Development of a Business Model for Industry 4.0 based on Industrial Analytics

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Master in Management of Services and Technology

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INSTITUTO UNIVERSITÁRIO DE LISBOA

UNIVERSITÀ DEGLI STUDI DI PALERMO

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Abstract

Over the last few years, the manufacturing sector has changed and is continuing to change due to the use of new technologies resulting from the advent of the fourth industrial revolution (Industry 4.0), such as the Internet of Things (IoT), technology whose importance is becoming increasingly recognized by citizens, businesses and governments and which is proving capable of changing not only our daily way of life, but also the way companies carry out their activities, redefining the relationships between companies themselves and their customers, employees and partners. This technology also allows the exploitation of new Industrial Analytics processes, which allow companies to perform a systematic computational analysis of data and statistics in order to better interpret such data, applying models that make the decision-making process more effective.

The goal of this thesis is to develop a new business model for Industry 4.0 based on Industrial Analytics. This model intends to act as a starting point and help for all those companies that want to install IoT solutions or platforms based for Industrial Analytics.

The methodology used to achieve this goal has consisted in administering a questionnaire to 3 companies, with the aim of understanding how these companies are changing their way of doing business thanks to the advent of the IoT, of Industrial Analytics. and other technologies that are part of the Industry 4.0 context. The analysis of the responses to the questionnaire was the basis for the development of the business models of the three companies interviewed. Finally, by comparing the three models, a new business model for Industry 4.0 based on Industrial Analytics was developed.

Key Words: Internet of Things; Industry 4.0; Canvas Business Model; Industrial Analytics;

JEL Classification System: L21; L25; O32; O33

Sumário

Nos últimos anos, o setor industrial mudou e continua mudando devido ao uso de novas tecnologias decorrentes da quarta revolução industrial (Indústria 4.0), tais como a Internet of Things (IoT); esta é uma tecnologia cuja importância está a ser cada vez mais reconhecida por cidadãos, empresas e governos e que se mostra capaz de mudar não só o nosso quotidiano, mas também a forma como as empresas desenvolvem as suas atividades, redefinindo as relações com os seus clientes, colaboradores e parceiros. A IoT viabiliza ainda a exploração de novos processos de Industrial Analytics, que permitem às empresas realizar uma análise computacional sistemática de dados e estatísticas conducente a uma melhor interpretação dos mesmos, aplicando modelos que tornam mais eficaz o processo de tomada de decisão.

O objetivo desta tese é desenvolver um novo modelo de negócios para a Indústria 4.0 baseado em Industrial Analytics. Este modelo pretende ser um ponto de partida e ajudar todas as empresas que pretendam instalar soluções IoT ou plataformas baseadas em Industrial Analytics.

A metodologia utilizada para atingir este objetivo consistiu na aplicação de um questionário a três empresas, com o objetivo de compreender como elas estão a mudar a sua forma de fazer negócio graças ao advento da IoT, da Industrial Analytics e de outras tecnologias que fazem parte do âmbito da Indústria 4.0. A análise das respostas ao questionário serviu de base para o desenvolvimento dos modelos de negócio das três empresas entrevistadas. Finalmente, desenvolveu-se um novo modelo de negócio para a Indústria 4.0 com base na análise avançada de dados industriais e por comparação dos três modelos previamente concebidos.

Key Words: Internet of Things; Industry 4.0; Canvas Business Model; Industrial Analytics;

JEL Classification System: L21; L25; O32; O33

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Acronyms and Abbreviations

CAGR – Compund Annual Growth Rate

CRF – Centro Ricerche FIAT

ERP – Enterprise resource planning

FCA – Fiat Chrysler Automobiles

FIAT – Federazione Italiana Automobili Torino

ICT – Information and Communication Technology

IoT – Internet of Things

IT – Information Technology

MES – Manufacturing Execution Systems

MOM – Manufacturing Operations Management

R&D – Research and Development

SACMI – Società Anonima Cooperativa Meccanici Imola

SAIC – Shanghai Automotive Industry Corporation

SMEs – Small and Medium Enterprises

TLC – Telecommunication

VPC – Virtual Private Cloud

1. INTRODUCTION

1.1. Context

Today, over 4,5 billion people use the Internet to search for information, communicate, work, play and keep in touch with friends: 3,8 billion people are active daily in social networks; it is estimated that internet users around the world will spend a total of 1,25 billion years online in 2020, with over a third of the time dedicated to social media (Zanon, 2020).

Starting from the decade just past, the concept of the Internet is in a continuous state of evolution towards a higher level, in which smart devices will be interconnected to provide additional information and services that, until recently, were considered utopian: the internet will gradually give way to the so-called Internet of Things (IoT) (Metallo et al., 2018).

The first evidence of a smart device network dates back to 1982, when a Coca-Cola vending machine in operation at the Carnegie Mellon University became the first machine capable of automatically reporting the number of drinks inside it to its inventory, as well as the first capable of monitoring the refrigeration status of newly loaded drinks (Palermo, 2014). However, the real concept of IoT was born a few years later, in 1999, when Kevin Ashton first coined the term Internet of Things during a conference held at the Procter and Gamble factories (Ashton, 2009). Since then, the IoT has gradually established itself worldwide to the point that, in 2019, the Italian IoT market was worth € 6,2 billion, with a growth of 25% compared to 2018. It is expected that by the end of 2020 there will be 20,6 billion devices connected to the internet worldwide (Channel City, 2020).

The use of IoT solutions and platforms has also extended to the manufacturing sector: today, sensors and mobile devices allow the collection of huge amounts of data (Industrial data) to be processed and analysed through Industrial Analytics. In particular, the term Industrial Analytics refers to the set of Artificial Intelligence methodologies and predictive statistical models that allow to perform complex multi-variable analysis, not possible with traditional methods. The new Industrial Analytics processes therefore allow companies to perform a systematic computational analysis of data and statistics in order to better interpret such data, applying models that make decision-making more effective. In this way, companies can reap various benefits, the most important of which are those related to less waste of resources, an increase in product quality and savings in both economic terms and used resources (Mourtzis et al., 2016).

1.2. Research Motivations and Objectives

Investments in IoT technologies in the manufacturing sector amounted to $ 221,18 billion in 2019, while it is estimated that in 2020 they will reach $ 575,36 billion, with a Compound Annual Growth Rate (CAGR) of 18,07%; manufacturing is therefore the area that is investing most in the technologies made available by the Internet of Things (ReportLinker, 2020)

IoT and Industrial Analytics are technologies that will change manufacturing companies as, through these technologies, companies will be able to reduce their costs and increase the quality of their products, especially thanks to the collection and analysis of data; therefore, it is crucial to understand how companies can adapt to these technologies and, consequently, transform their Business Models.

The goal of this thesis will therefore be to develop a business model for Industry 4.0 based on Industrial Analytics. This business model will constitute a framework capable of combining in a single model the advantages obtainable through Industrial Data.

1.3. Research Questions

In order to achieve the purpose of this thesis, the following Research Questions will be investigated:

- RQ1: What are the advantages that a manufacturing company can obtain through the use of Industry 4.0 solutions based on Industrial Analytics?
- RQ2: Is it possible to formalize a Business Model that takes into account all the advantages obtainable from the implementation of Industry 4.0 technologies based on Industrial Analytics?

1.4. Research Methodology

To achieve the purpose of this thesis, a literature review will initially be conducted; this will allow to understand the current state of the art regarding IoT solutions/platforms and, specifically, regarding the Business Models for Industrial Analytics most used in IoT field.

Subsequently, a questionnaire was developed and administered to three companies (AVIO, FCA and SACMI) which have implemented or intend to implement IoT solutions for Industrial Analytics, with the main aim of reconstructing their Business Models and understanding their operation.

From a joint analysis between the literature and the answers to the questionnaire, the objective of this paper (namely an innovative Business Model for Industrial Analytics) will therefore be obtained.

1.5. Structure

The goal of this work was achieved through the development of a Business Model created for Industry 4.0 and based on Industrial Analytics. This model was developed on the basis of a literature review, which will be presented in Chapter 2, and on the basis of the Operational Framework of the Business Model Canvas, which will be described in Chapter 3. The final model, presented in Chapter 4, will be based on the joint analysis of the three business models of the companies interviewed, and will be a support for all those companies that want to implement an IoT solution in the Industrial Analytics field.

2. LITERATURE REVIEW

In the literature there are numerous papers that study business models in the context of Industry 4.0 with reference to various aspects. In the course of this analysis, 4 main aspects covered by the literature that studied Business Models in the Industry 4.0 area were identified. The first aspect concerns the differences between traditional Business Models and those designed for the IoT; the second aspect concerns the Sustainable Business Models for Industry 4.0; the third aspect deals with the Ecosystem Business Models in the Industry 4.0 context; the last aspect concerns the analysis of the performance of companies that have decided to adapt their Business Model to an Industry 4.0 context.

Analysing the first aspect identified in the literature, which is related to the analysis of the differences between traditional Business Models and Business Models developed in the IoT context, several authors have investigated how companies are transforming their Business Models to adapt to this new reality, identifying the crucial aspects of this transformation. In this regard, Dijkman et al. (2015) highlights how the advent of the IoT is a phenomenon which companies must pay particular attention to, since it will radically influence and change some sectors that, to date, are among the most important and profitable in the market, such as manufacturing, healthcare and energy. In order to keep up with the times, companies are required to reformulate their Business Models according to the adaptation that these Business Models need to be profitable also in the IoT field, and for this reason the paper presents a Business Model Framework which aims to facilitate the adaptation of companies to the reality of Industry 4.0. Through a methodology based on interviews, questionnaires and the Canvas approach, the authors of the article draw up a ranking of the most important Building Blocks and which Items are most significant in order for a Business Model developed for the IoT to work and create value. both for the company and for its customers. Building Blocks are defined as the areas into which each business can be divided, distinguishing the areas destined for costs from those destined for revenues. The Building Blocks into which the Business Model Canvas is divided are: Value Proposition, Customer Segments, Channels, Customer Relationships, Revenue Streams, Key Activities, Key Partnerships, Key Resources and Cost Structure. By "items", on the other hand, we mean all the items inserted into the Building Blocks, i.e. all the aspects that characterize a specific area. The results of the article show that the Building Block that is considered most important is that of the Value Proposition, immediately followed by the Customer Relationships and Key Partnerships blocks; the most important items include: Cost reduction, Possibility of updates to the IoT platform/solution, Convenience, Performance, Co-Creation and Communities.

Another important paper that aims to study the differences between traditional Business Models and IoT Business Models is that of Metallo et al. (2018). In this article, which uses the approach of the Multiple Case Study, 3 companies with different characteristics are examined (Intel, a multinational company that has existed for decades; Solair, an Italian company that has existed since 2011 and was already involved in cloud-based software for systems IoT; Apio, an Italian start-up that deals with the creation of interconnected objects through IoT hardware and software systems). By putting together the data collected by these 3 companies, the authors of the article were able to create a Business Model Canvas in which were inserted the aspects that were considered most important in the opinion of the interviewed companies, allowing to understand which path a company that wants to adapt its Business Model to the IoT should take (considering, for example, if the company is already an established one like Intel, or if it is already mature but limited at national level like Solair, or even if it is a recently born company like Apio). The authors of the article demonstrate that the Building Blocks Value Proposition, Key Partners, Key Activities and Key Resources are the most important, while the part deemed of minor importance within the Canvas is that relating to Customer Relationship and Channels.

Two further important articles following the same aim of those just seen are those by Ismail et al. (2018) and Ju et al. (2016). Both articles report a Business Model Framework proposed by the authors based on interviews made with companies operating in the IoT sector, considering what are the most important aspects of their current Business Models. The results of both articles underline the importance of not leaving the Business Model unchanged when you decide to lead your company within the IoT reality. In addition, the authors list all the most important items to focus on during the transition from a traditional Business Model to one for the IoT, in each Building Block. The items considered most important are Convenience, Performance, Personalization and Product Development.

The second aspect discussed in the literature of Business Models regarding Industry 4.0 is that of Sustainable Business Models for Industry 4.0, i.e. those Business Models which, operating in the Industry 4.0 area, generate value and at the same time consider the environmental and social impact.

The article by de Man et al. (2017) offers an interesting insight into this topic, asserting that given the massive population growth we have witnessed since 1960 (humanity passed from 3 to 7 billion people), it is natural that has arisen an imbalance between supply and demand (with a scarcity of supply compared to demand), and consequently, there's a urgent need to transform current Business Models based on Industrial Analytics, including in these Business Models social and environmental factors linked to sustainability. In particular, the article highlights the link between Sustainable Products, Sustainable Business Models and Industrial Analytics, taking into consideration the coexistence of these three elements, together with the main purpose of each Business Model, that is to create value both for the own company that for consumers. According to the authors, this coexistence is not only possible but also financially feasible, by applying sustainability policies to each sector of the Business Model specifically designed for Industry 4.0 and Industrial Analytics, from the supply chain to the distribution and reuse of used components. In particular, the authors explain how it is possible to apply a Sustainable Business Model for Industrial Analytics by analysing three different scenarios: the Smart Laptop, the Serviced Wardrobe and the Smart Kitchen.

Another important article dealing with the topic of Sustainable Business Models for Industrial Analytics is that of Evans et al. (2017), in which the change of existing Business Models towards an area linked to the Internet of Things and Industrial Analytics is recognized as fundamental, in order to achieve sustainable innovations. The article proposes 5 useful propositions for the creation of Sustainable Business Models for Industrial Analytics, from which companies can draw inspiration to make their Business Models sustainable. Sustainable Business Models for Industry 4.0 will play a key role in the immediate future as the problems related to pollution will take greater importance in the current industrial context. Therefore, companies should start exploring the possibility of converting their Business Models for Industrial Analytics into Sustainable Business Models for Industrial Analytics, both to preserve the ecosystem of our planet and to enjoy a First Mover Advantage once these Business Models are widely adopted.

Another topic to which the literature has dedicated great importance is that of Ecosystem Business Models, i.e. those Business Models in which companies are not seen only as individual members of the industry, but in which they are all part of a single ecosystem in which they cooperate and compete, giving life to new products and satisfying the needs of consumers together.

The paper by Westerlund et al. (2014) offers an important contribution to the study of Ecosystem Business Models in Industry 4.0 as, after underlining the importance of changing the point of view from a single company to an ecosystem of companies, it lists the 3 major challenges that are encountered when wanting to design an Ecosystem Business Model for the IoT and offers a tool to companies to address these challenges. In particular, the first challenge is that of the Diversity of Objects, which consists in the fact that the number of objects capable of interacting with the internet will increase dizzyingly in the next few years, and will include a huge variety of objects with completely different characteristics, so that it will be difficult to find a common line for all. The second challenge is that of the Immaturity of Innovation, that is a challenge dictated by the fact that currently many technologies are actually immature, far from the typical standardization of mature products, and therefore it is difficult to establish an ecosystem between products that change continuously and which in any case are not adopted by the most part of the people. Finally, the third challenge is that of Unstructured Ecosystems, according to which the number of adopters, i.e. companies that have adopted these technologies, is still too small to be able to talk about an ecosystem. In fact, IoT is still fundamentally a new technology, and as such it has too few adopters to consider the ecosystems that will result from it. The article proposes an approach consisting of 5 pillars (Value Design, Value Drivers, Value Nodes, Value Exchanges and Value Extracts) thanks to which companies could be able to build their own Ecosystem Business Models, overcoming the problems related to the challenges described above.

An important contribution to the study of Ecosystem Business Models in the context of Industry 4.0 is offered by the article by Leminen et al. (2015). In this article the authors analyse the position of Small and Medium Enterprises (SMEs), asserting that where stakeholders are still looking for what their role should be (and even Ecosystems feel the lack of many "actors"), tools and templates currently available for Business Models provide little help, as they were basically designed for large enterprises, and do not fit the interdependent nature of new companies evolving in the same ecosystem. Through a study carried out with data collection methodologies (3 years of data, from 2012 to 2014) and interviews (14 respondents from 8 companies, all operating in the IoT sector), Leminen and the other authors were able to extrapolate some empirical findings regarding Ecosystem Business Models in the IoT field, such as the fact that it has been confirmed that there is a trend towards open-horizontal IoT applications in different industries, or the fact that different stakeholders (both service providers and customers) are actively seeking their "role" to play within these ecosystems.

Furthermore, another problem that characterizes Ecosystem Business Models emerges from the work of Leminen et al. (2017). This problem is the presence of an Unstructured Ecosystem, that is an ecosystem that is still "immature", in which there are few "characters" who do not know what their role is. The article then proposes a useful framework that allows to outline the role mechanisms in ecosystems, applying it to the analysis of data collected by 15 companies. The article then identifies 4 different roles that companies can play within IoT ecosystems (making a parallelism with the ecosystems present in the animal world), and finally the study demonstrates how companies tend to take possession of different roles in 4 emerging IoT ecosystems (Product, Company, Industry and Peer-to-Peer), which are structured in accordance with the identified roles.

Finally, the last aspect that emerged from the literature that has studied business models in the Industry 4.0 context is the one related to the analysis of the performance of companies that have decided to adapt their Business Model to an Industry 4.0 context. This aspect is essential to pay attention to as there is a need of a confirmation of the fact that changing your Business Model and adapting it to an IoT context is really profitable and therefore convenient for companies.

The paper by Yao et al. (2015) examines the case of the Asian e-commerce giant Alibaba, highlighting how as early as 2014 Alibaba had begun to launch its first initiatives related to the world of IoT. Although the IoT itself was at the time a technology born just a few years before, in March 2014 Alibaba signed a strategic agreement with Midea (a Chinese company leader in the field of electronics) to build an Open IoT Platform called AliCloud which could allow users to remotely control their applications and receive operational reports about their work directly on their smartphones. This choice was supported by the fact that Midea had simultaneously announced the launch of its first Smart Air Conditioner, choosing Alibaba’s platform as the sole reseller for its product. Over the years, Alibaba has focused on several other IoT-centred projects, such as the project in collaboration with Philips called Royal (in which Philips has decided to use AliCloud as the host of the IoT platform for its smart products), or the project in collaboration with SAIC (Shanghai Automotive Industry Corporation, a company belonging to the Fortune 100), which involved the construction of cars equipped with an internet connection. The authors, retracing the history of Alibaba and analysing the differences with the "pre-IoT" phase, were able to conclude that Alibaba’s (not only economic) effort to enter the IoT world was very costly in terms of resources, but the change made to its Business Model has allowed the company to make profit, as well as from the sale of the platform virtual space, primarily from the enormous amount of data that has been generated thanks to AliCloud, which has allowed the giant e-commerce to turn into a real “Information-Flow Firm” and a “Knowledge Generator”.

Table 1 contains all the articles cited in this literature review:

TITLE	AUTHORS	CLUSTER
Business Models for the Internet of Things	Dijkman et al, 2015	Differences between traditional Business Models and Business Models for the IoT
Understanding Business Model in the Internet of Things Industry	Metallo et al., 2018	
A Business Model Framework for Internet of Things	Ismail et al., 2018	
Prototyping Business Models for IoT Services	Ju et al., 2016	
An Industry 4.0 research agenda for sustainable business models	de Man et al., 2017	Sustainable Business Models for Industry 4.0
Business Model Innovation for Sustainability: Towards a Unified Perspective for Creation of Sustainable Business Models	Evans et al., 2017	
Designing Business Models for the Internet of Things	Westerlund et al., 2014	Ecosystem Business Models for Industry 4.0
Ecosystem Business Models for the Internet of Things	Leminen et al., 2015	
Actors in the emerging Internet of Things Ecosystems	Leminen et al., 2017	
Examining the effects of the Internet of Things on e-Commerce: Alibaba Case Study	Yao et al., 2015	Performance analysis

Table 1: Titles, Authors and Years of Publication of all the cited papers

3. ANALYSIS OF THE QUESTIONNAIRES

The analysis conducted, which used a questionnaire as the main tool, aimed at exploiting the knowledge acquired during the study phase of the literature, as well as the knowledge acquired through the study and analysis of the answers to the questionnaire, to introduce an innovative business model for Industry 4.0 based on industrial Analytics.

3.1. The questionnaire

The questionnaire on which the analysis is based aims to identify and describe the Business Model of the companies that have implemented or intend to implement an IoT platform/solution. The developed questionnaire is reported in Appendix A. The questionnaire questions were defined with the help of the Business Model Canvas tool shown in Figure 1. The Business Model Canvas was introduced by Osterwalder & Pigneur (2010), and defines a Business Model as "the rationale of how an organization creates, distributes and captures value". In particular, according to the Business Model Canvas it is possible to describe the business model of a company by identifying 9 areas (called Building Blocks), which describe the characteristic aspects of a company. Consequently, during the definition of the questions, the aim was to investigate the business model of the companies interviewed by retracing the 9 areas described by the Business Model Canvas.

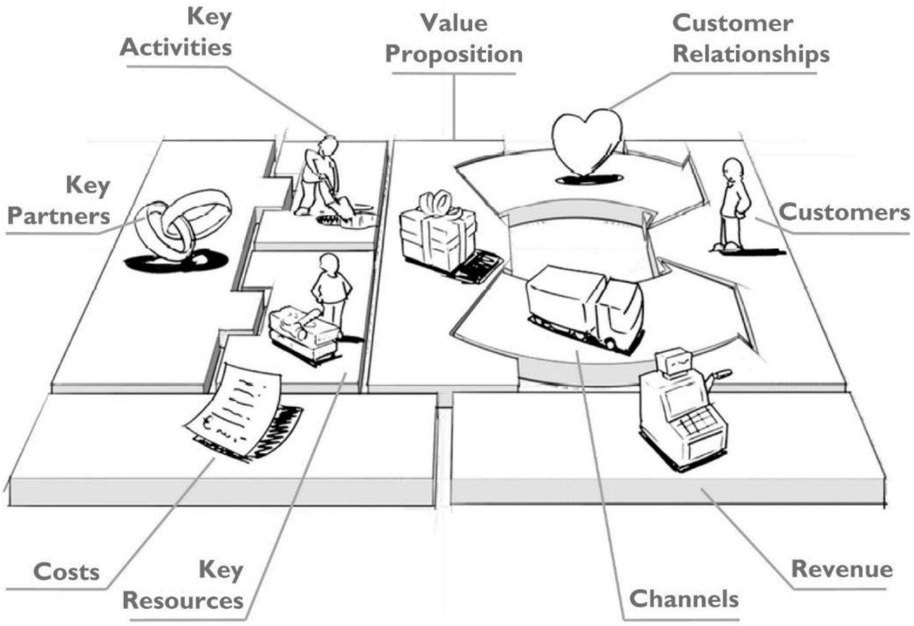

Figure 1: Illustration of the Business Model Canvas (Osterwalder & Pigneur, 2010)

As can be seen from Figure 1 above, the 9 Building Blocks into which the Business Model Canvas is divided are:

1. **Value Propositions**: in this Building Block are included those products and services that create value both for the specific customer segment to which the company refers and for the company itself.
2. **Customer Segments**: this Building Block identifies the different groups of people or organizations that the company intends to serve, i.e. those who will buy the company's value proposition.
3. **Channels**: this Building Block describes how the company manages to reach and communicate with its Customer Segments, in order to provide its Value Proposition.
4. **Customer Relationships**: this Building Block lists the types of relationship that the company establishes with its Customer Segments and the strength of these links (how strong the company/customer relationship is).
5. **Revenue Streams**: this Building Block describes the earnings that the company generates from each Customer Segment and, above all, the sources of such earnings.
6. **Key Resources**: this Building Block describes the most important resources (assets) that are required to ensure that the company's Business Model works well.
7. **Key Activities**: this Building Block lists the most important activities that the company must carry out to ensure that its Business Model works well.
8. **Key Partnerships**: this Building Block describes the network of suppliers and partners that help the company to make its Business Model work well.
9. **Cost Structure**: this last Building Block lists all the necessary costs that the company incurs to make its Business Model work.

The questions that are part of the questionnaire, which are also inserted simultaneously in the 9 Building Blocks, are the following:

- **Question 1**: Have you developed/Are you developing or are you planning to develop IoT solutions and/or platforms?

Question 1 cannot be framed into the Canvas, as it is only aimed at understanding whether the interviewed company has already thought or is thinking about the implementation of IoT solutions/platforms.

- **Question 2**: In case you haven't already done it, what is the reason why the company has not yet developed an IoT platform or solution?

Question 2, like the previous one, cannot be included into the Canvas as it aims at understanding why, in the case of a negative answer to the first question, the company has not yet thought about developing an IoT platform or solution.

- **Question 3**: Which application ambit does the IoT solution/platform that you are developing (or you want to develop) belong to?

Question 3 can be inserted in the Key Activities Building Block, as it aims to understand the application areas (activities) in which companies have decided to implement their IoT platforms or solutions.

- **Question 4**: Which technologies are you using/could you use for implementing an IoT solution/platform?

Question 4 can be included in the Key Resources Building Block as it aims to understand which technological resources the company uses for the implementation of its IoT platform or solution.

- **Question 5**: Which is the importance of the following technologies for developing an IoT solution/platform?

Question 5 can be framed in the same Building Block as the previous question, i.e. the Key Resources one, as it aims to understand the importance of the technologies (Resources) indicated by the company in Question 4.

- **Question 6**: Which benefits do you expect to get from the IoT platform or solution?

Question 6 cannot be framed in the Canvas as it is a question aimed at understanding the benefits that companies expect to obtain from the IoT platform or solution, and therefore does not belong to any of the areas of the Canvas. Nonetheless, this question is useful for the purposes of the questionnaire as it allows to understand what companies really think they are getting from the implementation of these new technologies.

- **Question 7**: How much is/could be involved each of the following business functions in the IoT solution/platform?

Question 7 can be included in the Key Resources Building Block as it requires to evaluate, through a scale of values, the business functions (Resources) that are or will be most involved in the IoT platforms or solutions implemented.

- **Question 8**: In which way will the IoT solution/platform allow to improve the relationship with your customers?

Question 8 can be inserted within the Building Block Customer Relationships as it aims to understand the degree of improvement that the implemented IoT solutions or platforms can bring to the relationship between the interviewed company and its Customers segment.

- **Question 9**: How did you develop/are you developing the IoT solution/platform?

Question 9 can be included in both the Building Blocks Key Partners and Key Activities as it aims to understand which Partners (if any) have helped (or will help) the company to develop the IoT platform or solution or if it was developed internally.

- **Question 10**: What types of data does the IoT platform or solution collect and analyse (or could it collect and analyse)?

Question 10 cannot be framed in the Canvas as it simply aims to understand what are (or will be) the types of data that the company intends to collect through the implemented IoT platform or solution, which does not fall within any area of the Canvas but is however useful to understand the scope of the data collection activities of the companies interviewed.

- **Question 11**: Where are/could be stored the data that the IoT solution/platform is supposed to analyse? Will you need a third-party cloud to store them?

Question 11 can be inserted within the Building Block Channels as it aims to understand which are the channels in which the data will be stored (if directly in the company, or by customers or suppliers).

- **Question 12**: The data you are collecting (or you want to collect) through the IoT solution/platform come only from your firm or also from some other third-party company?

Question 12 can be inserted in both the Building Blocks Key Partners and Key Activities because it aims to understand how the collected data will be managed, as they can be managed both internally (Key Activities) and externally (Key Partners).

- **Question 13**: The data you are collecting (or you want to collect) through the IoT solution/platform are going to be analysed internally or by an external company?

Just like the previous question, Question 13 can also be inserted in the Building Blocks Key Partners and Key Activities, as it aims to understand whether the data collected will be analysed internally (Key Activities) or externally, for example by customers or suppliers (Key Partners).

- **Question 14**: In which way will the analysis of the data collected from the IoT solution/platform bring a benefit to your customers?

Question 14 can be inserted within the Building Block Value Proposition, as the "benefit" to which the question refers is nothing more than the "value" that the company is able to provide to customers thanks to the aid of the IoT platforms or solutions implemented.

- **Question 15**: How much are/could be relevant the following costs for the process of managing the IoT solution/platform?

Question 15 can be framed within the Building Block Cost Structure, as the question is precisely aimed at understanding what are the most important costs incurred during the management phase of the IoT platform or solution.

- **Question 16**: Which is the revenue model chosen/about to be chosen for what concerns the IoT solution/platform?

Question 16 can be framed within the Building Block Revenue Streams as it aims to understand what is the Revenue Model chosen by the company for what concerns the IoT platform or solution.

Consequently, the questions of the questionnaire can be divided into the 9 Building Blocks according to the following scheme in Figure 2:

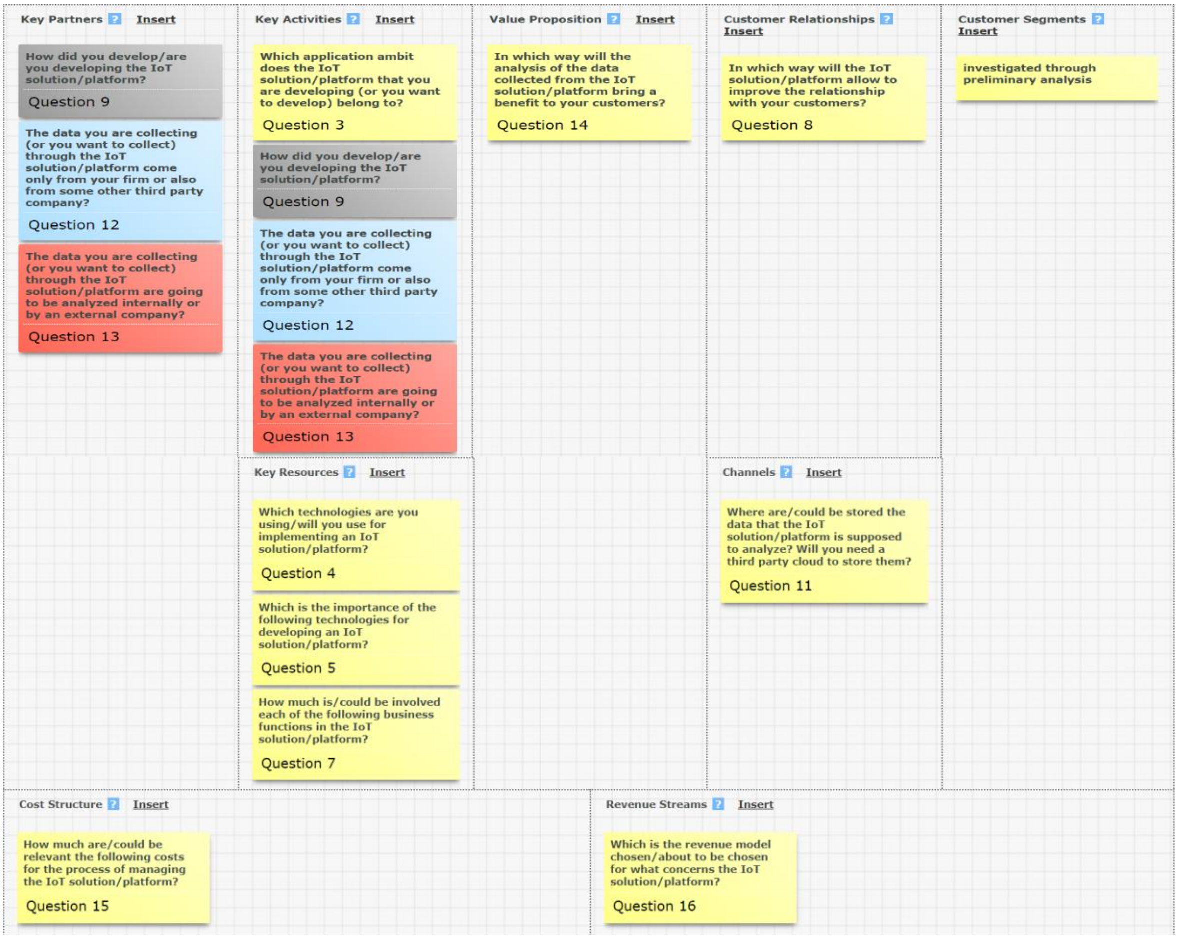

Figure 2: The Business Model Canvas of the Questionnaire's questions

The main objective of the questionnaire whose questions have just been illustrated is to interpret and understand the strategic choices made by the interviewed companies, in order to investigate the reasons that led these companies to adopt internal solutions and/or platforms in the IoT area for Industrial Analytics. This questionnaire also aims to fully understand the degree of implementation and use of IoT platforms and solutions, investigating if and how IoT solutions are used, how they are integrated with the company production system and what are the objectives that the company is set to achieve with the adoption of these solutions\platforms, as well as the expected potential benefits. The collection of this information will allow the development, in the next chapter of this work, of a new Business Model based on Industrial Analytics, in which it will be tried to combine in a single model all the advantages obtainable through Industrial Data.

To achieve this goal, the questionnaire was administered to 3 companies (AVIO, FCA and SACMI), in order to be able to analyse real operational scenarios and therefore to be able to elaborate the business models used.

The 3 interviewed companies will now be described.

3.2. AVIO

AVIO (full name GE AvioAero S.R.L.) is a General Electric business that operates in the design, production and maintenance of components and systems for civil and military aeronautics, in particular engines, mechanical transmissions, mass turbines and combustion chambers.

Figure 3: Logo of the company AvioAero

The company was founded in 2013, when it was bought by General Electric for 3.3 billion Euros, after being spun off from the mother company Avio S.P.A., with which today there are no longer any proprietary, control, supply or corporate coordination relationships of any kind.
The company has its registered office in Rivalta di Torino (TO), but owns other factories located in Brindisi, Pomigliano D'Arco (NA), Cameri (NO), Borgaretto (TO) and Bielsko-Biala (Poland).
To date, the company has more than 5,200 employees.
For what concerns the questionnaire, the choice of administering this questionnaire to AVIO was made because AVIO will be able to provide domain knowledge for the characterization of the Use Cases and the definition of appropriate IT solutions aimed at improving industrial processes with a view to Industry 4.0; on behalf of the company, the managers of the company's 3 main plants (those of Rivalta di Torino, Brindisi and Pomigliano D'Arco) answered to the questionnaire.

3.3 CRF – FCA

The Centro Ricerche FIAT (CRF) company belongs to the FIAT-Chrysler Automobiles (FCA) group. Founded in 1978, it is dedicated to the setting up and development of research and innovation activities in the automotive sector, with over 2,800 registered patents; thanks to its mission, that is to contribute to increasing the competitiveness of the products and services of the consortium members and customers in the medium-long term, the company is configured as a reference pole for innovation (also thanks to the numerous Research and Development initiatives) among the companies of the FIAT group, from which it is controlled.

Figure 4: Logo of the company CRF

The CRF has its registered office in Orbassano (TO), but has branch offices located in Trento, Valenzano (BA) and Foggia.

The company has about 900 employees.

With reference to the questionnaire, the choice to interview this company stems from the fact that CRF possesses knowledge of product / process design and development methods, guaranteed by its innovative development position in the field of manufacturing for FCA. The main expected result is therefore the definition of an implementation methodology for a new industrial business model based on Industrial Analytics, in particular in the field of application of big data. Various company figures responded to the questionnaire on behalf of the company, such as the IT Manager, the Factory Innovation Analyst, the Data Architect and Data Engineer, the Data & Analytics Manager and the Database Administrator

3.4 SACMI

The Società Anonima Cooperativa Meccanici Imola (SACMI) is a metalworking company at the head of an international group that is world leader in the supply of machines and systems for the Ceramics, Beverage, Food and Automation sectors.

Figure 5: Logo of the company SACMI

The company, founded in 1919 in Imola (BO), is a leader in the design of complete plants for the ceramic industry, with a market share of 60% for machinery with advanced technologies

(mills, dryers, presses, ovens) and leader in the segment of automatic machines for the production of metal and plastic caps. SACMI now has over 4,200 employees, with a turnover of 1.4 billion euros and an export share of 85%, being actively present in over 30 countries with 80 companies headed by the Imola headquarters. The company owns over 1,500 patents and over 700 registered trademarks. SACMI was selected to be interviewed because of its deep experience in the field of machinery and systems for ceramics; the company currently has full visibility on the automation and innovation needs to be implemented in the new control equipment, and therefore it will be able to provide case studies indicating in detail the needs whose to give a fully automated solution.
On behalf of this company, the following answered the questionnaire: the R&D Automation Manager, the ICT Director, the R&D Ceramics Manager, the MES Systems Manager, the Data Scientist and the IT Security Manager.

3.5. Analysis of the questions of the questionnaire

In this section will be analysed the responses of the 3 companies to the questionnaire that was administered to them; the analysis will be carried out on a question-by-question basis.

3.5.1. Question 1

Question 1, shown in Figure 6, aims to understand if the interviewed companies have already developed IoT platforms or solutions or if they have the intention to develop them.

Question 1.

	Yes	No
a) Have you developed IoT platforms or solutions?		
b) Are you developing / do you plan to develop IoT platforms or solutions?		

Figure 6: Question 1

From this question it is possible to see that two out of three companies (AVIO and FCA) have already implemented IoT solutions at the date of administration of the questionnaire. Instead, the remaining company (SACMI) has not yet been able to do so.

What can be deduced from the answers that the companies have provided in this question is that all the companies interviewed are interested in the implementation of IoT platforms and/or solutions for Industrial Analytics. This technology is in fact crucial in the sectors in which these companies operate, and not having IoT solutions in the short term could mean a high loss of profits in the medium term (Soiel, 2013)

3.5.2. Question 2

Question 2 (Figure 7) is complementary to the first one because in this question the interviewed companies are asked to explain the reasons why they eventually have not yet implemented IoT platforms or solutions. The possible reasons that the question includes among its answers are: the company does not consider the IoT solution/platform a strategic investment; the company does not currently have sufficient resources to implement the IoT platform/solution; the company's top management is not sensitive to the IoT issue; the company does not consider the IoT platform/solution useful for its business; other reasons chosen by the company.

Question 2. In your opinion, what is the reason why the company has not yet developed an IoT platform or solution? (It is also possible to mark more than one answer)

a) We do not consider it a strategic investment	
b) We currently have no resources available	
c) There is no sensitivity on the issue at the Top Management level	
d) We don't think it is useful for our business	
e) Other	

If "Other" please specify

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Figure 7: Question 2

As can be seen from the answers to the previous question (Question 1), only one company (SACMI) among the 3 analysed has not yet implemented IoT platforms or solutions, which is the reason why only SACMI answered to this question. In particular, the company replied "other", indicating in the comments "*We are developing some projects in the IoT field; the most critical element in the effectiveness of the execution of these projects is the lack of internal* *resources*". This answer therefore indicates that the main (if not the only) reason why the company has not been able, to date, to implement IoT solutions is the lack of internal resources within the company; this problem is also confirmed by a research published on the website elettronica-av.it which shows that "*36% of Italian companies do not have adequate know-how for the implementation, maintenance or monitoring of the IoT platform/solution*" and that "*the same percentage of respondents (36%) confirm that they consider the acquisition costs of the IoT platform/solution too high*", highlighting how the internal resources of the company (both economic and in terms of personnel and know-how) are the main brake, to date, of the implementation of IoT technologies (Elettronica AV, 2020).

3.5.3. Question 3

Once it has been ascertained that all 3 companies interviewed have already developed IoT solutions (or in any case they are already working to develop them), through Question 3, shown in Figure 8, we want to investigate the application areas in which the companies have decided to implement such IoT solutions. The possible areas proposed among the answers to the question are: Predictive maintenance (i.e. a type of preventive maintenance that is carried out following the identification of one or more parameters that are measured and processed using appropriate mathematical models in order to identify the remaining time before of the failure); Prescriptive maintenance (evolution of the concept of predictive maintenance that exploits IoT infrastructure data, automation and machine learning to monitor machinery, locate any anomalies and generate operational suggestions and prescriptive plans in real time); Warehouse automation (result of the combined work of Robot and Software, it minimizes human intervention in warehouse processes); Digitization of a production plant (collecting data thanks to a wide range of sensors and measuring tools previously installed in the production plant, in order to benefit from it); Energy efficiency management (reducing the impact on both costs and the environment of excessive energy use, optimizing processes); Production monitoring (installation of special displays and sensors that are able to monitor production data instant by instant); Innovation of product and business models (strategy for business growth that allows you to engage new customer segments by changing the way a company does business); Safety and Risk Management (set of activities, methodologies and coordinated resources to guide and control an organization with regards to risks and safety); Personalized products and services (using IoT technologies to be able to understand more deeply the needs of consumers and to be able to offer tailored products and services based on what the customer wants exactly); the company can also insert an application ambit that does not exist among the answers using the field “other”.

Question 3. Which application ambit does the IoT solution/platform that you are developing (or you want to develop) belong to?

a) Predictive maintenance	
b) Prescriptive maintenance	
c) Warehouse automation	
d) Digitization of a production plant	
e) Energy efficiency management	
f) Production monitoring	
g) Innovation of product and business models	
h) Security and risk management	
i) Personalized products and services	
j) Other	

If "Other" please specify

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Figure 8: Question 3

The answers to this question are summarized in Figure 9:

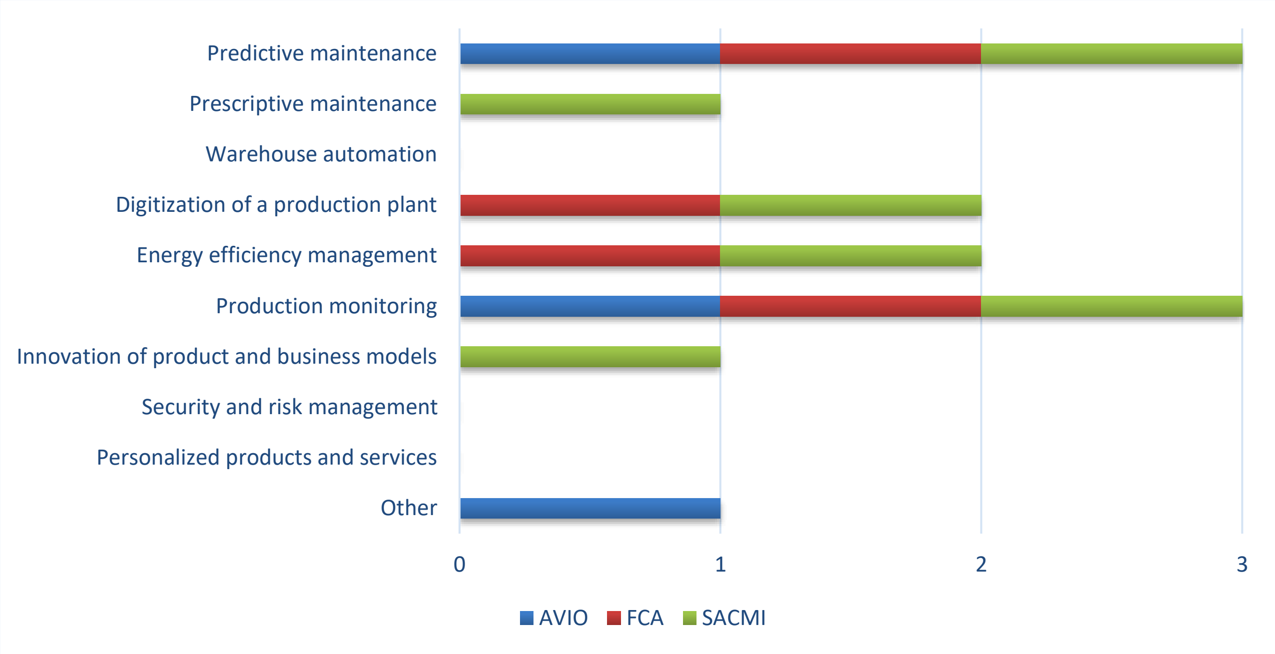

Figure 9: Answers to Question 3

As it's possible to see from the chart in Figure 9, two application ambits were indicated by all three companies interviewed, namely Predictive Maintenance and Production Monitoring. In addition, two application ambits were indicated by two out of three companies, namely the Digitization of the production plant and the management of energy efficiency, both indicated by FCA and SACMI. Three application ambits were indicated by a single company, namely Prescriptive Maintenance (SACMI), Product and Business Model Innovation (SACMI) and, under the voice "other", the usage of data for descriptive use (AVIO) has been added. Lastly, three application ambits have not been selected by any company, namely Warehouse Automation, Security and Risk Management and Customized Products and Services.

It is important to note that companies prefer to use IoT technologies to improve and monitor their current production, as well as to implement Predictive Maintenance and Servitization policies, rather than using them to introduce new products/services within their business models.

The answers to question 3 have also been summarized in the graphs below (Figures 10, 11 and 12) for each company:

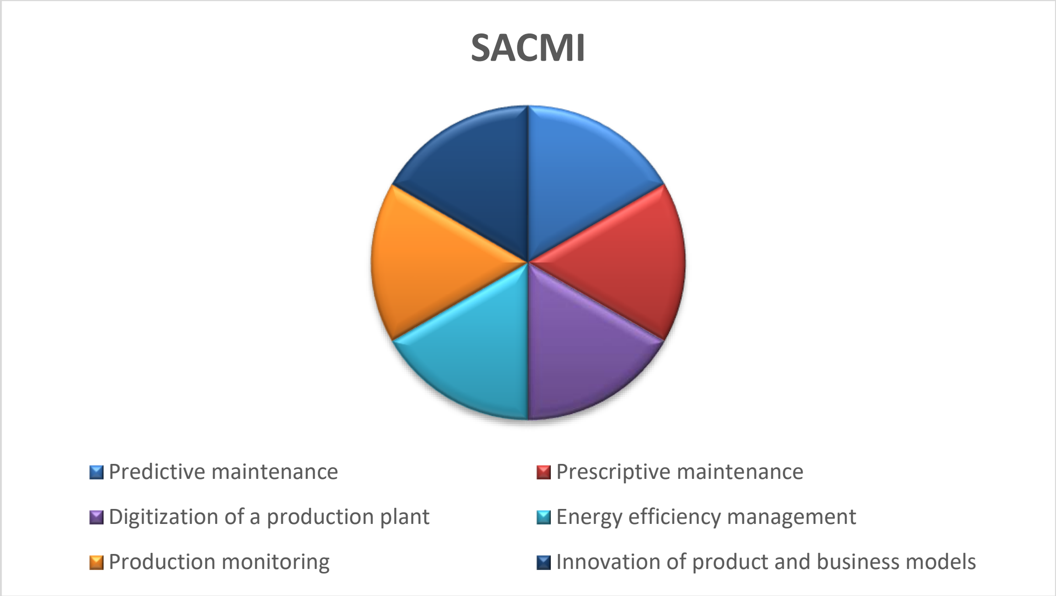

Figure 10: Answers of the company SACMI to Question 3

As can be seen from the graph in Figure 10, SACMI is the company that will apply IoT solutions to the highest number of areas (six, namely Predictive Maintenance, Prescriptive Maintenance, Digitization of a Production Plant, Energy Efficiency Management, Production Monitoring and Innovation of Product and Business Models).

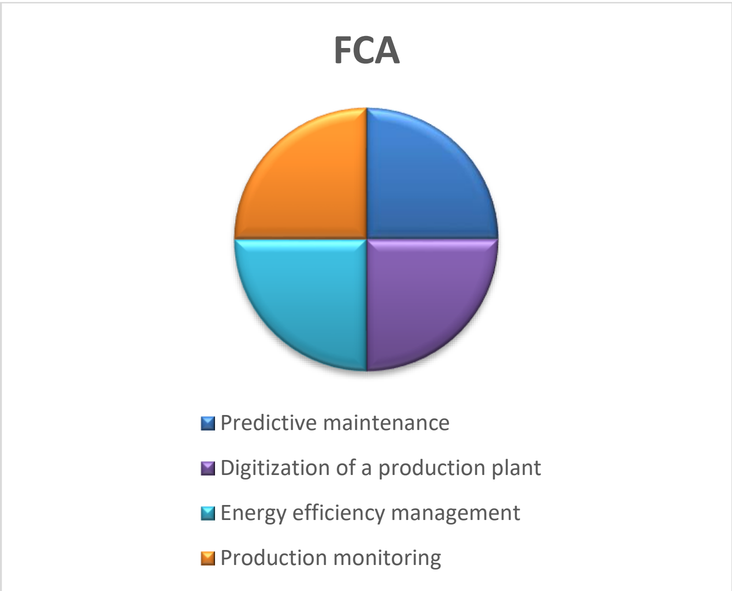

Figure 11: Answers of the company FCA to Question 3

From the chart in Figure 11 it's possible to see that FCA has already applied its IoT solutions to 4 areas (Predictive Maintenance, Digitization of a Production Plant, Energy Efficiency Management and Production Monitoring);

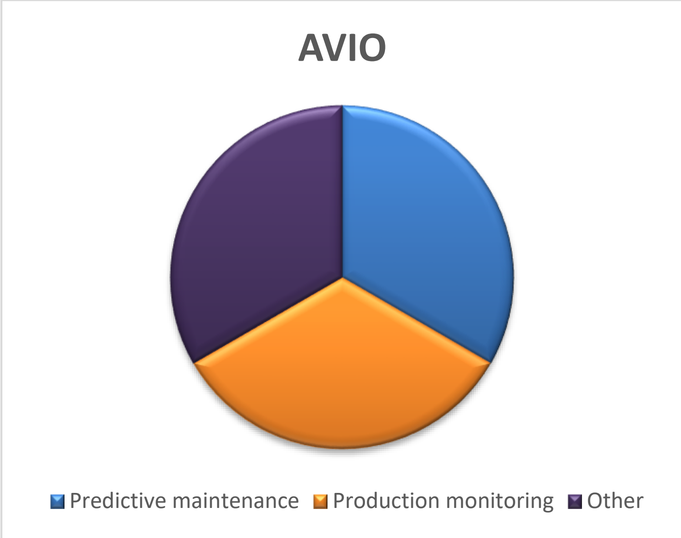

Figure 12: Answers of the company AVIO to Question 3

From the graph in Figure 12 it can be seen how AVIO applied its IoT solutions to 3 areas (Predictive Maintenance, Production Monitoring and Data Usage for Descriptive Use, indicated under the answer "Other").

3.5.4. Question 4

Question 4 (in Figure 13) aims to understand which technologies are most frequently used for the creation/implementation of an IoT solution. Among the possible answers to the question it is possible to find: Sensors and electronic components (useful for data collection); TLC hardware and software (telecommunications hardware and software systems); Cloud computing (technology that makes it possible to use software and hardware resources via a remote server); Integration platforms (managed solution for hosting, developing and integrating applications and data in the cloud); Big Data and Analytics (the set of heterogeneous data, i.e. obtained from multiple different sources, and the discovery, interpretation and communication of significant models in such data in order to initiate a more effective decision-making process); Specific vertical applications (software that respond to the specific needs of a single market or a strictly defined market, and therefore dedicated to a specific manufacturing or service sector, as opposed to horizontal software that is instead of generalized use); Wearables and/or mobile devices (mobile and/or wearable devices capable of constantly monitoring certain parameters).

Question 4. Which technologies are you using/will you use for implementing an IoT solution/platform?

a) Sensors and electronic components	
b) Hardware and software TLC	
c) Cloud computing	
d) Integration platforms	
e) Big Data and Analytics	
f) Specific vertical applications	
g) Wearables and/or mobile devices	

Figure 13: Question 4

The answers to this question are shown in Figure 14: from the chart it is clear that all the answers have been selected at least once despite the fact that there are only 3 companies responding, confirming the great variety of technologies that the IoT is able to cover but also confirming the fact that companies are thinking about the use of many technologies for the implementation of IoT solutions for Industrial Analytics.

It is also possible to note that out of the 7 proposed technologies, 4 (Sensors and Electronics Components, Hardware and Software TLC, Cloud Computing and Big Data and Analytics) have been chosen by all 3 companies, while the remaining 3 (Integration platforms , Specific Vertical Applications and Wearables and/or Mobile Devices) have been chosen by only one company each; there are no answers that have been selected by two out of three companies, nor answers that have not been selected even once.

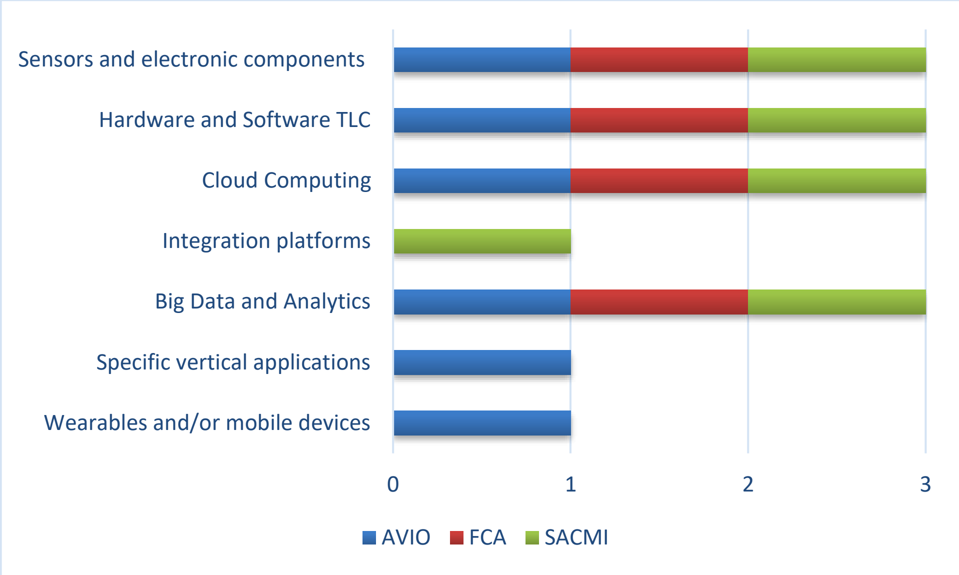

Figure 14: Answers to Question 4

In the following charts in Figures 15, 16 and 17 the answers for each company are reported:

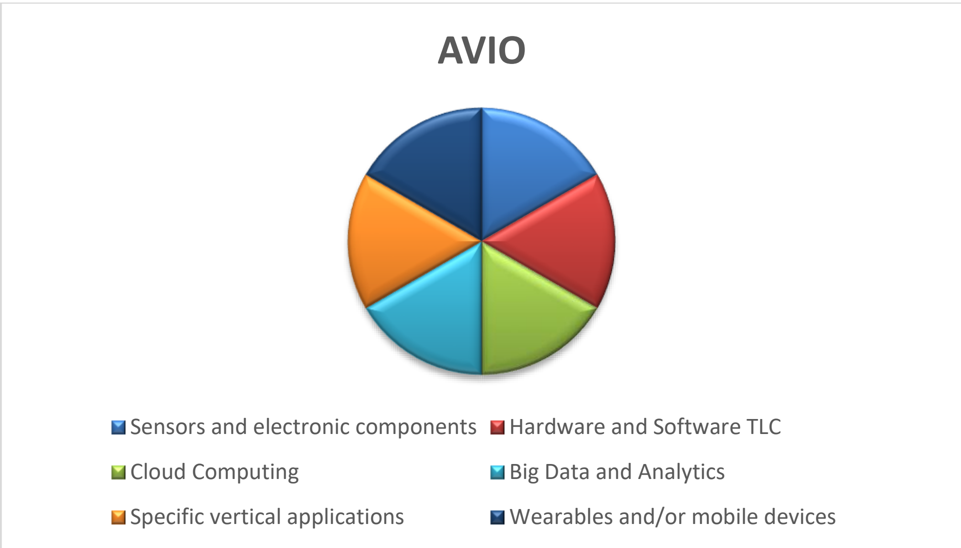

Figure 15: Answers of the company AVIO to Question 4

Analysing the graph in Figure 15, it's possible to note that AVIO has used 6 technologies out of the 7 proposed to implement its IoT solution, namely: Sensors and Electronic Components, Hardware and Software TLC, Cloud Computing, Big Data and Analytics, Specific Vertical Applications and Wearables and/or Mobile Devices.

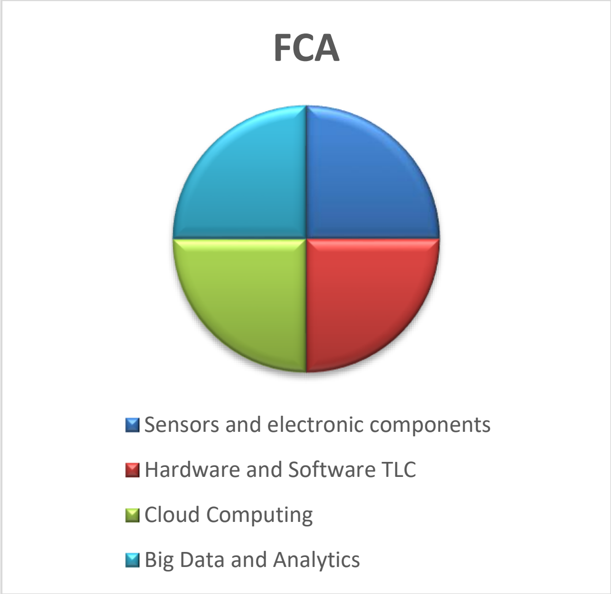

Figure 16: Answers of the company FCA to Question 4

From the graph in Figure 16 it's possible to note that FCA has used the technologies: Sensors and Electronic Components, Hardware and Software TLC, Cloud Computing and Big Data and Analytics.

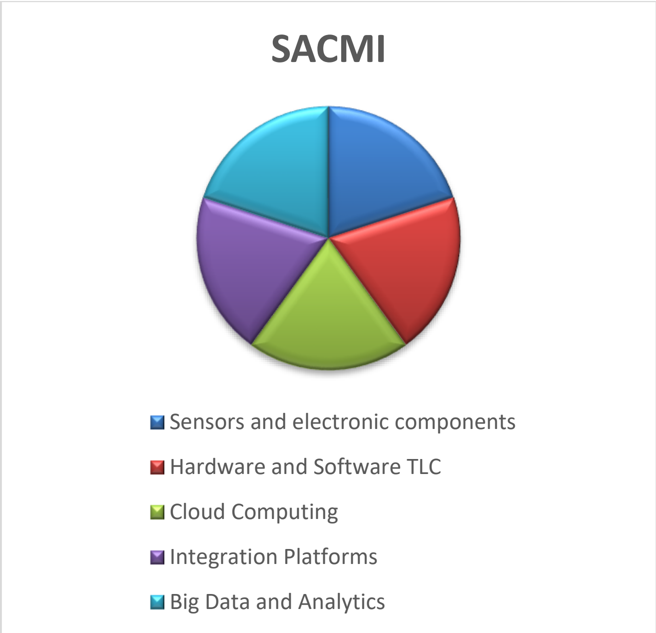

Figure 17: Answers of the company SACMI to Question 4

Finally, from the graph in Figure 17, we note that SACMI intends to use the technologies: Sensors and Electronic Components, Hardware and Software TLC, Cloud Computing, Integration Platforms and Big Data and Analytics.

3.5.5. Question 5

Question 5 (shown in Figure 18) is closely linked to the previous one because it is aimed at measuring how important are the technologies introduced in the previous question that the companies use (and also those not used), using a scale with values from 1 (=not important at all) to 4 (=absolutely important).

Question 5. In your opinion, which is the importance of the following technologies for developing an IoT solution/platform? (Define the level of importance from 1=not at all important to 4=absolutely important)

a) Sensors and electronic components	
b) Hardware e software TLC	
c) Cloud Computing	
d) Integration platforms	
e) Big Data and Analytics	
f) Specific vertical applications	
g) Wearables and/or mobile devices	

Figure 18: Question 5

The following graphs (Figures 19, 20 and 21) show the importance divided by company; in each graph the technologies that the company has decided to use will be indicated with green bars, while those technologies that the company has decided not to use will be indicated in red, in accordance with the answers given in the previous question (Question 4).

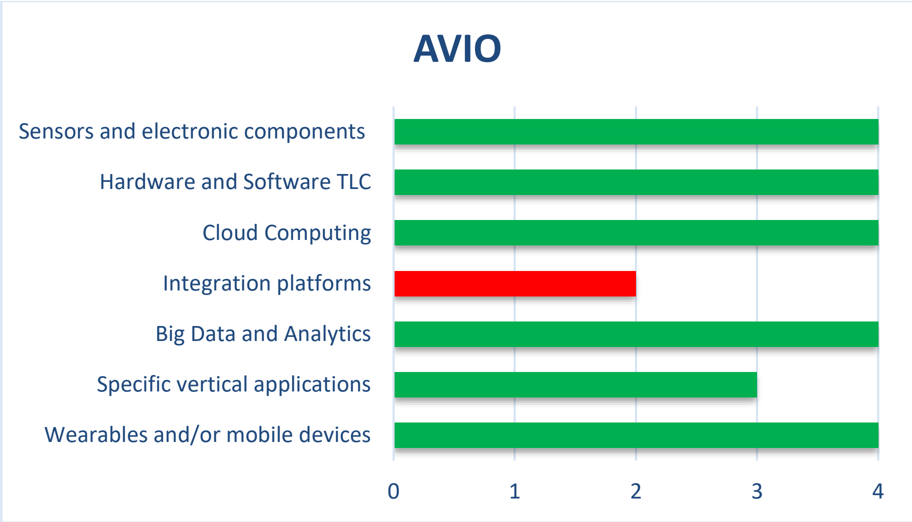

Figure 19: Answers of the company AVIO to Question 5

As for AVIO (graph in Figure 19), it is possible to see that almost all the technologies used are considered important with maximum score. In particular, Sensors and Components of Electronics, Hardware and Software TLC, Cloud Computing, Big Data and Analytics and Wearables and/or Mobile Devices received an importance equal to 4 out of 4. Specific Vertical Applications received a score of 3 out of 4. The only not used technology, namely Integration Platforms, was deemed unimportant and therefore received a score of 2 out of 4.

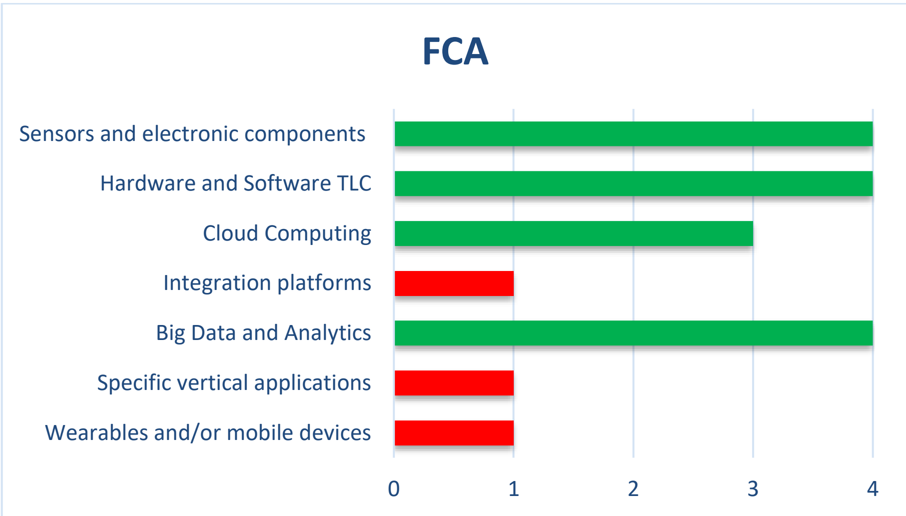

Figure 20: Answers of the company FCA to Question 5

As in the case of the previous company, from the graph in Figure 20 it is possible to note that FCA also considered very important the used technologies, while it considered unimportant the technologies not used. The company has in fact given the maximum score to the technologies

Sensors and Electronics Components, Hardware and Software TLC and Big Data and Analytics. Cloud Computing received a score of 3 out of 4. Finally, FCA assigned the minimum score of 1 out of 4 to all the unused technologies, namely Integration Platforms, Specific Vertical Applications and Wearables and/or Mobile Devices.

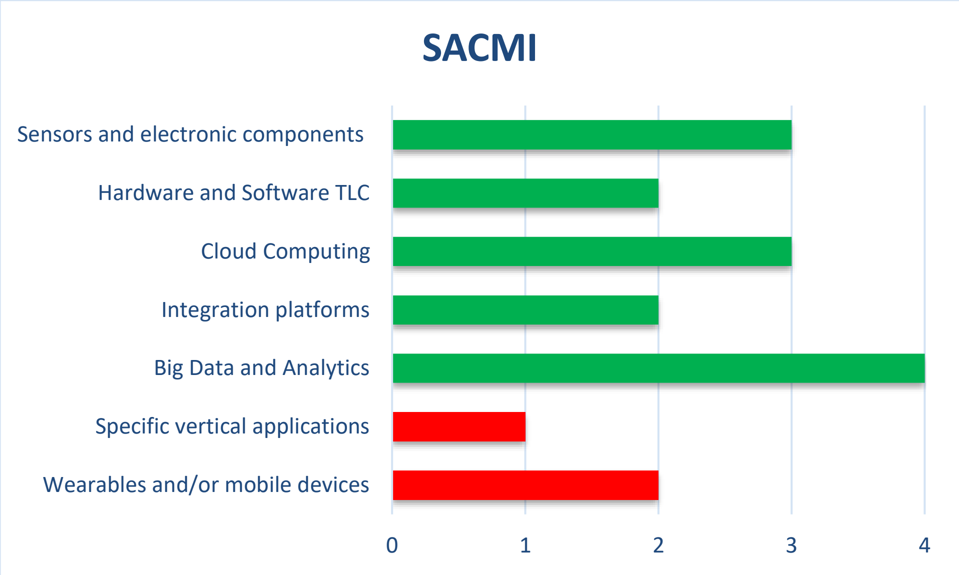

Figure 21: Answers of the company SACMI to Question 5

Finally, from the graph in Figure 21 it is possible to see that according to SACMI, the most important technology in the development of IoT solutions is represented by Big Data and Analytics, to which a score of 4 out of 4 was assigned. Then follow, in order of importance, the Sensors and Components technologies of Electronics and Cloud Computing, which were assigned a score of 3 out of 4. We then find the Hardware and Software TLC technologies, Integration Platforms and Wearables and/or Mobile Devices, which were awarded a score of 2 out of 4. Finally, the Vertical Application Specific technology was deemed unimportant, and in fact received a score of 1 out of 4.

In general, from the 3 previous graphs (Figures 19, 20 and 21) it's possible to draw up the conclusion that the companies seem quite satisfied with the technologies they use: the importance scores are in fact very high in correspondence of the technologies already used, and very low in correspondence of unused technologies, witnessing the fact that companies do not seem to be inclined to adopt new technologies for the development of IoT solutions rather than the already used ones.

Considering the scores assigned by the three companies to the technologies, it is possible to determine an average score for each technology and therefore determine which technologies are considered most important in general in the development and implementation of IoT solutions. The graph in Figure 22 shows the average score considering the responses of the three responding companies for each technology.

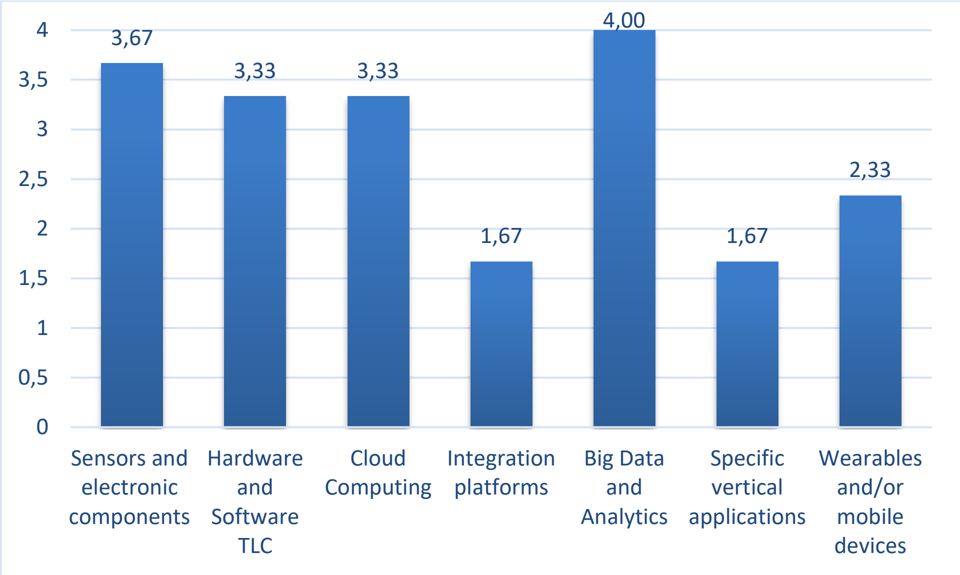

Figure 22: Average Answers to Question 5

From the graph in Figure 22 it is possible to see that Big Data and Analytics technology received the maximum score of 4 out of 4 from all 3 companies. There are also 3 other technologies with an average score of 3 out of 4 or higher: Sensors and Components of Electronics obtained an average score of 3,67, while Hardware and Software TLC and Cloud Computing obtained an average score of 3,33; all 3 technologies were selected by all 3 companies in the previous Question (Question 4), and were also considered very important by each of them. The only technology with an average score between 2 and 3 is Wearables and / or Mobile Devices, which achieved an average score of 2,33 and was only selected by one company in Question 4, as were the technologies deemed less important (importance less than 2), i.e. Integration Platforms and Specific Vertical Applications, which have also been selected only by one company.

3.5.6. Question 6

Question 6 (in Figure 23) aims to understand what are the benefits that companies have had (or expect to have) after the implementation of the IoT platform/solution. The possible benefits contemplated in the answers to this question are: Product and service customization (i.e. the possibility of diversifying and differentiating products and services, adapting them to the needs of each customer); Orientation towards single batch production (Make to Order, aimed at reducing waste thanks to the fact that production starts only after the order has been received); Reduction of Time to Market (i.e. the time that elapses between the start of the development process of a new product and the start of its marketing); Optimization of energy consumption and raw materials (plants capable of optimizing production and therefore reducing consumption and avoiding waste of energy and raw materials); Productivity improvement (ratio between the quantity of output and the weighted average of the inputs used in the production process); Reduction of production waste (reducing the number of substances or objects that the owner discards or has the intention or obligation to discard); Cost optimization (adopting new technologies that allow to reduce costs and consequently also optimize timing); Enhancement of human capital and better integration of skills (enhance the knowledge, skills, planning and experience that the human resources of a working reality can activate); Interconnection and correspondence between physical systems and simulated systems (collect a huge amount of data on the entire industrial system to prevent failures by reading the work cycles of the various components); Offering new services to customers (data collection in order to get more precise information about what customers want, in order to offer innovative and personalized services); Increase of information related to the product usage (understand more precisely what the products are used for); Increase of information related to the production processes (obtaining more precise data related to production processes in order to be able to optimize them); Increase of information related to distribution/logistics processes (obtaining more precise data related to distribution and logistics processes in order to be able to optimize them).

Question 6. Which benefits do you expect to get from the IoT platform or solution? (It is also possible to mark more than one answer).

a) Customization of the product and service (flexibility)	
b) Orientation towards single batch production (make-to-order)	
c) Reduction of the time-to-market	
d) Optimization of energy and raw materials consumption	
e) Productivity improvement	
f) Reduction of production waste	
g) Cost optimization	
h) Enhancement of human capital and better integration of skills	
i) Interconnection and correspondence between physical and simulated systems	
l) Offering new services to customers	
m) Increase of information related to the product usage	
n) Increase of information related to production processes	
o) Increase of information related to distribution/logistic processes	

Figure 23: Question 6

The answers to this question are summarized in Figure 24. From the graph shown it can be seen that all 3 companies expect benefits from the implementation of IoT solutions in terms of Improvement of productivity, Reduction of production waste, Optimization of Costs and Increase of information related to production processes. Other 4 benefits were chosen by 2 out of 3 companies, namely Reduction of Time to Market, Optimization of energy and raw material consumption, Interconnection and correspondence between physical systems and simulated systems and Increase of information related to the use of the product. Orientation towards single-batch production and Offer of new services to customers were instead chosen by only one company out of three. Finally, no company has indicated the areas Enhancement of human capital, Product/service customization and Increase of information relating to distribution/logistics processes.

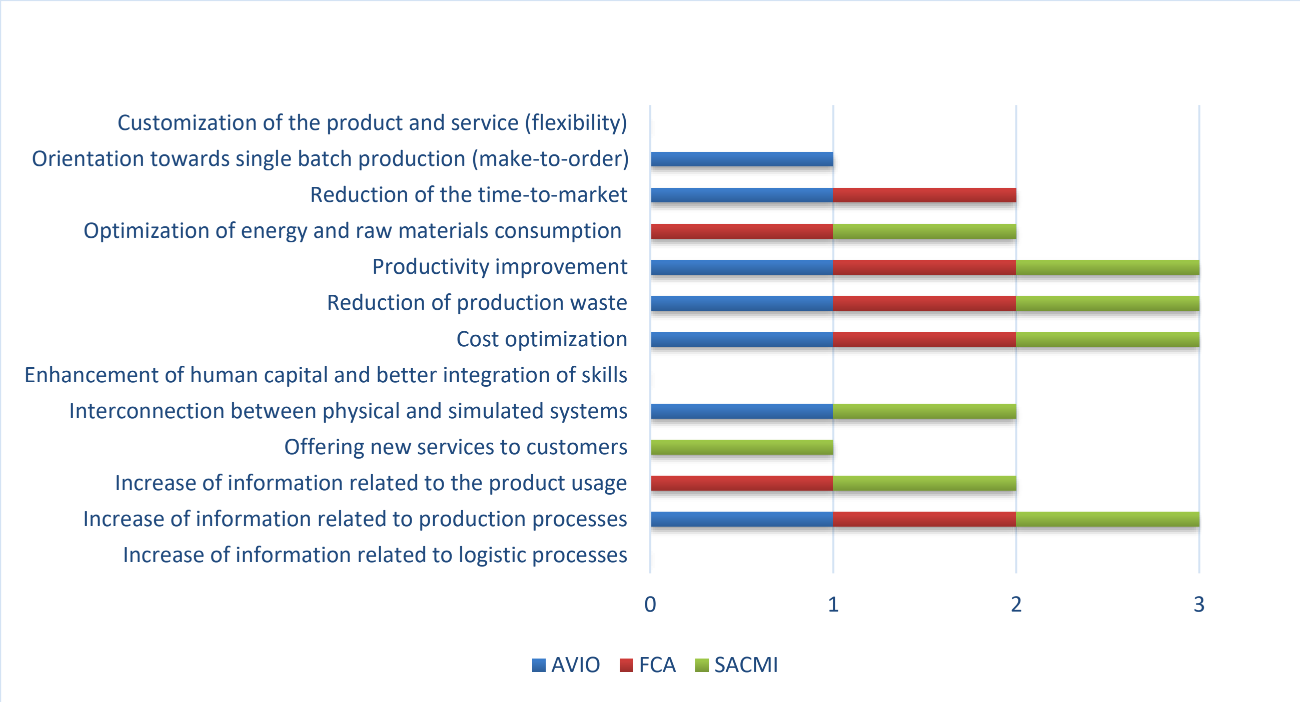

Figure 24: Answers to Question 6

The following charts in Figures 25, 26 and 27 summarize the answers of each company to Question 6:

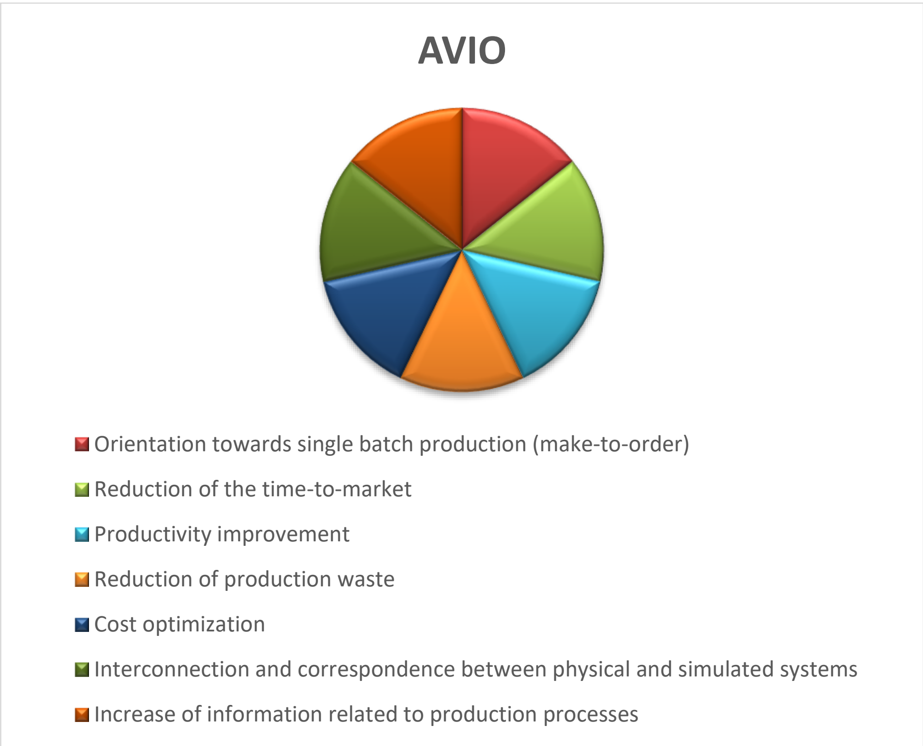

Figure 25: Answers of the company AVIO to Question 6

From the graph in Figure 25 it is possible to see that AVIO indicated 7 answers, which are: Orientation towards single batch production, Reduction of the Time to Market, Productivity improvement, Reduction of production waste, Cost optimization, Interconnection and correspondence between physical systems and simulated systems and Increase of information related to production processes.

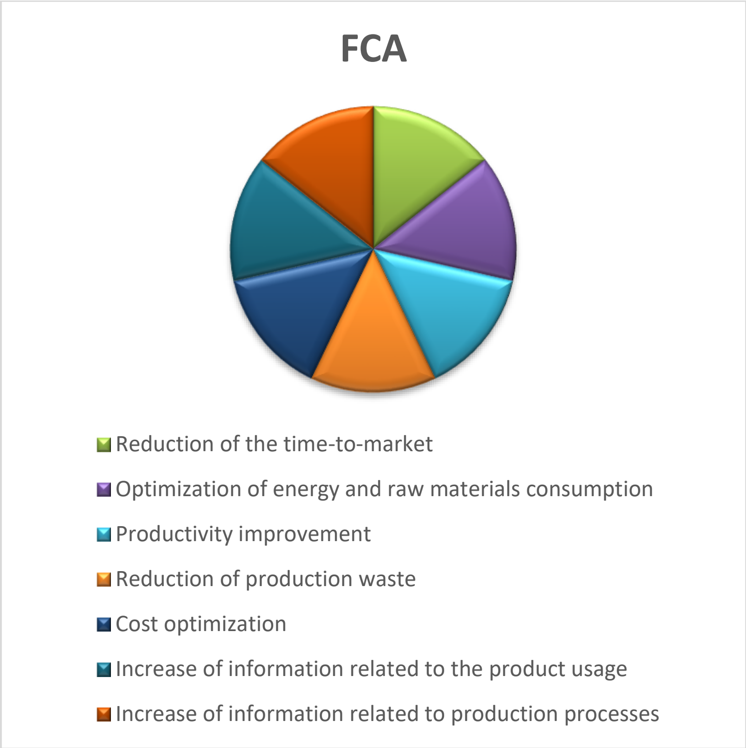

Figure 26: Answers of the company FCA to Question 6

From the graph in Figure 26 it can be seen that like AVIO, also FCA indicated 7 answers, namely: Reduction of the Time to Market, Optimization of energy and raw material consumption, Productivity improvement, Reduction of production waste, Cost optimization, Increase of information related to the product usage and Increase of information related to production processes.

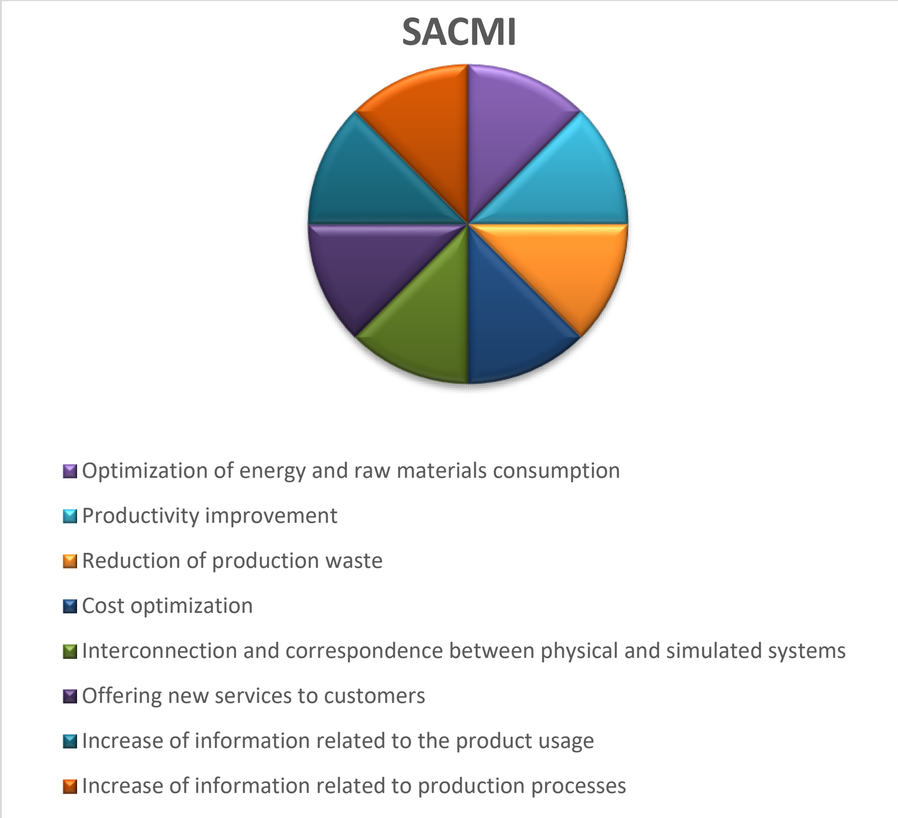

Figure 27: Answers of the company SACMI to Question 6

Finally, from the graph in Figure 27 it's possible to note that SACMI, although it has not yet implemented its own solution or IoT platform, appears to have even higher expectations than those of the other two companies, having been the only one to indicate 8 answers, which are: Optimization of energy and raw materials consumption, Productivity improvement, Reduction of production waste, Costs optimization, Interconnection and correspondence between physical and simulated systems, Offering new services to customers, Increase of information related to the product usage and Increase of information related to production processes.

In general, the graphs in Figures 26, 27 and 28 show that in this case there is a fairly balanced number of answers per company: out of 13 possible answers, companies have indicated an average a little higher than 7 answers each, which means that they expect (or have already had) improvements and benefits on many different aspects thanks to the IoT solutions implemented and also thanks to those in phase of implementation.

3.5.7. Question 7

Question number 7 (in Figure 28) requires companies to evaluate, on a scale from 1 (= not involved at all) to 4 (= absolutely involved), the business functions that are or will be most involved in the IoT solution chosen by the company. The business functions present in the answers are: Marketing, Sales, Research and Development, Operations (production and logistics); Information Technology (IT), Human Resources and Administration and Finance.

Question 7. How much is/could be involved each of the following business functions in the IoT solution/platform? (Define the level of involvement from 1=not at all involved to 4=very much involved).

a) Marketing	
b) Sales	
c) R&D	
d) Operations (Production and Logistic)	
e) IT	
f) Human Resources	
g) Administration and finance	

Figure 28: Question 7

The graph in Figure 29 gives information about the average of the answers of the 3 companies for each business function. The highest average score is recognized to R&D and IT functions (3,33 points) followed by Operations (production and logistics) with 3 points. At 2,33 points of average there is the Administration and Finance function. The Marketing and Sales functions achieved an average score of 1,67 points. Finally, the Human Resources function is the one that obtained the lowest average score (1,33) and is therefore considered the function least involved in the implementation and management of IoT platforms/solutions.

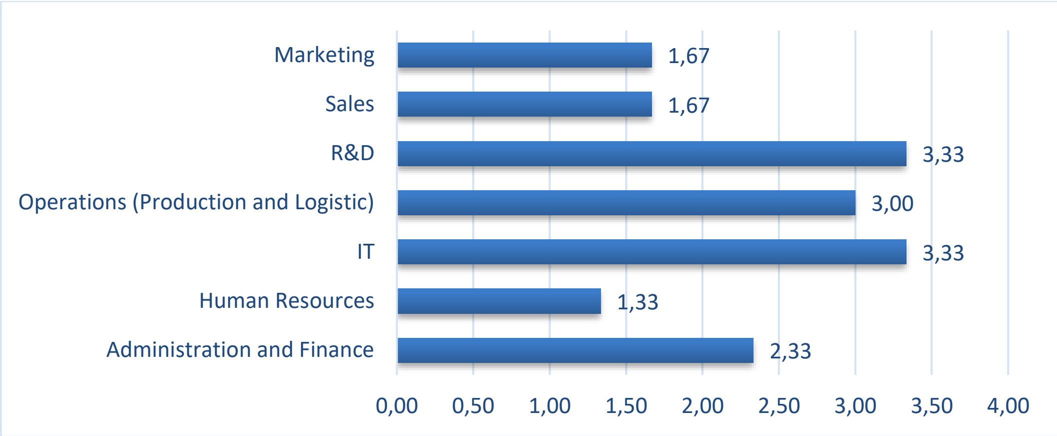

Figure 29: Average Answers to Question 7

The following Figures 30, 31 and 32 show the graphs divided by company:

Figure 30: Answers of the company AVIO to Question 7

According to the company AVIO (graph shown in Figure 30), the business functions that are most involved in the development and implementation of the platform are Operations, IT and Administration and Finance, which received a score of 4 out of 4. The function Research and Development then received a score of 3 out of 4. Finally, 3 functions, namely Marketing, Sales and Human Resources, received a score of 1 out of 4.

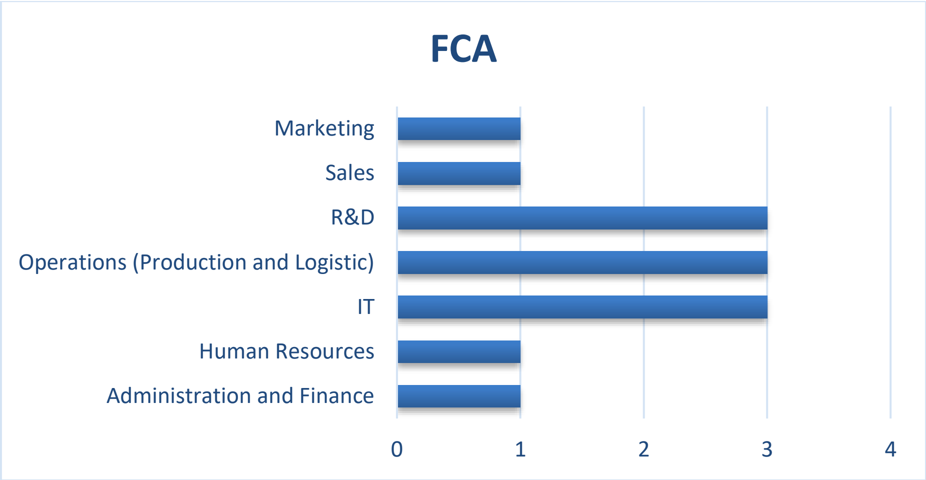

Figure 31: Answers of the company FCA to Question 7

From the graph in Figure 31 it is possible to see that FCA has not assigned any 2 or 4: in fact, there are 3 functions with a score of 3 out of 4 (R&D, Operations and IT) and 4 functions with a score of 1 out of 4 (Marketing, Sales, Human Resources and Administration and Finance).

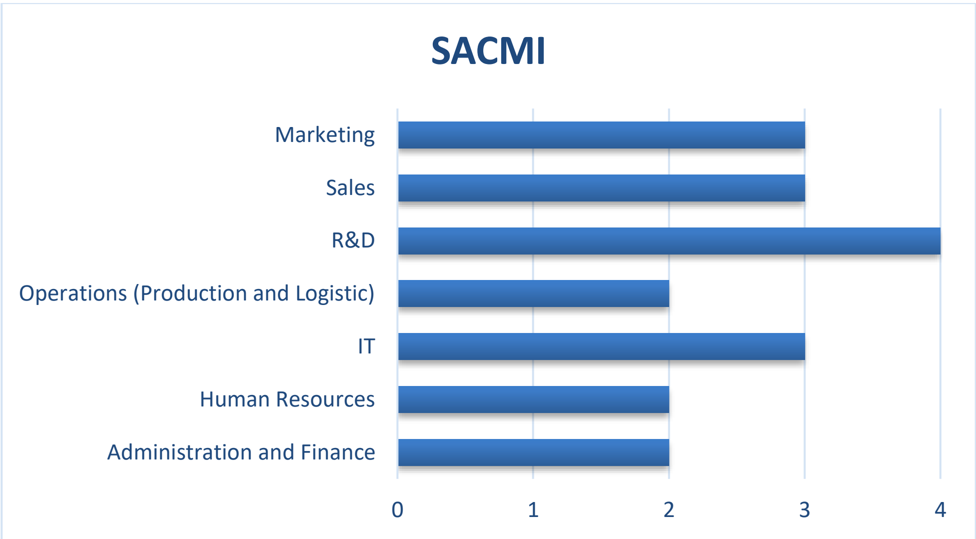

Figure 32: Answers of the company SACMI to Question 7

As can be seen from the graph in Figure 32, the most involved business function in the implementation of IoT solutions/platforms for SACMI is R&D, to which the company has assigned a score of 4 out of 4. Immediately after we find Marketing, Sales and IT with a score of 3 out of 4. After, we find Operations, Human Resources and Administration and Finance with a score of 2 out of 4. Finally, none of the company functions were given the minimum score of 1 out of 4.

3.5.8. Question 8

Question 8 (in Figure 33) is the first open-ended question of the questionnaire. The question aims to understand how the customers relationship could improve (or has already improved) after the implementation of the IoT solution chosen by the company.

> **Question 8.** In which way does the IoT solution/platform allow to improve the relationship with your customers? (Ex. the IoT platform has allowed us to customize our product; The IoT solution has allowed us to offer additional services to the customer; etc …).
>
> ____
>
> ____
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> ____

Figure 33: Question 8

Being an open-ended question, the answers of the 3 companies are shown in the list below:

AVIO:

- Reduction of the Time to Market
- Reduction of Production Waste
- Cost Optimization

FCA:

- Better Product Quality
- Reduction of Production Costs
- Reduction of the Time to Market
- Customer Satisfaction

SACMI:

- Offering New Services to Customers

From these answers we can draw various information. First of all, both companies that have already implemented their IoT solution (i.e. AVIO and FCA) have received a benefit in terms of Time to Market.

Furthermore, it is evident that all the remaining items have, as a common factor, a reduction in costs and waste: AVIO in fact chose between its answers "Reduction of production waste" and “Cost optimization”, while FCA wrote “Reduction of Production costs”, underlining once again how IoT solutions are able to make companies save a lot of resources, as well as make the best use of available resources.

Finally, the “Better Product Quality” perfectly matches the “Customer Satisfaction” chosen by FCA, showing the enormous potential that, already today (but we can only imagine in the future), the IoT is able to offer businesses. Although SACMI has not yet implemented its IoT solution, it replied “The IoT solution will allow us to offer to the customer additional services”, revealing the intention to implement Servitization strategies that will make the company improve the relationship with its customers.

3.5.9. Question 9

Question 9 (in Figure 34) intends to understand how the IoT platform or solution has been developed (or is being developed). In particular, the question intends to investigate whether the platform has been developed within the company, or in collaboration with company’s stakeholders such as suppliers, customers or even competitors.

Question 9. How did you develop/are you developing the IoT solution/platform?

a) We developed the IoT platform or solution internally, without collaborating with suppliers, customers and competitors	
b) We have developed the IoT platform or solution in collaboration with our suppliers	
c) We have developed the IoT platform or solution in collaboration with our customers	
d) We have developed the IoT platform or solution in collaboration with one or more competitor(s)	
e) We have outsourced the development of the IoT platform or solution to an external company	

Figure 34: Question 9

Assumed that in this question it was obviously possible to choose only one alternative, the answers of the 3 companies are summarized in Figure 35:

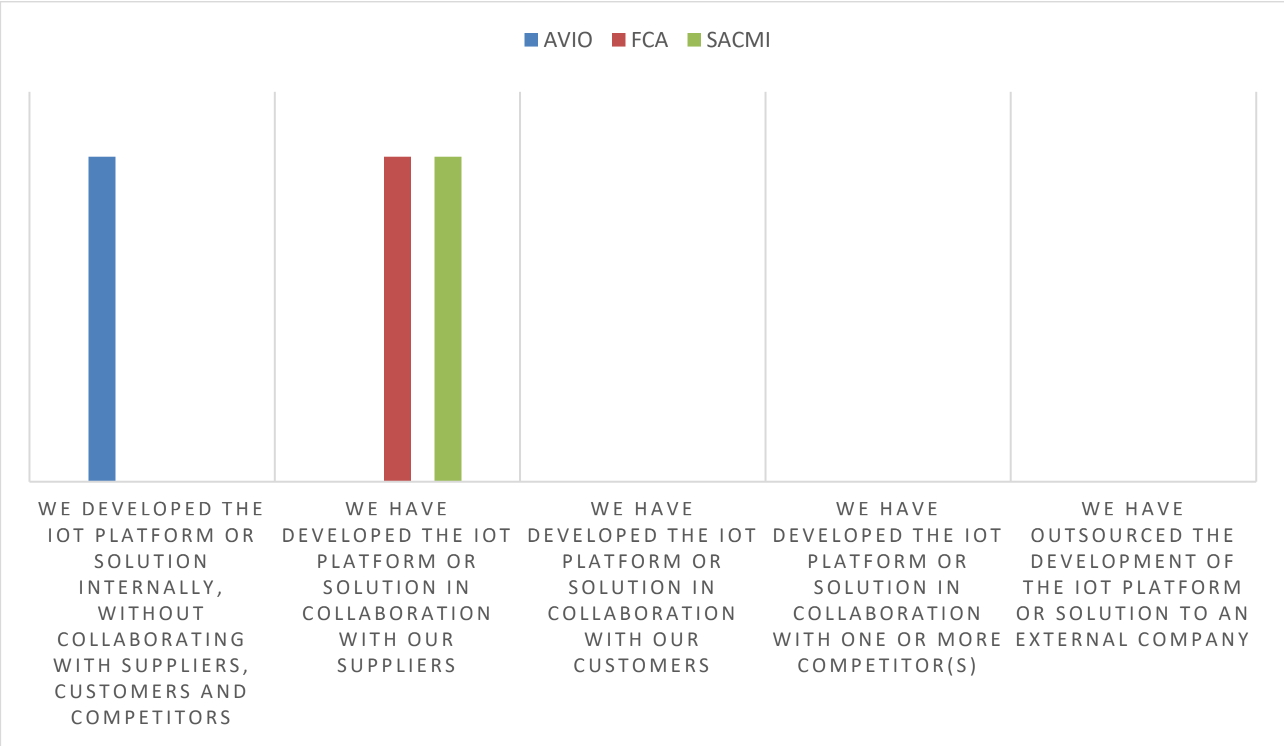

Figure 35: Answers to Question 9

As can be seen from the graph in Figure 35, only the company AVIO has developed the platform completely internally and without help from external stakeholders, while the remaining two companies (FCA and SACMI) have developed (or have intention to develop, in the case of SACMI) their own IoT solution in collaboration with their suppliers.

None of the 3 interviewed companies has developed its own IoT solution with the help of other external stakeholders (such as customers or competitors), just as no company has relied on outsourcing for this realization.

3.5.10. Question 10

Starting from Question 10, it starts a series of 5 questions (from Question 10 to Question 14) in which the main topic will be that of data. Question 10 (shown in Figure 36) asks each company to indicate the types of data that it aims to collect and analyse thanks to the implementation of its IoT solutions. The types of data indicated in the answers are: Design data, i.e. data on the design of the machine and product; Operating data on the work of the machine and its components; Labour efficiency data; Cost data (e.g. production costs); Logistics data; Data on environmental and climatic conditions (for example internal and external temperature, degree of humidity, noise); Data on failures and monitoring of the health of the plant; Product quality data (e.g. percentage of defective parts); Product usage data (for example repairs percentage and stock availability); Customer data (for example target market, feedback and feedback on the use of products, design suggestions); the item "other" has also been added in the case in which the interviewed company decides to collect a type of data not listed in the answers.

Question 10. What types of data does the IoT platform or solution collect and analyse (or could it collect and analyse)?

a) Design data, i.e. machine and product design data	
b) Operating data of the work of the machine and its components	
c) Labour efficiency data	
d) Cost data (e.g. production costs)	
e) Logistics data	
f) Data on environmental and climatic conditions (e.g. external and internal temperature, degree of humidity, noise)	
g) Data on failures and on the monitoring of the health of the plant	
h) Product quality data (e.g.% defective parts)	
i) Product usage data (e.g.% repairs, stock availability)	
j) Customer data (e.g. target market, feedback on product use, design suggestions)	
l) Other	

If "Other" please specify

Figure 36: Question 10

The answers of the 3 companies are presented in the following graph in Figure 37:

Figure 37: Answers to Question 10

From the graph shown in Figure 37 above, it is possible to see how, out of the 11 possible answers, 4 were selected by all 3 companies, i.e. Operational data on the work of the machines, Cost data, Data on failures and on monitoring the health of the Plant and Product quality data, a sign that these factors are considered important to be analysed by all the companies interviewed and that the data obtained from these factors can significantly help to improve the company once analysed and interpreted.

It is then possible to find only one type of data that is indicated twice, namely Data on environmental and climatic conditions, 3 types of Data selected once per company, which are Design data, Product usage data and Customer data, 2 types of data that were not selected by any of the 3 companies, i.e. Labour efficiency data and Logistics data and, finally, no company selected the item Other, witnessing the fact that the answers proposed in the question were exhaustive and complete.

As for the answers given by each individual company, they are summarized in the graphs below, which also show how there is balance between the number of answers for each company (Figures 38, 39 and 40):

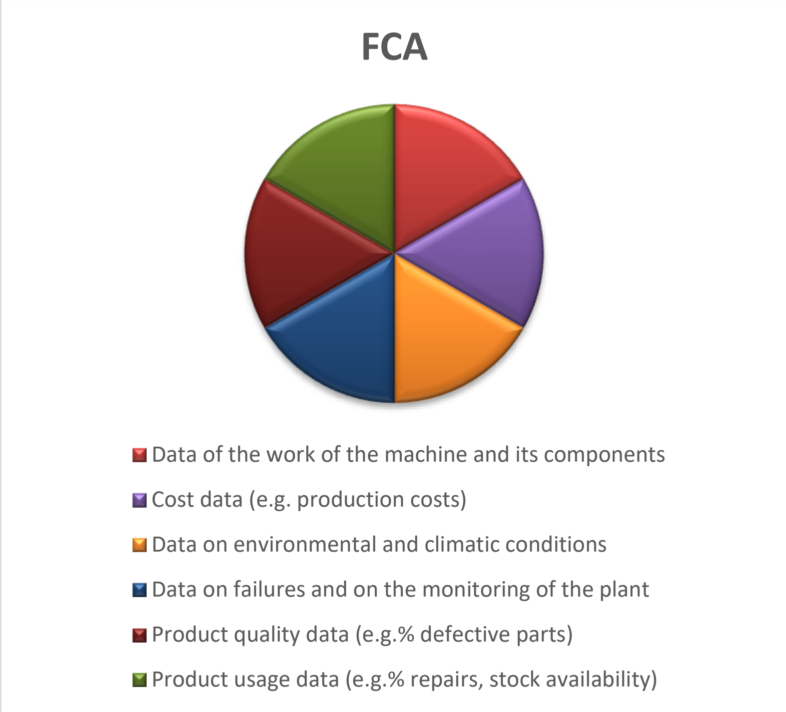

Figure 38: Answers of the company FCA to Question 10

The graph in Figure 38 shows that FCA has selected 6 types of data: Operating data on the work of the machine and its components, Cost data, Data on environmental and climatic conditions, Data on failures and on monitoring the health of the plant and Product quality data.

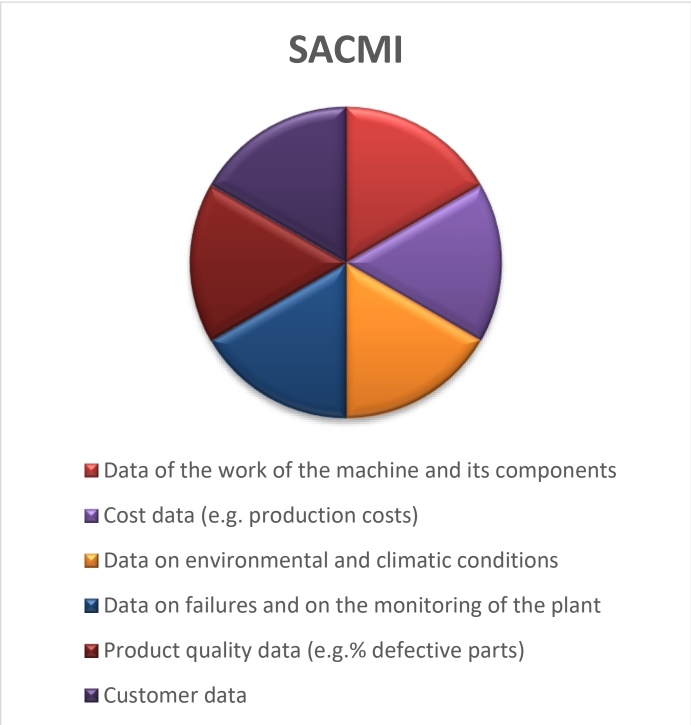

Figure 39: Answers of the company SACMI to Question 10

The graph in Figure 39 shows how SACMI has chosen, exactly like the previous company, 6 types of data, namely Operating data on the work of the machine and its components, Cost data, Data on environmental and climatic conditions, Data on failures and on monitoring the health of the plant, product quality data and customer data.

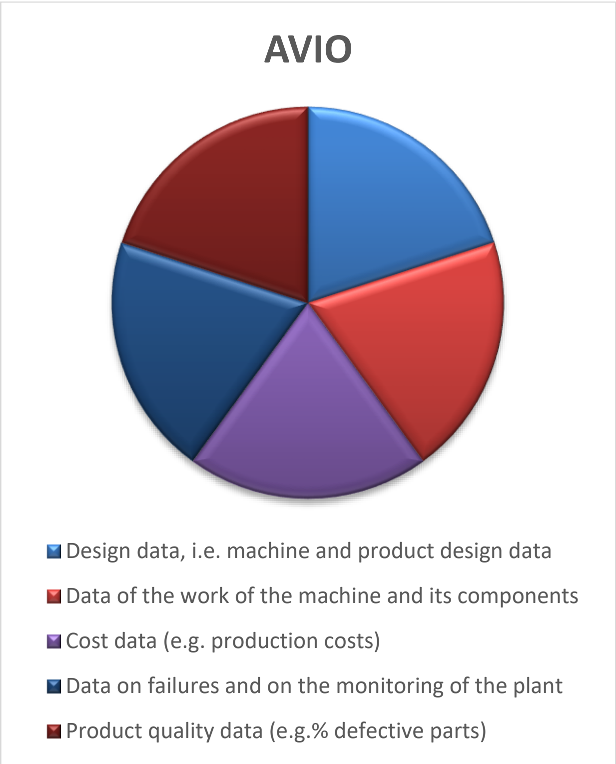

Figure 40: Answers of the company AVIO to Question 10

From the graph in Figure 40 it is possible to see that only one less type of data has been selected by AVIO compared to the previous company: AVIO selected 5 types of data, namely Design data, Operating data on the work of the machine and its components, Costs data, Data on failures and on monitoring the health of the plant and Product quality data.

Considering that there are 11 possible answers to the question, companies have shown the willingness to extract data from many different areas, in order to analyse these data and improve their performance.

3.5.11. Question 11

Question 11 (in Figure 41) aims to understand the source from which the data to be analysed will be collected. In particular, the company can collect data from the processes implemented within the company itself, from its suppliers and from its customers:

Question 11. Where are/could be stored the data that the IoT solution/platform is supposed to analyse?

a) Directly in the company	
b) From your customers	
c) From your suppliers	

Figure 41: Question 11

Figure 42 summarizes the answers to question 11.

Figure 42: Answers to Question 11

As it is possible to see from the graph in Figure 42, the only answer selected by all 3 companies is “Directly in the company”, which means that all 3 companies intend to collect data from the processes that take place within their own structure, and this is consistent with what was said by the companies in Question 3, where they have expressed the desire to apply their IoT solutions also to Predictive Maintenance, an area that requires an analysis of internal data; 2 out of 3 companies said that it wanted to collect data from suppliers, while only one company said that it wanted to collect data from customers.

Furthermore, still from the graph in Figure 42 it is possible to see that the situation is completely different for each of the 3 companies interviewed: we can in fact note that FCA is the only company to have declared that it does not want to collect data either from its customers or from its own suppliers, trusting as the only source of data supply those coming from its own internal. Furthermore, it is possible to note that SACMI, which has not yet implemented its IoT solution, was the only company to declare its intention to collect data from each of the 3 possible sources. Finally, it is also possible to note that AVIO has instead declared that it will collect data not only from its internal processes, but also from its suppliers.

3.5.12. Question 12

Question 12 (shown in Figure 43) aims to understand if companies have an internal data collection and storage system, or if they need to rely on an external company to collect and store the data that will subsequently be analysed.

Question 12. The data you are collecting (or you want to collect) through the IoT solution/platform come only from your firm or also from some other third-party company? Please explain the reason of your choice.

Figure 43: Question 12

The question is open-ended but it is still possible to summarize the answers in the following graph in Figure 43.

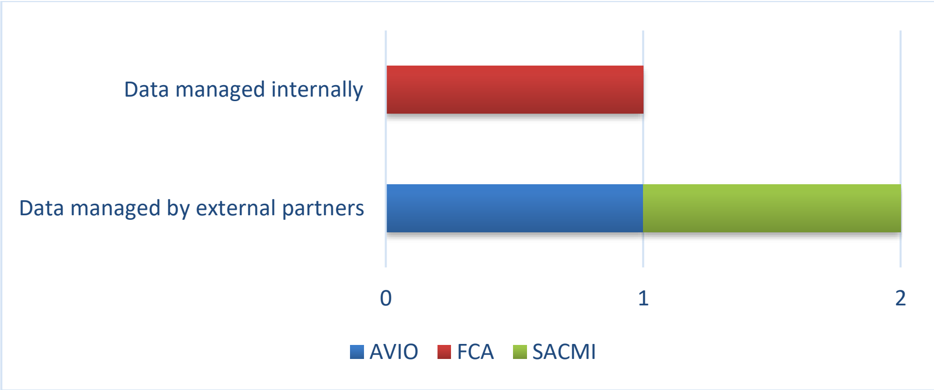

Figure 44: Answers to Question 12

As can be seen from the graph in Figure 44, two companies (AVIO and SACMI) expressed their willingness to entrust their data to external partners: in particular, AVIO replied “Data are currently saved on a private Cloud (Amazon VPC)”, while SACMI said that “Data can be entrusted to external clouds, in order to benefit from specialized analytics and greater computing power”.

Only one company (FCA) stated instead of storing data internally within its own company, focusing on the fact that by managing the data through an internal cloud it is possible to have greater confidentiality. This is also an aspect not to be underestimated, as companies that deal with large amounts of data (such as external companies specialized in data storage) could be more attractive as targets of cyber-attacks.

3.5.13. Question 13

Question 13 (Figure 45) aims to understand who will carry out the analysis of the data collected through the IoT solutions implemented by the companies. Also in this case, the question is open-ended.

Question 13. The data you are collecting (or you want to collect) through the IoT solution/platform are going to be analysed internally or by an external company?? Please explain the reason of your choice.

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Figure 45: Question 13

The answers of the three companies to the question indicate that these companies are all pointing to the same direction. In fact, AVIO analyses the data “*internally*”, FCA confirms that it has “*internal expertise on the process*” and SACMI declares that the data “*can be analysed directly by the company, so that all the corporate bodies involved can benefit from data analysis collected*”. However, all 3 companies (even those who had chosen to store data in external clouds) declared that the analysis of the collected data will take place through an internal process: this choice is consistent with the answers to the previous questions as companies prefer to collect, store, process and analyse data through an internal process which, by processing their data directly, aims at improving the company's performance over time.

3.5.14. Question 14

Question 14 (in Figure 46) investigates the benefits that companies expect to be able to offer to their customers from the analysis of the data collected by the IoT solutions implemented in the company.

Question 14. In which way will the analysis of the data collected from the IoT solution/platform bring a benefit to your customers?

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Figure 46: Question 14

The answers given by the three companies are shown below.

AVIO:

- Product quality improvement
- Greater reliability in delivery times

FCA:

- Better quality products
- Reduction of processing costs
- Reduction of the Time to Market
- Improved Customer Satisfaction

SACMI:

- Predictive and prescriptive maintenance
- Integration with company tools such as MOM and ERP

From the answers it's possible to deduce that only AVIO has indicated two aspects that certainly offer direct benefits to their customers, namely the Improvement of product quality and the Greater reliability of delivery times.

FCA was consistent with its own answers given to Question 8 (which instead regarded the customers relationship, not the benefits that could be offered), showing that in any case the aspects indicated are therefore linked to both the relationship that the company seeks to maintain with their customers and the benefits offered to them, even if some are certainly not direct benefits, but can also turn into benefits for the customer: for example, the Reduction of processing costs is certainly not a direct benefit for the customer, but it can be an indirect benefit as if the company has lower costs, the customer will either pay lower prices or buy a better quality product with the same amount of money.

SACMI, on the other hand, indicated only indirect benefits for customers. In fact, thanks to a Better maintenance and a Better integration with the company tools currently present in the company such as MOM (Manufacturing Operations Management) and ERP (Enterprise Resource Planning), SACMI will be able to benefit from a reduction in costs and an improvement in the quality of its products. which will translate into benefits for their customers in terms of better products at a lower price.

3.5.15. Question 15

Once the questions focused on data collection and analysis have been addressed, let's see the last two questions of the questionnaire which are instead focused on the Costs and Revenue Models of companies.

Question 15 shown in Figure 47 intends to understand which costs are (or could be) most relevant in the management of the chosen IoT solutions. The question requires the assignment of a score from 1 (= not at all relevant) to 4 (= absolutely relevant) considering 6 different cost items: Data cloud-storage costs; Data management and analysis costs; Development costs of the IoT platform/solution; Costs of maintenance and updating of the IoT platform / solution; Research and Development costs; Cybersecurity costs.

Question 15. How much are/could be relevant the following costs for the process of managing the IoT solution/platform? (Please define the level of relevance of the cost from 1=not at all relevant to 4=very relevant).

a) Data cloud-storage costs	
b) Costs of data management and analysis	
c) Development costs of the IoT platform or solution	
d) Costs of maintenance and updating of the IoT platform or solution	
e) Research and development costs	
f) Cybersecurity costs	

Figure 47: Question 15

The graph in Figure 48 shows the average score for each answer to Question 15, taking into account all the answers given by the 3 companies. In the graph it’s also possible to see the costs that, according to companies, have the greatest impact are those related to the development of the IoT platform/solution, which scored an importance of 3,67.

After that, two cost items have an average relevance equal to 3 (costs of Data Management and analysis and Cybersecurity costs) and two cost items received a score of 2,67 points (Maintenance costs and Research and Development costs).

The cost item with the lowest relevance is the Data cloud-storage cost, which has a score of 2. Probably, as we have seen from Question 12, these costs are considered of low impact precisely because 2 of the 3 companies entrust data storage to an external cloud, thus limiting costs.

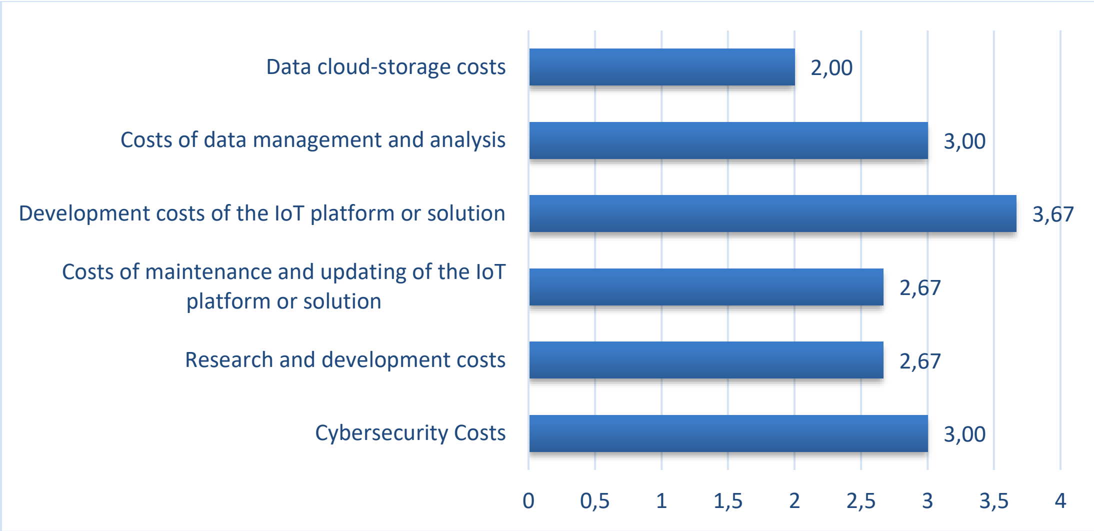

Figure 48: Answers to Question 15

In the following graphs in Figures 49, 50 and 51 are shown the answers individually given by each company.

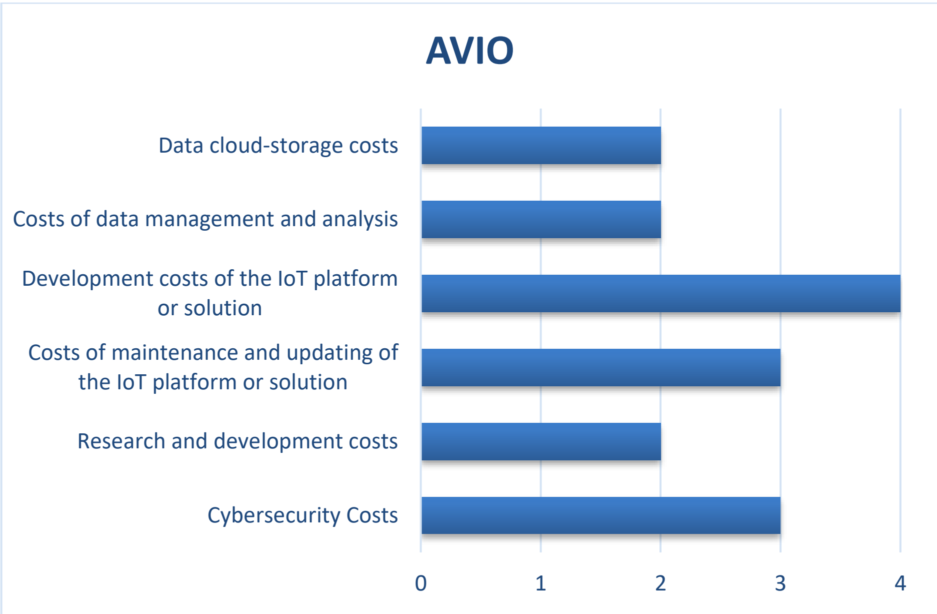

Figure 49: Answers of the company AVIO to Question 15

As can be seen from the graph in Figure 49, AVIO assigned the maximum score only to a single cost item, i.e. Development costs of the IoT platform/solution, and then assigned a score of 3 out of 4 twice, namely to Costs of Maintenance/updating of the IoT platform/solution and to Cybersecurity Costs. Finally, the company assigned a score of 2 out of 4 to the remaining answers, i.e. Data Cloud-storage costs, Costs of Data management and analysis and Research and development costs.

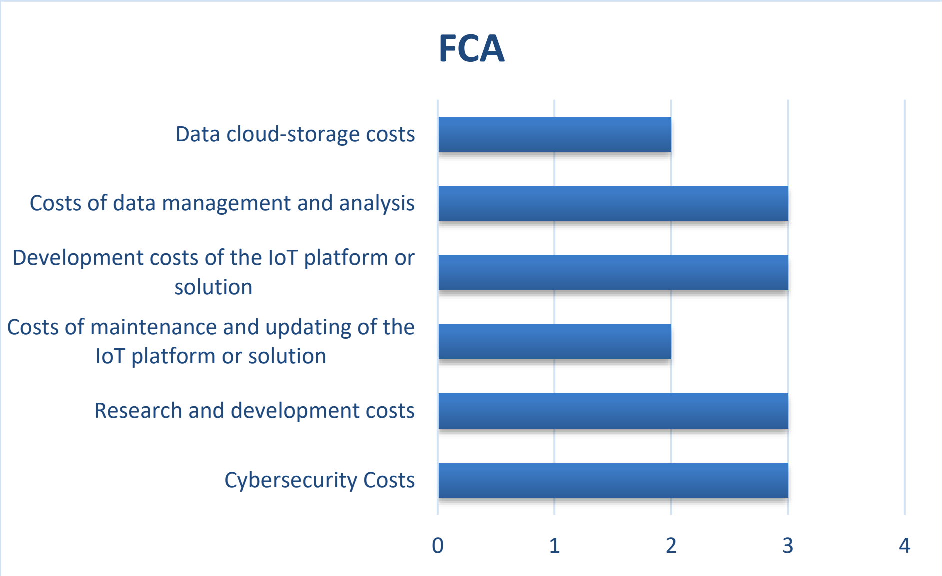

Figure 50: Answers of the company FCA to Question 15

As we can see from the graph in Figure 50, FCA has not assigned neither the maximum nor the minimum score to any item, but it assigned a score of 3 out of 4 to 4 cost items, namely Costs of Data Management and analysis, Costs of development of the IoT platform/solution, Research and development costs and Cybersecurity costs. The company then assigned a score of 2 out of 4 to the remaining 2 cost items, i.e. Data Cloud-storage costs and Costs of maintenance and updating of the IoT Platform/solution.

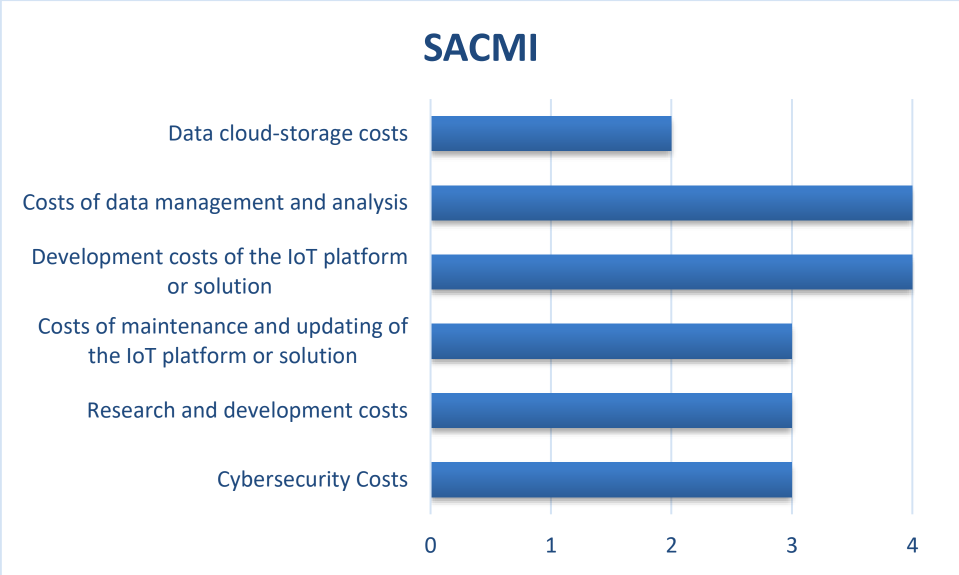

Figure 51: Answers of the company SACMI to Question 15

Finally, as we can see from the graph in Figure 51, SACMI assigned the maximum score to two cost items, which are Costs of Data Management and analysis and Development costs of the IoT platform/solution, and then assigned a score of 3 out of 4 to the items Costs of Maintenance/updating of the IoT platform/solution, Research and development Costs and Cybersecurity costs. Finally, the company assigned the score of 2 out of 4 to the item Data cloud-storage costs.

From a joint analysis of the graphs in Figures 49, 50 and 51, it is possible to note that, in total, only three "4 out of 4" were given, two of which to the answer Development costs of the IoT platform/solution (AVIO and SACMI) and one to the answer Costs of data management and analysis (SACMI). SACMI is the only one to have assigned the maximum score of 4 out of 4 to 2 answers (i.e. Costs of Data Management and analysis and Research and Development costs), probably because, given that it has not yet implemented its IoT solution, the costs in this phase are very high especially in these aspects.

No answer received the minimum vote of 1 out of 4: all cost items received at least a 2 out of 4 from each company, a symptom of the fact that costs, to date, are still high for companies, especially since they have not yet had the opportunity to benefit, at least for the moment, from advantages due to economies of scale, economies of scope or learning economies.

3.5.16. Question 16

Question 16 (in Figure 52) is the last question of the questionnaire, and is related to the Revenue Model chosen by each company:

Question 16. Which is the revenue model chosen/about to be chosen for what concerns the IoT solution/platform?

a) We have raised the price of all our products / services regardless of whether our customers choose to use IoT services or not	
b) Our customers can choose to use IoT services by paying an additional fixed price	
c) Our customers can choose to use IoT services by paying exclusively for the IoT services they actually used	
d) Other	

If "Other" please specify

____

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Figure 52: Question 16

All 3 companies chose "other" as their answer. AVIO answered saying that "*The cost of improving internal production efficiency does not impact on customers*", suggesting that one of its intrinsic reasons for the choice to implement the IoT solution is not to earn directly through this solution. The IoT solution will therefore be used by AVIO to improve its internal processes and increase profits through a renewed production efficiency. FCA answered saying that the IoT solution will mainly lead to a "*Reduction in maintenance costs and an improvement in product quality*". This response suggests that FCA also does not intend to earn directly from its IoT solution but, rather, this solution is focused on improving the efficiency of production processes, in order to be able to obtain, through data analysis and subsequent improvements, a reduction in costs and an improvement in terms of product quality. Finally, SACMI responded by saying that "*The revenue model is still under study*", confirming the fact that, having not yet implemented its IoT solution, SACMI has not yet decided whether to earn directly from it or whether, as AVIO and FCA did, gain indirectly from their IoT solution by reducing their costs and improving production processes and therefore product quality.

By analysing the three answers jointly, it is possible to note that FCA is the only one that expressly declares to have associated a revenue model with the IoT solution they have implemented, saying that the revenue will come mainly from the reduction of maintenance costs and the improvement of the quality of their products; AVIO instead declares that it does not intend to earn directly from its customers following the implementation of the IoT solution, limiting the usefulness of this solution to improving production efficiency. Finally SACMI, having not yet implemented the IoT solution within its company, responded by saying that it has not yet thought about its revenue model.

4. THE PROPOSED BUSINESS MODEL

After analysing the questionnaire and the related answers provided by the 3 companies interviewed, in this chapter will be developed an innovative Business Models for Industry 4.0 based on the responses received from the 3 companies seen in Chapter 3, but also based on the literature analysis performed in Chapter 2.

First, the Business Model of the 3 companies will be developed on the basis of the analysis of the responses to the questionnaires; once this is done, thanks to the information obtained, the new Business Model will be built step by step.

4.1. Business Model Canvas of the Interviewed Companies

4.1.1. AVIO

From the answers to the questionnaire, the AVIO Business Model Canvas (shown in Figure 53) was developed.

AVIO's Value Proposition is based on the Improvement of product quality and on a Greater reliability of delivery times. The main market segment in which AVIO is active is a Niche market, as it mainly produces parts for aircrafts and also maintenance, still for aircrafts. AVIO, in order to provide its customers with its Value Proposition, performs key activities such as Predictive Maintenance, Production Monitoring and Data Analysis for descriptive use (data that are analysed internally but that are collected with the help of Amazon, external partner).

AVIO has developed and implemented its own IoT platform by itself, without resorting to the help of customers, suppliers or partners, exploiting key resources such as Sensors and electronics components, Hardware and Software TLC, Cloud computing, Big Data and Analytics, Specific Vertical Applications and Wearable and mobile devices.

Among the key resources mostly used by AVIO for the management and development of its IoT platform, it is possible to note Research and Development, Operations in the field of production and logistics, Information Technology and Administration and Finance.

AVIO is also paying particular attention to improving its relationship with customers through a reduction in time to market, a reduction in production waste (especially in the 3D printing sector) and cost optimization; in order to do this, AVIO uses, as a channel, that of data collection through the services offered by its suppliers.

For what concerns costs, AVIO claims that the costs that will have a greater impact will be the development costs of the IoT platform/solution, the maintenance and updating costs of the IoT solution/platform and the cybersecurity costs.

Finally, AVIO claims that the cost of improving internal production efficiency (i.e. the cost of implementing and developing the IoT solution/platform) will have no economic impact on its customers, nonetheless, AVIO will take advantage from it in terms of Revenue Streams, thanks to cost reduction and waste reduction.

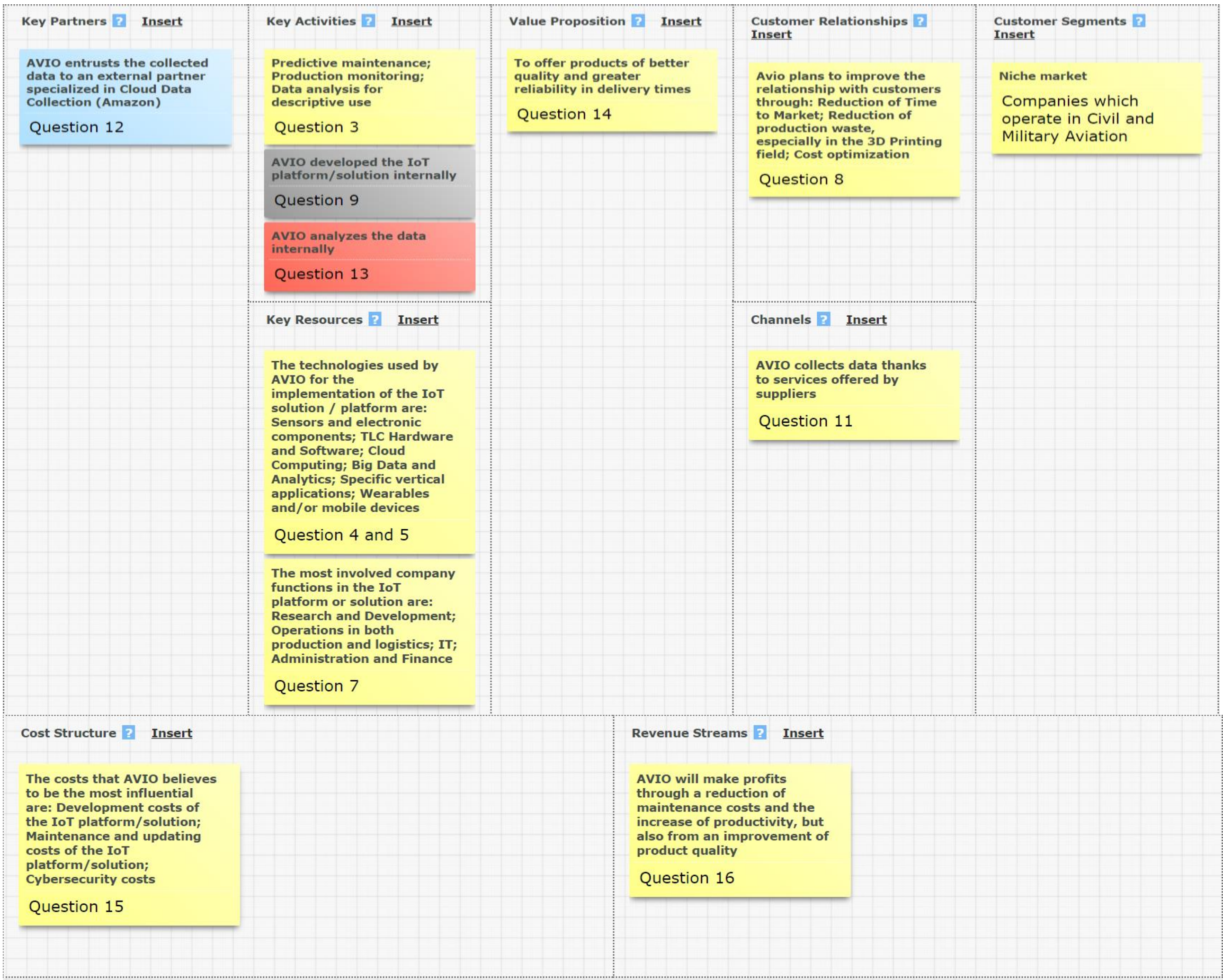

Figure 53: Business Model Canvas of the company AVIO

4.1.2. FCA

For what concerns the company FCA, from the company's answers to the questionnaire it was possible to deduce the following Business Model Canvas (in Figure 54).

From FCA's business model it is possible to see that the company's Value Proposition is based on trying to offer better quality products, as well as on the reduction of processing costs and time to market and, consequently, on a greater satisfaction of the final customer; furthermore, these are also the reasons that led FCA to think that its IoT solution/platform will help it improve its relationship with customers, as well as the reasons why FCA has decided to use an internal channel for data collection. As regards the Customer segment of FCA, the company tries to reach mainly a Diversified market as different models of cars are produced (electric, hybrid, convertible, minivan, utility, sports, family) that tend to satisfy customers with very different from each other.

To make sure that it is able to provide its customers with its Value Proposition, FCA performs key activities such as predictive maintenance, the digitization of its production plant, energy efficiency management and production monitoring. The data generated by the FCA plants are managed and analysed completely within the company, in order to have greater mastery and control.

FCA has developed its IoT platform/solution in collaboration with its suppliers, leveraging key technological resources such as Sensors and electronics components, TLC hardware and software, Cloud computing and Big Data and Analytics. As for the key resources most involved in the management and development of its IoT platform, FCA uses resources such as Research and Development, Operations in the production and logistics sector and Information Technologies.

As regards costs, FCA argues that the costs with the greatest impact are: the costs of managing and analysing data, the development costs of the IoT platform/solution, the costs of research and development and the costs of cybersecurity.

Finally, FCA believes that the revenue model resulting from the implementation of the IoT platform/solution will be based on the reduction of maintenance costs and on the improvement of product quality.

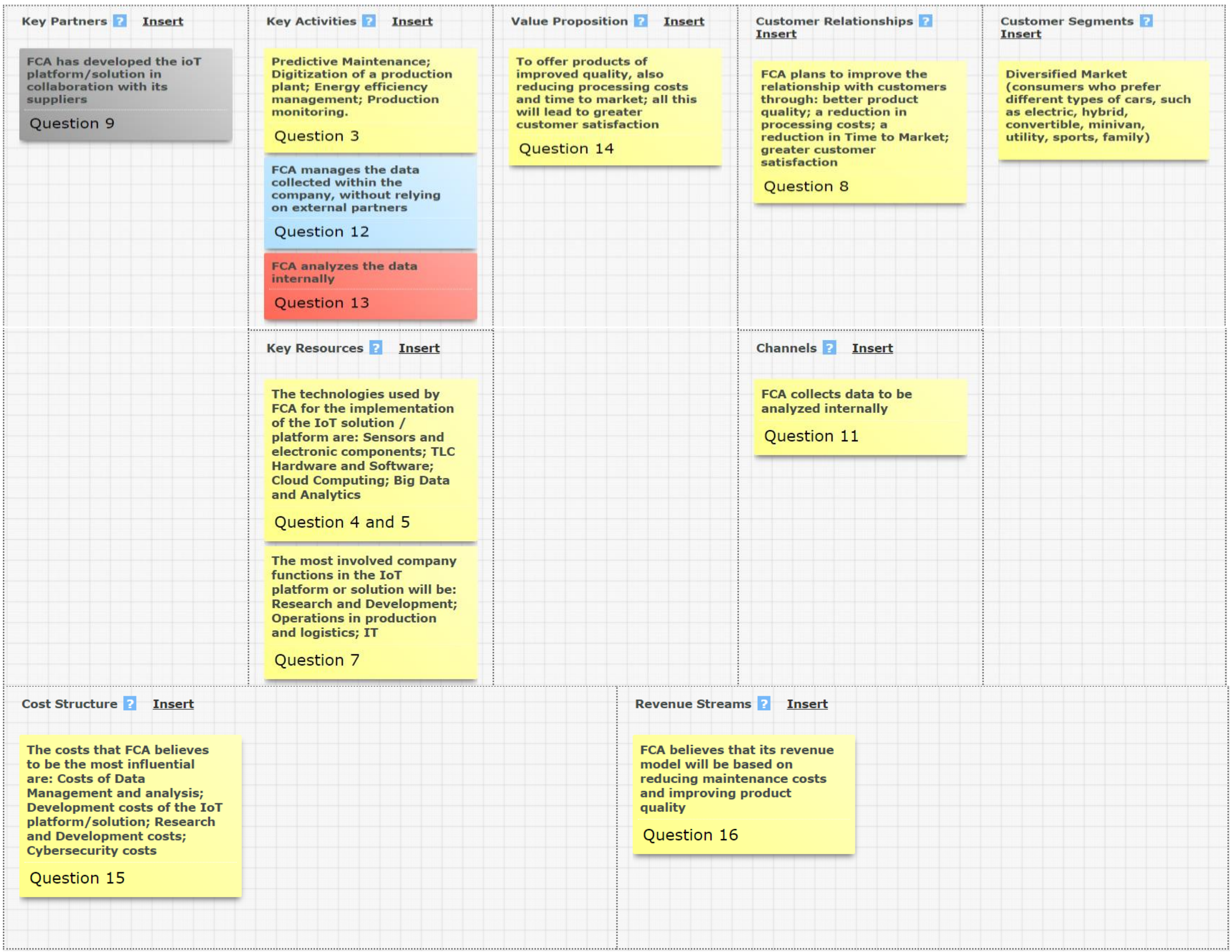

Figure 54: Business Model Canvas of the company FCA

4.1.3. SACMI

As regards SACMI, also for this latter company it was possible to reconstruct the Business Model (in Figure 55) based on the responses it gave to the questionnaire.

From the Business Model it is possible to see that SACMI's Value Proposition is based on the use of predictive and prescriptive maintenance, as well as on integration with business tools such as Manufacturing Operations Management (MOM) and Enterprise Resource Planning (ERP). The main Customer Segment of SACMI is represented by the Mass market and the Segmented market: SACMI produces in fact a huge variety of different products (some very simple such as corks, others much more complicated such as machinery for processing ceramics), many of which (especially the simpler ones) in considerable quantities. To ensure that the Value Proposition is correctly provided to its customers, SACMI performs key activities such as Predictive and Prescriptive Maintenance, the Digitization of production plants, Energy efficiency management, Production monitoring and innovation of product and business models. The data that SACMI is able to extract from its production plants are analysed internally (a choice that allows all company entities to benefit from this analysis), but are entrusted to external clouds, in order to benefit from analytics tools and greater computing power.

SACMI is developing its IoT solution/platform in collaboration with its suppliers, taking advantage from technologies such as sensors and electronic components, TLC hardware and software, Cloud computing, Integration platforms and Big data and analytics. This IoT solution/platform also exploits key resources such as Marketing, Sales, Research and Development and Information Technology.

SACMI is also looking after the aspect of the relationship with its consumers: the IoT solution/platform in fact, according to the company, will allow it to improve this relationship thanks to the additional services that the company will be able to offer; in order to do this, SACMI has decided to use the channel of internal data collection, but also that of external data collection (through customers and suppliers).

As regards costs, SACMI believes that the most influential costs are those relating to data management and analysis, the development of the IoT platform/solution, the maintenance and updating of the IoT platform/solution, research and development and those of Cybersecurity.

Since SACMI has not yet implemented its IoT solution/platform, its revenue model is still under study.

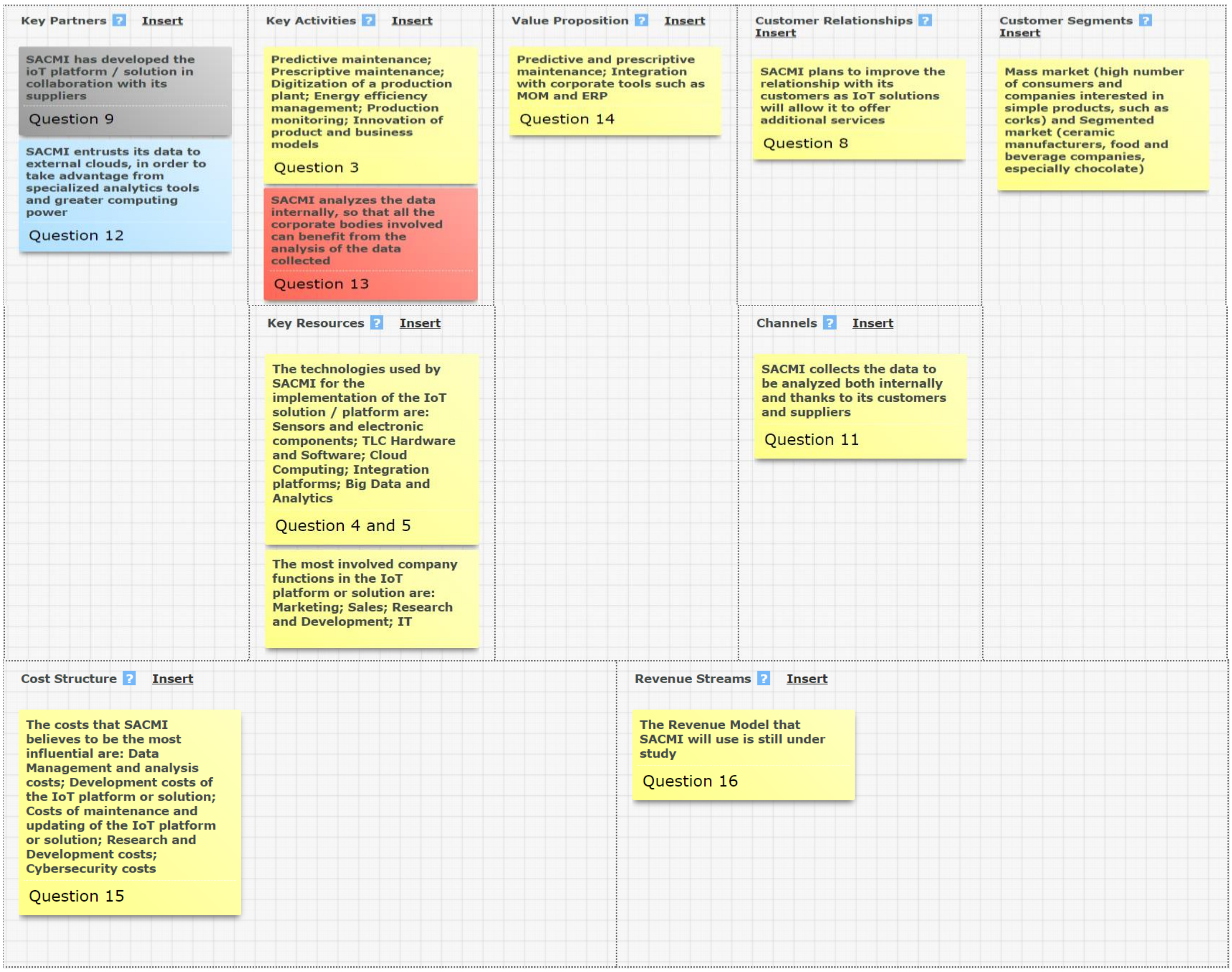

Figure 55: Business Model Canvas of the company SACMI

4.2. Development of the new Business Model for Industry 4.0 based on Industrial Analytics

The development of the new Business Model for Industry 4.0 based on Industrial Analytics is based on the analysis of the business models developed for the three companies AVIO, FCA and SACMI. In particular, from the analysis and comparison of the 3 business models resulting from the analysis of the questionnaires, similarities and differences were sought taking into account the reference literature. The new Business Model for Industry 4.0 based on Industrial Analytics is shown in Figure 56. The Building Blocks and the items of which it is composed are described in detail below.

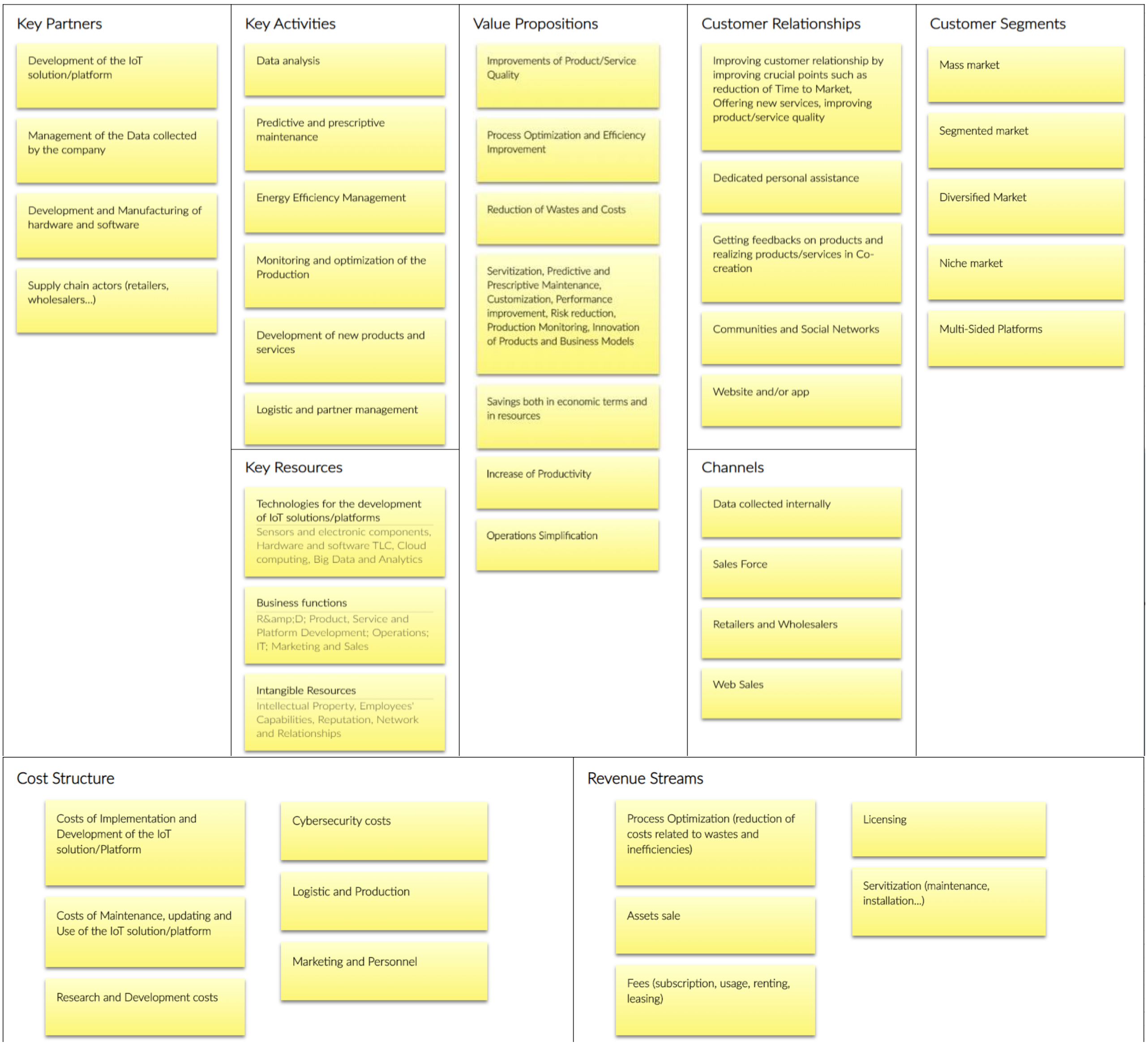

Figure 56: The proposed Business Model Canvas for Industry 4.0 based on Industrial Analytics

4.2.1. Building Block #1: Customer Segment

The Customer Segments Building Block defines the different groups of people or organizations that a company aims to reach and serve.

Internet of Things is a very versatile technology that lends itself to many market scenarios, including in the context of Industry 4.0, Manufacturing and Industrial Analytics, and consequently the Customer Segments are numerous. From the analysis of the 3 companies interviewed, we saw how some reference markets are the Niche Market, the Mass Market, the

Diversified Market and the Segmented Market. However, from the literature we know that the Multi-Sided Platforms can also be added to these 4 market segments (Metallo et al., 2018).

4.2.2. Building Block #2: Value Propositions

The Value Propositions Building Block describes the bundle of products and services that create value for a specific Customer Segment.

The main Value Proposition that the IoT is able to offer is related to a better quality of products and services (thanks to the reading and analysis of the information that IoT technologies allow to extract) and to a reduction in costs and waste, mainly thanks to the optimization of production plants.

IoT technologies mainly offer services to their customers, as the IoT uses the Servitization approach to allow companies to transform any product into a platform for accessing specific services. As we have been able to see mainly from the questionnaires examined, the services that the IoT allows to enable concern: Maintenance (predictive and prescriptive), Personalization, Performance increase, Risk reduction, Production monitoring, Innovation of product and business models.

Furthermore, still in the IoT context, and as confirmed by the questionnaires administered to the three companies mentioned above, the main advantages recorded by the companies are linked to the increase in productivity, the increase in process efficiency, the savings both in economic terms and in resources and time), the simplification of operations (also with regards to logistics) and to the increase in the quality of products

4.2.3. Building Block #3: Channels

The Channels Building Block refers to how companies intend to ensure that their Value Proposition is correctly provided to their Customer Segments.

In the case of the three companies interviewed, the focus was on the provenance of the data collected. In particular, considering the possible risks and possible benefits, data collection can be carried out both internally (through the resources owned by the company) and externally (through the resources owned by the stakeholders, such as customers and suppliers). For the Business Model that we are trying to build here, internal data collection was preferred as it was the only answer selected by all 3 companies interviewed, and also if the data are collected internally, as well as being easier to store and analyse, it is also easier to perform crucial activities such as Predictive Maintenance, which requires internal data analysis.

From the literature, on the other hand, important aspects related to channels emerged, such as the importance of stores, both own (with an adequate sales force) and partners ones, the importance of relying on retailers and wholesalers, as well as the importance of digital channels, hence the Web Sales (Dijkman et al., 2015).

4.2.4. Building Block #4: Customer Relationships

The Customer Relationships Building Block aims to understand what kind of relationship the company should try to build with its customers.
From both analysis (case studies and literature), it is clear that it is preferable to have a strong customer relationship, thus preferring direct channels. The company must therefore aim to build and maintain the relationship with its customers over time, trying to improve some essential points such as the reduction of time to market, the offer of new services and, in general, a better quality of the product/service, which are all characteristics that tend to increase customer satisfaction.
In addition, other important features necessary to build a strong customer relationship are: dedicated personal assistance, feedback processes on products and co-creation, the community (also through social networks) and the website or application (Metallo et al., 2018).

4.2.5. Building Block #5: Revenue Streams

The Revenue Streams Building Block aims to understand from where and how the revenues will be generated.
From the analysis carried out, several important factors emerged: first of all, a large part of revenues will come from optimization (IoT technologies make it possible to reduce costs related to inefficiency and waste), while obviously another important part of the earnings will come from the asset sale, from fees (subscription, usage, renting, leasing) but also from licensing and servitization, like for example selling services such as installation or maintenance of equipment (Dijkman et al., 2015; Ismail et al., 2018).

4.2.6. Building Block #6: Key Resources

With the Key Resources Building Block begins the "back-end" part of the Canvas, that is the part in which everything that generates costs within the Canvas, but at the same time is necessary to obtain profits, is listed.

From the analysis carried out, it was possible to identify several key resources to be allocated in this Building Block. On the one hand, the technologies used for the development of IoT platforms/solutions (sensors and electronic components, hardware and software for telecommunications, Cloud, Big Data and Analytics) play a critical role, while on the other hand we find the most important business functions (Research and Development, Product Development, Service Development, Platform Development, Operations, IT, Marketing and sales).

Also important are the so-called "intangible" resources such as Intellectual Property (i.e. the intangible property of the company), Employees Capabilities (i.e. the skills possessed by employees), Reputation and Relationships (company network): they are very important key resources for companies as they are capable of providing a sustainable competitive advantage over time (Metallo et al., 2018).

4.2.7. Building Block #7: Key Activities

The Key Activities Building Block contains a list of the most important activities that must be carried out for the Business Model to function properly.

From the analysis carried out, it emerges that the most important activities are linked initially to the development of the IoT platform/solution, which can be developed both internally (i.e. only with internal company resources) and externally (i.e. thanks to the help of partners such as customers and/or suppliers); the same is for data management and analysis: these two processes can be managed internally or externally. Taking both cases into consideration, a mixed approach was deemed appropriate: the IoT platform/solution should be developed in collaboration with partners, as well as the management of the collected data should be implemented with the help of partners (for the reasons, the reader is referred to the next paragraph), while the data analysis should be performed internally as all the company figures involved can thus discuss and better understand the data themselves, benefiting from it.

There are also other important activities that must be properly carried out for the Business Model to function properly, such as Predictive and Prescriptive Maintenance, Energy Efficiency Management, Production Monitoring and Optimization, Development of new products and services, Logistics and Partner Management.

4.2.8. Building Block #8: Key Partnerships

The Building Block Key Partnerships refers to the network of stakeholders that help the company to make its Business Model work. As already mentioned in the previous paragraph, there are 2 fundamental processes that must be managed in collaboration with the partners, which are the Development of the IoT solution/platform and the Management of the collected data. For the first process, it is a priority to find suitable partners as, especially at the beginning, the company may not have sufficient knowledge to install and develop an IoT platform/solution (therefore the process requires the help of a partner already experienced in this area, thanks to which the company can also learn), while as regards the process of managing the collected data, also in this case it is preferable to entrust the data to an external cloud (such as Amazon or Alibaba) since, in addition to being a cheaper process than installing a cloud system within the company, companies that rent their cloud space offer anti-piracy services (for data security) and other specific services for a first macroscopic analysis of data and for their management.
In addition to the two partnerships mentioned above, it is important to have partners for the development and manufacturing of hardware and software and also for the management of all the players in the supply chain management process (Suppliers, Distributors, Resellers, Wholesalers).

4.2.9. Building Block #9: Cost Structure

The last Building Block contains all the main and most important cost items that are necessary to make the Business Model work properly.
During the course of this analysis it has been possible to observe how the main sources of costs with regard to IoT platforms/solutions are represented by the costs of implementing and

developing the platform, as well as the costs of maintenance, updating and use of the same, due to the need for qualified personnel. Other important costs are related to Research and Development and Cybersecurity. Finally, there are other important costs that are related to the administrative part, such as Logistics, Marketing, Production and Personnel.

5. CONCLUSIONS

Nowadays it becomes increasingly important for manufacturing companies to invest in IoT solutions in order to stay competitive in the market. In particular, the investment in IoT technologies requires to companies an adaptation of the Business Models with regards to the Industry 4.0 field.

In this thesis, by adopting the Business Model Canvas as a reference framework, a new business model for Industry 4.0 based on Industrial Analytics was developed. This business model constitutes a framework capable of combining in a single model the advantages obtainable through Industrial Data: the improvement of the quality of the product/service (obtainable through data collection and a subsequent analysis of the same data), the possibility of performing predictive maintenance and prescriptive maintenance (which can be pursued thanks to special sensors installed in the machinery that are able to continuously monitor the state of usury), the possibility of offering the customer a package of services connected to the product (servitization, such as the possibility of selling maintenance, installation or training packages regarding product operation), the possibility of making production processes cost-efficient but also waste-efficient, reducing waste related to resources and, consequently, the associated costs.

5.1. Answers to the Research Questions

- RQ1: What are the advantages that a manufacturing company can obtain through the use of Industry 4.0 solutions based on Industrial Analytics?

From the answers of the three manufacturing companies to the questionnaire, it was possible to understand what are the advantages that, in general, manufacturing companies are able to obtain through the use of IoT solutions and platforms.

The manufacturing companies interviewed stated that they were able to provide their customers with better quality products thanks to IoT technologies and in particular thanks to Industrial Analytics. In fact, by exploiting the enormous amount of data generated by IoT systems, it was possible for companies to obtain useful information for the purpose of improving the company's products, services and efficiency. In this way, companies derive benefits in terms of revenues, customer retention and customer satisfaction; moreover, thanks to IoT technologies, companies are able to exploit information to reduce costs and waste, thus generating a competitive advantage.

Companies have also seen benefits in terms of cost and waste reduction, productivity increase, risk reduction, innovation and operations simplification.

- RQ2: Is it possible to formalize a Business Model that takes into account all the advantages obtainable from the implementation of Industry 4.0 technologies based on Industrial Analytics?

Through the analysis carried out in the course of this work, we have come to the formalization of a Business Model for Industry 4.0 based on Industrial Analytics which is able to take into account all the most important aspects for companies, i.e. those that, according to the companies, create an advantage for them.

The essential components that have been obtained from the analysis are visible in Figure 56. The items for each Building Block of the 9 of the Business Model Canvas have been identified, taking into consideration not only the answers to the questionnaire, but also the literature analysis.

It has been seen that essential factors that should never be missing in a Business Model for Industry 4.0 based on Industrial Analytics are, among others: the improvement of product quality as regards the Value Proposition; a strong customer relationship, based on the reliability of products and on dedicated personal assistance, apart that from the community; channels that must be appropriate to the value proposition, both own and third party and both online and physical; the analysis, storage, management and study of the collected data; production monitoring and optimization; the partners for the development, maintenance and management of the IoT platform / solution, as well as the partners for the sale of products; research and development; human resources for the development and management of the company; a revenue model and costs structure appropriate to the size and production plans of the company.

Companies that intend to adapt their Business Model to an Industry 4.0 context can draw inspiration from the proposed Business Model Canvas and independently choose, among the proposed aspects, those most congenial to them in order to develop a Business Model capable of working in the company specific business.

5.2. Relevance and Contributions to Theory, Investigation and Practice

The development of this work offered contributions to several field.

First of all, it has been built a new and innovative Business Model, based on the Canvas Framework, that takes into consideration all the possible scenarios that a manufacturing company can go into: for achieving this purpose, the three interviewed companies were selected from three different areas of the manufacturing field:

- AVIO is a company which mainly produces components and systems for civil and military aeronautics, such as engines, mechanical transmissions, mass turbines and combustion chambers, apart from also focusing on selling services like maintenance and installation of such products. This means that AVIO operates in a Niche Market, and therefore its contribution to the building of the Business Model is very important for other companies who operates in a Niche Market.
- FCA is a well-established company in the manufacturing and automotive field, which means that its contribution to the Business Model that has been built is very important for those big manufacturing companies that are still undecided about entering or not in the reality of IoT and Industrial Analytics. Moreover, FCA operates in a very broad and diversified market, which means that its experience in the IoT and Industrial Analytics sector can act as an inspiration for all those companies that operate in such markets, even on a smaller size (like regional or local companies).
- SACMI is a company specialized in very different areas (such as machineries for the treatment of ceramics rather than bottle caps or chocolate packages). Such different business units make this company very versatile: SACMI is an example of how IoT and Industrial Analytics can be used and coexist within different departments of the same company: the customer segments in which SACMI operates are multiple, like the mass market (for what concerns for example corks) but also the segmented market (like for example ceramics machineries and food/beverage packages). Such versatility can help companies which are in similar situations, like for example smaller multi-business companies that need to decide to which sector must the IoT technologies be allocated first.

Thanks to the answers of these companies, but also thanks to the literature that has been analyzed, it has been build a Business Model Canvas which can encompass all the possible areas that a manufacturing company can run into. Therefore, this work is thought to embrace a

large variety of companies: from what we have seen in Chapter 1, it is estimated that the companies that will adopt technologies such as IoT and Industrial Analytics will increase year by year, so that the objective of this work is that of helping as much manufacturing companies as possible to enter in the IoT and Industrial Analytics field.
Moreover, thanks to the Case Study approach, this work aims at carrying on the work made by the authors seen in Chapter 2 (v. Table 1), especially those inserted in Cluster 1, adding some important and new items in the final Business Model that can help several types of companies.

5.3. Limitations of the Work and Future Recommendations

This work also presents some limitations, which are written in the same paragraph of the future recommendations because the future recommendations of this work are totally inspired from the limitations.
First of all, the proposed Business Model is not specific: the aim of the proposed Business Model is to help as much companies as possible, therefore, differently from the works seen in Table 1 (Chapter 2), this Business Model comprises several items that some companies may not find interesting for their businesses; it's important that companies take into account that the proposed Business Model is intentionally made with the purpose of helping as many companies as possible, and therefore each company should understand that there may be items that could not be useful for them. For this reason, a recommendation for future works is to try to build specific Business Model focused on specific areas of the manufacturing industries, in order to provide to companies a tool that can easily match their specific requirements.

Moreover, another limitation is the one that the proposed Business Model has been built taking into account only three case studies from as many companies. Unfortunately, this happened for 2 reasons: first of all, the pandemic that is actually spreading all over the world obliged us to send a virtual questionnaire, therefore it was not possible to physically go to the headquarters of the companies, and it's much easier to contact companies directly going to their headquarters, rather than contacting them via e-mail; second, even if we had the possibility to contact more companies, such companies did not meet the requirements that me and my supervisors decided for the companies to interview, and therefore could not be interviewed. A recommendation for future works in this case is to replicate this kind of work taking into accounts more companies, in order to have a broader point of view thanks to the experience of more companies, when (hopefully) we will get rid of this Covid-19 pandemic.

Lastly, it would be interesting to extend the concept of this work to the world of Small and Medium Enterprises (SMEs): we have analyzed the cases of 3 important manufacturing companies but, as we know, SMEs have not the same economic power of large manufacturing companies. Since IoT and industrial Analytics technologies are very expensive to implement right now (as we have seen in Chapter 1), a recommendation for future works should be the one of extending what we have seen in this thesis to SMEs, in order to compare the results and understand whether or not SMEs are able to easily implement those kinds of technologies.

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Appendix A

Question 1.

	Yes	No
a) Have you developed IoT platforms or solutions?		
b) Are you developing / do you plan to develop IoT platforms or solutions?		

Question 2. In your opinion, what is the reason why the company has not yet developed an IoT platform or solution? (It is also possible to mark more than one answer)

a) We do not consider it a strategic investment	
b) We currently have no resources available	
c) There is no sensitivity on the issue at the Top Management level	
d) We don't think it is useful for our business	
e) Other	

If "Other" please specify

Question 3. Which application ambit does the IoT solution/platform that you are developing (or you want to develop) belong to?

a) Predictive maintenance	
b) Prescriptive maintenance	
c) Warehouse automation	
d) Digitization of a production plant	
e) Energy efficiency management	
f) Production monitoring	
g) Innovation of product and business models	
h) Security and risk management	
i) Personalized products and services	
j) Other	

If "Other" please specify

Question 4. Which technologies are you using/will you use for implementing an IoT solution/platform?

a) Sensors and electronic components	
b) Hardware and software TLC	
c) Cloud computing	
d) Integration platforms	
e) Big Data and Analytics	
f) Specific vertical applications	
g) Wearables and/or mobile devices	

Question 5. In your opinion, which is the importance of the following technologies for developing an IoT solution/platform? (Define the level of importance from 1=not at all important to 4=absolutely important)

a) Sensors and electronic components	
b) Hardware e software TLC	
c) Cloud Computing	
d) Integration platforms	
e) Big Data and Analytics	
f) Specific vertical applications	
g) Wearables and/or mobile devices	

Question 6. Which benefits do you expect to get from the IoT platform or solution? (It is also possible to mark more than one answer).

a) Customization of the product and service (flexibility)	
b) Orientation towards single batch production (make-to-order)	
c) Reduction of the time-to-market	
d) Optimization of energy and raw materials consumption	
e) Productivity improvement	
f) Reduction of production waste	
g) Cost optimization	
h) Enhancement of human capital and better integration of skills	
i) Interconnection and correspondence between physical and simulated systems	
l) Offering new services to customers	
m) Increase of information related to the product usage	
n) Increase of information related to production processes	
o) Increase of information related to distribution/logistic processes	

Question 7. How much is/could be involved each of the following business functions in the IoT solution/platform? (Define the level of involvement from 1=not at all involved to 4=very much involved).

a) Marketing	
b) Sales	
c) R&D	
d) Operations (Production and Logistic)	
e) IT	
f) Human Resources	
g) Administration and finance	

Question 8. In which way does the IoT solution/platform allow to improve the relationship with your customers? (Ex. the IoT platform has allowed us to customize our product; The IoT solution has allowed us to offer additional services to the customer; etc …).

Question 9. How did you develop/are you developing the IoT solution/platform?

a) We developed the IoT platform or solution internally, without collaborating with suppliers, customers and competitors	
b) We have developed the IoT platform or solution in collaboration with our suppliers	
c) We have developed the IoT platform or solution in collaboration with our customers	
d) We have developed the IoT platform or solution in collaboration with one or more competitor(s)	
e) We have outsourced the development of the IoT platform or solution to an external company	

Question 10. What types of data does the IoT platform or solution collect and analyse (or could it collect and analyse)?

a) Design data, i.e. machine and product design data	
b) Operating data of the work of the machine and its components	
c) Labour efficiency data	
d) Cost data (e.g. production costs)	
e) Logistics data	
f) Data on environmental and climatic conditions (e.g. external and internal temperature, degree of humidity, noise)	
g) Data on failures and on the monitoring of the health of the plant	
h) Product quality data (e.g.% defective parts)	
i) Product usage data (e.g.% repairs, stock availability)	
j) Customer data (e.g. target market, feedback on product use, design suggestions)	
l) Other	

If "Other" please specify

Question 11. Where are/could be stored the data that the IoT solution/platform is supposed to analyse?

a) Directly in the company	
b) From your customers	
c) From your suppliers	

Question 12. The data you are collecting (or you want to collect) through the IoT solution/platform come only from your firm or also from some other third-party company? Please explain the reason of your choice.

Question 13. The data you are collecting (or you want to collect) through the IoT solution/platform are going to be analysed internally or by an external company?? Please explain the reason of your choice.

Question 14. In which way will the analysis of the data collected from the IoT solution/platform bring a benefit to your customers?

Question 15. How much are/could be relevant the following costs for the process of managing the IoT solution/platform? (Please define the level of relevance of the cost from 1=not at all relevant to 4=very relevant).

a) Data cloud-storage costs	
b) Costs of data management and analysis	
c) Development costs of the IoT platform or solution	
d) Costs of maintenance and updating of the IoT platform or solution	
e) Research and development costs	
f) Cybersecurity costs	

Question 16. Which is the revenue model chosen/about to be chosen for what concerns the IoT solution/platform?

a) We have raised the price of all our products / services regardless of whether our customers choose to use IoT services or not	
b) Our customers can choose to use IoT services by paying an additional fixed price	
c) Our customers can choose to use IoT services by paying exclusively for the IoT services they actually used	
d) Other	

If "Other" please specify

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