costs that are considered as downsides in the short-term can be a source of competitive advantage in the long-term. In conclusion, technological investment decision-making can increase switching costs and it is a risk that can create lock-in (Hagiu, 2014).

In "Control in terms of rules to use the platform", when there are open source platforms anyone can inspect the code and see what it does, this means transparency between the partners (Choudary et al., 2016). If the source codes are freely available for all the participants (it is allowed to modify and use them); technology and the platform can be improved by developers. But there are also downsides of letting all members to participate in the platform because too much competition may discourage to invest in developing high quality products or services (Hagiu, 2014).

Table 6: *Impacts that the openness of the supply-side creates on the end-user.*

<table>
<tr><th>Openness criteria</th><th>Detailed criteria</th><th>Type of impact</th><th>Impacts on end-user</th></tr>
<tr><td rowspan="6">Supply-Side User (Application developer)</td><td rowspan="2">Core Developers</td><td>Benefits</td><td>• Core developers can create customized solutions and deliver value (Choudary et al., 2016).
• Functionalities and features reduce search costs, transaction costs and product development costs (Hagiu, 2014).</td></tr>
<tr><td>Downsides</td><td>• More applications mean more search costs when selecting the best application.
• Asset specific investments users can make in certain apps increases uncertainty, transactional costs and switching costs, which can create lock-in (Hallikas et al., 2002).</td></tr>
<tr><td rowspan="2">Extension Developers (3rd Party)</td><td>Benefits</td><td>• Extension developers can provide valuable extra services and customized service to platform users (Choudary et al., 2016).</td></tr>
<tr><td>Downsides</td><td>• Poor quality service providers can join the platform if it is too open and many providers of the same type of service and reduce the incentive of developers to customize services (Choudary et al., 2016).</td></tr>
<tr><td rowspan="2">Data Aggregators</td><td>Benefits</td><td>• Consumer experience improves in the platform because they can match platform users with producers whose goods, services or technologies are interesting and potentially valuable for them.</td></tr>
<tr><td>Downsides</td><td>• They can access and merge information creating poor quality information.
• End users may not want other companies/industries to have their intellectual property.</td></tr>
</table>

In general, app developers create customized applications and features that add value to the platform. However, there are downsides because customized solutions increases switching costs and the fact of multiple developers joining the platform can increase search costs because the end-user has to spend more resources in finding the best solution for their needs.

When "Core developers" and "Extension developers" are opened, on one hand innovation increases based on an increase of diversity (Boudreau, 2010), but on the other hand innovation can lead to excessive complexity, which makes the platform more difficult for users to navigate (Choudary et al., 2016). The usefulness of diversity depends on whether the complementors are motivated and willing to contribute significant investment and effort. Wider access can reduce incentives by strengthening direct competition (Boudreau, 2010).

"Data aggregators" as app developers contribute to improve the end-user's experience but, if this sub-dimension is very open, it is risky because they are using companies' data and information. There is not much theory related to this detailed criteria.

Table 7: *Impacts that the openness of the platform provider and sponsor side creates on the end-user.*

<table>
<tr><th>Openness criteria</th><th>Detailed criteria</th><th>Type of impact</th><th>Impacts on end-user</th></tr>
<tr><td rowspan="8">Platforms Provider and Sponsor related openness</td><td rowspan="2">Proprietary Model</td><td>Benefits</td><td>• More integrated systems and unified design approach than shared platforms (Eisenmann et al., 2008)</td></tr>
<tr><td>Downsides</td><td>• Users can suffer hold-up in the form of aggressive price hikes because the platform has no rival platforms (Gawer and Cusumano, 2014).</td></tr>
<tr><td rowspan="2">Licensing model</td><td>Benefits</td><td>• Licenses may have unique capabilities to create platform varieties that meet users' differentiated needs (Eisenmann et al., 2008).</td></tr>
<tr><td>Downsides</td><td>• Customers may insist upon a second source of supply to reduce vulnerability to hold-up and supply interruptions (Eisenmann et al., 2008).</td></tr>
<tr><td rowspan="2">Joint Venture Model</td><td>Benefits</td><td>• Many sponsors are developing technologies together, which may produce higher quality products (Eisenmann et al., 2008)</td></tr>
<tr><td>Downsides</td><td>• The inherent awkwardness of multisponsor decision making can affect the elegance, simplicity, and ease of use of technology (Choudary et al., 2016).</td></tr>
<tr><td rowspan="2">Shared Model</td><td>Benefits</td><td>• Product and technology compatibility reduces end-users' switching costs are reduced such as platform-specific investments (hardware, software, training) or learning the platform's rules (Eisenmann et al., 2008; Choudary et al., 2016).
• Users are protected against hold-up (Eisenmann, 2008).</td></tr>
<tr><td>Downsides</td><td>• Shared platforms do not always provide protection against hold-up.
• Incompatible variants of the platform can be created and innovation can be retarded (Eisenmann et al., 2008) due to the legacy systems of companies.
• Shared platform model can create monopoly.</td></tr>
</table>

In a “Proprietary model” there is only one sponsor and one provider, which means there is a strong control that leads to more qualified products (Anvaari and Jansen, 2010). (Choudary et al., 2016) explains, this model provides more intuitive tools and services because there is only one standard control by a single company has a unified aesthetic and technical vision, rather than a more open model. But in a proprietary model there are also risks because in the absence of competition, the end-users can suffer abuse in the form of large price increases. Large users can act strategically but small network users have more difficulties to protect themselves from hold-up.

In a “Licensing model” as there are more providers, they can offer solutions that meet better the needs of the end-users; however, the hold-up problem is still there.

Openness at the sponsor level implies greater openness at the user level, as it implies not only non-discrimination in platform access, but also in the process of defining platform standards (Eisenmann et al., 2008). In the “Joint Venture model” more open means many sponsors that are jointly working to develop a technology, which means there is a high collaboration between them, they share expenses, and they can create products with a very high quality. In addition, many sponsors means more open standards, which is more interoperability, that reduces end-user’s lock-in (Eisenmann et al., 2008). But the fact that there are multiple sponsors deciding difficult the use of technology.

In general, a more open model such as Joint Venture or Shared model, means more innovation because of more partnership but it could also delay or reduce the investments because of more competition and this can slow innovation (Eisenmann et al., 2008).

In a “Shared model”, as in a Joint Venture model, there are many sponsors who decide backward compatibility between next-generation platforms and previous platform generations. In a Shared model, sponsors collaborate and compete with each other in providing differentiated but compatible versions of the platform to users. This means that users can switch between rival providers of a shared platform (Eisenmann et al., 2008).

A Shared model includes platforms that are interoperable, it entails that users from these platforms can interact, not only the demand-side but also the supply-side that offer features and enhance functionality to the platform (Eisenmann et al., 2008). Another benefit of a Shared model is that multihoming costs are reduced because users don't need to affiliate to several platforms; they have access to several platforms with the same cost of access.

In the Table 7 it is written that the Shared model protects you against hold-up, but the truth is that this model does not always provide protection because if the platforms lead the market, they can be organized in ways that limit the price competition. They can control the price and in the case that network effects increase, the prices increase too.

However (Mack and Veil, 2017) argues that as long as platforms can differentiate and switching costs are not too high for customers, monopolization is rather unlikely. Although it is difficult, such agreements may be challenged by regulators or antitrust courts to avoid illegal price fixing or restraint of trade (Eisenmann, 2008).

It is important to emphasise that, especially when there is a fast and continuous technological change, a very open model requires high effective data management, if it is not well manage between platforms transactional costs can increase (Hallikas et al., 2002).

3.2.2 MAIN IMPACTS

Once the general impacts are described, as explain in the introduction at the beginning of 4.2, a selection between the general impacts has been done in order to deepen the study. The four main categories of impacts are: Interoperability, Positive Network effects, Transaction costs and Switching costs. In this section each impact will be explained individually and in the next section 4.2.3 a relationship between all the main impacts will be done.

A. Interoperability

Interoperability enables devices, and systems to communicate seamlessly and ubiquitously (GE), devices from one app connected with devices of another app and users from one platform connected to users of another platform. Interoperability is defined properly by (Opara-Martins et al., 2014) as, "the ability of cloud computing services, from different providers, and other applications or platforms that are not cloud dependent to seamlessly exchange assets".

Interface standardization is the key to ensure technical interoperability. It refers to the extent to which app and platforms can communicate, interoperate, and share resources and exchange data through those interfaces, protocols or rules that can't change. This means that if apps are changed, it shouldn't be a problem (Tiwana, 2013; Cepeda and Figueredo, 2016).

Interoperability with rival platforms is a progressive strategic choice from the platform owner's perspective. If the market is young , a dominant platform is likely to avoid interoperability but once platforms are stablished they need compatible policies (Eisenmann et al., 2008). In addition, incompatibility is more profitable when end-user needs and preferences are more heterogeneous and network effects are relatively low (Tiwana, 2013).

Table 8 explains how the dimensions of openness are affected when interoperability is added to the platform:

Table 8: *Main impacts that affect users: Interoperability.*

Main impacts that affect users	Main dimension of openness affected	Explanation
Interoperability	Demand-side users (End-users)	• Interoperability allows end-users to access information of other users and applications in the same platform or cross-platform through open standards (Eisenmann et al., 2008).
	Supply-side users (App developers)	• Application developers can adapt their apps to multiple platforms (Eisenmann et al., 2008) and generate innovation. • Interfaces and a modular architecture specify the basic set of rules to ensure the technical interoperability of apps with the platform. A modular architecture ensures interoperability between platforms and apps.
	Platform Providers and Sponsors	• Platforms owners can choose to make a platform incompatible with a rival platform, one-way compatible (where the focal platform can interact with a rival platform but not the other way around), or compatible both ways (where a rival platform can interact with the focal platform as well). • Opening a platform (from proprietary to shared model) needs an increase of interoperability (Gawer, 2011). • Interoperability may eliminate the motivation for some users to multihome.

B. Positive network effects

Network effects are explained in section 3.4, but Table 9 contains elaborated information of how the dimensions of openness are particularly affected by positive network effects.

Table 9: *Main impacts that affect users: Network effects.*

Main impacts that affect users	Main dimension of openness affected	Explanation
Positive network effects	Demand-side users (End-users)	• More end-users who value improvements in functionality and usefulness of a platform attract more app developers (positive cross-side network effects) increasing the variety of apps available to end-users. This in turn attracts more

		end-users to the platform (positive same-side network effects) creating a feedback loop that feeds on itself (Tiwana, 2013).
	Supply-side users (App developers)	• More app developers attract more end-users to the platform (positive cross-side network effects). This in turn attracts more app developers (positive same-side network effects) to a platform, creating a feedback loop that feeds on itself (Tiwana, 2013).
	Platform Providers and Sponsors	• Opening the platform side means increasing partnerships; for e.g. in a shared model more platforms will be together, therefore, more users will be in the same network, and this will create positive network effects.

C. Transaction costs

Transaction cost management is an issue of resource allocation and reducing transaction costs which improves efficiency and effectiveness (Suematsu, 2014). The transaction effectiveness increases when more time and effort is spent. Platforms dramatically lower transaction costs (Choudary et al., 2016), an example could be that, each machine utilizes better its resources providing a reliable service; another example is the effort and cost of trustworthiness that prevented exchange is reduced. The types of transaction costs are described in the following Table 10 and include search, presentation, contracting, exchange, monitoring and enforcement costs:

Table 10: *Types of Transaction Costs.*

Types of Transaction costs		
Transaction costs	**Searching**	Gathering information to identify and evaluate potential trading partners (Dyer, 1997).
	Presentation	Presenting their needs and requirements to the suppliers and understanding and evaluating their products and services and characteristics (Suematsu, 2014).
	Contracting	Negotiating and writing an agreement (Dyer, 1997).
	Exchange	Processing documentation of orders, confirmation of acceptances and deliveries, inspections, payments, and so forth (Suematsu, 2014).
	Monitoring	Monitoring the agreement to ensure that each party fulfils the predetermined set of obligations (Dyer, 1997).
	Enforcement	Ex post bargaining and sanctioning a trading partner that does not perform according to the agreement (Dyer, 1997).

Opening a platform (open intellectual property, relationships or innovations) requires sharing and trustfulness (Suematsu, 2014). The transaction costs are reduced due to improvements in information on terms of symmetry, speed, etc. In addition, if more information regarding a partner and transaction conditions, is presented in both directions, the probabilities of finding the best product and partner and of determining transaction conditions that satisfy both must increase. Interfaces decreases transaction costs and makes sharing fundamentally easier (Suematsu, 2014). The Table 11 explains how dimensions of openness are affected by transaction costs:

Table 11: *Main impacts that affect users: Transaction costs.*

Main impacts that affect users	Main dimension of openness affected	Explanation
Transaction costs	Demand-side users (End-users)	• Improved information can reduce end-users search and bargaining costs, as well as opportunistic behaviour by establishing responsibilities and controlling transactional decisions which allows organizational and operational flexibility (Amit and Zott, 2001).
	Supply-side users (App developers)	• Open source means the cost of negotiation disappears since the price is agreed as zero a priori, encouraging participation of app developers and effectiveness of transaction costs (Suematsu, 2014).
	Platform Providers and Sponsors	• A huge amount of transaction costs (such as monitoring costs) are required to protect against hold-up, to scape it is necessary looking for a new partner, negotiating a contract, etc. (Suematsu, 2014). Good governance is the key to avoid hold-up. • Platforms allow providers to create new switching costs that are the same time are enabling end-users to reduce traditional ones such as transaction costs, search costs, etc. (Choudary et al., 2016).

D. Switching costs

(Tiwana, 2013) explains that “an end-user incurs a switching cost associated not just with having to abandon the investment in a platform but to abandon benefits that accumulate from having used a platform”, this means switching costs include investments costs and opportunity costs (Hess and Enric Ricart, 2003).

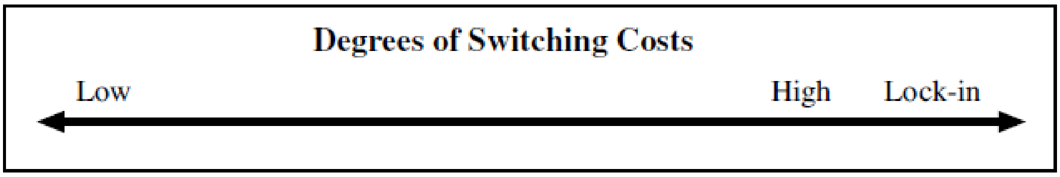

Figure 10: *Degrees of Switching Costs (Hess and Enric Ricart, 2003).*

As shown in Figure 10 switching costs evolve during the time and have different degrees, a high degree of switching costs creates lock-in (Choudary et al., 2016). (Amit and Zott, 2001; Mack and Veil, 2017; Opara-Martins et al., 2014; Silva et al., 2013; Tiwana, 2013; Marinoso, 2001) explain that there are several reasons why consumers face lock-in in II-platforms, the set of all of them is exposed below:

- Limited rights and controls for users.
- Ambiguous and ultimately expensive switching costs (for e.g. training and learning costs) and vendor complacency.
- Contractual terms.
- Physical holding of the customer's data.
- Designing a system incompatible with software developed by other vendors (technical incompatibility).
- Using dominant design proprietary standards that lack interoperability with other applications.
- Licensing the software under exclusive conditions.
- Platform-specific investments to affiliate the platform.
- Non-portable network effects.
- Personalization and customization.
- Lowering end-user's search costs.
- Loyalty programs.
- Trustful relationships with customers.

The next section 4.2.3 explains better the relationship between switching costs and lock-in. Table 12 contains information related about how switching costs affect all the participants in the II-platform.

Table 12: *Main impacts that affect users: Switching costs.*

Main impact	**Main dimension of openness affected**	**Explanation**
Switching costs	Demand-side users (End-users)	• Switching costs are created by app developers and the platform owners to retain end-users in the platform.
	Supply-side users (App developers)	• App developers offer special features and complementarities for end-users that increase

		efficiency, switching costs, reduce transaction costs and foster lock-in (Amit and Zott, 2001)
	Platform Providers and Sponsors	• A proprietary platform creates greater switching costs than an open model such as shared model because opening a platform typically reduces users' switching costs and increases competition among platform providers (Eisenmann et al., 2008).

3.2.3 SWITCHING COSTS

The Figure 11 shows the relationship between the impacts presented in the previous section 4.2.2. It is possible to see that all the impacts create an effect, positive or negative, on the switching costs.

Positive network effects increases switching costs slowly (this is the reason why there is a delay) because users have a network that is useful for them and they won't like to move. In addition, an increase in positive network effects creates an increase in interoperability, this is because the market demand and the ability to attract more customers are creating more pressures on platform providers to support interoperability (Opara-Martins et al., 2014) and users' willingness to pay for platform affiliation increase when interoperability provides access to a larger total user base (Eisenmann et al., 2008). There is a delay because only very strong positive network effects foster platform sponsors to increase interoperability. At the same time more interoperability creates more positive network effects because more open standards encourage users to join the platform (Eisenmann et al., 2008).

End-users favor more interoperability because it allows customization and to switch easily between platform providers. In short, more interoperability helps to reduce switching costs, a direct benefit of avoiding vendor lock-in (Opara-Martins et al., 2014). More interoperability also reduce transaction costs (Eisenmann et al., 2008) because it enhance transaction efficiency by enabling faster and more informed decision making (Amit and Zott, 2001).

Less transaction costs increase slowly the switching costs because the same changes in technology that provide platforms opportunities to create new switching costs are enabling end-users to reduce traditional transaction costs. Less transaction costs also creates positive network effects because if there are less costs while searching, contracting, etc. more users would like to join the platform. (Hagiu, 2009) states that positive network effects make transaction among the sides more efficient or more frequent or both; therefore reducing transaction costs, but the reality is that it depends on partner effectivity that those costs are actually reduced.

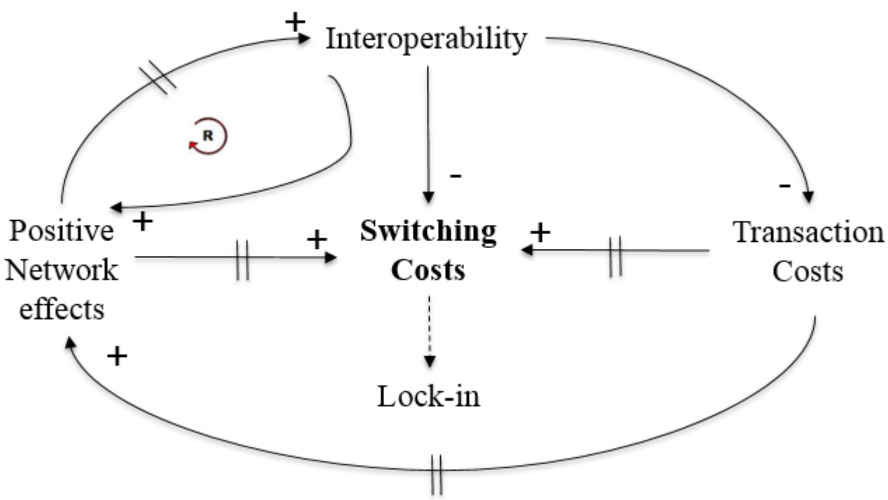

Figure 11: *Relationship between the main impacts of openness.*

In the Figure 11 it is also possible to see that switching costs lead to a lock-in position (Opara-Martins et al., 2014). However; according to (Harrison et al., 2015) switching costs is only one of the factors that create lock-in. There are four broad categories of service relationship lock-in factors emerged from the data:

1. Moral/Obligatory Factors
2. Personality Factors
3. Switching Costs and Lack of Alternatives
4. Positive Benefits of Staying

In this case, the research if focus on the third category, switching costs, because it is relevant for the topic.

Lock-in is a problem characterized by expensive and time-consuming migration of application and data to alternative providers (Opara-Martins et al., 2014), in this case it refers to the high costs the end-user would incur if he wants to switch to another platform. (Zauberman, 2003) defines lock-in as “consumers decreased propensity to search and switch after an initial investment, which is determined both by a preference to minimize immediate costs and by an inability to anticipate the impact of future switching costs”. Last definition emphases how end-users tend to consider only the short-term. Lock-in is important because it is used for the long-term taking into account future costs and benefits.

Many researches have investigated about switching costs. Table 13 gathers information of different types of switching costs from different sources:

Table 13: *Evolution of types of switching costs.*

Types of switching costs	References

• Transaction costs incurred when switching (For e.g. contracting) • Learning costs (For e.g. by switching to a new provider after having learned how to use one platform • Artificial switching costs (For e.g. created with loyalty programs that reward customers)	(Klemperer, 1987) (Beggs and Klemperer, 1992)
• Previous investments (including purchase, complementary purchase, relationship, learning/training, search, specialized supplier, loyalty programs, information and database, psychological and network costs) • Potential investments (including durable purchase, complementary purchase, relationship, learning/training, search, contractual commitment, risk of failure, switching back costs) • Opportunity costs (including network and complements costs)	(Hess and Enric Ricart, 2003)
• Setup cost (including search costs and entry and customization) • Ongoing usage costs	(Zauberman, 2003)
• Costs related to production (incurred when replacing manufacturing equipment) • Costs related to transaction (to set up the relationship with new transaction partners include search, presentation, negotiation etc.)	(Suematsu, 2014)
• Procedural costs • Financial costs • Relational costs	(Burnham et al., 2003) (Matzler et al., 2015) (Blut et al., 2016)

(Blut et al., 2016) distinguishes between three dimensions of switching costs in B2B businesses:

- Procedural switching costs: It involves the time and effort expended in locating, adopting, and using a new brand/provider as well as the uncertainty associated with this process.
- Financial switching costs: It involves the loss of financially quantifiable resources, including the monetary losses (e.g. Fees to break contract, initiation

fees to adopt a new provider) and the loss of benefits (e.g. loss of preferred access, or special status)

- Relational switching costs: It involves the loss of identification and emotional bonds with both the brand/provider and any employees with who the customer interacts.

These categories at the same time have sub-dimensions explained in the Table 14:

Table 14: *Dimensions of switching costs (Blut et al., 2016).*

Dimension of switching costs	Sub-dimension	Definition
Procedural switching costs	**Uncertainty costs**	Perceptions of the likelihood of lower performance when switching.
	Search costs	Perceptions of the time and effort of gathering and evaluation information prior to switching.
	Cognitive costs	Perceptions of the time and effort of learning a new service routine subsequent to switching.
	Setup costs	Perceptions of the time, effort, and expense of relaying needs and information to provider subsequent to switching.
Financial switching costs	**Sunk costs**	Perceptions of investments and costs already incurred in establishing and maintaining relationship.
	Lost performance costs	Perceptions of the benefits and privileges lost by switching.
Relational switching costs	**Brand relationship costs**	Perceptions of losses with breaking the bonds of identification that have been formed with the brand or company with which a customer has associated.
	Personal relationship costs	Perceptions of losses associated with breaking the bonds of identification that have been formed with the people with whom the customer interacts.

Lock-in cannot be completely eliminated, but the end-user can mitigate its impact with the right knowledge and research, planning, strategy, technical know-how and vendor selection. There are many ways to mitigate the risks: Standard solutions enables interoperability and portability (Opara-Martins et al., 2014) which at the same time helps to mitigate vendor lock-in (Silva et al., 2013); also, policies are important to ensure interoperability between platform providers and guarantee the control of the ownership and destiny of the end-user's data.

5. METHODOLOGY

5.1. CASE STUDY APPROACH

Many researchers have discussed the term ‘case study’ which is constantly appearing in publications (Yin, 2013).(Yin, 2013) gives a technical definition of ‘case study’: “an empirical enquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident”. Case study is very useful when the researchers have very little or no control over the context of the study (Yin, 2013), and there is a need to answer ‘how’ and ‘why’ questions (Ghauri and Grønhaug, 2005). II-platform openness related to switching costs is a very new topic and a case study approach is useful to learn deep phenomena.

(Mark et al., 2009; Yin, 2013) explain that there are two types of case study reporting formats:

- Single-case study is a classic format in which a single text is used to describe and analyze the case. It is relevant when the case represents a critical, extreme or unique case worth documenting; a typical or a revelatory case with unique opportunity to observe previously inaccessible or common situation; or a longitudinal case, where the same case is studied at various points in time.
- Multiple-case study which is the multiple-case version of the single-case study. This design is generally considered more applicable when researcher seeks exemplary outcomes (i.e. literal reproduction or generalization) or contrasting results for predictive reasons (i.e. theoretical reproduction) in relation to a specific theory.

This case is a multiple-case study that allows reporting the single cases in separate sections in order to have a general view of how II-platform openness impacts the end-user business and contrast the results for long-term predictions.

Case studies have usually an explanatory, exploratory, descriptive or emancipatory nature. This case study has an exploratory, descriptive and explanatory purpose because it aims to find what is going on and generating ideas for the future (such as the relationship between switching costs and openness), also it is necessary an extensive prior knowledge about the topic and it aims to identify and explain relationships (openness impacting on switching costs and businesses) (Bryman and Bell, 2015).

According to (Bryman and Bell, 2015) there are different types of research strategies: quantitative, qualitative and mixed methods. (Yin, 2015) states the difficulty of arriving to a clear and unique definition of qualitative research due to its relevance to different disciplines and professions. But there are five features that can help to define a qualitative research: qualitative research studies the meaning of people's lives under real-world conditions, represents the views and perspectives of the people, covers the contextual conditions within which people live, contributes insights into existing or emerging concepts that may help to explain human social behavior and uses multiple methods and data sources.

In this case a qualitative study has been selected and the main steps are shown in Figure 12.

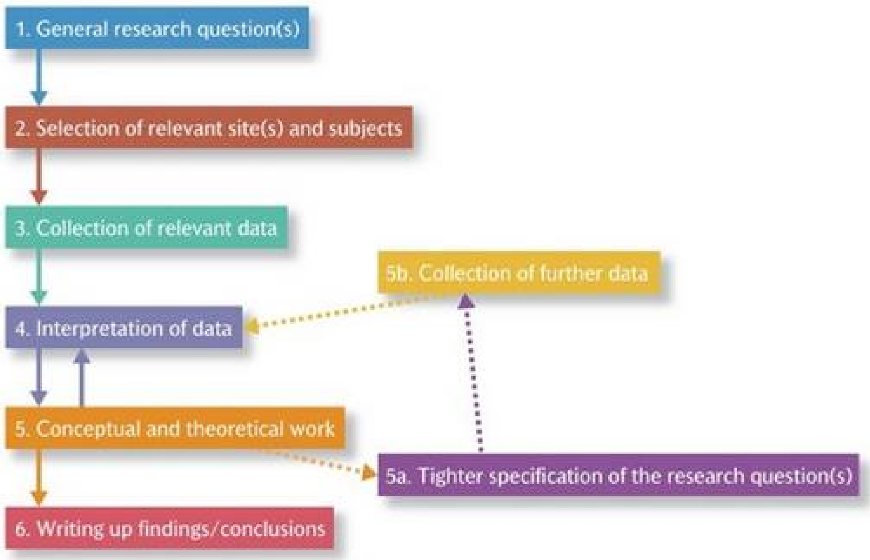

Figure 12: *The main steps of a qualitative research (Bryman and Bell, 2015)*.

In conclusion, the selected approach is a qualitative research case study, reported in a multiple-case format with an exploratory, descriptive and explanatory research nature. Case selection criteria and further implications of the research methods are described in section 4.2.1 of this chapter.

5.2. CONDUCTING THE RESEARCH

5.2.1. COMPANIES SELECTION STRATEGY

There are two main strategies for the selection of samples and cases: Random selection for generalization and Information-oriented selection to maximize the usefulness of the information collected from the single cases, which are selected carefully on what is expected to achieve with their information content (Flyvbjerg, 2006).

The selected strategy is an information-oriented selection. The subset of companies belongs to the manufacturing sector and the companies were selected based on the following inclusion criteria:

1. Companies that are end-users of one or several II- platforms.
2. Companies with respondents that have a high degree of knowledge about II-platform openness and its impacts.
3. Companies with a different/same degree of openness and different type of business which allows a broader analysis of impacts.

Figure 13 represents a supply chain in which an automation company with its own provider is supplying to a machine builder, and at the same time, the machine builder has its end customers.

The selected companies are an automation company and a machine builder company because they have different types of business and views within the same supply chain, which gives a broader perspective. In addition, they both are end-users of II-platforms; the MB uses three different kinds of platforms, unlike the AC who is the end-user of a platform owned by the same company. The next section presents the new design framework that was created to interview the companies.

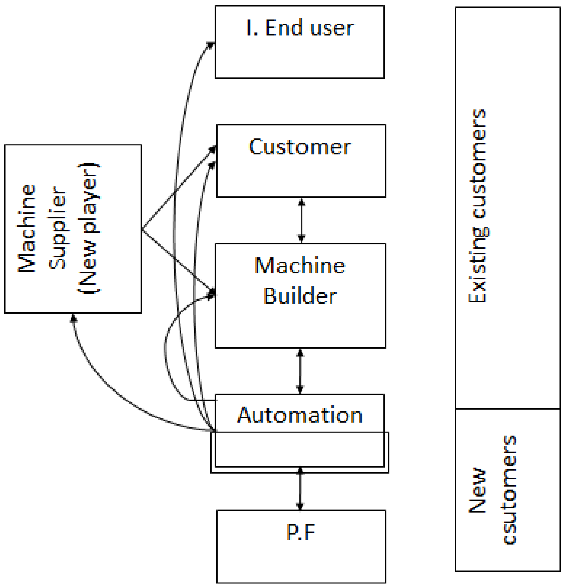

Figure 13: *Selected companies.*

5.2.2. PROPOSED FRAMEWORK FOR THE COMPANY

The main contribution of this thesis from the empirical perspective is the framework developed for the companies to identify and evaluate the impacts of openness in terms of switching costs. This framework will be used in the third section of the case study.

The proposed framework arises from the idea of showing the impacts of openness on the end-user business (see Figure 14). Openness has some dimensions and sub-dimensions, and each detailed criteria is creating some impacts on the end-user. Thus, in order to follow the criteria of the thesis (section 4.2); these impacts can be grouped in four main categories as shown below. But, Figure 11 demonstrates that the central category is switching costs. In addition to that, for the end-user it is easier to evaluate in terms of costs.

Another reason to use the switching costs framework is that the goal is to investigate the long-term downsides of openness, so as explained before the positive and high switching costs create risks in the future to the end-user. The impacts on the end-user business are visible through the evaluation but also through the 'why', which allows to understand better the business priorities and risks.

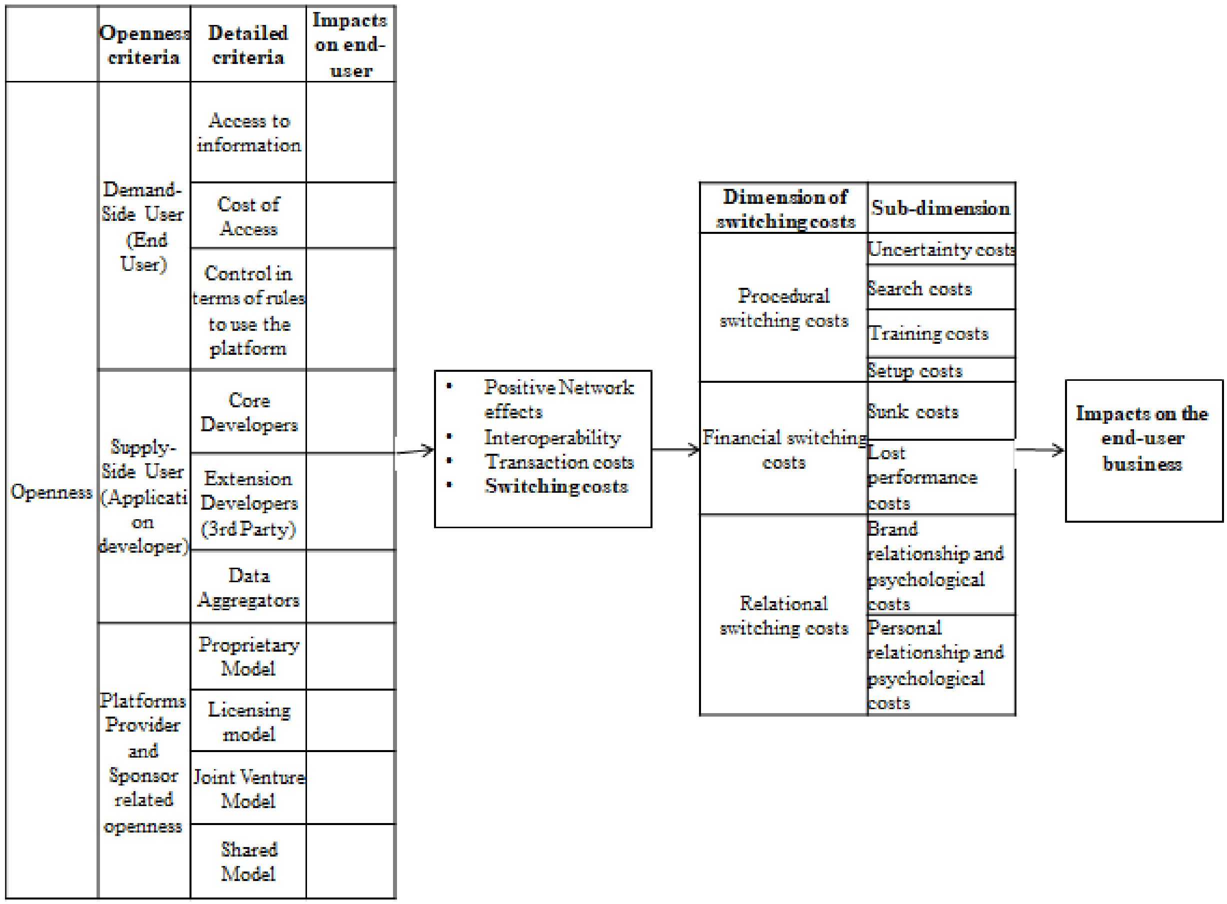

Figure 14: *Evolution for the proposed framework.*

Table 15 is a combination of the framework of openness (see Table 4) and the framework of switching costs (see Table 14), each framework contains the dimensions and sub-dimensions of both the openness and switching costs:

Table 15: *Proposed framework for the companies.*

			SWITCHING COSTS							
			Procedural switching costs				Financial switching costs		Relational switching costs	
			Uncertainty costs	Search costs	Training costs	Setup costs	Sunk costs	Lost performance costs	Brand relationship and psychological costs	Personal relationship and psychological costs
OPENNESS	End-user related openness	**Access to information** (open standards)								
		Cost of Access								
		Control in terms of rules to use the platform								
	Application developer related openness	**Core Developers**								
		Extension Developers (3rd Party)								
		Data Aggregators								
	Provider and Sponsor related openness	**Proprietary Model** (one provider-one sponsor)								
		Licensing model (many providers-one sponsor)								
		Joint Venture Model (one provider-many sponsors)								
		Shared Model (many providers-many sponsors)								

5.2.3. DATA COLLECTION

One of the most common methods to collect data in a qualitative study is interviews (Gill et al., 2008). Two interviews have been done face-to-face to individual participants from a machine builder and an automation company in order to have a deeper understanding on the impact of openness on the II-platform end-user business in terms of switching costs.

According to (Gill et al., 2008) there are three main types of research interviews: structured, semi-structured and unstructured. In this case, the interview is semi-structured which means some fundamental questions are done, but it provides the flexibility to the interviewer or the respondent to deviate in order to obtain more details of the answer or discuss any relevant topic perceived as related or important.

When designing an interview it is important to take into account several factors (Gill et al., 2008; Yin, 2015):

- The limited time for the interview conditions the type and number of questions, which should cover as much information as possible and address the goal of the research.
- Good questions in qualitative researches are open-ended, neutral, non-directive, sensitive and understandable.
- The length of interviews varies depending on the topic, researcher and participant, but usually it lasts 20-60 mins.
- The participants have to be informed about the details of the interview, and their anonymity and confidentiality must be assured.
- The interview should take place in a space without distractions, where the respondent can be productive and relax.
- Establishing rapport with the interviewees impacts positively on the development of the interview.
- One of the fundamental skills of the interviewer is to listen carefully what the respondent is answering without interruptions and analyzing while interviewing. It is important the adoption of a neutral body language and to support and encourage the participant with smiles and noises, being silent when necessary.
- All interviews should be tape recorded and transcribed afterwards. An interview guide can be used during the interview, it helps to ensure all the questions are covered and help the interviewer to take notes meanwhile.

The interview design was structured into three blocks with a total duration of 60 minutes. After explaining the purpose and background information, the flow of the interview begins with generic questions, followed by questions related to openness and ends with questions related to openness and switching costs.

Generic question:

It is important to start with easy questions and then, to go through to more difficult and sensitive subjects. Some generic questions were designed to introduce the topic to the respondents, build up confidence and to collect rich data related to the end-user business and its opinion about II-platforms and openness. The questions asked are as follows:

- *What does II-platform openness mean to you?*

- *What is the role of openness related to your particular strategy (level of openness your company would like to achieve) in the II platform? Why?*
- *What is your main industry? Why do you think the use of an II platform benefit your industry? (Purpose of the use of II platform)*
- *What are the 3-5 top business opportunities for an II platform user? Why these in the top 3-5?*
- *What are the top 3-5 business challenges for an II platform user? Why these in the top 3-5?*
- *What is the overall strategy of your company related to the growth of your business in the II Platform? (Growth of maturity in the adoption of Industrial Internet)*

<u>*Questions related to openness*</u>

Once the general questions are covered, the interviewer proceeds to the questions related to openness. It has two parts; the first one is a question about openness in general:

- *If openness is added to the II platform, what kind of impacts (positive or/and negatives) do you see in your business?*

The second part includes questions related to various dimensions of openness (degrees of openness). Therefore, the following framework (see Table 16) is provided to the participants, in which general criteria of openness are presented, as well as the detailed criteria of each dimension. The interviewees are asked to grade the level of openness and their dimension priority regarding their business:

Table 16: *Framework of openness provided to the respondents.*

Openness criteria	*Detailed criteria*	*Score*
End user related openness	*Open access to information to the user (open standards)*	
	Low cost of access to platform data and information (as in patent or licensing fees)	
	Open the control in terms of rules to use the platform (open governance)	
Application developer related openness	*Open Core Developers access to platform data and information*	
	Open Extension Developers (3rd Party) access to platform data and information	
	Open Data Aggregators access to platform data and information	
Platforms Provider and Sponsor related openness	*Proprietary Model*	
	Licensing model	
	Joint Venture Model	
	Shared Model	

- *From 0 (totally close) to 5 (totally open), what do you think is the current level of openness of each dimension of the II-platform?*
- *On a more general level, out of the three dimensions of openness, does your company prioritize one dimension over the other regarding your business? Why and how?*

Questions related to openness and switching costs

The last part is the most complex and requires the participant's concentration to answer adequately. The framework shown in Table 17 is explained to the respondent in order to proceed with the identification and evaluation of the most impacted switching costs when opening a platform. In addition, the score system is provided.

Table 17: *Framework of switching costs provided to the respondents.*

Dimension of Switching Costs	Sub-dimension	Description
Procedural switching costs	*Uncertainty costs*	*Lower performance when switching.*
	Search costs	*Gathering and evaluating information prior to switching.*
	Training costs (Cognitive)	*Learning a new service routine subsequent to switching.*
	Setup costs	*Relaying needs and information to provider subsequent to switching.*
Financial switching costs	*Sunk costs*	*Investments and costs already incurred in establishing and maintaining relationship (For e.g. specialized investments, compatibility costs, contractual commitment, etc.)*
	Lost performance costs	*Benefits and privileges lost by switching (e.g. preferred access, special status, customized solutions, etc.)*
Relational switching costs	*Brand relationship and psychological costs*	*Losses with breaking the relationship with the brand or company with which a customer has associated.*
	Personal relationship and psychological costs	*Losses associated with breaking the relationship with the people with whom the customer interacts.*

- *For each detailed criteria of openness: If it was significantly more open (to make an impact on your business), what kind of switching costs are impacted?*
- *In addition try to evaluate the impact (positive, negative, neutral or unknown) of the selected switching costs using the following scale:*

Negative switching costs		*No change*	*Positive switching costs*		*Unknown*
High (-H)	*Low (-L)*	-	*Low (+L)*	*High (+H)*	?

- *Why the high positive switching costs are impacted significantly when opening that specific openness criterion?*

Table 18: *Framework of openness and switching costs provided to the respondents.*

			SWITCHING COSTS							
			Procedural switching costs					Financial switching costs	Relational switching costs	
			Uncertainty costs	Search costs	Training costs	Setup costs	Sunk costs	Lost performance costs	Brand relationship and psychological costs	Personal relationship and psychological costs
OPENNESS	**End-user related openness**	**Access to information** (open standards)								
		Cost of Access								
		Control in terms of rules to use the platform								
	Application developer related openness	**Core Developers**								
		Extension Developers (3rd Party)								
		Data Aggregators								
	Provider and Sponsor related openness	**Proprietary Model** (one provider-one sponsor)								
		Licensing model (many providers-one sponsor)								
		Joint Venture Model (one provider-many sponsors)								
		Shared Model (many providers-many sponsors)								

- *Is there any other switching cost of opening an II-platform that is not identified previously? How it would be its level of impact?*
- *In your opinion, how difficult was to identify and evaluate the switching costs when opening the dimensions? Why?*

5.2.4. ANALYSIS METHOD

There are different ways of combining theory and data from the research. According to (Bryman and Bell, 2015) there are two methods: inductive approach means that the data is generating new theory; and deductive approach means data is tasted again using theory. However; there is another analysis method positioned between these two: systematic combining, which is closer to an inductive approach (theory development) (Dubois and Gadde, 2002). In this thesis, the analysis method used is a systematic combining approach.

This method is characterized by the role of the framework. The original framework changes constantly due to new results from the empirical part and the theoretical insights learnt during the research process.

The fundamental goal of a research process is to match theory with the empirical world, which is allowed thanks to the use of a systematic combining method. This process is possible directing and redirecting the evolution of the framework and the case study (see Figure 15).

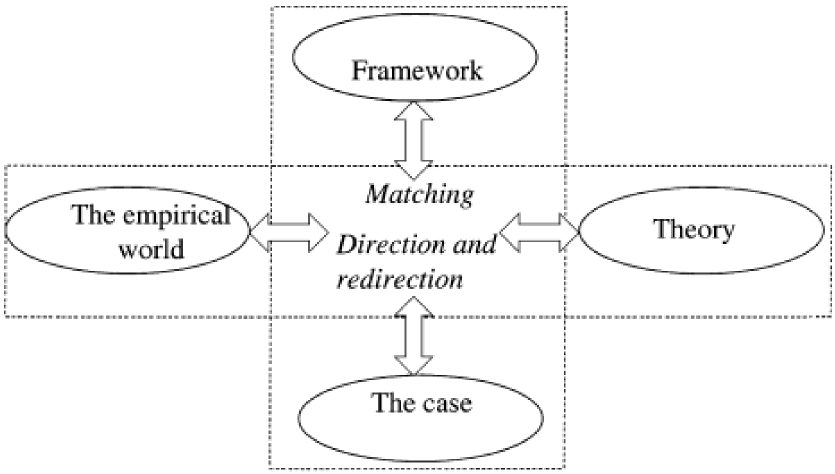

Figure 15: *Systematic combining (Dubois and Gadde, 2002).*

6. RESULTS

This chapter focuses on the results of the two case interviews done to a Machine Builder, called MB, and Automation Company, AC. The respondents from both companies answer the questions from the end-user perspective.

The structure of the chapter follows the interview structure explained in the previous section. Therefore, the findings have been divided in three sections:

5.1 Perceptions on II-platform openness (Generic and open questions).

5.2 Level of openness and prioritization (Openness framework).

5.3 Impact of openness in terms of switching costs (Openness and Switching costs framework).

6.1. PERCEPTIONS ON II-PLATFORM OPENNESS

This part contains the results and findings of the first part of the interview where some general and open questions are asked to the respondents. The questions are related to the companies' industry, benefits of the use of II-platforms, its business opportunities and challenges from the end-user perspective, their own understanding of openness and the impacts that openness creates on their business. Previously, a clear definition of II and II-platform is given to the companies.

It is possible to see that both companies have very different views and openness affects differently depending on their business and their strategy in the long-term.

What is your main industry? Why do you think the use of an II platform benefit your industry? (Purpose of the use of II platform)

The MB is making machinery and selling power plants, paper machines and tissue machines. The respondent explains: "It is a very long business track that we have built, so the red-sea market, fixed price levels we have seen there and how we are acting, how to get some additional added value for our products and have to use software, somehow differentiate our standard tissue machine from other vendor tissue machine and add value with different kind of packages of software that can optimize the energy usage, the run ability or the predictions about the maintenance spare parts, etc. So we have to know how to bring new features or additional value to our end customer by software".

The use of an II-platform benefits the MB because of the platform's ecosystem; all the participants of the ecosystem can integrate their business lines to the same platform.

The AC is producing lot of different type of hardware and software with open interfaces. Their customers can select according the requirements of the application, how and which kind of components will be used. The company explains: “This is basically our philosophy. This is giving us interesting capabilities because it is very easy to integrate the existing systems; PC-based is really helping because most of these features, what IoT is offering it is between those based or at least PC-based. We can use standard communication methods to control that. And, of course, from hardware point of view, this can be totally open, so PC or embedded PC, or if the customer is really willing to have something special, which is embedded close system, of course we can do that also”.

The AC has a platform which is a combination of hardware plus software plus the services to integrate this package. The II-platform benefits the company giving them flexibility which is their main point. The respondent specifies: “Services as, customer is willing to do this application, sometimes they really want to do it by themselves because they have the knowhow, but in some cases they want to have a lot of support from us which is basically meaning that we are doing the whole programming of the automation system (development of applications and implementation of the system) and everything between that”.

As shown in the Figure 16, there is a portfolio in which one part can be called IoT. There are tool boxes where customers can select different kind of components from hardware and software point of view:

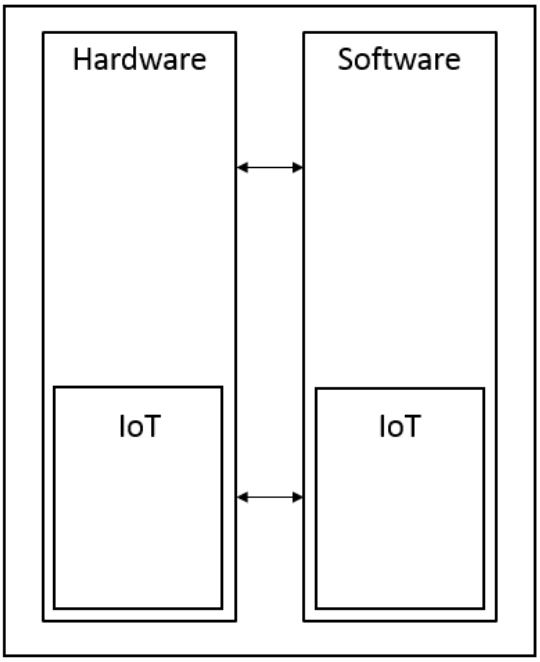

Figure 16: *II-platform of the AC.*

What are the 3-5 top business opportunities for an II-platform user? Why these in the top 3-5?

The MB, thanks to the use of II-platforms, knows better how the customer is using the machine which allows the company to learn how the customer is making profit with that machine. The company explains: “We can actually see how he manages to do the better performance, how they are running. In Europe, they can actually pre-calculate and sub-produce the paper beforehand; they know where the material and the energy are and the other regulations, so they can focus on optimizing their production”.

II-platforms also help the MB to know how the company is making the spare part business that allows optimizing its own stock and production.

The AC is developing everything on their own because it allows the company to maintain control, be flexible with the customer, work with different kind of industries, fulfill the requirements, and also there is a reason of earnings. The company explains: “We are doing the entire R&D, all the PC pots, everything by ourselves and then, we are flexible to ask what the requirements of the customer are because we have free hands and we have enough capabilities inside the house”.

In the Figure 13, it possible to see the AC existing customers (customer base already generated). However, in the future, there will be a growth in this area with new customers (15% increase as the AC has done last 20 or 30 years) due to the supply of the IoT related products and services. The company explains: “To get that new business I think that, this can be one of the main questions, how we are surviving there. As I said, we have this connectivity, which is meaning that we are supporting basically all the field buses, all the communication protocols, also for the IoT, we are wondering what will be our scope of supply in certain cases in the future”.

What are the top 3-5 business challenges for an II-platform user? Why these in the top 3-5?

The MB affirms that the main challenge is always security. It is also challenging to get the customer trust and to add some value that the customer is willing to pay.

The AC explains that there are some risks for an II-platform end-user. As shown in the Figure 13, there can be a new player who can have the supplier power to the machine builder (AC’s customer) and can take part of the AC’s business, who can become a sub-contractor of the new supplier. The company explains: “In this case, it will affect to us also because we have to start to play with this one, it could be so that it is having different kind of rules as the traditional machine builder and way of earning. That is something we have to be aware, what is going on. It can be really important in the slow but new potential customer area”.

What does II-platform openness mean to you?

The MB explains that II-platform openness means standard protocols. The respondent clarifies: "You have the SDK's really available from the GitHub, so you can study and use those, so you don't have to pay any licenses at that point, and you have a lot of documentation and examples so you get everything you need to start to implement, study or find solutions for your problems".

The second part of the meaning of openness is the standard pricing you will get. The MB explains: "You have perhaps some tool that will calculate the cost if you use so much disk, so much memory, so much CPU, and those components. Therefore, you can actually make the estimated price, before buying, using or implementing". In addition, openness means for the company, the ease of documentation and ease of information available that it is not necessary to search for it.

For the AC II-platform openness means open interfaces in order to connect different kind of other systems (also competitor systems). The company explains: "We are thinking that we are winning more with this opening than losing because we have such a good connectivity to other systems and it has happened in the last 20-30 years".

What is the role of openness related to your particular strategy (level of openness your company would like to achieve) in the II-platform? Why?

The MB argues that the business part is very price-cost related; and they are not thinking of how to implement the openness but they think about the applications or added value. However; the company believes that openness creates an impact on the business related decisions in the sense that the platform has to grow coming mandatorily with new features, or some other attributes: "It has to have those features we see that in the long-term we want to integrate and start using them".

The MB says it is important to focus on openness in the long-term because it is possible to see the roadmap where the platform is actually growing. The company compares what features the different platforms are bringing because of the competition between platforms providers: "We can run some prototyping with other platforms also, because some features are coming earlier and some are coming later. Actually, I have been using some platforms with different Apps issues, to test how it is used those".

The AC explains that in the future openness will continue: "It will be the same with the IoT strategy, so we open all the interfaces and you can easily connect to other different kind of systems and we are supporting all the hardware interfaces and, of course, the communication methods or from communication frame point of view".

If openness is added to the II platform, what kind of impacts (positive or/and negatives) do you see in your business?

On one hand, the MB sees opportunities because they can implement possibly something new. On the other hand, the company explains that the feature gap can appear (gap between what is wanted by the sales and product business owners and what could be immediately given by the company): “That is very common in the business cases that the sales want to sale, and we are not yet ready to implement everything”.

In addition, the MB believes that openness makes the feature gap bigger but the goal is to maintain the gap small enough (for e.g. some months) that the new features are stable and the company/end-user doesn’t get any negative feedback from customers that are using them: “You have to get the balance with what are the latest features and what are stable and mature features. So you have to take time in testing and pre-evaluation before we decide we will take that into use”.

The AC sees also two effects. On one hand, the available market will grow because a solution can be implemented to more applications. But on the other hand, there is the risk that there will be new players who are taking this supplier power out from the company: “Imagine that the software is the thing that we are really doing, if someone is taking that software part out, starting to supply these applications software and only subcontracting some hardware from us or someone else; it becomes a problem. In addition, someone else can supply the hardware part, that´s why we have to be very competitive also separately in these both sides, not only as a full system”.

6.2. LEVEL OF OPENNESS AND PRIORITIZATION

This section contains the results related to the level of openness of the II-platform evaluated by both companies. In the case of the MB, the respondent makes reference to the three different platforms the company is using, although the knowledge is mostly from AWS point of view. The AC evaluates the level of openness of its own II-platform.

In the Table 19 and Table 20, each company explains in detail why they score that concrete level of openness, why it is beneficial to have a certain degree of openness or, on the contrary, risky. In addition, the companies prioritize which dimension or criterion is more important regarding their business and how it is affecting them.

Before proceeding to the evaluations, the framework of openness was explained to the companies, as well as the score system, using a scale 1-5, meaning 0 (totally close) and 5 (totally open). For the last dimension, provider and sponsor related openness, it was only necessary to mark with an ‘X’ the model of the corresponding platform. It is important to emphasize that the score usefulness is a matter or guidance, and it has to be mandatorily accompanied by reasoning.

MACHINE BUILDER

Table 19: *Level of openness of the II-platform evaluated by the MB.*

Openness criteria	Detailed criteria	Explanation of the level of openness	Score
End user related openness	**Open access to information to the user** (open standards)	• The MB has access to all data and information, which is stored in different but standard ways (the redshift and the S3 open storage in AWS and the end-user time series database), also data access is optimized in an effective way (all the data is stored automatically through the lambda functions).	5
	Low cost of access to platform data and information (as in patent or licensing fees)	• It is very open because the three platforms that the MB is using are competing continuously: Azure has the highest cost because they have a lot of users already using a lot of the capacity they have and they are most probably expanding those servers. The second one is IBM and AWS is the cheapest one.	5
	Open the control in terms of rules to use the platform (open governance)	• It is open but not extremely open because of the high number of interfaces. It is very complicated due to the use of three different platforms with the added difficulty of platforms integration and the development to parametrize those.	4
Application developer related openness	**Open Core Developers access to platform data and information**	• The level of openness can't be the maximum because opening this side is risky, some bad things could happen and the system can even crash. It has to be protected as the SDK's are made and other libraries that can be used.	4 (AWS) 2 (Azure) 3 (IBM)
	Open Extension Developers (3rd Party) access to platform data and information	• It is very open because the platforms have the marketplace (such as AWS, PTC, etc.) and the end-user can buy their instances. The key is to keep a balance between core developers and third party; however, AWS tools are somehow better than the marketplace tools because AWS has already the track record and long history.	4
	Open Data Aggregators access to platform data and information	• Data aggregators calculate different kind of indexes from the data and that data is calculated from all the company's customers, it is benchmarking (KPI's). It is very open because it is already implemented by the end-user who is doing business intelligence. The source code comes from the end user but the company uses the functions of the platform (S3 and redshift) and their own database features when they are aggregating.	4
Platforms Provider and Sponsor related openness	**Proprietary Model** (For e.g. AWS)	• The MB explains that they prefer the proprietary model because they are acting globally (there are multiple regions and continents, and regulations that forbid to move or store data outside), therefore there is a need for a global management provided by this	X

		model.	

The table above explains the level of openness of each sub-dimension; nevertheless there is still important information explained below.

In addition to the effective optimization of data access, AWS makes a secure solution according to the end-user and according to documentation (standards features and standard examples); avoiding the end-user to worry about some security leaks, or some other problems. Moreover, the MB really appreciates the serverless feature that AWS and Microsoft Azure are bringing which avoids the end-user to worry about how many servers are dedicated and there is no need to monitor anything.

In cost of access there is a high competition. One thing platforms such as AWS, Azure and IBM are bringing is that the end-user can see the current price of storage and other used services; some calculation makes the estimation for the next month from the current usage and a little bit from history.

The respondent explains there are different kinds of roles when using the platform: the developer role, the administrator role and some maintainers who have full access to everything. The administrator can decide to allow in or not to other users. But the company stresses that it is very complicated how to authenticate the people who are coming in. The business target was that the end-user could use the one signal sign that can be reused and the customers can login through the end-user portal to access their data but no other customers' data.

When the MB says they have a proprietary model, the company explains that platforms are starting now to provide edge on cloud edge servers (edge computing) which allows running some instances on you own machine. The MB thinks hybrid models are coming back, hybrid clouds from all those windows (IBM, Azure and AWS are bringing it) because sometimes something has to be pre-process at the machine before it is transferred. It is coming more, because it is actually the business requirements, you have to process something locally and then reduce the amount of data that you have to upload to the cloud.

The end-user finds interesting to have many sponsors and many managers, however, they think this model creates problems and delays when making a new release because the end-user perhaps has to wait 3, 4, or 5 years till for example all the others are sync, interoperability works or there are the features you the end-user wants to use. Moreover, the company thinks it could be painful to have different platforms with partners in other countries because the price will increase a lot and it could be complicated to deploy all the applications everywhere; having to rewrite most of the paths, connectivity paths, and storage paths. Only if the shared model can hide the complexity, then the end-user is in favor of this model but if there are many increased fees complexities, they prefer to stay at proprietary model.

On a more general level, out of the three dimensions of openness, does your company prioritize one dimension over the other regarding your business? Why and how?

The MB prioritizes the application development because the company is selling this part; it is definitively what affects the business: "We have to get something that we can sell fast and featured it. This is the operational model of the platform and this is the details that are not related to what is the business value".

AUTOMATION COMPANY

Table 20: *Level of openness of the II-platform evaluated by the AC.*

Openness criteria	Detailed criteria	Explanation of the level of openness	Score
End user related openness	**Open access to information to the user** (open standards)	• Access to information is open but not extremely open because the AC still can have more interfaces and methods to communicate with all the different kind of systems.	4
	Low cost of access to platform data and information (as in patent or licensing fees)	• It is not so open because there will be more service providers (not only the 2 or 3 big ones) and the AC knows the need to improve the communication requirements and the features which are coming from the customer.	3
	Open the control in terms of rules to use the platform (open governance)	• It is very close because the libraries that are open for the customers are not so critical libraries; the AC is not sharing their knowhow with their customers. However; the company has affection in the sense they can give it more features, change the source code or at least get the desired result.	1
Application developer related openness	**Open Core Developers access to platform data and information**	• Core developers have full openness because they are behaving like one company with one common goal (get customers), that's why they support the end-user fulfilling their requirements. • In the case of the customers, the company only shares the result but not how the knowhow is programmed inside the system. Although. It is a trust-related relationship.	5 (For the end-user) 3 (For the end-user's customers)
	Open Extension Developers (3rd Party) access to platform data and information	• The AC has a system partner program. The level of openness depends on how demanding an application is from technology point of view. If it is very complex, the company is able to share if business result is visible. But it also depends critically on how long relationship the company and the partners have had.	3
	Open Data Aggregators access	• There are some operators that the company is using but in a general level, no trivial data or sensitive in-	3

	to platform data and information	formation is needed to do the selection.	
Platforms Provider and Sponsor related openness	**Proprietary Model**	• This model is the AC's priority business because that's why they are putting lots of resources to get out features that are fulfilling the requirements of the customers.	X
	Licensing model	• Currently, the AC prefers to be in a proprietary model but the trend in moving towards a more open model. The end-user is already doing licensing because there will be lots of the new businesses that will force them to partner.	

In addition to this table, there is relevant information provided by the company. To begin with, the open to access to information is generally seen as an advantage that can benefit the end-user, it can help them to enter bigger part of applications under the condition of being competitive and maintaining a high technological level.

Besides, cost of access can affect the AC because their turn over is generated from hardware and software licenses. They charge nothing according to the usage, only in HMI software it might depends on how many screens and the power of the CPU. The company's goal is to open this kind of toolbox from hardware and software point of view, so if the customer wants to do his private cloud in the future when the business is bigger, he can do it and don't need to change this basic platform or application at all.

Table 20 shows that the model the end-user has is a proprietary model. However, the company is open to cooperate and do partnerships if they have enough business. Platforms such as PTC, Azure, etc. are more partners rather than competitors.

The AC thinks always in what the real added value is in this scope of supply (for e.g. producing nice hardware, from the programming environment, from the knowhow they have from different kind of applications). In conclusion, there has to be a balance between open and close, to be enough active to invent new things without losing competitive advantage.

On a more general level, out of the three dimensions of openness, does your company prioritize one dimension over the other regarding your business? Why and how?

The AC prioritizes the access to information or open standards: "We are going to the direction that all the interfaces will be open, and this closed life in systems starts to be over (of course our suppliers try to maintain this in some extent). But I think it will go in smaller and smaller parts which are having open interfaces, it doesn't matter if its industry or IT or whatever. It will be collected in smaller parts with these interfaces and the winner is the one who is able to collect from this toolbox right components and do such a system which is fulfilling the requirements best".

The company explains that they have to be able to take partners such as Microsoft or SAP, to supply the features that are fulfilling the requirements: “We need to do partnership with this kind of operators. It is coming only that we are able to offer from our hardware and software point of view these interfaces”.

How companies do their networks and how open they are is crucial for the survival: “If you are trying to do everything alone compared to one who is very good with networking and is taking the best components from different places, of course this package is more competitive. On the other hand, you are not so dependent on one supplier; in this case, you are depending on one supplier who is having this big power”.

The AC discuss that same case is happening with healthcare because they have the problem that they have one supplier for everything and if it’s not working they increase the price as a solution, turning the business in a monopoly.

6.3. IMPACT OF OPENNESS IN TERMS OF SWITCHING COSTS

This part contains the findings of the third part of the interview where some switching costs are identified and evaluated when opening significantly the sub-dimensions of the platform. Before doing this part of the interview, the switching costs framework was explained and the relation with the openness framework.

The Table 21: Switching costs evaluated by the MB. and Table 22: Switching costs evaluated by the AC. show the evaluation of the impacted switching costs for each company separately.

The reasoning of the ‘why’ of the evaluation is important for the discussion and conclusions; however, it is more relevant the explanation of the high positive switching costs as it is the goal of this thesis to analyze the downsides of openness in the long-term.

As explained each case will be presented individually, after some common results will be shown together (see Table 23) in order to facilitate the discussion and conclusions. In addition, there are some questions related to the difficulties the companies had when evaluating the framework and if there are other relevant switching costs they consider that can affect their business and they are not included in the framework.

<u>MACHINE BUILDER</u>

In the case of the MB, as it was explained before, they are using three different platforms at the same time; they chose AWS to simplify the work of the evaluation of the framework.

Table 21: *Switching costs evaluated by the MB.*

			SWITCHING COSTS							
			Procedural switching costs					**Financial switching costs**	**Relational switching costs**	
			Uncertainty costs	**Search costs**	**Training costs**	**Setup costs**	**Sunk costs**	**Lost performance costs**	**Brand relationship and psychological costs**	**Personal relationship and psychological costs**
OPENNESS	**End-user related openness**	**Access to information** (open standards)			(+) L	**(+) H**	(+) L			
		Cost of Access		(-) L				(-) L		
		Control in terms of rules to use the platform							**(+) H**	(+) L
	Application developer related openness	**Core Developers**			(+) L		**(+) H**			(+) L
		Extension Developers (3rd Party)			(+) L	(+) L	**(+) H**			(+) L
		Data Aggregators		**(+) H**			**(+) H**		**(+) H**	
	Provider and Sponsor related openness	**Proprietary Model** (one provider-one sponsor)				(-) L	(-) L	(-) L		
		Licensing model (many providers-one sponsor)								
		Joint Venture Model (one provider-many sponsors)								
		Shared Model (many providers-many sponsors)								

The score system employed by the respondents for the evaluation of the switching costs is the following one:

Negative switching costs		Positive switching costs	
High (-H)	Low (-L)	Low (+L)	High (+H)

When opening significantly the *access to information*, it means for example if the company has been using a S3 as a storage and they switch to a new storage that is cheaper and faster; there will be a transformation and the impacted switching costs will be: training costs will increase but in a low way because the training of people lasts only a couple of weeks or days, same with sunk costs because the sunk cost is one point something multiplied by some months or weeks when switching. However, the *setup cost* is most probably high because they have the setup totally new what is the storage area, the volumes and the dynamic volume, it is almost starting from the beginning if it's a new storage.

When opening significantly the *cost of access*, the switching costs will be reduced: the performance should be better and the search access to data should be faster.

When opening significantly the *control in terms of rules to use the platform*, the positive switching costs impacted are: personal relationship in a low way because when the company uses the better database, it is also for their in customers or their users, they have the state of the art that could affect them. In addition, *brand relationship* is impacted in a high way because it affects directly their customers when they are also thinking what kind of platform they should join.

When opening significantly the *core developers*, there will appear positive low training costs because they have to maintain the personal development and personal relationship switching costs. *Sunk costs* will be high because they have to maintain two branches of code.

When opening significantly the *extension developers,* there will be the same switching costs as in the core developers including the high *sunk costs*. But in addition, there will be setup costs, impacted in a low and positive way, because the company perhaps has used two versions and for the developers is always painful.

When opening significantly the *data aggregators*, all the switching costs will be impacted in a high a positive way: *search costs* because the company has to validate everything, *sunk costs* and *brand relationship costs.*

When opening the *proprietary model* towards more partnerships, everything should be minus because it would be cheaper; therefore, there will appear negative and low setup costs always, sunk costs and lost performance costs.

<u>AUTOMATION COMPANY</u>

In the case of the AC, it is important to understand that they are the end-users of the II-platform provided by the same company. An example of the differences between them is that if they would add more open standards, it would add setup costs for the company because they have to develop them all, but in the case of end-user, they don't have the power to change this.

Table 22: *Switching costs evaluated by the AC.*

			SWITCHING COSTS							
			Procedural switching costs				**Financial switching costs**		**Relational switching costs**	
			Uncertainty costs	**Search costs**	**Training costs**	**Setup costs**	**Sunk costs**	**Lost performance costs**	**Brand relationship and psychological costs**	**Personal relationship and psychological cost**
OPENNESS	**End-user related openness**	**Access to information** (open standards)			(+) L	(+) L				
		Cost of Access								
		Control in terms of rules to use the platform	(+) L		(+) L	**(+) H**		**(+) H**	(+) L	(+) L
	Application developer related openness	**Core Developers**								
		Extension Developers (3rd Party)	(+) L		(+) L	(+) L	(+) L	(+) L	(+) L	(+) L
		Data Aggregators	(+) L		(+) L	(+) L	(+) L	(+) L	**(+) H**	**(+) H**
	Provider and Sponsor related openness	**Proprietary Model** (one provider-one sponsor)	**(+) H**		**(+) H**	**(+) H**	**(+) H**	**(+) H**	**(+) H**	**(+) H**
		Licensing model (many providers-one sponsor)								
		Joint Venture Model (one provider-many sponsors)								
		Shared Model (many providers-many sponsors)								

The score system employed by the respondents for the evaluation of the switching costs is the following one:

Negative switching costs		Positive switching costs	
High (-H)	Low (-L)	Low (+L)	High (+H)

When opening significantly the *access to information*, the training and setup costs will raise because the end-user has to understand more; it is pretty linear, the more openness you get, the more cost you have. The switching costs are low because the access to information is already very open (grade 4 in the previous section).

When opening the *cost of access,* there are not switching costs identified because it is not very relevant in this case due to the end-users are in the same company as the platform providers.

When opening significantly the *control in term of rules*, the uncertainty will increase because the end-user's customers will have more possibilities to use or different ways of using their services. In addition there will be training costs and *setup costs* if openness is added, being the second the highest one. There are *lost performance costs* because other people can come to eat the end-user's work and it is a high risk. It is also affecting the brand relationship because other people can take part of the end-user's products and sell them as own. It can be harmful in some cases to the end-user reputation. In personal relationship there will be also costs, in where the end-user's earnings are and where the others' earnings are.

When opening the *core developers*, there are any identified costs, same as in cost of access.

When opening significantly the *extension developers*, there will be uncertainty, training, setup costs and sunk costs. For performance it is the same because the roles are not anymore clear or defined. Brand and personal relationship affect too.

When opening significantly the *data aggregators,* the switching costs are the same of extension developers; however, there is a higher risk in *brand relationship* and *personal relationship* because they can spoil the whole thing for the end-user.

When moving from the *proprietary model* towards a more open model, there will appear high positive switching costs such as *uncertainty costs, training costs, setup costs*, *sunk costs* which could mean the end of the end-user's business, *lost performance costs, brand relationship costs* and *personal relationship costs*.

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Figures from Figure 17 to Figure 23 show the impacted switching costs when opening the different sides of a platform. The graphics combines data taken from the frameworks (see Table 19and Table 20) which allows creating the Table 23 that presents the similarities and differences between the MB and the AC. The objective is not to compare between both companies but to make some statements that demonstrate the importance and different impacts of openness from different perspectives.

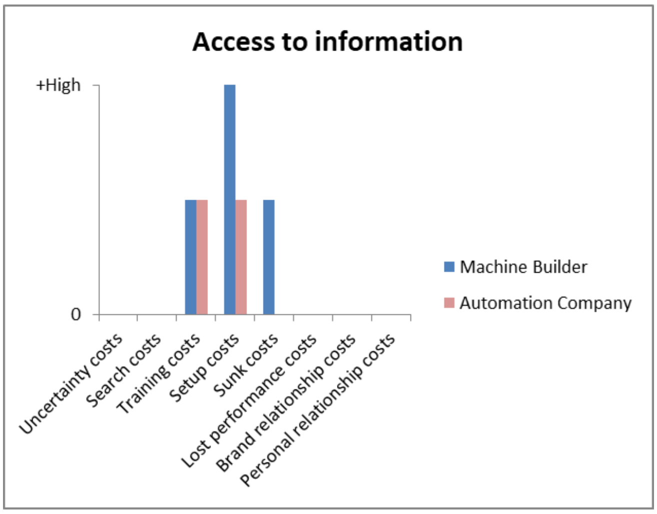

Figure 17: *Switching costs when opening the access to information.*

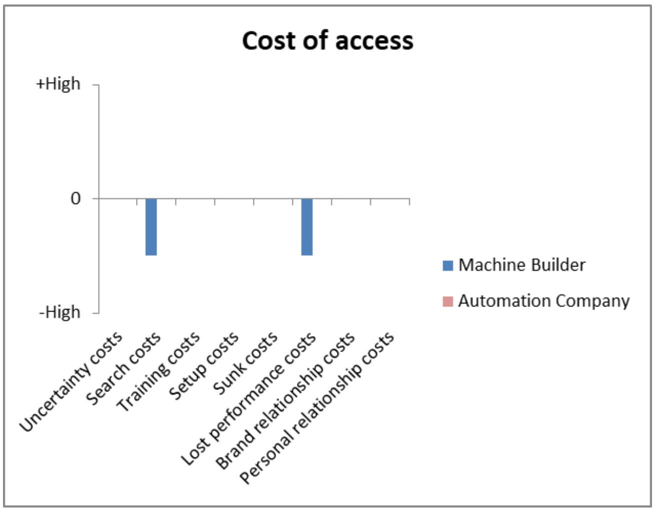

Figure 18: *Switching costs when opening the cost of access.*

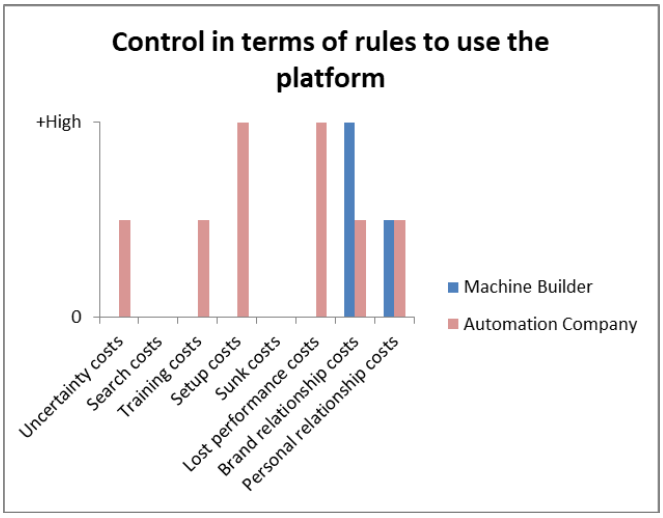

Figure 19: *Switching costs when opening the control of rules to use the platform.*

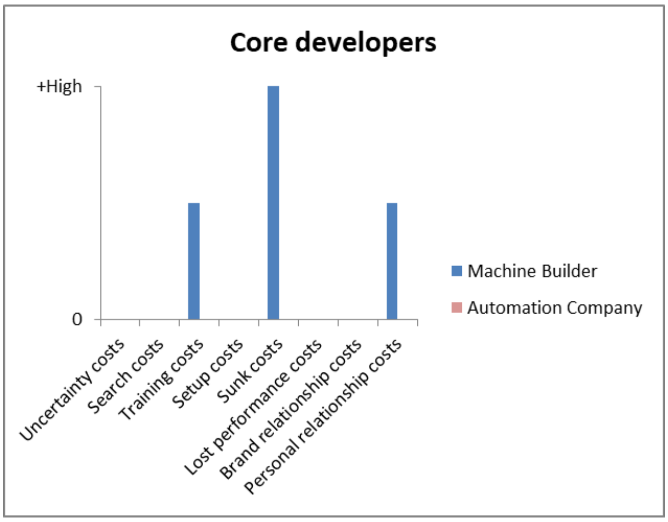

Figure 20: *Switching costs when opening the core developers.*

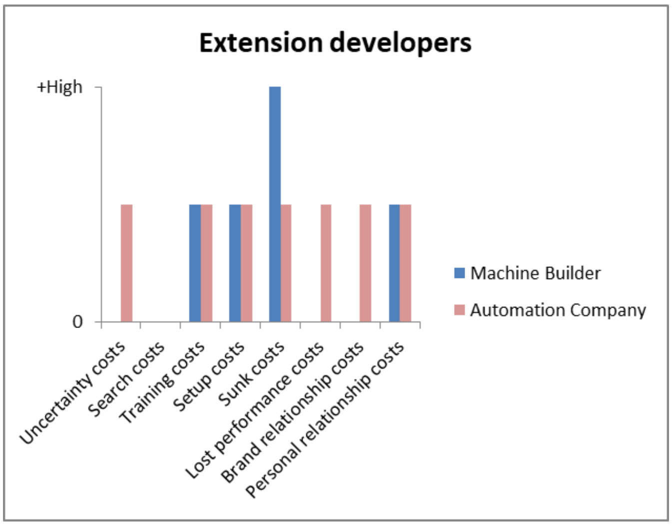

Figure 21: *Switching costs when opening the extension developers.*

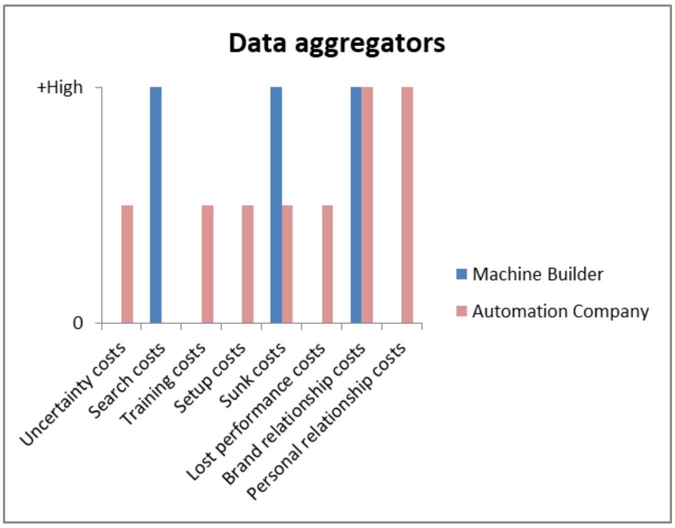

Figure 22: *Switching costs when opening the data aggregators.*

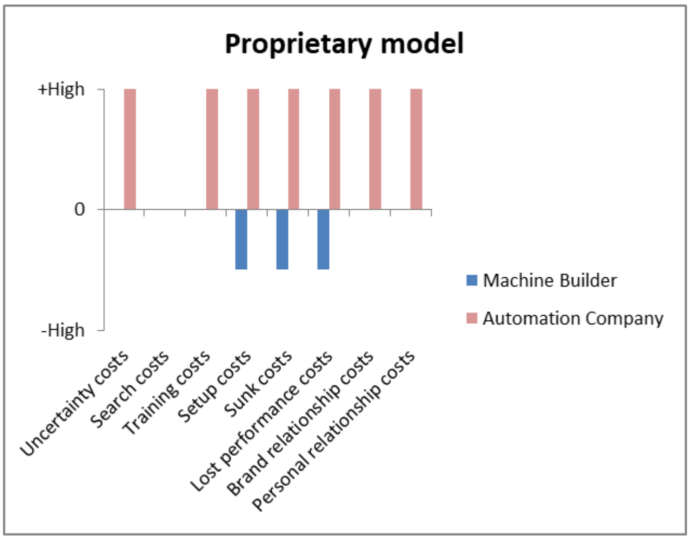

Figure 23: *Switching costs when opening the proprietary model.*

Table 23: *Similarities and differences in the evaluation of the impacts of openness in terms of switching costs.*

Similarities	Differences
• In "access to information", both companies identify training and setup costs; however for the MB setup costs have a higher impact (see Figure 17). • "Cost of access" is the dimension that creates less switching costs, the MB has negative switching costs and the AC has no effect (see Figure 18). • In "control in terms of rules to use the platform", both companies identify brand and personal relationship costs; however, the highest positive switching costs in the MB is brand relationship costs, and in the AC are setup and lost performance costs (see Figure 19). • In "extension developers", both companies identify training, setup, sunk and personal relationship costs; however, the MB considers that sunk costs have a higher im-	• The MB has negative (low) switching costs when opening cost of access and proprietary model; however the AC has only positive switching costs. • The MB has the critical dimension on the app developer side: "Data aggregators" creates the highest positive switching costs, followed by extension developers and core developers (see Figure 22). • The AC has the critical dimension on the Provider and Sponsor side; it creates high positive switching costs in all the types (except search costs) (see Figure 23). • The MB doesn't find any impact in uncertainty costs and the AC in search costs. • "Core developers" are more critical for the MB (high positive sunk costs) rather than for the AC who can't identify any switching cost

pact (see Figure 21). • "Data aggregators" is a critical criterion for both companies, they identify sunk and brand costs, and coincide that brand costs have a high positive impact. In addition, the MB believes that search and sunk costs have also a high impact but the AC personal relationship costs (see Figure 22). • "Relational switching costs" is the most impacted dimension (high positive switching costs) for both companies.	(see Figure 20). • In the AC, the setup cost is the highest positive switching cost when opening all the dimensions and the less impacted one are search costs. • In the MB, the sunk cost is the highest positive switching cost when opening all the dimensions (mostly due to the developer side) and lost performance cost is the one more impacted negatively.

In addition, there are some questions related to the questionnaire of this part and other possible missing switching costs that are affecting directly the end-user business:

In your opinion, how difficult was to identify and evaluate the switching costs when opening the dimensions? Why?

In the case of both companies it was pretty clear. The MB has identified two positive high switching costs in the end-user side but five in the developer side. The reason is that the app developer side is affecting immediately the end-user business and their relation with their customers. It is directly related with their developers and how they are developing; because this is directly what the end-user is selling out.

The AC has identified two positive high switching costs in the end-user side and same in the app developer side, but seven in the platform side. As an automation company of IoT solution, the end-user would like it to be in a proprietary model because it would be easier and simpler for them to deal with one company.

In addition, the AC has a not defined customer group (for e.g. as it could be if they were suppliers of mobile phones), but they have everything starting from the building automation going to the nuclear. Customer pace is varying so much and the requirements are so different, that is why they need the flexibility provided by a proprietary model.

Is there any other switching cost of opening an II-platform that is not identified previously? How it would be its level of impact?

The MB thinks about the possibility of any natural disaster or some really bad business case that can break up the contract and force them to switch immediately to something else (for e.g. a dramatic license fees change or a higher price of the cost of access).

The AC thinks from the marketing and sales point of view, that if you have a new customer's audience (see Figure 13), you are marketing and selling to an increased number of customers, which means the costs will be pretty high: "For example, we have the machine builder or the group of machine builders and now it will be hundreds of integrators which are implementing our products and services, so we should get information to the real end customer. Same situation with sales because now we have pretty clear where we should sale, which are our customers but in this case we don't know, they are somewhere behind this network. This is a direct transparency to really this end user, and if it's hard, in this case it will be very hard. At the same time you are also losing your touch to the market".

In addition, the AC explains that there will be much more filters if they change to a more open model, in which they can lose control and lose the supplier power: "Maybe you are not getting the real data anymore, what is going on, the real customers who are really evaluating if it is good or bad".

7. DISCUSSION AND CONCLUSIONS

Once the results of the two empirical cases have been presented, it is time to analyze and discuss the findings. For this, each research question is discussed separately and in the end reference is made in the conclusions to the primary ontological question. Also, the managerial implications are discussed, as well as the evaluation of the thesis. To conclude the chapter, the limitations of the study and the possible lines for future research are presented.

7.1. DISCUSSION

The research questions presented in chapter 2 (section 2.2) are discussed separately through theory and empirics, it is recalled that chapters 2 and 3 belong to the theoretical part of the research and 4 and 5 to the empirical part.

RQ 0 What is Industrial Internet (II, IoT, Smart factories, Industry 4.0., CPS (CPPS)?

This question is answered only with literature, the information related to II and related topics are found in section 3.1 and 3.2. II is a topic very commented recently that affects many advanced economies. Its adoption is growing among different industries and it is the third wave after the Industrial revolution and the Internet revolution, as shown in the Figure 6.

The term was firstly introduced in 2012 by GE and it has three essential elements: intelligent machines, advanced analytics and people at work (see Figure 3). II transform the way businesses operate and thanks to data analytics the decision-making process is improved. Also; it improves productivity, efficiency and reduces costs. In addition, as explained in section 3.2, II has different related concepts such as Industry 4.0, CPS/CPPS, IoT and Smart factory. Table 1 contains definitions of each concept.

Industry 4.0 is the German term to refer to II. Figure 5 shows the relationship between them. It explains that II has a greater focus on many areas, unlike Industry 4.0 that has the focus on manufacturing and logistics processes. Industry 4.0 involves the integration of CPS and IoT, which are the core technologies for the Smart Factory, heart of the Industry 4.0. These concepts are developed in more depth in the sub-sections 3.2.1, 3.2.2, 3.2.3 and 3.2.4.

RQ 1 What are the II-Platforms?

This thesis has given a definition of II-platform although in the literature there is no clear definition. The answer to this question is taken up with theory from section 3.3 and with empirical results contained in section 6.1.

II-platforms are beating traditional pipelines; they are used in many industries, have more than one purpose, and are continuously evolving from product platform in 1997 till multisided platforms in 2015. (Gawer and Cusumano, 2014) distinguishes between internal and external or industry-wide platforms, which are defined as "products, services, or technologies developed by one or more firms, and which serve as foundations upon which a larger number of firms can build further complementary innovations and potentially generates network effects". The definition of II-platform arises from the combination of II and external platforms. Section 3.3 provides an example of II-platform.

In the interview companies are asked the following question: "*What is your main industry? Why do you think the use of an II platform benefit your industry?*" in order to understand the purpose of the II-platform in their specific industry. Section 6.1 explains that the MB is making machinery and selling power plants, paper machines and tissue machines. The MB is using three different existing platforms and values the II-platform because it is an ecosystem in which all the participants can integrate their business lines in the same platform, this allows the MB to know to know how to bring new features and add value to the end customer by software, which is their core business. However, the AC is producing lot of different type of hardware and software with open interfaces and has its own platform which is a combination of hardware plus software plus the services to integrate this package. The II-platform benefits the company giving them flexibility which is their main point, so their customers can select according the requirements of the application, how and which kind of components will be used.

In conclusion, the selection of one or more platforms, the selection of existing platforms or own the platform and the purpose of use of the II-platform differs between industries and the selection is crucial to achieve the goal of the company, in case of the MB three existing platforms allows them to bring new features to their customers and in case of the AC one own platform allows them to keep control and work with different kind of industries and provides them the flexibility to satisfy their customers' requirements.

RQ 1.1 What kinds of impacts do II-platforms carry towards platform users?

II-platforms create several impacts on users; however, section 3.4 contains the most important effects within the literature and section 6.1 from a practical point of view.

The impacts can be positive and negative, II-platforms suppose the creation of multiple interactions between different participants, also users need to do platform specific-investments that lead to switching costs and lock-in. There is the problem of cooperation and competition, but the most important effect is network effects, Table 2 includes the definition of the types of network effects: direct and indirect, positive and negative. Also, in the Figure 7 it is possible to see visually the network effects in II-platforms between end-users and app-developers.

In the interviews the companies are asked for the business opportunities and challenges of the use of an II-platform. The MB thanks to the use of the II-platform can know better how the customer is making use and profit of its machines and helps them to optimize its production and stock to provide a better service. But the MB finds challenging the security due to that cooperation and sharing intellectual property commented in the theory. The AC finds opportunities to grow the existing customer base thanks to the use of the II-platform. But, for the AC it is also challenging to keep the supplier power to the MB because a new player could take part of the business and lose control.

In conclusions, II-platforms have many participants interacting all the time which create business opportunities and challenges towards the II-platform end-user. Some of the opportunities are customer-related such as knowing better the customer or growing the customer base area. The challenges have to do more with security and control, how to secure your business and how to maintain control and power over other possible participants.

RQ 2 What does openness mean for II-platform end-users?

Section 4.1 contains two sub-sections. Sub-section 4.1.1 provides a clear definition of openness from theory. Goeffrey Parker states: "a platform is open to the extent that (1) no restrictions are placed on participation in its development, commercialization, or use, or (2) any restrictions-for example, requirements to conform to technical standards or pay licensing fees-are reasonable and non-discriminatory that is, they are applied uniformly to all potential platform participants".

The participants are the demand-side users or end-users, the supply-side users or application developers, the platform providers and the platform sponsors. Its degree of participation in the II-platform defines the dimensions of openness, which at the same time have some sub-dimensions as it is explained in section 4.1.2 and its meaning in terms of openness is developed in Table 4.

Although there is a theoretical definition, for the end-users openness can have a specific meaning. Section 5.1 shows that for the MB openness means standard protocols and the standard pricing the end-user gets. Also, openness means for the company, the ease of documentation and ease of information available reducing search costs. For the AC openness means open interfaces in order to connect different kind of other systems.

In addition, companies have different strategies related to openness in the II-platform. The MB and AC will continue increasing the degree of openness. On one hand, the MB thinks that openness helps growing the platform coming with new features and it is important to focus on openness in the long-term because it is possible to see the roadmap where the platform is actually growing. On the other hand, the AC still want to open more interfaces and leverage connectivity.

In terms of prioritization, companies prioritize different dimensions of openness regarding their business. The MB prioritizes the application development because a feature is what they are selling. The AC prioritizes the access to information or open standards to fulfill better the customer requirements. In addition, the AC agrees that partnership is important to supply certain features and the way companies create their networks is crucial for the survival.

In conclusion, companies have a good understanding of the meaning of openness (open standards, open interfaces, standard pricing, available information, etc.). Openness is seen as a long-term strategy that provides companies more features, more open interfaces, etc. In this sense, companies prioritize the dimensions of openness according to which one is the one that gives more benefits to its industry (see RQ 1); for example, the MB prioritizes the app developer side because they are selling that part or the AC wants more access to information because the flexibility provided by open standards gives them flexibility to fulfill the requirements.

RQ 3 How can the impacts of II-platform openness for the II-platform end-user be identified?

This question is answered exclusively through theory. Section 4.2.2 explains that there are general impacts, which can be benefits or downsides that affect the end-user:

- Opening the end-user side gives control and ownership to the end-user, open standards allows the creation of high quality content, etc. Some of the downsides could be security problems and other costs such as training costs.
- Opening the app developer side allows the creation of customized solutions, features, enhanced functionalities to the II-platform, and improves end-user experience. There are also downsides, poor quality information can be created, too many developers increase search costs. In addition, sharing intellectual property is risky and some apps can create lock-in.
- Opening the platform side means an increase in interoperability, reduces the hold-up problem, satisfy better the end-users' needs, improves the quality of technology and reduces switching costs and lock-in, among others. But innovation can be retarded, the ease of operation and use of technology can be diminished and there is the risk of many platforms creating monopoly.

These impacts are divided into four broad categories of impacts according to section 4.2.3: interoperability, positive network effects, transaction costs and switching costs. But they are all related to switching costs (see Figure 11) which can lead to lock-in in the long-term. This means switching costs provide a framework (see Table 14) to evaluate the role of openness in the long-term and in addition, it facilitates the impacts assessment because they are terms that companies manage frequently in the business environment.

RQ 4 What is the impact of II-platform openness to the II-platform end-user's business?

As seen in the previous research question, RQ 3, there are many impacts that openness carries towards end-users. However; most of the question is answered with the empirical part in section 6.1 and 6.2.

If openness is added to the II-platform, both companies see two effects. They MB sees opportunities because they can implement possibly something new but the feature gap can appear between what is wanted by the sales and product business owners and what could be immediately given by the end-user, creating a demand that the end-user is not able to supply and the customers give a negative feedback. The AC says that the available market will grow because a solution can be implemented to more applications. But on the other hand, there is the risk that there will be new players who are taking this supplier power out from the company (same challenge the AC has when using an II-platform).

To sum up, openness has opportunities and benefits and risks and downsides. So that there are more opportunities than risks companies have to select the right level of openness, which is very complex. Therefore, the respondents are asked to evaluate the degree of openness of each sub-dimension, and thus be able to understand how it affects their particular business.

Section 6.2 contains the results of the assessment. The MB explains that the end-user side is very open due to the high competition between all the II-platform. Platform providers are in charge of everything, offering features to the end-user with a competitive price. The app developer side is half open because core developers can do bad things. The MB uses a proprietary model because it responds better to their business needs.

The AC has greater openness in access to information; however, they are looking for more. The control is very close because the end-user has not affection to add features or change the result. App developers can participate but it is a trusted-related relationship. The AC has also a proprietary model where they have invested many resources and allow them to grow their business; but they are also going towards also licensing because of business requirements.

In conclusion, the level of openness is crucial for their business. The end-user side usually is very open, although the control can never be fully open, especially when the company is end-user of their own II-platform. The app developer side usually is a trust related relationship and the degree of openness depends on it. Extension developers usually don't create advertisements but other kind of index and graphics. The model is chosen according to what the companies think will fulfill better the business needs. There is a clear trend towards more open models such as licensing but they are still reticent because of the loss of competitive advantage, delays, complexity and greater fees they might cause.

RQ 5 What are the impacts in terms of switching costs of II-Platform openness for an II-platform end-user?

This question has to be answered with the empirical part in section 6.3. The switching costs framework is used because of the detailed reasons described in the RQ 3. The important analysis comes from the high positive switching costs because they are the ones creating downsides for the end-user.

From Table 21 and Table 21, some visual graphics are developed in order to reach to some conclusions:

- The MB has negative switching costs when opening the cost of access and the proprietary model. The AC has only positive switching costs.
- The MB has the critical dimension on the app developer side (data aggregators, core developers and extension developers) which correspond to their priority explained in the RQ 2. The AC has the critical dimension on the platform side because the proprietary model is the strategy of their business, if it is more open it supposes the end of their business. However; data aggregators is a critical criterion for both companies because they can spoil all the end-user's work and spend lots of resources checking everything.
- In the MB, the sunk cost is the highest positive switching cost when opening all the dimensions (mostly due to the developer side) because it means the end-user losing money abandoning their investments and lost performance cost is the one more impacted negatively because when changing they can just get something better due to the high competition. In the AC, the setup cost is the highest positive switching cost when opening all the dimensions because they would need to start everything again and the less impacted one are search costs because they have already all the information available. However; Relational switching costs is the most impacted dimension (high positive switching costs) for both companies because, as the AC said, the network is the key to be competitive and fulfill requirements.

In conclusion, companies know what switching costs are and they are conscious openness creates an impact on them, which at the same time affects directly their business. It is clear that openness is not free because it creates positive switching costs, but sometimes companies see it as something positive. Theory stated that adding openness to a proprietary model reduces switching costs but the truth is that for example the switching costs of the AC increases. This is because depending on which business and which industry is involved, the impacts of openness on the switching costs are positive or negative, one dimension is more critical over another and some switching costs are more impacted.

7.2. CONCLUSIONS

The main purpose of this thesis is to understand the role of openness in terms of switching costs for the II-platform end-user. In order to address this research gap, the major ontological question was formulated and split into seven research questions that will guide the whole research process. In the previous section 7.1 the research questions are discussed in order to answer the primary question: *What is the role of Openness in terms of switching costs for the Industrial Internet Platform end-users.*

The thesis starts with a literature review about II, II-platforms and openness. Although there is more and more research related to II and similar concepts it is still a young research area. Its adoption is transforming the manufacturing industry radically with benefits such as predictive maintenance and the creation of new business models. Much research is done related to II-platforms openness from the owner perspective but very little from the end-user point of view. In addition, many researches emphasize the importance of switching costs; however, it is not so common to apply them to this field. These facts motivated the present research in order to cover the gap existing between II-platform end-users, openness and switching costs.

The literature is followed by the empirical part, which consists in two interviews to a machine builder and an automation company. The conclusions deduced from the results are concentrated into these four bullet points:

1. The selection of the right number of platforms, to own the platform or choose an existing one and the purpose of the platform differs between industries creating different challenges and opportunities.
2. Openness is a trend which is seen as positive and as a long-term strategy. Stablishing the correct degree of openness is complex, crucial and challenging. Openness creates two kinds of impacts, benefits and downsides that affect directly to the end-user business. In addition, it is demonstrated that openness creates switching costs.
3. Switching costs is a good way to identify the impacts of openness, the framework allows evaluating in terms of business and, as a high degree of switching costs might lead to lock-in, it means switching costs provides a framework to evaluate the long-term.
4. These switching costs impacted and the way they are impacted are very different depending on the company who is evaluating and their business. Sometimes switching costs that lead to lock-in are desired by companies.

The first conclusion pinpoints the relevance of II-platforms which its related decisions create positive or negative impacts on the end-user, this means business opportunities and challenges. On one hand, opportunities are a better knowledge of the customer or growing the customer base area, but in the other hand challenges are related to security and control, how to secure your business and how to maintain control and power over other possible participants.

Companies have a good understanding of the meaning of openness: open standards, open interfaces, standard pricing, available information, etc. However this is not the rule, in general companies have a low knowledge of openness in special SME's. Of course openness is not the only criteria when deciding to join a platform but it is clear that openness is seen as a trend and as a long-term strategy because it provides companies more features, more open interfaces, etc. what companies need to sell and do business. It is obvious that companies prioritize the dimensions of openness according to which one is the one that gives more benefits to its industry (the MB prioritizes the app developer side because they are selling features or the AC wants more access to information because the flexibility provided by open standards gives them flexibility to fulfill the requirements).

In addition, the selection of the right level of openness is very complex and crucial in the creation of benefits and downsides for the end-user (for e.g. the machine builder found many problems when managing three interfaces at the same time). The end-user side usually is very open, although the control can never be fully open, especially when the company is end-user of their own II-platform. The app developer side usually is a trust related relationship and the degree of openness depends on it. Extension developers usually don't create advertisements but other kind of index and graphics. The model is chosen according to what the companies think will fulfill better the business needs. There is a clear trend towards more open models such as licensing but they are still reticent because of the loss of competitive advantage, delays, complexity and greater fees they might cause.

Switching costs is the main impact between interoperability, positive network effects and transaction costs, as explained in sub-section 4.2.3. Companies know what switching costs are and they are conscious openness creates an impact on them, which at the same time affects directly their business. Also, a high degree of switching costs plus the combination of some of them may lead to a long-term impact, lock-in, which means switching costs provide a framework to evaluate the long-term impacts.

It is clear that openness is not free because it creates positive switching costs as shown in the results section 6.3, but sometimes companies see it as something positive in contradiction with the literature. Theory stated that adding openness to a proprietary model reduces switching costs but the truth is that for example the switching costs of the AC increases radically. This is because depending on which business and which industry is involved, the impacts of openness on the switching costs are positive or negative, one dimension is more critical over another and some switching costs are more impacted.

To sum up, openness is a fundamental choice during all the PLC of an II-platform, not only when selecting the II-platform but when deciding and following a long-term strategy. It has many business implications that will become more and more important in the near future. The next section explains the managerial implications that this topic carry towards II-platform end-users.

7.3. MANAGERIAL IMPLICATIONS

The discussion and conclusions from the research findings provide practical managerial implications with respect to decisions on II-platform openness, it changes the way managers think or do things. It helps managers to support their decisions on openness and II-platform selection with coherence and understanding so many mistakes, losses, etc. will be avoided.

Managerial implications differ from theoretical implications but it's related because managerial knowledge needs are dominantly addressed by empirical findings but also with frameworks, in this master thesis much research and the openness and switching costs framework are used for the empirical part.

Managerial implications are more useful to give a recommendation (for e.g. for a transition process), more than to follow a strategy to the letter. It is important that managerial implications are role-relevant; this is that they are mostly recommendations to a particular manager/business etc., instead of a broad group or industry because the focus on solution business limits the generalizability of findings.

This thesis provides recommendations to two companies, the machine builder and the automation company. The results confirm the relevance of openness in II-platforms and inform managers that its impacts affect directly their business. In addition, the results reveal that SC provides a framework good enough to evaluate these impacts.

In conclusion, it is important that companies are aware of the benefits but overall the risks or downsides of openness when selecting an II-platform, which specially the long-term ones are more difficult to identify, grasp or mitigate. This helps the end-users to select a platform in accordance with their business model and helps them to design a mitigation plan for the long-term.

7.4. EVALUATION OF THE THESIS

The evaluation of the thesis aims to explore the reliability, validity and usefulness of this thesis including the theoretical and the empirical part, also to discuss what is interesting or unexpected.

In general, the evaluation of the thesis is positive, the literature is abundant and fairly consistent; however, there are some methodological limitations in the empirical part. The results seem to confirm its reliability but it is not possible to generalize issues such as industries or companies doing the same business. Also, the respondents had a broad knowledge about the subject and the industry; however, the fact that they couldn't find any impact in certain SC (the MB in uncertainty costs or the AC in search costs) might mean these SC were misunderstood by the end-user.

In addition, it is a viable thesis because managers find the topic significant and relevant and they can use it and implement it. Also, there are interesting and significant findings but also non-significant results which must be interpreted with care. For example, it is interesting the explanation of the level of openness the end-users have on their platforms and why, also the benefits and risks of openness and II-platforms or how the SC are impacted. Other results are less interesting such as other switching costs they find when opening (see section 6.3) a platform which might be included in some of the proposed SC or other very detailed and technical concepts.

In the results, it is remarkable that there are inconsistent findings with existing knowledge. As commented in the conclusions, it can be that SC are not reduced when adding openness to II- platform but increased in a high way. Managers should take this into account and consider their core business when selecting the degree of openness and model.

The flow of the thesis is interesting; it starts from concrete definitions of the dimensions of openness and derives into general impacts. From these impacts the main ones are selected and the relationship between them is found in terms of SC. The ease of use and high quality results that the SC framework provide, leads to an important conceptual contribution to the literature and substantive motivation for future research. The nest section explains what kind of limitations the thesis has and the future research that can be done about the topic.

7.5. LIMITATIONS AND FUTURE RESEARCH

As explained in the previous section there are some limitations related to the study, although these limitations are an opportunity to make suggestions for future research. Firstly, it is important to realize that subject such as II, platforms, openness and switching costs are broad topics and sometimes it is complicated to define well the concepts because of their complexity, but this study is a master thesis with its limited time and scope of research. Also, a broad and general research is done, the main impacts are superficially studied (except SC) but in the future it could be interesting to study more in detail impacts such as interoperability, positive network effects and transaction costs.

(Flyvbjerg, 2006) explains that one cannot generalize from a single case; therefore the single case study cannot contribute to scientific development. This means that the nature of companies extremely limits the research, and also the number of companies selected for the empirical part because the research process occupies a significant time. The empirical part is done to a specific automation company and machine builder, the results might variate when choosing another particular company, also the findings depend on the chosen company of the supply chain.

More research should be done to other companies within the same industry (more automation companies and more machine builders) but also to other different industries within the same supply chain (customers, providers, etc.). This would help to understand better the range of businesses, industries and impacts.

(Gerring, 2006) argues that the ‘case study approach’ to research is “the intensive study of a single unit or a small number of units or cases, for the purpose of understanding a larger class of similar units or population of cases”, but a qualitative study limits the quantity and quality of data collection. More interviews would serve to compare results and stablish a long-term pattern that would be useful for companies and facilitate their decision-making process.

In order to know more about the II-platform openness, it could be interesting to do an intensive research about app developers and platform owners and combine the information about all the participants which can be useful to understand their behavior and the impacts that their interactions cause. Also, the use of other tools, not only SC, would help the research process and its completion.

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APPENDIX A: INTERVIEW GUIDE

Impacts of openness for the II-platforms end-users in terms of switching costs

(Case Study)

(Estimated time 60 mins)

Purpose

The purpose of the present case study is to identify and evaluate some important short and long-term impacts that openness creates on the II-platform end-user business. One way of recognizing the impacts is focusing on Switching costs and the long-term impact that they can create: lock-in.

Background information (10 min)

- Industrial IoT is "the convergence of the global industrial systems with the power of advanced computing, analytics, low-cost sensing, and new levels of connectivity provided by the internet".
- Industrial Internet (II) platforms are "products, services, or technologies developed by one or more firms, and which serve as foundations upon which a larger number of firms can build further complementary innovations and potentially generate network effects".
- A platform is "open" to the extent that (1) no restrictions are placed on participation in its development, commercialization, or use; or (2) any restrictions-for example, no requirements to conform with technical standards or pay licensing fees-are reasonable and non-discriminatory, that is, they are applied uniformly to all potential platform participants.
- An end-user incurs a switching cost associated not just with having to abandon the investment in a platform but to abandon benefits that accumulate from having used a platform.

Background questions (5 min)

1. **Generic questions**

    a) What does II-platform openness mean to you?
    b) What is the role of openness related to your particular strategy (level of openness your company would like to achieve) in the II platform? Why?

Related to Openness (10 min)

2. **Questions related to openness in general**

a) If openness is added to the II platform, what kind of impacts (positive or/and negatives) do you see in your business?

3. Questions related to various dimensions of openness (degrees of openness)

According to the following framework in which general criteria of openness are presented, as well as the detailed criteria of each dimension:

Openness criteria	Detailed criteria	
End user related openness	**Open access to information to the user** (open standards)	
	Low cost of access to platform data and information (as in patent or licensing fees)	
	Open the control in terms of rules to use the platform (open governance)	
Application developer related openness	**Open Core Developers access to platform data and information**	
	Open Extension Developers (3rd Party) access to platform data and information	
	Open Data Aggregators access to platform data and information	
Platforms Provider and Sponsor related openness	**Proprietary Model**	
	Licensing model	
	Joint Venture Model	
	Shared Model	

a) From 0 (totally close) to 5 (totally open), what do you think is the current level of openness of each dimension of the II-platform?
b) On a more general level, out of the three dimensions of openness, does your company prioritize one dimension over the other regarding your business? Why and how?

<u>Related to Openness and Switching Costs (35 min)</u>

4. **Identification and evaluation of the most impacted switching costs when opening a platform**

According to the following framework of Switching Costs in which different types of switching costs are presented, as well as the sub-dimensions:

Dimension of Switching Costs	Sub-dimension	Description
Procedural switching costs	**Uncertainty costs**	Lower performance when switching.
	Search costs	Gathering and evaluating information prior to switching.
	Training costs (Cognitive)	Learning a new service routine subsequent to switching.
	Setup costs	Relaying needs and information to provider subsequent to switching.
Financial switching costs	**Sunk costs**	Investments and costs already incurred in establishing and maintaining relationship (For e.g. specialized investments, compatibility costs, contractual commitment, etc.)
	Lost performance costs	Benefits and privileges lost by switching (e.g. preferred access, special status, customized solutions, etc.)
Relational switching costs	**Brand relationship and psychological costs**	Losses with breaking the relationship with the brand or company with which a customer has associated.
	Personal relationship and psychological costs	Losses associated with breaking the relationship with the people with whom the customer interacts.

For each detailed criteria of openness:

a) If it was significantly more open (to make an impact on your business), what kind of switching costs are impacted?

b) In addition try to evaluate the impact (positive, negative, neutral or unknown) of the selected switching costs using the following scale:

Negative switching costs		No change	Positive switching costs		Unknown
High (-H)	Low (-L)	-	Low (+L)	High (+H)	?

c) Why the high positive switching costs are impacted significantly when opening that specific openness criterion?

			SWITCHING COSTS							
			Procedural switching costs				Financial switching costs		Relational switching costs	
			Uncertainty costs	Search costs	Training costs	Setup costs	Sunk costs	Lost performance costs	Brand relationship and psychological costs	Personal relationship and psychological costs
OPENNESS	End-user related openness	**Access to information** (open standards)								
		Cost of Access								
		Control in terms of rules to use the platform								
	Application developer related openness	**Core Developers**								
		Extension Developers (3rd Party)								
		Data Aggregators								
	Provider and Sponsor related openness	**Proprietary Model** (one provider-one sponsor)								
		Licensing model (many providers-one sponsor)								
		Joint Venture Model (one provider-many sponsors)								
		Shared Model (many providers-many sponsors)								

d) Is there any other switching cost of opening an II-platform that is not identified previously? How it would be its level of impact?

e) In your opinion, how difficult was to identify and evaluate the switching costs when opening the dimensions? Why?

If enough time

1. **Generic questions (10 mins)**

    a) What is your main industry? Why do you think the use of an II platform benefit your industry? (Purpose of the use of II platform)
    b) What are the 3-5 top business opportunities for an II platform user? Why these in the top 3-5?
    c) What are the top 3-5 business challenges for an II platform user? Why these in the top 3-5?
    d) What is the overall strategy of your company related to the growth of your business in the II Platform? (Growth of maturity in the adoption of Industrial Internet)
    e) Have you considered the risks of switching costs and the possibility that they create lock-in in the long-term? If yes, how?