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# Workplace implications of Industry 4.0 at the Port of Barcelona

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## Abstract

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**Studied Case** This thesis focuses the research on the impact of Industry 4.0 at the Port of Barcelona. It considers of relevance the affect that the fourth industrial revolution is taking place in the workplaces all around the world. The researcher takes the case of the logistics service provider as the Port of Barcelona to understand the implication that the five major technologies characteristic of Industry 4.0 have in the functioning of the port.

**Purpose** The purpose of this research is to get deep understanding of how a logistical company implements Industry 4.0 and how this affects the workplace. On a more particular level, the purpose of this thesis is to analyse this workplace alteration caused by the application of Industry 4.0 for the Port of Barcelona. The research will be constructed by obtaining qualitative data through interviews to managers and employees of the Port of Barcelona.

**Methodology** The methodology used throughout the thesis follows a qualitative approach with inductive reasoning. The data was obtained from semi-structured interviews completed through purposive sampling of managers working in different departments at the Port Authority of the Port of Barcelona and at the terminal BEST. These interviewees, 13 in total, were representative of the port administrative departments considered of more relevance in relation to the topic of Industry 4.0.

**Conclusions** This master thesis has obtained data through interviews that were addressed to managers at the Port Authority and at the terminal BEST of the Port of Barcelona. The results of these interviews indicated that the port is broadly competitive regarding technology innovations characteristic of Industry 4.0. On the other hand, different difficulties from the public nature of the organization were also presented as a burden to the proper development of the port.



**Keywords** Industry 4.0, Internet of Things, Big Data, Cloud, Cybersecurity, Automation, Logistics, Workplace Change

## Acronyms

| | |
|---|---|
| APB | Port Authority at the Port of Barcelona |
| BEST | Barcelona European South Terminal |
| GAV | Gross Added Value |
| GDP | Gross Domestic Product |
| GPS | Global Positioning System |
| ICT | Information and Communications Technologies |
| IoT | Internet of Things |
| IT | Information Technology |
| LPR | License Plate Reader |
| MSC | Mediterranean Shipping Company |
| nGen | Next Generation Terminal Management System |
| OCR | Optical Character Recognition |
| PEMA | Port Equipment Manufacturer Association |
| RFID | Radio Frequency Identification |
| R&D | Research and Development |
| TEU | Twenty-foot Equivalent Unit |
| TOS | Terminal Operating System |
| USD | United States dollar |

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# 1. INTRODUCTION

This chapter provides an introduction to the thesis, presenting the area of focus and a short description of the topics. It also introduces a concise description of the case problem, the objectives, the delimitations and an explanation of the overall design that structures the research.

## 1.1 Background

While Spanish economy grew a 3% on the last year 2017, the Port of Barcelona grew a 26%. This extraordinary growth was due to multiple factors that made the port appear in many newspapers and reports. Some of these factors were the headquarters opening of two large shipping companies in the Port of Barcelona, the opening of the main Mediterranean distribution centre of Amazon in the same city and the consolidation of the port as an important logistics hub for several regions of Spain and the south of France. Moreover, the Port of Barcelona is the third one in size in Spain, representing the 10% of total traffic distribution by port authorities in the country (Puertos del Estado, 2016). These facts add relevance to the significance of the logistic sector in Spain, where the ports represent the 8,7% of the national GDP and the 57% and 78% of exports and imports respectively (CdS, 2017). This data is of crucial importance to understand the choosing of the scope of the author of the research. In such a relevant sector for the economy of Spain, the appearance of the fourth industrial revolution makes the research a very interesting sector to be studied. This new industrial revolution is characterized by manufacturing processes but is also applicable in logistics and in all supply chain actors. It is also called Industry 4.0 and has started to affect a large part of the national industries of the country. The fast progress of technology and its capability to be shared and connected internationally is starting to cause an impact on a socioeconomic level. After the third industrial revolution and the spreading of internet, not only in industrial levels but also in public infrastructure, there has been a continuous transformation of the social and economic scenery. Concepts like Internet of things (IoT), cloud technology, and others have originated and are changing the world making it more interconnected and collaborative (Morrar et al., 2017).

The original idea of this thesis started with the combination of both topics, the importance that the ports of Spain represent to the Spanish economy and the introduction of Industry 4.0 in the sector. While the Port of Barcelona provides a local and practical scope, the fourth industrial revolution brings new elements and an international socioeconomic perspective. The technological characteristics of Industry 4.0, automation, data processing and sharing, cyber-physical systems, Internet of Things and cloud technology, have an increasing importance in how supply chains are coordinated. As people is connected anytime and anywhere through social media, industries, machines, materials and employees are also starting to be connected in a virtual dimension, changing many workplaces and social interaction (Szozda, 2017). Industry 4.0 is adding competitive advantage to the companies that implement its strategies. It enhances processes to become faster, more flexible, more efficient and reduce costs (Rüssmann et al., 2015). Therefore, it is crucial for the Port of Barcelona to remain competitive by applying the technologies of this new industrial revolution in as many levels as possible to

avoid losing competitiveness. Furthermore, a social perspective on the field is also needed to understand the implications of all these revolutionary concepts in the work environment. Automation, the cloud, new technologies and other characteristics of Industry 4.0 are altering the workplaces and systems in most of the manufacturing and logistics industries, making the Port of Barcelona a good case of study to be analysed.

The application of Industry 4.0 has been proven to contribute in increasing flexibility, productivity, quality and velocity in manufacturing, design, delivery, products and services (Rüssman et al., 2015). In addition, it implies improvements in lowering costs, increasing efficiency in the value chain, indicating that the characteristics of Industry 4.0 are crucial for companies to gain or achieve competitiveness.
However, there are challenges that Industry 4.0 must face. Automation of processes and systems require great investments, digitalization with IoT and Big data, which it is the extensive data collection and its subsequent understanding. This is only possible through powerful filtering software that analyzes the data gathered; IoT implies a super-connected atmosphere with multiple sources of data being only useful with Big data and its mentioned needs. Additionally, data gathering that can be fulfilled through different methods (manually or automatically in multiple formats) may cause the use of information to be complex and time consuming. These and many other problems and challenges appear when Industry 4.0 is being implemented or when it is already implemented. Thus in this thesis, the technological, economic and social requirements of Industry 4.0 will be presented and discussed with the focus on workplace repercussion.

Industry 4.0 must be adopted not only by producers or suppliers, but also by all members of the supply chain, including governments, unions, and businesses to make it efficient and smoothly functional. The mentioned components of Industry 4.0 improve the efficiency in a business level as well as in the whole supply chain of flows of goods and information (Heizer et al., 2017). Technological investment must provide security, reliability and speed to the industry in order to allow it to remain competitive in the long run. Furthermore, the workforce must be trained and the future employees educated in order to comprehend the complexity of the new technologies and its connotations (Rüssman et al., 2015). In relation to the topic of this research, the author explored the implications of the innovations in the workplace of the chosen sector. Managers and employees will surely experience changes in their daily jobs and will probably change their mentality when more innovations are take part on their daily performance.
To sum up, this research puts together the concepts of logistics, service management and Industry 4.0. Logistics is included in the functioning of the Port of Barcelona, which is the case of study of this thesis. Service management can be found in the way this port manages the logistical services. The Port of Barcelona works as a public service provider, its services not only influence the entire logistics chain from arrivals, departures and up to the end consumer but also to the surrounding economy. The port causes direct effects on the competitiveness of the industrial and commercial institutions to which they serve, and this is a service that the logistics hub manages at socioeconomic levels. Lastly, the introduction of Industry 4.0 is the present and future of the sector, changing the way services are managed and provided.

## 1.2 Problem definition

It has been proven that the major characteristics of the Industry 4.0 (Internet of Things, Big Data and automation) improve the efficiency of goods and information flows in businesses and in their supply chains (Heizer et al., 2017). However, there have been few investigations about the actual implications in the workplace, and even less in the logistics sector. The impact of applying new technologies, distinctive of Industry 4.0, the complexity of data processing and the application of innovative systems causes an effect on employees. In addition, it also alters the orientation of the chosen strategies from their managers. Therefore, the research questions presented in this thesis will try to provide answers to this socioeconomic element that is changing the workplaces in a global scale.

As indicated above, the Port of Barcelona has been growing at a great rate in the past ten years, and especially in 2017. This growth came together with the logistical characteristics of the industry and the implementation of new infrastructures and systems exemplary of Industry 4.0, such as the semiautomatic terminal BEST (Barcelona European South Terminal). This made the Port of Barcelona a good case study to investigate the impacts of the fourth industrial revolution at the workplace.

Innovations in technology and systems that Industry 4.0 imply have been proven to provide competitiveness in the adopting businesses but there has not been a study on the implications in a more social perspective. As it was fictionally written at “End of work” by J. Rifkin (1995) the new technological revolution will cause mankind to become obsolete in manufacturing. In reality it has been studied that there is a widespread fear of technology mostly in old workers who think that technology could take over their jobs or they could feel outdated without the proper training (Gray, L. & McGregor, J., 2003). In addition, there have been studies that show a typical reluctance to change in the workplace from employees in traditional industries (Vakola & Nikolaou, 2005). Based on the presented background, this research will investigate the current situation of the Port of Barcelona. The port will be the case of study making it an adequate example of a logistical hub. The implications of changes in the workplace caused by the implementation of Industry 4.0 will be the main topic of research in this field. The investigation will follow the Research Questions indicated in the next subsection, leading the research into the analysis of qualitative responses.

In the proposed project, the benefits, implications and risks of implementing methods of Industry 4.0 will be explained, providing a solid framework. Previous studies and explanations of Industry 4.0 will be taken into consideration for a more reliable and understandable foundation. That way when studying the answer of the Research Questions there will be a starting point to work from. The chosen method to provide answers was the formulation of semi-structured interviews. These interviews were conducted to managers and employees of the Port of to get a broader vision of the implications of Industry 4.0 in the workplace.

To conclude, it can be said that there are many studies and written material about the relevance of Industry 4.0 in manufacturing and operational level. The majority of these studies focus on profits, challenges and risks of the characteristics of this fourth industrial revolution. They indicate that Industry 4.0 provides competitiveness, flexibility, and reduction of costs (Rüssman et al., 2015), but there is little explanation on the impact of implementing these characteristics in the workplace and in a service environment such as logistics. Therefore, this

thesis provides qualitative data to answer these particular unaddressed points adding a focus on the managing logistic services at the Port of Barcelona.

### 1.3 Purpose and Research Questions

The purpose of this research is to get deep understanding of how a logistical company implements Industry 4.0 and how this affects the workplace. On a more particular level, the purpose of this thesis is to analyse this workplace alteration caused by the application of Industry 4.0 for the Port of Barcelona. The research will be constructed by obtaining qualitative data through interviews to managers and employees of the Port of Barcelona. This will also make the thesis accomplish the purpose of adding valuable information about Industry 4.0 and its challenges in the workplace, which is a topic that has been addressed in a very low extent on previous researches.

In order to accomplish the presented purpose, the author will formulate and follow all along the research the following Research Questions:

> **Research Question 1:** What are the workplace implications of implementing characteristics of Industry 4.0 in the Port of Barcelona?
>
> **Research Question 2:** How is the application of Industry 4.0 perceived by managers at the Port of Barcelona?

In order to search answers for the questions mentioned above, this project will be focused on answering these questions and the ones that generate from them through interviews. Moreover, from the presented research questions, other questions were also considered by the author regarding Industry 4.0, change at work and technology acceptance. These questions orientated the interview guideline and some examples are: is Industry 4.0 a well known concept by the employees of the Port of Barcelona? Are these employees stressed by the constant input of new technologies in their workplace? Do they feel threatened by the automation of processes? Are managers dealing with new pressures and responsibilities when making decisions? Do they feel the virtual world of information-sharing is secure? Cameras are everywhere, are workplaces being more controlled and monitored? Are old employees aware of the new technologies? Do they feel their job is being threatened by younger employees (supposedly more familiar with new technologies)? Do managers consider this when hiring new workers? Is training the only solution? Etcetera.

### 1.4 Aim and delimitations

The aim of this study is to understand the phenomena of change in the workplace from an Industry 4.0 context in a logistical environment. In order to follow this aim and answer the research questions, there is a need for the research to have a focus and specific orientation of the research in the Port of Barcelona.

The concept Industry 4.0 is very broad and can be linked to many industries, technologies and strategies. The fourth industrial revolution started as a manufacturing improver leaded by the evolution of new technologies related to robotics and Internet. Thus, the research focused on the consequences of the implementation of these technologies at the workplace, more in detail on the workplace of a logistical company: the Port of Barcelona. In addition, it is

important to put an emphasis on indicating that the aim of the research is limited on workplace impact, not on economics, operations or other aspects of the port.
It is important to note that as Industry 4.0 has many different characteristics, each implementation is unique and changes the environment of the employees in diverse ways. Moreover, each department can also be affected in different levels and since the studied case is a port, there are many organizations and divisions in it.

Another delimitation that appears in this study is the choosing of five out of nine technologies characteristic of Industry 4.0. Since this thesis focuses on the technological performance at workplaces in the Port of Barcelona, as well as in managerial levels, only the technologies that have a direct impact on the logistics operations and service management of the port are considered. In that matter, Internet of Things, Big Data, Cloud technology, cybersecurity and automation are explained and studied in the research. On the other hand, technologies such as augmented reality, simulation, additive manufacturing and horizontal and vertical integration are just pointed out. This helped the researcher to focus on the most relevant technologies and not to spend time looking for real or future applications of these last technologies for the Port of Barcelona. In addition, the logistics nature of a port was also taken into consideration throughout the research. Nevertheless, the logistic as a separated topic to study was not introduced since the author of this thesis has found it logic that all readers interested in the content of this paper will have previous knowledge about the broad topic of logistics. As mentioned, logistics is a very wide concept with an even wider definition that can include many aspects and details. Therefore, this research only presents the logistic aspects that are directly related to the Port of Barcelona and to the fourth industrial revolution. Additionally, the same can be said about service management; the wideness of the topic and the supposed prior knowledge of the readers, made the author avoid a general introduction of the concept and focus on the practical considerations. To clarify this point, logistics and service management are not introduced from scratch in this research to avoid redundancy. The concepts are present in the practical characteristic of the research in the Port of Barcelona and workplace implications of Industry 4.0.

### 1.5 Structure

As Berg (2001) explained, very often research projects start with an idea. This idea proposes a problem or research gap that needs a solution or an answer. To continue with the research, the authors take the topic of their idea and search for previous data about it. When the researchers achieve a good knowledge base, a literature review is done. Afterwards, the researcher collects data to fill the research gap presented initially and it ends the project by analyzing this data and writing down the findings and final conclusions of it.
This Master thesis follows a similar structure and it starts with the presented introduction of the topic and the initial idea of the researcher. Later the Methodology will be introduced, giving fundamental information to understand the processes and methods used to complete the research. It will provide the overall methodological structure and theory that has been followed.
The following chapter, called Literature Review, will help to accomplish the aim of the research by providing a great source of knowledge. Therefore, it will offer deep understanding of the presented topics that make the answering of the research questions more precise. Since the

literature review will explain the concepts Industry 4.0, change at work and technology acceptance, it will present useful knowledge to achieve the mentioned purpose.

In the fourth chapter, the researcher will provide valuable information regarding the current situation of the Port of Barcelona. This information will be transcribed from the interviews and the official websites and documentation of the Port of Barcelona and Hutchinson Port Holdings. In addition, considering the sources of the mentioned data, this chapter will provide relevant information about the evolution of the port, the functioning of it, and the impact of Industry 4.0.

In the Analysis chapter, an examination of the research will be carried out. This analysis will consist on comparing the presented theory in the Literature Review and the empirical data obtained through interviews and official documentation of the Port of Barcelona. In addition, this chapter will also identify patterns that were found in the data collection process, indicating new theory and problems presented by the interviewees.

Finally the conclusions will indicate the answers to the research questions. Additionally, an explanation of the accomplished purpose will be presented together with an explanation of the completed research.

# 2. METHODOLOGY

In this chapter a description of the used methodology for the thesis, together with its implications, will be explained. The whole section will be divided into three major sections; the first one, research positioning, will explain the chosen methodologies for this thesis and the reasons they have been chosen. The second will present the research design and process in detail, meaning a description of how the research was developed and what steps were taken. There will also be a description on how the literature review was retrieved, indicating how was the process of gathering documentation for the theoretical framework and the types of information that were explored. Finally, the last section will discuss the credibility of this qualitative research.
This part of the thesis gives fundamental information to understand the processes and methods used to complete the research. It provides the overall methodological structure and theory that was followed; it is a map for the reader as it was a guideline for the writer.

## 2.1 Research positioning

Theory has been determined as a broad collection of assertions that describe different characteristics of phenomena. It is often described by social scientists as the logical explanation of relationships between two or more studied subjects called variables (Babbie, 1998). This thesis will use previous theory regarding the concepts and specifications of the research, whose selection and argumentations are found in the following paragraphs.

Choosing the research method is the core part when realizing a research in social sciences. This is because methods are the characteristic through which intellectual advancement is strengthened (May, 1997). From a social sciences perspective, a method has been defined as a practice for data collection (Bryman, 2012). Consequently, the choosing of a methodology has to be done carefully because the gathered data constructs the ground for the research.
The social perspective that this research takes, together with the aim and purpose of it, made this research simple to classify among the different traditional theories. As Von Wright firstly presented in 1971, there is an epistemological clash between positivism and hermeneutics. He displayed the conflict between the different approaches, where the first relies on the facts and scientific explanations of human behaviour and the second tries to empathise and understand them. This research followed a hermeneutic approach because it is the method of the understanding or perception of the actions carried out by humans. Hermeneutics has its origins on the analysis of theological texts and since the interpretation of a text is influenced by the author, he will subjectively alter the meaning of it. When analysing human behaviours, this subjectivity on the meaning of actions will also take place. Characterizing hermeneutics as a method for qualitative researches; quantitative data or “scientific facts” are not obtained and the key of the research resides on finding an understanding of the human world (Bryman, 2012).

Since this thesis has a delimited scope on understanding human reactions to innovative changes in a service environment, a qualitative approach was considered appropriate to be adopted for the study of this social phenomenon. Moreover, linking the previous paragraph to this, the qualitative approach makes it completely compatible with a hermeneutics

perspective. It has to be kept under consideration that hermeneutics is characterized by the subjectivity of the research, where the author achieves the obtained results in an unconditionally biased way (Cassel and Symon, 2004). On the other hand the use of qualitative methods is important in this thesis because a qualitative research consists on providing answers to different questions of a study of the real world, mainly answering the question "how" to get a better understanding of social phenomena (Silverman, 2013). May (1997) suggested that it is as crucial to grasp the advantages of a specific method as to understand their limitations (May, 1997). It is reasonable to consider that any research method, even if it is qualitative or quantitative, has its strengths and its weaknesses. Nevertheless, the majority of the data that is being collected is based on individual experiences. Qualitative research are found limited when trying to provide a direct and objective answer to a social problem; data collected from human experiences is not the most reliable source (Silverman, 2013). Otherwise, they provide deep knowledge and understanding of the social situation of the study; the qualitative characteristic of this thesis fulfilled its purpose achieving in-depth outcomes.

As Näslund suggested back in 2002, due to the statistical and data-generation characteristics of the industry, there has always been reclaim for qualitative researches in logistics. The author claims that while logistics studies are being dominated by a quantitative approach, the use of qualitative studies should be also included in order for logistics to develop. In accordance to that, this thesis has the research scope in logistics and uses a qualitative approach to solve this social oriented research problem, where the main research questions seek for a non-numerical answer and analysis for the impact on the work conditions in the Port of Barcelona. In addition, the main source of data for this research came from the qualitative method that will be explained later.

The scope of this research, in a narrower perspective is the understanding of the current situation of the workplace in the port of Barcelona being affected by the implementation of Industry 4.0 at some extent. Therefore, the qualitative data gathered from the interviews of employees lead to the comprehension of the situation regarding the explained topic in relation to their social and historical context at work. The data also provides in-depth knowledge about the service and managerial characteristics of the Port of Barcelona. As Bryman explained in the book Social Research Methods in 2012, the essential part of hermeneutics is the connection between interpreting data (texts, interviews, observation or others) from the perspective of the subject and the social background that generates it. There is no doubt then, that positivism, on the contrary, would fail to conduct this thesis when expecting an explanation to be confirmed by objective and quantitative data.

In relation to the chosen theory method, the research of this thesis is conducted by an inductive approach. While the most common one is the deductive approach, with the classical perspective of confirming or denying a firstly presented hypothesis by observations, the inductive approach, on the contrary, starts with the findings and constructs theory from them. A representation of this can be seen in the following figure.

Figure 1: Deductive and inductive approach in relation with theory and findings linkage.

Deductive approach:


Inductive approach:


(Bryman, 2012)

In this thesis the approach that suits the most is the inductive one. From the inductive approach it is expected that the obtained data from the interviews generate knowledge and understanding of the real world, and from that, theory can be generated. The induction process that this research carries out consists on examining the specific aspect of social life (workplace impact of Industry 4.0) and the development of theory from the consequential data (May, 1997). In addition, the inductive approach answers the research questions from a social and subjective perspective, not from statistical data that can approve or deny an initial hypothesis.

### 2.2 Research design and data collection

As explained above, the aim of this methodology chapter is to follow a hermeneutic method to obtain answers from an inductive approach which lead to the pursuit of qualitative data. Due to the limited amount of time of this research together with the shortage of depth that observations could provide, the main source of data of the research in this thesis comes from interviews. As May (1997) explained, interviews are found to be the most suitable method for this type of research because they provide deep comprehension of the meaning and actions of people with their environment.

Interviewing is perhaps the most common method in qualitative research due to its appealing flexibility (Bryman, 2012). As Silverman indicated in his book in 2013 “qualitative interview studies tend to be conducted with quite small number of individuals and with rather informal patterns of questioning where the aim is to allow the interviewee to set the pace”. This flexibility in the data obtaining process, as well as in the freedom of the interviewee, gain significance in semi-structured interviews. In this type of interviews the interviewees answer and explain their point of view from a more open approach than the structured ones, providing great knowledge about how they view the world. The characteristics of this kind of interview are explained in the following paragraph, providing at the same time understanding about the design of the research of this thesis. In addition, the next part of the text also indicates the differences between the different types of interviews, showing that the semi-structured one is the most appropriate for this particular research.

As May firstly explained in 1997, interviews can be classified depending on the degree of pre-planning, from a structured interview (more suitable for quantitative studies) to an unstructured one (best for qualitative studies). On one side the researcher makes an effort to control the interview by making the interviewee answer specific questions in a specific way

following a standardized questionnaire that was previously prepared. On the other extreme, the interviewee is free to answer questions from his unique perspective providing qualitative insight.
Semi-structured interviews are located between both sides of the range utilizing characteristics of both. There is usually a guideline of predetermined questions made by the interviewer but the respondent can answer questions freely with limited standardizations. Some questions may still have to be answered in a standardized layout but others will go beyond the answers enhancing a discussion between the interviewee and the interviewer (May, 1997).
Despite the mentioned characteristics of openness, semi-structured interview results can still be comparable at some extent, giving more reliability than an unstructured one but also having differences between interviews regarding the obtained information in terms of usability and quality (May, 1997). Consequently, as this thesis uses semi-structured interviews, the research will have its singular attributes and each interview will count up to the concluding outcome of the research.

To obtain the right people to interview, the sampling method to be used was purposive sampling. This type of sampling provided the possibility to find interviewees from taking into consideration the focus of this thesis together with the previous knowledge about the topic, the company and the previous network of the author (Bryman, 2012). Being from Barcelona helped him become closer to possible candidates. Moreover my previous network provided a contact who had worked in the Port of Barcelona in an intern program. This contact introduced the author to the first interviewee who, later on, helped him contact more interviewees. In addition, by checking LinkedIn users who work at the port, the author could identify potential candidates who could be more suitable for the topic of this thesis. This was carried out by looking at their job positions and responsibilities inside the business. Keeping some diversity in the areas the interviewees work was also an important point to get a more realistic answer to the research question. For that matter, the interviewees were found to be managers in different departments at the Port Authority (public organization that manages the Port of Barcelona). Moreover, two managers working at the BEST (semiautomatic terminal of the same port) were added to the research in order to get a more practical point of view of the operations of the port.
The fact that a port is a crucial point for logistics, where almost all services of a supply chain can be located (inbound and outbound logistics with multiple means of transport, warehousing, delivery management and tracking, and even some modification of the products or changes in packaging), the connection of both topics Industry 4.0 and logistics seemed to be appropriate for this business. Of course the research could have been oriented on another company or industry. On the other hand, living close to the place, the mentioned contacts and the linkage between the concept Industry 4.0 and logistics made it reasonable to develop an interesting research in the Port of Barcelona.

### 2.2.1 The interviews

In order to arrange interview appointments emails were sent to the candidates that were found to be interesting to get information from. In these emails, there was a brief but explicit description of the author, the thesis and what was expected from the interview. As Silverman

pointed out in 2013, a researcher should provide valid and detailed information about the research to the prospective participants so they could get to decide if they wanted to voluntarily participate or not.
It was important to send the emails a few weeks before the meeting in order to give people enough time to get the email, answer and arrange a meeting. At the same time, by having the email of the researcher, they were able to contact him if they needed more information in advance to be sure they would be ready to answer the prepared questions for the interview. Thus, a similar document to the interview guideline prepared for the interviews was created (see Appendix 1). This document was a simplified version of the mentioned, indicating only main concepts regarding Industry 4.0, general questions that would probably be asked during the interview, and how it would proceed, remarking again the openness of the meeting. This document was not always requested because there was a brief but precise introduction in the first informative email. Furthermore, this email offered a first contact between interviewee and interviewer which established mutual understanding of the aims of the research and the expectations of both parties.
From the qualitative perspective taken for this thesis, the interviews as well as the previous emails sent to contact the interviewees were in Catalan and Spanish despite the official language of this thesis being English. In total, 12 interviews were made in Catalan and one in Spanish. This provided more trustworthiness to the obtained results in each interview by minimizing risks of misunderstanding, and by making them more dynamic and fluid. Consequently, interviewees could communicate in their native language, deleting at the same time possible language barriers.

As mentioned above, thanks to previous social network of the author of this thesis, in particular to an acquaintance of his who did an internship at the analysis department of Port of Barcelona, contact was first established to have access to one of the current members of the analysis team. This person, who became the first interviewee, opened the doors to a chain of interviews that followed from interviewees to colleagues of them. All of them were very participative and offered contact information of other workers at the port, where the ones that had a more suitable profile were contacted to be interviewed. In addition, these employees offered mostly positive replies and were willing to be interviewed. People contacted from other employees were more participatory than the ones contacted only via LinkedIn. Almost all of the former replied quickly and positively and only the half of the candidates contacted via LinkedIn responded, but most of these responses were also positive.
These interviewees were managers or employees of diverse departments of the Port Authority. As it can be seen in the later chapter of Empirical Data (figure 5) all departments and sub-departments (except accountability and infrastructures, since they do not have a direct implication on the functioning of the port) participated in the interviews. This offered a broad perspective of the organization of the Port of Barcelona. Additionally, two interviews of the semiautomatic terminal BEST were included to get more practical and operational data.

Prior to the first interview, a pilot study was conducted which helped the researcher become more self-conscious about the questions. It also provided awareness of things that could be misunderstood, questions that needed to be added or deleted and the time that was required in order to carry out the interview. The guideline for the interviews was also supervised by the

tutor of the thesis who also provided useful tips and directions to make it more profitable. Since the interviews were semi-structured, and questions could be adapted to people and situations, there was no need to make a lot of changes, but it was a good to have them tested beforehand.

The first interview was crucial to establish a first contact with the workforce of the port of Barcelona. It was also a great source of inspiration for improvement and to gain confidence about the industry and interviewing skills. Thus, this interview was a great step into achieving confidence in interviewing professionals of the studied sector. Together with the mentioned pilot study, it helped analysing the questions made during the interview and its structure. It also provided great knowledge about the functioning of the port and its structure, getting a clear picture of the existing departments and organizations that make the port work every day. This helped understand the position, responsibilities and the relevance on the research of the next interviewees. As interviews followed, a better and better picture of the workforce at the port was created. This happened at the same time as the growing understanding of the implications of the interviewees in their job and the possible impact of the Industry 4.0 on them. Each interview helped to build a path to the next one by changing department, skills or responsibilities of the interviewee. For example, it was noticeable that since the first interviewee had only been working at the port for a short period of time, there was a lack of experience on technological changes at the port. Despite he provided other examples from his previous job in a shipping company, the researcher decided to focus the selection of the next interviewees to have a more veteran profile in the organization.

The researcher managed to interview 13 people working at the Port of Barcelona. The majority of them, 11, worked at the Port Authority and 2 at the BEST. These interviews took place in the offices of both organizations during working times and added a total interviewing time of almost 14 hours. This made an average of a little bit more than one hour per interview. It was hard for the researcher to get longer interviews since most of interviewees were managers and had many responsibilities and task to do. I general, they offered good availability and willingness to participate in the research because they found the topic very interesting. On the other hand, despite all questions and topics where answered, they could not afford to invest as much time to the interview as they would have liked. In many cases, they also offered to be contacted back via email in order for the researcher to ask further questions if it was needed.
In the following table a list of all interviews is presented. In it, the department, job position of the interviewees can be observed as well as the date and duration of each interview.

Table 1: Detailed list of interviews.

| Respondent | Organization | Department | Job position | Duration | Date |
|---|---|---|---|---|---|
| R1 | APB | Commercial Department | Analyst | 1h 27’ | 12/03/2018 |
| R2 | APB | Strategy and Business Development | Strategy and Innovation Planner | 1h 8’ | 05/04/2018 |
| R3 | APB | Business Development | Head of Logistic Chains | 1h 13’ | 24/04/2018 |

| | | | | | |
|---|---|---|---|---|---|
| R4 | APB | Business Development | Logistic Chains Administrative | 53’ | 24/04/2018 |
| R5 | Hutchinson Port Holdings - BEST | Project Development | Project Manager Director | 1h 2’ | 25/04/2018 |
| R6 | APB | Strategy and Business Development | Strategy director | 55’ | 26/04/2018 |
| R7 | APB | Operations and Planning | Head of Port and Merchants Operations | 1h 1’ | 27/04/2018 |
| R8 | APB | Internal Communication at Human Resources | Digital Contents and Internal Communication | 1h 5’ | 30/04/2018 |
| R9 | Hutchinson Port Holdings - BEST | Executive team | Engineering and Technology Manager | 1h 22’ | 30/04/2018 |
| R10 | APB | Information Systems Management | Head of project management | 1h 6’ | 02/05/2018 |
| R11 | APB | Organization and Internal Resources Management | Head of Organization and Internal Resources Management | 55’ | 02/05/2018 |
| R12 | APB | Human Resources | Head of Human Resources | 55’ | 02/05/2018 |
| R13 | APB | Business Organization and Consultancy | Head of Business Processes Improvement | 51’ | 02/05/2018 |

In the “Organization” column, interviews at the Port Authority (ABP) and at the BEST can be differentiated. An explanation of the performance of both organizations will be presented in the chapter of Empirical Data. When referencing the interviews in this future chapter, there will be a classification between managers at the APB and the ones working for Hutchinson Port Holdings BEST. The references will go as it follows: “Managers at the APB, 2018” and “Managers at the BEST, 2018”.

It has to be mentioned that carrying out theses interviews in the service management context of the Port of Barcelona brought some difficulties. Since the functioning of the port is to provide services to logistic chains and to the Catalan industries, the way these services are managed had little to do with the way Industry 4.0 is supposed to be applied in a manufacturing environment. Moreover, despite all participants agreed to be familiar with the concept of Industry 4.0 and its technologies, not all of them could give a definition of these concepts. On the other hand, this was also useful qualitative information for the researcher to understand the current impact of Industry 4.0 at the port. The lack of deep knowledge about the fourth industrial revolution was an indicator of the managerial situation. Managers were aware of the new technologies and systems that are and will be introduced in the sector, but

they did not seem to comprehend that these innovations were part of Industry 4.0, a broad concept that includes them for their characterization. Therefore, the qualitative approach of this research was of good relevance for the researcher to understand the current situation of the managing organization of the Port of Barcelona.

### 2.2.2 Ethical Considerations

All interviews started in a very similar way: an informal small talk to make the meeting more relaxed, a brief introduction to remind the interviewee the purpose of the research and the interview, and later the start of it with questions regarding the professional life of the interviewee. Before the first question was asked, the possibility that the interviewee could remain anonymous was presented. This was a great ethical point that was considered when developing the research: "the confidentiality of information supplied by research subjects and the anonymity of respondents must be respected" (Silverman, 2013). And despite all interviewees did not mind about not being anonymous, their confidentiality was respected at all time.

The anonymity proposal at the beginning of each interview was followed by having the interviewer ask for permission to record the whole dialogue in order to make the process more fluid by making the researcher not constantly write while the interview was being carried out. As implied by Creswell (2013), it was indicated that the recording could be stopped at any moment just in case the interviewee wanted to add something that would not want to be recorded.

### 2.2.3 Data Analysis

As the research was conducted by a qualitative approach, a qualitative analysis method was applied. Due to the large amount of data generated typically in a qualitative research, the analysis of such becomes complicated; the data has a great value but is very hard filter the useful ideas from it (Bryman, 2012). In other words, a qualitative research can be completed in an exceptional way, but if the analysis process does not accomplish to work with the right procedure to get the expected results, the research will fail to provide a good answer to the research questions. Therefore, the appropriate qualitative analysis method must be applied and thoroughly carried out.

There are two main general strategies for qualitative data analysis: analytic induction, where the researcher pursues for a universal explanation derived from the studied phenomena, and grounded theory, characterized for the derivation of theory from the gathered and analyzed data (Bryman, 2012). In the case of this research, the most suitable strategy to follow was grounded theory, mainly used in inductive researches where the theory is generated after having a question to answer or after collecting qualitative data. Therefore, the grounded theory is the premise that the researcher creates after finding it grounded in the data (Glaser, 2010).

In order to conduct a grounded theory analysis there has to be a data gathering before, in this case accomplished through semi-structured interviews. From that, the researcher started coding it once it was already transcribed. Coding is explained by Bryman (2012) as the technique in which data is decomposed into several named elements. A characteristic of coding in qualitative research is that data interpretation is built from the researcher's resulting

codes and not from standardized ones as it would happen in a quantitative study. Moreover, coding is essential when carrying out a grounded theory analysis; it implies going through the transcripts of the interviews and naming the elements that are likely to contribute to theory generation and that explain the social perspective of the studied context (Bryman, 2012).
As the semi-structured interviews provided the qualitative data for this research, the subsequent transcript and analysis implied coding. This coding process was separated in three phases as Bryman indicated (2012). The first one, called open coding, consisted into breaking down the transcripts into concepts. These concepts were the beginning of theory-construction, and in this part of the analysis they were classified as ideas or specific events depending on the researcher's perspective. Axial coding came next and consisted on taking the mentioned concepts into categories or groups and linking them to establish a consistent theory. The third phase resided in comparing the main concept or category to other sub-categories or concepts, this step is called selective coding. Coding in qualitative data analysis was constantly revised and compared in order to make sure the outcome proposed useful theory to answer the research questions.
In the case of this thesis, the coding process of the transcript of the interviews included codes referring to the main topics of this research. Therefore, each transcript of the interviews was classified into the codes that now represent the structure the chapter Empirical Data; general information regarding the Port of Barcelona, information about the Port Authority or Hutchinson Port Holdings - BEST, Industry 4.0 and its technologies within the port and workplace changes. In order to bring information together into these groups, more specific concepts were also included in the coding of the transcripts and later grouped together into the mentioned subsections of the Empirical Chapter. Furthermore, these codes were later analysed in the Analysis chapter in order to construct theory from them.

### 2.2.4 Searching on literature

In this part of the Methodology chapter the process that was followed in order to collect the written material will be discussed. Therefore, this subsection explains the construction of the theoretical framework created in chapter three, the literature review. This chapter followed a structure that depended on the topics and concepts relevant for the research. As it will be shown, there were two major sections, the one concerning logistics and Industry 4.0, another one about the implications of changes at the workplace and technology acceptance.

The reason of the researcher for choosing the Port of Barcelona to study the implications of Industry 4.0 in the workplace is because a port is a great actor in logistics that involves most of the elements of the industry. As mentioned previously, this is due to the transport, management, warehousing, control and even some manufacturing or packaging that takes place in its location. Therefore, the port provides a good example of a logistical hub to study the presented topic of Industry 4.0. Moreover, a port offers multiple businesses with different implications and effects typical from the technologies of Industry 4.0 that can take place at the same time. Therefore in order to obtain depth knowledge about the Port of Barcelona and Industry 4.0, a literature review was carried out. This literature review looked for concepts related to logistics, ports and Industry 4.0, also how changes in a workplace affect employees,

and technological acceptance at work. These concepts were the ones searched for collecting data in order to complete the literature review.

To be more precise, the research needed crucial understanding of the studied areas in a port that can be affected by Industry 4.0. In addition, all related concepts both from supply chain and Industry 4.0 had to be clarified in detail. To do this, an extended literature review had to be done, collecting written material about ports and supply chain functioning, Industry 4.0 and its implications, and the consequences or side effects of implementing new technologies and strategies in an existent industry or business. This literature review was completed with books, academic journals and other research papers and theses concerning the indicated topics. The structure of this literature review was organized from more general topics to more focused ones on the research questions; starting with supply chain, logistics and the Port of Barcelona, Industry 4.0 and its implications, challenges and effects, and ending up to the alteration on the workplace and technology acceptance.

The literature was found over the Internet searching for books, academic journals and publications in LUBsearch and Google Scholar by following the list of concepts: “Industry 4.0”, “Logistics”, “new technologies”, “impact of industry 4.0”, “Internet of things”, “effects of automation”, “supply chain innovation”, “changes in the workplace”, “technological acceptance” and other topics or synonyms of the mentioned ones related to the research questions. This research of written material was directed so that the two research questions could be answered. In addition, the research questions themselves marked the direction and order of the literature review as well as the overall research. At the end, the research of this thesis was conducted by combining the descriptive research approach of the literature review and the obtained qualitative data that was gathered as a result of the literature reviews.

### 2.3 Credibility

To finalize this chapter it is important to analyse the reliability of data gathered from semi-structured interviews. As Silverman (2013) suggested, the accuracy of the answers of the interviewees revealing their own experiences are not always certain. Moreover, own assumptions appear when interpreting open-ended answers, making the reliability of qualitative research harder to prove than a quantitative research.

The case study provided information that was also useful to understand the interviewees in some specific concepts or features of the port. This collection of data of the port could have biased the author and may have caused errors when conducting the interviews. On the other hand, their semi-structure condition caused them to be very open and the multiple numbers of interviews and questions reduced the risk of the author of being biased by his own perceptions (Voss et al., 2002). Moreover, recording the interviews facilitated their transcription in a more objective way because the whole interview could have been listened over again at any time, avoiding confusing notes taken during the interview.

To understand the validity of the gathered data, it is important to understand that the study may mirror the reality at some extent. In other words, the interviews provided a picture of the current situation of the port and its workforce related to Industry 4.0 implementation; it could probably be applied to another port or another logistics hub, but it would hardly fit in another sector or business. On the other hand, the interviewees were chosen based on the variety of their work position, but also on their relevant relation to a possible application of Industry 4.0. The different jobs and responsibilities of the interviewees provided different points of view,

achieving a more genuine perspective and avoiding generalizations. Therefore, this could add value to the external validity of the thesis. In accordance to that, the reliability of the research, implying that the outcome of the research could have appeared similarly in another context if the same procedure was carried out, is not that relevant due to the taken qualitative approach.
Internal validity plays a major role in the work of the researcher; the existence of open-questions raised by the interviewer diminished the risk for the participants to misinterpret the questions. Moreover, the interviewees were asked diverse questions to reapprove their answers to avoid confusions and preventing the researcher to make early assumptions.

In order for this research to achieve greater reliability qualitative and quantitative methods could have be combined. This could have provided deep knowledge from the former and solid objective results from the former. For this combination, the research could have included surveys to employees from all areas and business of the Port of Barcelona. This would have required a huge investment on time and resources to make the surveys arrive to all workplaces. Due to the limitation of time and the complexity on carrying out this method the quantitative approach was discarded. On the other hand, the researcher gave great importance on the analysis process of the qualitative data obtained through interviews. As mentioned above, the analysis becomes crucial element for obtaining credibility on the results of a qualitative study.

# 3. LITERATURE REVIEW

In this chapter the main topics that concern the research of this thesis will be presented. In order to do that previous studies and articles will be taken into consideration. This will take place in order to achieve deeper understanding on the field of this study. This chapter will start with the presentation of the topics. It will continue with an extensive examination of the broad concept Industry 4.0 and taking it later into more detailed levels of application, specifically in logistics sector and in a port infrastructure level, where this thesis focus its research. After that, the literature review will shift the topic to how changes influence the introductions of changes in the workplace. This will be helpful to the researcher to understand what challenges can the implementation of Industry 4.0 cause, or may have caused, to the Port of Barcelona. Finally this third point of the thesis will study the technology acceptance of previous studies. That will be useful to empathise with the employees at the Port of Barcelona when looking for their possible problems when working with characteristics of the Industry 4.0.

## 3.1 General background

This literature review represents an important part of the thesis because it helps to accomplish the aim of the research by providing a great source of knowledge. Therefore, it provides deep understanding of the presented topics that make the answering of the research questions more precise. As mentioned in the introduction chapter, the purpose of this research is to get deep understanding of how a logistical company implements Industry 4.0 and how this affects the workplace. Since the literature review explains the concepts Industry 4.0, change at work and technology acceptance, it provides useful knowledge to achieve the purpose.
In this section of the Literature Review, an introductory text of the presented topics will take place. This will create a background of theory to consider when moving to the following sections, where theory will become more specific in Industry 4.0 and Change at Work.

With globalization, ports obtain higher economic significance in local and international scopes. They become crucial points for the proper development of the economy of a city or country representing logistical hubs in international markets. Ports are large actors in all international supply chains and create important amount of jobs. Moreover, they add attractiveness in the connected industries; enhancing their growth and making other markets become closer. Therefore, a port can be considered as a service-oriented hub that put together logistic businesses to improve the economic performance of organizations, regions and countries (Sanchez et al., 2011).
Since services are the most relevant factor in almost every economy in developed countries, it is important to consider logistics and the functioning of ports as an essential actor for these service-oriented economies. Therefore the management that takes place in a port can be considered as service management, and all changes induced by the application of Industry 4.0 are intrinsically affecting the way a port is managed. Services influence manufacturing industries by providing efficiency, adding value to products throughout the whole supply chains. Therefore, ports as service providers offer these positive added complements (Looy et al., 2013). With the implementation of new technologies ports introduce automation, digital devices that connect different equipment, sensors, and other digital elements that enhance this efficiency and added value. As Yang et al. (2018) explain that through the implementation

of new technologies “port authorities to provide essential services in a faster and more efficient manner. The major drivers in these ports are productivity and efficiency gains”. Therefore, it can be said that there are studies that analyze the impact of new technologies in a port environment, but only few studies involve the whole Industry 4.0 in the sector. Moreover, there is a lack of understanding on the workplace implications of the fourth industrial revolution, which is what this thesis argues about. For instance, the linkage of ports with Internet of Things has already been done in other researches, proving conclusions that as Internet of Things is on an introductory phase, further researchers should be considered (Yang et al., 2018). The author of this thesis decided to link a port with the concept of Industry 4.0. Industry 4.0 includes Internet of Things and other technological advances that provide a bigger perspective of the fourth industrial revolution and the functioning of a port. It is true that Internet of Things is one of the most important elements of Industry 4.0 but the combination of all of them is what makes an industrial revolution.

## 3.2 Industry 4.0

The origins of the term Industry 4.0 goes back to the German Fair of Hanover in 2011 when it was firstly introduced and promoted by the German Federal Government to popularize the high-tech planning of the country (Kang et al., 2016). The same concept was also introduced in other countries under different names, for instance, in the United States of America it is known as Industrial Internet, and in China as Internet +. (Wang, Wan, Li, & Zhang, 2016).

### 3.2.1 Definition

The definition of Industry 4.0, as Lasi et al. suggested in 2014, can be constructed by the aggregation of digitalization and automation of the manufacturing industry and the developing of a digital value chain that empowers the connectivity between products, the actors of the chain and its environment.

From this manufacturing perspective, Industry 4.0 also includes the concept of Smart Factory, appearing when a manufacturing plant uses smart technology. Smart technology includes several characteristics such as software usage for production and planning, automation of management and logistics, new systems when developing products and services and wireless equipment to operate machinery and program it (Marjanovic et al., 2017). Furthermore, despite the initial orientation of the technological development into the manufacturing industry, Industry 4.0 is also known as the fourth industrial revolution challenging all socio-economic areas and creating digitalized value chains. (PWC, 2015). In other words, Industry 4.0 is the intelligent and interconnected production system driven by nine components of which there are four core elements, Cloud technology, the Internet of Things (IoT), automation, and Big Data (Khan and Turowski, 2016).

### 3.2.2 Historical background

Managing the impact of the Industry 4.0 is currently one of the biggest challenges in the socio-economic landscape. The main feature of this new industrial revolution is the application of

the new technologies into the factories but also on the overall of the supply chain. These technologies are part of the practical world nowadays, but they are continuously improving and entering new sectors and areas of businesses. In addition, the entire adoption of Industry 4.0 will probably need twenty more years before its total capability is met (Rüssmann et al., 2015). The main challenge will be the correct implementation and maintenance of the new technologies, such as connected sensors, Big Data, cloud storage or predictive analysis. Combine them with the manufacturing process and in the whole supply chain while having an efficient and profitable use is the real defiance that companies are facing and will continue to deal with in a future.

Since the introduction of the term in 2011, it can be said that the Industry 4.0 is found in the introductory phase. On the other hand, the widespread application of Industry 4.0 has several and important implications on all supply chains independently on the area of activity in the chain. The introduction of new technologies that represent the base of Industry 4.0 affect all the other supply chain operators (Dreyer et al., 2009). Moreover, the Information and Communications Technologies (ICT) offers the companies the possibility for supply chain integration. In addition, ICT is a crucial feature in this fourth economic revolution. This feature is related to the sharing of all data collected both within the manufactory and between companies to improve the level of integration and reach more profitable goals. Within the ICT there are several technologies such as Cloud Computing, Radio Frequency Identification (RFID), microchips, Big Data, GPS identification and Live-tracking of the product in all the supply chain. For instance, RFID allows the company to store data about the products of the processes with a wireless system. By having, analyzing and storing the data, companies are able to improve their efficiency, control raw material inflows, and also help to monitor the equipment performance (Ivanov et al., 2016).

To get a better understanding of the concept Industry 4.0, it is important to recognize "industry" is the part of an economy that produces goods through mechanised and automated processes (Lasi et al. suggested in 2014). With the origin of industrialization in the eighteenth-nineteenth century, improvements in technology have caused impact on the economy and society, causing what is called as industrial revolution. Industry 4.0 owes number four for being considered the fourth industrial revolution of history, and of course, this means that there have been three previous ones. For a better understanding of Industry 4.0, and its implications, the previous industries will be briefly explained in the next lines. This will provide the reader awareness about the connotations of an industrial revolution that has repercussions in technology, economy and society. The first industrial revolution happened when water steam engines were introduced for the first time as the power of machines and resulted in mass production in unseen levels before. This industrial revolution appeared during the end of the eighteenth century, and brutally impacted in technology, society and economy, with many new economists that studied the revolutionary change and introduced economic theories that are still in use nowadays, changing the way the human world works (Lasi et al., 2014).

The second industrial revolution surpassed the first one when electricity was implemented in factories and processes, giving more energy-efficiency and opportunities for both machines and humans. This lead to an enlargement of economies in both scope and scale (Gnimpieba et al., 2015).

The third one took place with the introduction of modern computers. They started to be able to perform calculations that surpassed human capacity and speed, enhancing statistic usage, providing better forecasting, monitoring machines and processes in a more controlled and efficient way (Gnimpieba et al., 2015). Computers never stopped to improve their performance. With the introduction of Internet, other wireless communications systems and the expansion of transport, global economies were found in an interconnected world. This brought the start of the fourth industrial revolution or Industry 4.0. The conceptualization of Industry 4.0 implies the overcoming of the three explained revolutions and, from the combination and improvement of them, introducing new approaches in the economy of manufacturing and services creating the current world.

There have been written theory and researches about the implications of Industry 4.0 in the real world. It is important to remark that the impact of the fourth industrial revolution will continue to take place in a socioeconomic landscape. Therefore, as this thesis takes social perspective on workplace implications, it is relevant to present a brief introduction on the social part of this revolution, considering its impact in society, the environmental and ethical issues. Nevertheless, researchers agree that profound and long term impacts of Industry 4.0 on society and the environment need further investigation (Raihanian & Behdad, 2018).

Society has always worried about technological advances abruptly changing their lifestyles and threatening their jobs. All industrial revolutions have created this feeling on people and history has proven that technology has always accommodated to society and vice versa. Moreover, society, the economy and jobs, have continued to grow (Vacek, 2017). This can also be applied to the case of Industry 4.0; society should not feel threatened by innovations and changes in industries. On the other hand, the fourth industrial revolution is differentiates from the previous industrial revolution on the fast rate of technology innovations. The trend, previously linear, is taking exponential characteristics and this speed could cause society to not have sufficient time to adjust. Additionally, the absorption capacity of the society is also enhanced by governments and their legislation and bureaucracy which often slow down the adoption and adaption process (Vacek, 2017). Considering this, the social perspective that organizations applying Industry 4.0 should take is that they will probably need training and education programs. These programs focus on customers and employees to make this fast rate of changes become less disruptive and for society to become more prepared.

The environmental impact of Industry 4.0 has been found to be very complex to analyze (Raihanian & Behdad, 2018). Despite the advanced technologies that improve electronic devices to be more efficient and to consume less energy; they are now able to operate on higher levels and their functionality has increased. This has caused the energy consumption to remain stable instead of decreasing rate as technological improvements induce (Raihanian & Behdad, 2018). The benefits that new technologies provide in decreasing the consumption of raw materials and increasing efficiency in the utilization of resources and processes are accompanied with a negative effect on higher energy consumption. Automation and digitalization of processes offer a reduction of errors which translates to a decrease of produced waste. In addition, digitalization provides flexibility on supply chains, which reduces unnecessary transportation and a general increase of information flows and a decrease of material flows. Therefore, waste and pollution caused by production and supply chain processes are reduced by the efficiency implication of new technologies but the energy

consumption is increased with their installation and functioning (Raihanian & Behdad, 2018). Additionally, with the introduction of Internet of Things and Big Data, tracking and measuring environmental impacts caused by industries become more simple and accurate than ever. And this can makes society and organizations more aware on their environmental repercussions.

Ethical issues are far to be completely analyzed on the case of Industry 4.0. Ethics only appear in researches on the work environment, usually presenting difficulties with robot and employee rights and interactions (Vacek, 2017). With the digitalization of organizations there is a huge need for digital equipment; from large processing computers to small tracking chips. Therefore, the lifespan of these electronic devices also offer ethical considerations in both organizations and final customers. From the perspective of profitability of an organization, it makes sense for it to reduce the lifespan of their electronic devices in order to maintain a certain level of sales. On the other hand, Internet of Things remains competitive if the digital investment pays off. This means that if the electronic devices are required to be often replaced, the amount of waste increases and the benefits that digitalization provides are reduced by this hypothetical continuous replacement (Raihanian & Behdad, 2018). Again, ethical considerations directly caused by Industry 4.0 needs to be studied to obtain consistent theory.

### 3.2.3 Components

Nowadays, as Rüssmann et al. explained in 2015, industry is in the beginning of the fourth revolution characterized by the upcoming of technological advances. The boost of this new digital revolution is caused by the combination of the following technologies:

Figure 2: The nine technologies powering the fourth industrial revolution.


(Rüssmann et al., 2015)

By combining these technological characteristics, Industry 4.0 will make it possible for companies to collect and analyse data beyond its equipment. This will make processes to become faster, more flexible, more efficient and to reduce costs. Moreover, the productivity will increase, moving forward economics and induce industrial growth. And this will eventually be followed by a modification process of the profiles of the workforce (Rüssmann et al., 2015).
As mentioned before, the focus of Industry 4.0 started in Germany with the intention to foster the manufacturing industry. Therefore, these nine technologies are already in use in this sector and at the same time transforming the whole supply chain by enhancing integration, automation, and optimization of flows. This will also lead to more efficient relationships between all actors of the supply chains and also in human-machine interactions. Finally, by exploiting these nine technological advances the physical world connects with the digital one, enabling more precise data gathering and upgrading the overall quality of the industry along with a better monitoring and control of all its components.

Due to the logistics nature of the field of research, as well as the relevance of four of the nine technological advances indicated by Khan and Turowski (2016), there will be a definition of the four core characteristics of Industry 4.0 plus the Cybersecurity which is the main risk of these technologies. These four technologies are also consistent in logistics and are Internet of Things, cloud technology, automation and Big Data.
In other words, the following paragraphs will present five out of the nine technologies that characterize Industry 4.0. These five characteristics are relevant to logistics, to a port and represent the four core elements of Industry 4.0 plus cybersecurity which is the main present problem of these technologies (Khan and Turowski, 2016).

Internet of things:

This popular term in the new industrial revolution is composed by the words “internet” and “things”, indicating that the linkage between Internet and all that can be considered things in an industry; machines, vehicles, goods, equipment and other ‘devices’ and also humans . Moreover, this usage of internet provides inter-connectivity between them, not only between employees and machines, but also between all physical objects that are now connected to each other. In addition, the technology of IoT also provides the service of the “things” to adapt and react to their environment or to the management of the company through sensors and processors (Internet of Things Sweden, 2016; Khan and Turowski, 2016).
The notion of “Theory of Things” was firstly introduced in 1999 to provide a definition of the current situation of the world, where physical objects were starting to be able to transfer data and link it to computers. Witkowski (2017) has recently indicated an interesting fact: “nearly ten years after the introduction of the concept, the amount of devices connected to the network exceeded the number of inhabitants of our globe”.
Internet of Things has four characteristics that help users get different types of information. The first ones is Context, which represents the information related to the place of activity, the physical status or the atmospheric condition of the so-called “things”. Second, Omnipresence indicates the interconnection of objects, which are not only connected with human supervisors but also among themselves. Internet of Things is also characterized by the functionality that every object possesses, being called Optimization. And the fourth characteristic of IoT is that it offers real time surveillance, very practical to know what is happening to every component of the supply chain at any time. Basically, IoT allows firms to develop customer service in a better way by decreasing the lead time of logistics operations and also their expenses (Witkowski, 2017).
To conclude, with the application of IoT, companies are able to virtualize every single part of its business, creating a virtual map of the whole supply chain considering every “virtual object”. These virtual objects will be remotely linked to other objects at every time and will also be able to provide vast information of them, such as their moving location or status. The virtualization will also facilitate managers or users to have a fast response in variations along the supply chain. Moreover, the data collected will not only serve in the present but also to replicate and optimize processes in the future. Eventually, supply chains will be able to gain levels of autonomy from self-adaptive systems where virtual objects will be able to work with few or without human intervention (Verdouw et al., 2016).

Big Data:

Big Data represents the collection and management of large amount of data. It is one of the four core characteristics of Industry 4.0 and it is highly connected to the other three and also to cybersecurity.

Internet of Things leads to the creation of a huge amount of data that corporations should consider and use for a better future performance, solve problems and identify new ones. This amount of data generated, called Big Data, offers the possibility to control and treat the increasing amount of information, separating useful information from the rest, in a fast and efficient way. Moreover, it helps to plan and to support actions to achieve business objectives through the knowledge obtained. Nowadays, the business world is driven by data, and this data is daily generated and gathered in enormous volumes throughout the whole chain of an industry. Furthermore, the improvement in the collection of data from goods, processes, machines, equipment, services, sensors, etc., contributes to this increase in data gathering (Khan and Turowski, 2016). It is reasonable to say that the continuous growth of Big Data moves at the same rate as the development and implementation of the technology of the IoT.

Automation is another great generator of Big Data. It is connected to IoT because it generates huge amounts of data by having digital complements included in the machines or equipment that make the process automated. This equipment is held by computers and sensors that generate Big Data.

Big Data is responsible for creation of cloud computing (see following point “The Cloud”) because this enormous amount of digital data needs a safe and large place to be stored. Big Data is often stored in “the cloud”, remote servers hosted online, that enable to access this data from any point connected to the server and at any time. Furthermore, cloud computing is often designed as a software support in which Big Data can also be processed (Bi et al., 2014).

The connection of Big Data, a huge amount of private data generated by the company for specific employees, customers or providers, together with the online storage of it makes it sensitive to cyber attacks and must be supported with strong software security.

The Cloud:

Despite that The Cloud or Cloud computing is an evolving concept with many variants on its definitions. It can be described as a model that allows networks to have shared access through several servers in which data is stored, managed and processed online (Mell and Grance, 2010).

With the interconnection of “things” through the internet characteristic of IoT and the Big Data that is generated from that, a problem of storage and management of this enormous amount of data is created. This data cannot be stored in a personal computer or in a typical physical hard disk. Every business that generates data has to invest in larger digital storage devices. This data will also have to be available to be analyzed and to provide information about all the supply chain at any time, because it implies a crucial source of information for the performance and improvement of the company.

The so-called cloud, applied in this case, is based on Internet connections that allow the storage of huge amount of data online. This software facilitates users to access the data without any professional assistance, providing information sharing in a flexible way. This flexibility enables users to increase or decrease the storage capacity to optimize the process and storing needs (Bi et al., 2014).

The use of the cloud, involving the exchange of information among the whole company, represents also a privacy risk. There can be robberies of data where both private and company data are illegally stolen from the servers. All cloud companies are creating higher and higher protection measures and also some governments, the EU in particular. They are establishing several laws to protect all these information, but these efforts cannot protect completely the companies that store their data in the cloud. In order to evaluate the effectiveness of the cloud each company should consider both the opportunities and the threats of the implementation of these technologies. This has to be done also considering the costs of implementation, installation, maintenance and cybersecurity. The classical way to store data has usually been through an internal server, but nowadays this is becoming obsolete due to the ineffective exchange of data among the businesses of a supply chain. Moreover cloud technology provides the mentioned flexibility and openness (Bi et al., 2014). It is easier for small businesses to benefit from cloud storing data than larger firms because the transition from servers to cloud software is less expensive and less time consuming when implementing the change throughout all the organization. On the other hand, the present technology development fosters the change to cloud technology through the reduction of the cost (Bi, Xu, & Wang, 2014).

Automation:

Another characteristic of the Industry 4.0 is automation. Companies in Industry 4.0 refer to this term as the use of new technologies to improve the level and the quality of production through "robotization" of processes. The use of robots enhances the interaction of IoT characteristics, being able to communicate among each other, with products and also with humans. Moreover, these robots will cost less, reduce production costs and produce fewer errors as technology advances (PwC, 2015). Big Data and IoT offer convenient capabilities of measurement, classification of goods, tracking and control. All these characteristics enhance the rise of automation levels in production by improving equipment and processes with more digital elements. Automation can be exemplified as the installation of sensors along a production process that substitute the employees. The application of technologies often provides faster calculations and performance, becoming more effective than humans. On the other hand, technology installation requires a higher initial investment and digital appliances are limited to their job purpose (Bi, Xu, & Wang, 2014). Therefore, it can be said that there is an ongoing debate on human labour and automation that is also present in logistics. While former is typically found in the traditional industries and represent society in the workplace, the latter represents a gain of competitiveness for the industry.

Automation is widespread in all industries and economies since the start of machines in the first industrial revolution. It has always been represented as a threat for employment but has also made the markets to evolve, creating new needs and new types of jobs. Through history, the understanding that automation eliminates jobs has been presented many times and it has made the concept unpopular among workforces. On the other hand, it is necessary to consider that human force is far from becoming obsolete; even though automation is created to replace employees for more effective machines, the workforce is complementary instead of being eliminated. Despite machines present characteristics of self-functioning on production processes, human surveillance and maintenance will always be required (David, 2015).

Cybersecurity:

As indicated in the previous figure 2, cybersecurity is one of the nine advances of technology characteristics of Industry 4.0 (Rüssmann et al., 2015). Security on systems, networks and data is crucial for the application of new technologies in all industries. Without this security on private knowledge companies are at risk of cyber attacks that can steal sensitive data and know-how. Furthermore, a company that is perceived as insecure on cybernetics can incur into a big cost in terms of reputation and reliability.

Cybersecurity uses specific software with highly encrypted algorithms that are designed to protect all components of the digital part of the company. This type of software is very important to reduce the mentioned risk of cyber attacks and external data exposure. Even if a small amount of data is stolen it can represent a stolen idea or design (Li et al., 2015).

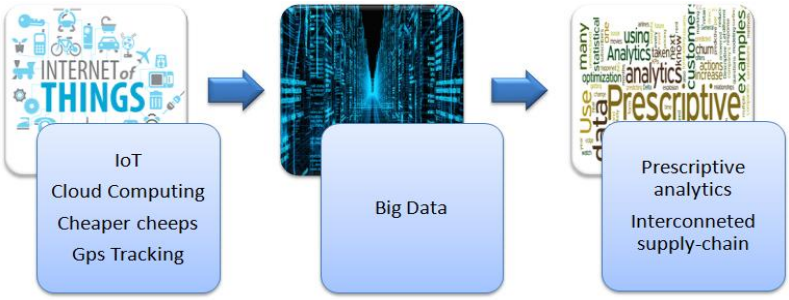
Cybersecurity does not stop only with the stored data, but it also plays a vital part on the sharing of this data among all parts of the network. When data is shared online, even in private networks, it becomes more vulnerable. Therefore, it is a challenge for cybersecurity to sustain the levels of security in all digital processes. It seems reasonable that to ensure cybersecurity, professionals on this matter are required to be present on the installation and maintenance of the securing software, that is the reason why most companies buy this software from specialized brands or hire IT professionals on the field to develop their own security system.

During the last summer of 2017, one of the biggest shipping companies in the world, A.P. Moller-Maersk, suffered a cyber attack that shook the global logistic industry. This shipping company known as Maersk represents one fifth of all fright operations in the world. This means that even such a huge company as Maersk, with extremely powerful software that manages the enormous amount of data that is generated every day, is not out of risk from cyber attacks. The company values this attack with a cost of more than $200 millions (all $ numbers in USD). This indicates the impact of such attacks can have to all types of companies if they don't develop a strong and reliable cybersecurity system. Moreover, the article that presented the news also provided the approximated value of $5 billion of expected global loses caused by cyber attacks on a single year (Mathews, 2017). Therefore, it can be said that the example of this news provides a hint on how important is cybersecurity for the right development of Industry 4.0 and for the safety of a modern port.

### 3.2.4 Applying Industry 4.0

The collected data from the IoT is not only used for targeting customers or to evaluate the productivity, but also to analyse it with algorithms to get indications to choose the best strategy for the firm in a faster and more efficient way than a human could do. There are, in particular two kinds of analysis, the Predictive Analytics, which uses the information for demand forecasting, maintenance scheduling and product-use insights, and the Prescriptive Analytics, which automates the decision-making from the continuous received flow of data. The combination of both comes up with the best decision for the company (Ivanov et al., 2016).

Figure 3: Flow of Internet of Things.




This figure summarizes in a way the mentioned theory in this section of the paper. It provides the general implications of the Industry 4.0, as a consequence of the Internet of Things, that imply the use of a great amount of data to be analyzed and applied for efficiency, being called Big Data, and the final implications on a supply chain. Moreover, it has been said that Industry 4.0 is a consequence of Internet of Things and Big Data due to its technological implications and influence in businesses development (Witkowski, 2017).

### 3.2.5 Logistics and Industry 4.0

Nowadays, Industry 4.0 has become a well-known concept used to describe the tendency of industrial settings towards automation and digitization. Apart from the production optimization and maintenance, logistics is also crucial to obtain higher efficiency in a manufacturing company. Logistics involves managing inventories and the inbound and outbound flows of products (Li et al., 2015). All five chosen characteristics of Industry 4.0 explained before can be found in a modern logistics environment. This research will later demonstrate this statement in the specific case of the Port of Barcelona, in both the Empirical data and Analysis chapters. Therefore Industry 4.0 is not a revolutionary change only in manufacturing but also in the distribution and procurement business of a company (Szozda, 2017).

Szozda (2017) claims that, in contrast with the origins of Industry 4.0, IoT is not focused on the manufacturing processes of an organization but on the distribution sector of it. In addition, she claims that business models that have implemented IoT technology are different from the traditional ones. IoT adds value to the whole supply chain by connecting it and improving customer service and the design of products. Furthermore, the creation of connected supply chains by IoT is also supported by the use of Big Data; all connected devices generate data that can be gathered by any participant. This sharing could not be done without cloud computing technology or the online security of its software. Communication is a crucial aspect on supply chains influenced by Industry 4.0, they become more flexible, efficient and manageable.

Cloud technology can be also implemented in this data sharing along the supply chain. That way Big Data could be manage at the same time from different parties and use a standardized set of programs and tools available on the Cloud. On the other hand, use of Big Data and Cloud technology can only be secure by having a strong cybersecurity system, capable of avoiding cyber attacks and preserving confidentiality.

Automation is present in the logistical sector as well. In addition, it can also be found in the Port of Barcelona. Many cases of automated vehicles or processes have appeared in the current decade such as the creation of autonomous cars, trucks, warehouses and port terminals. These cases represent a great step further on logistics as it has always been considered a very traditional industry.
The description of the existent innovations in the Port of Barcelona influenced by all technologies characteristic of Industry 4.0 will be presented and explained more in detail in the following chapter. There, real case implementations of Industry 4.0 will also be introduced, presenting the company and technological landscape; from the high implementation of cybersecurity to the semiautomatic terminal BEST, which represents the clear automated evolution that is taking the port.

An innovative concept that is being introduced in the logistic sector is blockchain. This concept takes supply chains work more connected by deleting unnecessary elements and connecting all actors together to work more efficiently. Moreover, blockchain increases transparency in the tracking of shipments, deliveries and status of the transfer of physical goods between suppliers, who have no implicit trust. Therefore, confidence increases thanks to safe controls and monitoring (Gromovs, & Lammi, 2017).
Blockchain can be defined as a tool that conceives the structure of an innovative way to process and distribute data. As explained by Gromovs and Lammi (2017), when the concept is applied to logistics, blockchain becomes "an instrument for special kind of management of digital business flows". This definition combined with the use of IoT brings a new perspective for supply chains to evolve into integrated information systems, parties and organizations (Gromovs, & Lammi, 2017).

At Spanish level, the maritime transport sector is probably one of the most anchored in traditional management methods. In addition, it can be said that the progress towards the digital transformation of the sector is not being carried out homogeneously in all actors that participate in the value chain of the maritime industry. The shipping companies have been the ones to lead this progress, especially the large operators, and the freight forwarding companies are still accumulating a clear delay in the adoption of digital models. For instance, almost all these freight forwarding companies do not allow customers to request quotation online, which represents a serious impediment to the interests of customers (Tintoré, 2018).
The responsibility on changing the delay falls on large companies in the sector. They are in charge on taking a step forward and invest in digitalization, acting as a reference for the rest. This would allow the industry to save costs and offer a much more satisfying customer experience than today (Tintoré, 2018).
On the other hand, novel experiences in this field are found in Spain in ports like the one in Barcelona, which have begun to implement digital management models that aspire to transform these infrastructures into smart ports. The advances and benefits of smart ports are multiple: they reduce transport costs and consequently the connections are much more attractive. In addition, they offer a competitive advantage over other enclaves and maximize available resources thanks to the application of new technologies.

As mentioned, the logistic sector in Spain needs improvement as a whole. This way synergies would be created along supply chains and increase the capacity of Spanish ports to compete in the context of a global economy (Tintoré, 2018).

### 3.3 Change at work

From the previous point in this literature review it can be considered that for the technological advances of Industry 4.0 to be adopted there has to be some changes in the way the business is run and the way employees perform their job. Since manufacturing firms are already implementing IoT, cloud, Big Data and automation, what the revolution is also shifting is the nature of products. Manufacturers are moving from offering products to selling service products. The new technologies add value to the products, making them more attractive for the end costumers and to the whole supply chain operators. The level of autonomy f the machinery, the capability to be remotely controlled and data collection make new products very interesting for the companies. Firms can analyse the data generated automatically from them and respond to changes in needs or environment all along the supply chain achieving more competitiveness. The data not also helps the firm to respond the present changes but also to have more proactive attitude and anticipate the future market shifts. As corporations change from offering products to offering services, the relationship with customers also change becoming more open-ended (Heppelman and Porter 2015). Therefore, it can be said that the application of Industry 4.0 in a company not only affects the inner functioning of it but also the communication levels with the exterior, making the whole supply chain more aware and responsive to all its integrants.

These changes caused by the implementation of Industry 4.0, involve so many parts of a firm (from how a factory runs, to how communication among parties of the supply chain goes) that may also affect the business model. Moreover, firms will have to reconsider their main business, often moving to "service-products" model (Heppelman and Porter 2015). As explained before the service-products concept represents the utilization of IoT technologie to add value to products by offering services with them. The uses of business models related to Industry 4.0 provide several advantages. In the first place, they make business more able to face the typical challenges of IoT and communicate them to stakeholders. The second advantage is that implementing these business models enhances adaptability by making the different parts modified and adjusted to the changing environment easily. One of the biggest challenges that Industry 4.0 entails is the renewal of the organization. For instance, as Industry 4.0 enhances departments to be more collaborative there is a need to make this collaboration effective. For example, to bring closer the designers of the products and the service developers with cloud operation technology. In other words, create a stronger communication level between R&D and the IT department.
Furthermore, firms need to deal with change in an efficient way in order to recognize the great potential that the technological characteristic of Industry 4.0 has. There are multiple management threats that are required to be faced with Big Data, such as the connected to decision-making, to the corporate culture, leadership and also to the implications of the new technologies (McAfee et al., 2012).

### 3.3.1 Competences needed in Industry 4.0

It is essential that managers empower and modify the competencies of their workers. These competencies that need to be acquired have to be delimitated in a strategic plan that takes the long-term influence of the effects. This could be managed by adjusting the recruitment, modifying current job positions, and providing professional education to achieve the needed IT knowledge in the business that will be required in the future (Rüssmann et al., 2015). When referring on employees requirements to work on an Industry 4.0 environment, the more important skills are related to data management and software development (Heppelman and Porter 2015).

In order gor Big Data and IoT to work in an appropriate way, there is a need of applying IT in the organizations. In order to achieve that, the competences of the employees have to be adequate for the proper installation and funcitioning of this IT landscape (McAfee et al., 2012). The application of Big Data and IoT in a workplace does not translate to reducing the workforce but to empower employees. Actually, there are studies that indicate a growth of employment in industries that utilize these technologies. For instance, more personnel specialized in software development, IT and engineering fields will be demanded. This clearly leads to the idea that new workers in the manufacturing and logistics industries will have to be more technology-oriented and the old ones will have to achieve new level of skills. On the other hand, monotonous task will indeed be eliminated from human labour force and substituted by new automated processes. Therefore, new competences for current and future employees will be required required (Rüssmann et al., 2015). In addition, for Industry 4.0 to be efficiently implemented in an organization, the new competencies of the workforce will have to affect operational and a managing levels (Mörstam, 2016).

In traditional industries, operations usually include plain and repetitive tasks, quality controls and maintenance on reactive attitudes. These jobs can also consist of physically hard duties, precise operations or managing hazardous materials. With automation, these tasks are often substitutes by standardized machines. These machines, or robots, improve and secure the working settings of the employees. In addition, other characteristics of Industry 4.0 such as Big Data and IoT also become shifters on the tasks of quality control, monitoring and maintenance. These technologies change the orientation of the traditional tasks to monitoring and supervision the machines that take over the processes. In order for this transformation to succeed there has to be an adequate combination of the new technological competences of employees with the new standardization of processes by robots (Mörstam, 2016). Furthermore, the workforce is required to achieve new levels of openness and flexibility to be able to switch tasks. To obtain these changes in the competences of the workforce, companies have to involve re-education programs for their employees (Mörstam, 2016).

On managerial levels, the evolution of companies towards the usage of technologies characteristic of Industry 4.0 needs strong leadership on digital levels. Managers need to be aware of the upcoming opportunities and challenges in automation and data processing. They are also required to have a broad vision in the application of these technologies and bring new digital ideas. Thus, managers will foster the technological evolution of the company and bring example to their subordinates (Mörstam, 2016).

### 3.3.2 Organizational acceptance of technologies characteristic of Industry 4.0

The wide adoption of new IoT technologies and services will count on the data privacy and information security on a great extent. These two aspects are complicated matters in IoT because of their complexity, mobility and arrangement (Wan and Jones, 2013). In relation to the previous section of this chapter, organizations need to educate their workforce and have managers with digital knowledge in order to use technologies of Industry 4.0 efficiently. In addition, security on the application of these technologies should also be provided.

As mentioned in the previous section of this literature review, one of the major concerns for companies about the implementation of IoT and Cloud technology is cybersecurity. Therefore for the acceptance of Industry 4.0 in an industry, the security of the data generated from its characteristic technologies must be ensured. For example, IoT enables companies to monitor, track and connect operational data from both machines and personnel. This generates a large amount of confidential data and exposes personal performances of employees, involving ethical considerations from the workforce. For that matter, the protection of the private data of the company represents a vital point since all know-how and processes could be exposed. Protecting private information in the settings of IoT becomes more important and complex than in a traditional operational process. With IoT, more elements are connected and this means that in the case of a cyber attack, more information could be obtained and more devices could be affected. Additionally, when IoT is being used in the supply chain, by monitoring the location and status of goods to clients, this would mean that in the case of a cyber attack, the reputation of the company and its customers could be compromised (Xu et al., 2014).

It can be said that for an optimal acceptance and performance of Industry 4.0 in a company, all departments, managers and employees should work under the same principles. This means that these elements have to know the current situation of their business and the evolution it is taking by the application of new technologies. Training is a must for employees to remain competitive and for managers to guide the company into an efficient digital environment. In addition, synergies created in all levels of the organization should be oriented and supported by technologies (Xu et al., 2014).

### 3.3.3 Technology acceptance in the workplace

There are other considerations for the acceptance of the technologies of Industry 4.0 in the workplace. There are many motives to be reluctant to change, and new technologies may make the current employees feel threatened. They may think technologies will overcome them and will make them think that are too complicated for them to control, causing stress and reluctance to change. On the other hand, if the new technology is perceived to be beneficial and easy to use, it is expected to have high degree of acceptance among the workforce (Alsaadi and Tubaishat, 2015).

Innovative apps and devices in not only an aspect of social life but it also affect communication and performance in work environments. Before the introduction of computers in workplaces, people used to work on a single task basis. With new technologies coming up, new computer programs, smart phones, and others, people are found to work with different programs at the same time. The productivity has increased with the usage of computers and new technologies

but employees complain that they do not have as much time to do their job as they used to. This may be caused from the distractions these devices generate (Rius, 2018). In addition, job performance can be found to be of lower quality because nowadays it is harder to stay focused on a single activity with constant digital inputs at the workplace. The diversification of attention caused by these technological improvements can increases the probability of accidents, stress and failures at work (Rius, 2018).

# 4. EMPIRICAL DATA

In this chapter, the researcher will provide relevant information regarding the current situation of the Port of Barcelona. This information will be transcribed from the interviews and the official websites and documentation of the Port of Barcelona and Hutchinson Port Holdings. In addition, considering the sources of the mentioned data, this chapter will provide valuable information about the evolution of the port, the functioning of it, and the impact of Industry 4.0. Moreover, the presented literature in the previous chapter will be used as a reference to construct theory from the case of the Port of Barcelona.

## 4.1 The Port of Barcelona

This subsection will be used to bring a broad but relevant description of the Port of Barcelona to picture its current situation in all fields. In the first part of it, a general introduction of the port will be provided, indicating business characteristics such as its impact on the local economy, the turnover, the traffic, the number of jobs and the mission and the vision of the port.

### 4.1.1 Presentation

The Port of Barcelona has existed since the same origins of the city it belongs to. They have coexisted and have been growing together to the point there would not be one without the other. The strategic location of the city, with close maritime connection to Italy, the North of Africa and the Balearic islands, and land connection with the south of France, Europe and the rest of Spain, makes it one of the most important ports in the Mediterranean Sea and in Europe. It is classified among the 15 top container ports in Europe, the third largest one in Spain, and the largest one in terms of cruise ship traffic in the Mediterranean Sea (Port de Barcelona, n.d.).

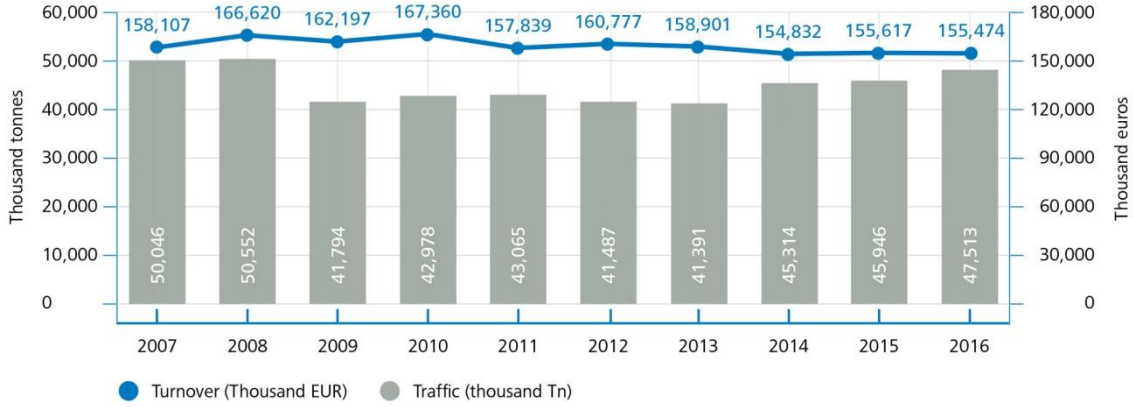
As the Port of Barcelona is administrated as a public service provider, its performance goes beyond the typical profit-generation mindset of private organizations. The port runs as a wealth enhancer for the overall economy supported by the government. Its services not only influence the entire logistics chain from arrivals, departures and up to the end consumer but also to the surrounding economy. The port causes direct effects on the competitiveness of the industrial and commercial institutions to which they serve. Furthermore, the activities performed by the Port of Barcelona, such as shipment, logistics and intermodal transport services, generate value to the Catalan economy in a direct and indirect way. Therefore, a Gross Added Value (GAV) is generated going up to 2.291 billion Euros, representing 1,4% of the total GAV of Catalonia. In addition to that, for every 100 € of income generated by the companies located in the port, 58 € are additionally generated in the economy due to this value adding service that the Port of Barcelona provides to the industry (Port de Barcelona, n.d.).

As it is pointed out in the official website of the Port of Barcelona, the port represents a strategic infrastructure for the competitiveness of the trade and the industry of Catalonia. In other words, the value provided by the Port of Barcelona increases the competitiveness of the logistics chains of the companies using its services. The contribution of the port to the competitiveness of its customers is equivalent to 6,1% of the sales of the industrial and commercial businesses of Catalonia, representing 22.865 billion Euros of sales. This increase in

sales for the customers of the port is achieved as a result of boosting the internationalisation and diversification of them by providing access to a large number of external markets fulfilling with the demanded requirements of frequency and quality.
Furthermore, this increase in the external activities of productive sectors of Catalonia generates additional incomes for them, adding to the Catalan economic environment an additional 5,7% of GAV which also represents the creation of 5,4% of all jobs. Overall, combining the values of direct and indirect activity of the port with this competitiveness enhancer to the economy, the Port of Barcelona is responsible for 7,1% of the GAV and the 6,3% of total employment in Catalonia. Looking at these numbers it can be said that the benefits that the port provides to its customers in terms of competitiveness and externality are much greater than the direct and indirect economic impact of the offered services of the port (Port de Barcelona, n.d.).

The following chart indicates the evolution of yearly turnover and traffic in thousands of tonnes from 2007 to 2016. It is of great relevance in order to understand the current situation of the port after the financial crisis that started in 2008 and made the port implement changes to become more competitive and recover from the impasse.

Figure 4: Progression of turnover and traffic volume of the Port of Barcelona.




(Port de Barcelona, 2016)

Despite the Annual Report of the Port of Barcelona for the year 2017 is not public yet, the website of the port provides values for that year. Thus, the total traffic of 2017 went up to 60.070 thousand of tonnes, representing a growth of more than a 25% from the previous year 2016 and getting a value higher than the ones before the crisis in 2008. In addition, the turnover also increased to 167.000 thousands of Euros, setting a new record for the past 7 years and breaking the decreasing tendency of growth that started in 2008.

The figure presents the interesting evolution of the port after the crisis, showing a decrease in tonnes of goods passing through the port but a maintaining the turnover throughout all these years. These indicators are representative of the closing of business inside the port and the effort that the Port Authority (APB) made to provide competitiveness to the sector. For instance, APB invested in the tourist sector, empowering the cruise business in the port when no one was thinking in investing there. As mentioned, this caused the port to maintain a

stable level of turnover despite the decrease of volume in tonnes (Port de Barcelona, 2016; Managers at the APB, 2018).
Additionally, the tourism sector of the city of Barcelona has continued to benefit from that investment over the last few years, making this sector one of the most relevant for the Catalan economy. In 2016 almost four million tourists (representing an increase of 6,4% from 2015) arrived to the city through the Port of Barcelona. Of the four million tourists 1,27 million arrived through the regular ferries lines that connect the city with the Balearic Islands, Italy and North Africa, and more than 2,68 million were passengers from cruise ships. This last number helps understand the reason why Barcelona is the fourth port in the world in the cruise sector. In addition to that, it is also relevant to acknowledge the economic impact of tourism on the city, which is estimated to be 22 million Euros per day and generates 100.000 jobs (Port de Barcelona, 2016).

Another significant indicator of the relevance of the port is the number of jobs that are directly or indirectly implicated. As it is indicated in the official website of the Port of Barcelona (n.d.), the businesses located in the Port Community directly employs 13.365 people. If this value is added to the indirect employment created by the port the number rises up to a total of 32.101 jobs, representing almost 1% of the job market of Catalonia. In a country where the unemployment rate has been constantly high after the last financial crisis in 2008, it is of relevance to know that for every two jobs generated in the Port of Barcelona, three additional jobs are created in the encircling economy.

### 4.1.2 Mission and Vision

Despite the Port of Barcelona has thousands of businesses, each one with different activities and interests, the overall strategy is being guided by the Port Authority (APB). As it is indicated in the Spanish law, all ports in Spain must be managed by a public institution that represents the “Ministerio de Fomento” (Ministry of Development) controlled and supervised by the sub-ministry of “Puertos del Estado” (State Ports). Therefore, as a public institution, the APB guides and connects all these businesses together to achieve common goals, share values and improve the performance of the port (Managers at the APB, 2018). Thus, the APB has implemented, as indicated in the official website of the Port de Barcelona (n.d.) a shared mission and vision for the whole port community.

Mission:

> “To lead the development of the Port of Barcelona, to generate and manage infrastructures and to guarantee reliable services in order to contribute to clients' competitiveness and create value for society at large.”

Vision:

> “Barcelona: Europe’s port solution in the Mediterranean.”

The mission provides, as a public administration, the focus on the benefit for the customers and the society. Moreover they put emphasis on the generation and management of infrastructures, not profitability, as well as in the reliability and competitiveness provision to customers. When looking at the vision, it can be seen a much more brief and broad sentence, referring to the Port of Barcelona to become the maritime gate or “solution” for Europe in the

Mediterranean. The mission of the port is also explained in the official webpage of the Port of Barcelona (n.d.) its objective is to strengthen the competitiveness of its customers by offering efficient services that satisfy their logistic needs.

It is important to understand that other ports among European countries are managed by different types of institutions. For example, ports in Germany are being managed by the "Lands" (regional administration), in The Netherlands, the ports are being managed by municipalities and in Anglo-Saxon countries they are generally private. This will certainly change the way the port is being managed, and the missions and visions of different ports will have many orientations. On the other hand, the Port of Barcelona, as it is managed as an institution of the Spanish State, it focuses on the enrichment of all actors and territories of influence (Managers at the APB, 2018). In accordance to that, the five established values for the Port of Barcelona put emphasis to these public administration characteristics. They can be found in the official website of the Port de Barcelona (n.d.) as "Appreciation for and commitment to people, Ethical and professional management, Client orientation, Social responsibility and Innovation". The values are oriented towards socio-economic implications, ethics and innovation, which matches public mission of gaining competitiveness in all areas of influence (employees, customers, environment and the industry) while having society in mind. The connection between competitiveness and innovation that can be taken from the values, can be also related to the gain of competitiveness that businesses gain when implementing characteristics of Industry 4.0 such as automation.

To carry out the mission of the Port of Barcelona, the port has to evolve at the same speed as its area of influence, also known as hinterland, which it serves. The hinterland of the Port of Barcelona, mainly represented by the Catalan Autonomy, the East of Spain and the South of France, is characterised by its wide variety of production sectors which has made the port have a diversified profile when answering to all these sectors. Catalonia is one of the most powerful regions of Spain in economical terms, containing large industries such as automobile, food, pharmaceutical, energy, chemicals, metal, building materials, distribution and retail. In accordance to that, the Port of Barcelona serves nearly 3.000 different companies, and all of them combined represent a turnover of 300 billion Euros and more than a million jobs.
Each of these companies has different logistic needs that the Port of Barcelona has to fulfil creating a useful added value for all of them. In addition, the process of adding value is based on the arrangement of multiple logistic services. These services are meant to go beyond standard port work and generate competitive advantage to customers. Furthermore, the port is a great actor in enhancing development and in offering a gate to internationalisation for all industries that use their services.

### 4.1.3 Area of influence and environment

As mentioned above, the hinterland of the Port of Barcelona involves the whole Iberian Peninsula, where the northeast and centre of the peninsula takes more relevance, and other European and Mediterranean countries such as France, Italy and the north of Africa (see Appendix 2). The port has created a network of services and infrastructures that are set at strategic locations. These locations work as inland terminals that bring the spread industries

closer to the services of the port. Inland businesses that require maritime logistics in order to export or import their goods use these strategic points as a local connection to the port, making a more efficient communication network and also helping to build a more integrated supply chain from or towards the Port of Barcelona. Other strategic locations can also be found overseas, in Argentina, Japan and China to strengthen relationships, and increase commerce with the huge markets that these countries represent (Port de Barcelona, 2016).

The Port of Barcelona has a huge impact in its hinterland but the highlight is in the Catalan economy surrounding the port. On the other hand there is a direct influence in all companies working in and with the port, with higher relevance on the former. The port has nine companies running the nine cargo terminals for vehicles, passengers, bulk and liquids. Furthermore, the port influences another vital sector typical of the logistical landscape, transport. The transport on road is composed by many logistic companies which make it complex to control. Rail infrastructures are just the opposite, they are all owned by the country but changes on them require extensive planning and great investments. On the other hand, they provide fast, efficient, direct and less polluting connection to the hinterland of the port, that is why it has become one of the sectors in which most management and sustainable innovation is required. But most important, the maritime transport also receives and transmits influence from the port. Shipping companies that operate in the port, such as the giant MAERSK, MSC and others, plus the cruise companies, have to evolve at the same time as the port, adapting their specifications and needs from one to the other.
In general, the Port of Barcelona aims to create a future scenario in which it works as a wealth generator for the surrounding areas of influence and to support new ideas to establish stable and sustainable development of its community. Since there are a lot of participants in the daily functioning of the port, communication plays a big role on satisfying the needs of everyone. Therefore a lot of information is shared and put together in order to work at the same speed and collaborate to build a better port. Furthermore, when a participant of the port, or the APB itself, wants to implement a characteristic of Industry 4.0 all other actors will also be aware.

The Port of Barcelona is located next to urban areas such as El Prat de Llobregat or the city of Barcelona and to natural environments such as the Delta del Llobregat and other natural parks around the Llobregat River. Moreover, the port is just a few kilometers away from the first touristic beaches of the area. Both people and nature put environmental pressure on the pollution controls of the port. In accordance to that, the objectives of the Port of Barcelona are to take care of the environment by controlling the impact of port activities on the environment and to improve waste, air, water and soil management. It also helps and promotes initiatives originated by the terminals and by other companies working in the port.
The Port of Barcelona is responsible for the monitoring of environmental data including water temperature, salinity and composition (control of materials in suspension). Also the presence of air pollutants, which have been decreasing in the past years in general, and the waste generated inland, which also indicates a decreasing tendency. Moreover, the port is also responsible to control the energy consumption to make sure efficient installations and processes are made or improved. All these controlled data has specific action plans for emergencies or potential environmental problems. For example, the port registered 150

procedures of waste correction with successful results on the year 2016 (Port de Barcelona, 2016).

### 4.1.4 Operators and general functioning

The public characterisation of the Port makes it work with the same system as a landlord, responsible for the exploitation of its soil and infrastructures. Therefore, the administrative organization or Port Authority offers land concessions for about 25-30 years, to companies that want to operate in the port (Managers at the APB, 2018). The Port Authority plays a big role in coordinating, analysing and managing the functioning of the whole port but a more developed explanation of the Port Authority will be developed in the next subsection of this chapter. In this subsection general processes and operations will be presented in order to get a deeper understanding of all main participants of the daily functioning of the port.

It is important to notice that the Port of Barcelona does not sell any product; it simply offers logistic services to the local or regional economy, adding value at the logistic chains within the hinterland. Therefore, a customer of the port is a business or institution that has decision power on the movement of its goods. Customers require the port to be reliable on its time slots, transparent in order to check that their goods are operated in the right specifications, fast and cost-effective. If the port does not supply value on their logistic operations, it fails to satisfy the needs of its customers (Managers at the APB, 2018).

A good way to present the effective performance is to show the processes that a container takes when it goes through the port, from its arrival until its departure. Containers represent almost 50% of all cargo operations in the port (Port de Barcelona, 2016) and despite their way along the port is physically “simple” all required documentation and data that is generated is found to be complex to manage (Managers at the APB, 2018). This complexity can be seen when noting that data starts to generate approximately one week before the ship has even arrived to the port. Generally, before the container arrives, the port consignee (representative of the shipping company) contacts the ship-owner (person or organization in charge of equipping and supplying ships) to indicate the estimated day and time of arrival as well as the dimensions of the ship and its cargo. The ship-owner contacts the Port Authority and requests a stopover number and the time slot, terminal and position that need to be determined for the unloading of the vessel.

On the one hand, once the ship is on shore, the physical operation of a single container at the port can be described as, unloading, disposal and loading. The tendency is to automate all operations as much as it is possible. The traditional way that these operations are carried out is with the work of stevedores, terminals and carriers and can go from a ship to trucks, other ships or trains or also vice versa. A more detailed explanation of these operations will be explained in the subsection of Hutchinson Port Holdings, describing the procedure in a semiautomatic terminal and its differences with the traditional ones. Nowadays, the port is in very good competition shape and can unload the whole cargo of a vessel, containing 3.000 TEU (special shipping containers of Twenty-foot Equivalent Units), in less than 24h (Managers at the APB, 2018).

On the other hand, all these movements that start a week before the container finally arrives at the port, are accompanied with a huge amount of documentation. A study was made before

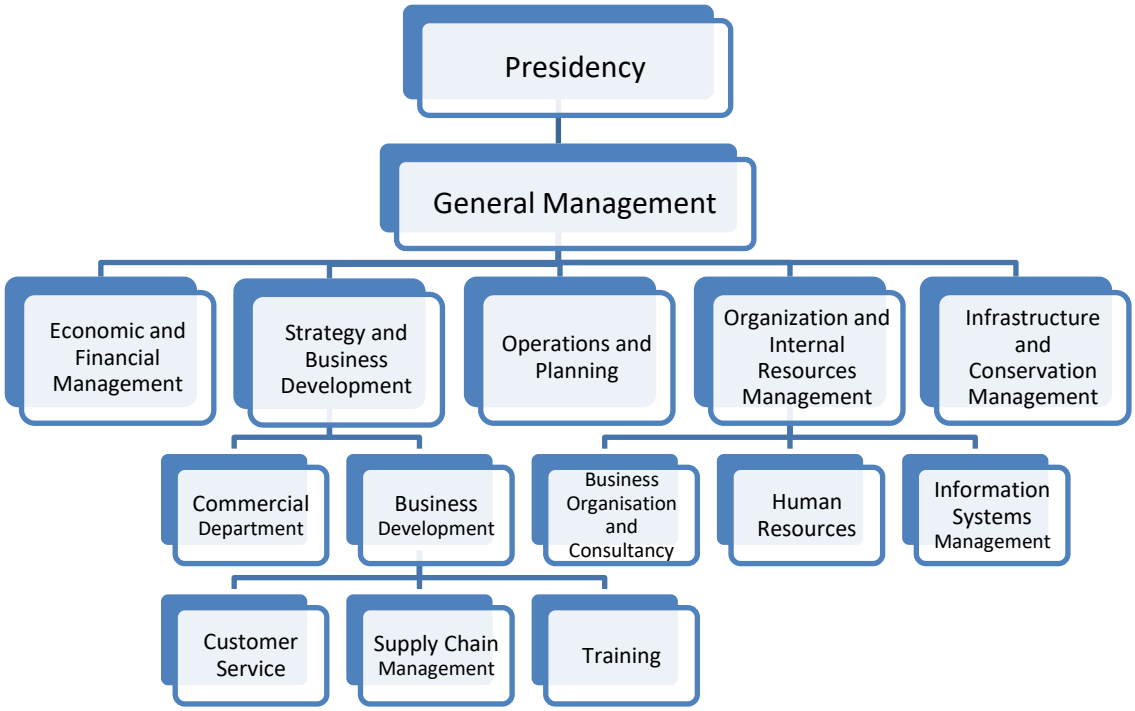
communication processes started to become digital, which showed that 9kg of paper where generated in documentation in order to carry a container from China to the Port of Barcelona (Managers at the Port of Barcelona, 2018). Despite all improvements and changes, this shows an idea of how complex and large is the movement of goods in an international supply chain. In addition, when a container passes through the Port of Barcelona, a big amount of documentation is being produced. This documentation consist on custom formalities, payment of fees to the Port Authority, container and terminal data, Bill of Lading (property specifications of the merchandise when it is changing hands along the port chain), payment of import / export fees and all communication between terminal, ship-owner, freight forwarder and the importer or exporter (Managers at the APB, 2018). Moreover, all this information is added to the one required to plan the continuity of the container in its supply chain, reserving trucks, trains, planes or other ships.

### 4.1.5 Port Authority

The Port Authority, also known as Barcelona's Port Authority or APB is the public organization in charge of managing the Port of Barcelona. It reports to the Spanish institution of "Puertos del Estado" or Spanish National Ports in English, which establishes the government guidance and port policy. This national authority is part of the Ministry of Development and it also coordinates and supervises the efficiency of the port network of Spain, which contains the 28 port authorities that manage the 44 main ports in the country. Under the estate regime, the APB is expected to accomplish several tasks. These tasks are listed in the official webpage of the port and consist "to provide general port services while authorising and monitoring them; manage the port service area and port use; plan, design, construction, maintenance and operations pertaining to works, port services and navigational aids" etc. (Port de Barcelona, n.d.)

In the following figure, a schematic organizational chart of the Port Authority is presented. This is useful to understand and see the variability on the interviewees chosen for this thesis. After the presidency and the general department, there are five main branches in the organization. The interviewees at the APB listed in the Methodology chapter are present in only three of these major departments because the Financial and Infrastructure departments have little relevant influence on the daily work at the port. It can be seen that employees at all sub-departments of the three main ones had been represented in the interviews, facilitating the researcher to obtain a more complete vision of the organization.

Figure 5: Organizational chart.



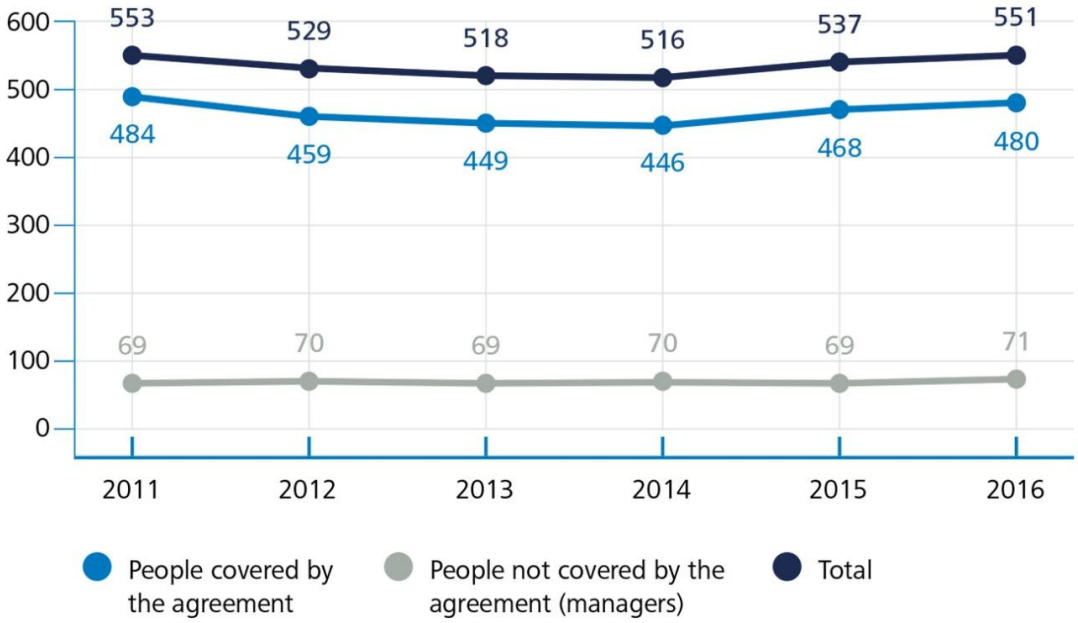

(Port de Barcelona, 2016)

Because the APB is considered a public administration there are some implications. As it was mentioned before, the port works as a landlord owner of the public piece of land that offers concessions to business to exploit the operations of the port. This means that all businesses integrated in the port have to follow some guidance from the government and the APB in order to operate in the port. Moreover, the APB is being managed under an umbrella of public guidelines that involve transparency and bureaucracy. Managers at the APB (2018) mentioned that such public characteristic of the institution has altered the functioning of the organizations when talking about billing, budget, paperwork and human resources. For instance, the bureaucracy is present with many controls and traditional paperwork required to accomplish budgeting or accounting of projects. Furthermore, despite some improvements have been made to reduce the amount of paper generated by introducing digital firms, the tendency on controls and bureaucracy has noted to become worst being an obstacle for the optimal development of the port and its digitalization (Managers at the APB, 2018).

Another example of the public characterization of work at the APB is relevant in the department of Human Resources. Since public employees are limited by law, the port has found itself to not be allowed to hire new people for many years. With surprise, the author of this thesis found through the interviews that not even deceased employees could be replaced. On the other hand, firing workers is a very rare case in public institutions and this lead the APB to constantly train and adapt its employees to new positions and skills. Furthermore, the hiring process which has recently started again but working only in very little occasions was found to be very old-fashioned and full of bureaucracy, making it unattractive for young people (Managers at the APB, 2018). The department of Human Resources is currently working hard to implement changes on the hiring process, to make it more simple, dynamic and attractive.

In the following chart, the evolution of workforce is shown, indicating the low hiring rates of the past recent years.

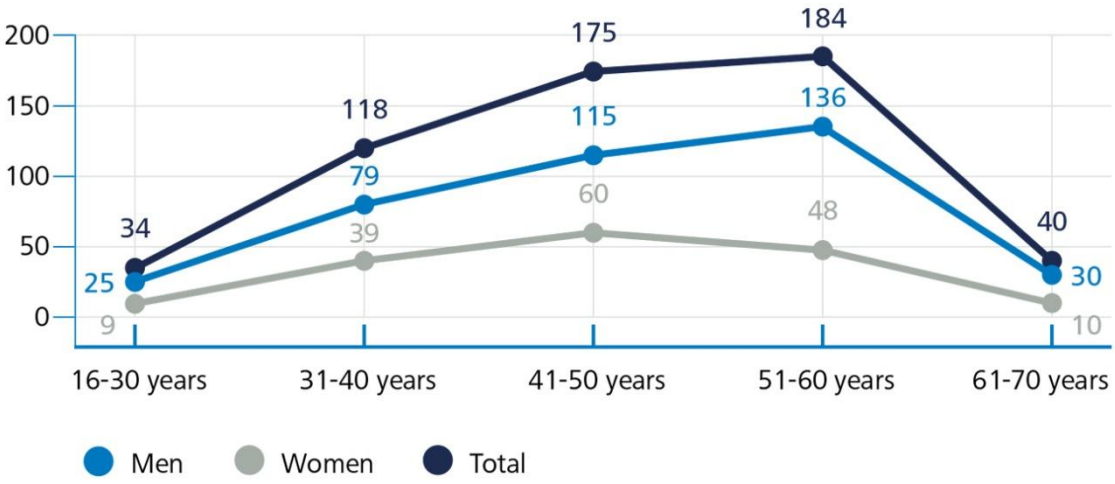
Figure 6: Workforce evolution.




(Port de Barcelona, 2016)

The lack of new people has made the average age of the workforce to go up, making it nowadays above 50 years old. In the following chart it is shown that in 2016 the majority of employees were already located in the 51-60 years age group.

Figure 7: Workforce by age group.




(Port de Barcelona, 2016)

Despite the majority of the employees at the APB are that old, the extensive training system makes workers to constantly learn new concepts, skills and competences that make them very resourceful and competitive at work. Employees are offered voluntary trainings that are required to achieve promotions. This makes them become more motivated and adaptable to changes that may occur in the industry. Human Resources indicated that technology

acceptance and change at work has never been a big deal at work (in similar consonance with other companies) but their general mentality could be based on traditional ideas which make the systems and way of thinking less innovative. The department of Human Resources is responsible to motivate their employees to compensate this antiquated mentality and managing systems which make the APB remain updated and pushing the sector towards more use of characteristics of Industry 4.0 (Managers at the APB, 2018). The department instantly offers new training every time a new application, program or system is introduced at the workplace. It also creates new training for departments or people that request them. Additionally, in order to make the workplace more attractive for their employees, Human Resources are working on the creation of a new brand for the organization, making it seem more innovative and attractive from the inside and the outside.
Moreover, it has been indicated by other departments such as Operations and Planning, that the APB is actually pushing all companies, customers and providers towards the fourth industrial revolutions through the implementation of new digital services (Managers at the APB, 2018). In relation to this, the port also offers training to their customers, being the sub-department Training in charge of these courses, creating a positive tendency in the direction of more and more training programs.

### 4.1.6 Hutchinson Port Holdings - BEST

The organization started back in 1866 in Hong Kong as a dock company in charge of repairing and building ships. Later, Hutchinson Ports Holdings diversified its operations to cargo handling and started to be named Hong Kong International Terminals or Hutchison Ports HIT. In the 90s the international network grew and they started to expand into other logistic areas such as cruise ship terminals, airport operations, distribution centers, rail services and ship repair.
The company, present in 52 ports and 26 countries around the world, is characterized for deeply investing in IT and operational effectiveness with automated systems. This has made its customers to become more competitive and aware of technologic solutions in shipping operations. In 2016, all terminals owned by Hutchison Ports handled a total of 81,4 million TEU all over the world (Hutchinson Ports, n.d.).

In Barcelona, Hutchison Ports, built the first semiautomatic terminal in Spain. This terminal, called Barcelona European South Terminal (BEST) is capable of serving several ships at the same time, and has the biggest on-dock railway installation in the Mediterranean. BEST has 11 Super Post-Panamax cranes, which are the ones in charge of loading and unloading the vessels, 54 automated cranes responsible of the disposal of the containers in the 79 hectares of storage surface. In addition to that, the terminal is being managed by the Terminal Operating System (TOS) nGen (Next Generation Terminal Management System) developed by Hutchison Ports and modified to serve the specifications of the semi-automated system in the Port of Barcelona (Hutchinson Ports, n.d.).

It is considered a semiautomatic terminal because there are still some operations where the human interaction is required. The whole disposal and relocation of containers along the storage surface is done automatically with immense automated cranes. Human action appears on the more precise and complicated tasks of loading and unloading both trucks and ships.

These operations could have been automated with the existing technology, but the labour union of stevedores put pressure on the company to integrate their work on the system. This shows the traditional tendencies that still run in the logistic sector in Spain, where technology acceptance and change adaptation is yet to be improved (Managers at the BEST, 2018). The stevedores are now fewer than in a traditional terminal but are more skilled in their jobs and technology oriented. Their performance is now carried out in an office, where they manage the loading and unloading cranes from the distance, being able to sit comfortably, and operate with digital helps on their computers (Managers at the BEST, 2018).

## 4.2 Industry 4.0 within the port

In this section the information obtained through interviews plays a major role in the description of Industry 4.0 in the Port of Barcelona. Industry 4.0 and its technologies were the main focus on the interviews and questions conducted to achieve deep knowledge about the level of integration of the concepts concerning the fourth industrial revolution. On the other hand, figures and numbers may also be obtained from the data provided in the official websites of the organization.

The Spanish logistic sector is known to be very traditional and reluctant to changes. Therefore companies interested in the development of the port are the ones that contract logistical services, not the ones that work in it. For that reason, the final customers (clothing firms, automobile industry, etc.) put pressure to the port to achieve a more efficient supply chain. On the other hand, shipping companies are logistic operators that do seek innovation but since they often work internationally the changes they achieve are concerned in their own operations and do not affect others. It would be very complicated for them to push the supply chain to work like them, since they are many and each port works in different ways. Otherwise, as mentioned by the managers at the BEST, the tendency is to standardise processes in both shipping companies and in ports. Therefore, since clients and providers push the logistic sector towards becoming more competitive, the APB is responsible to listen to their needs and also to anticipate improvements to make the port more efficient and attractive. The port Authority is also responsible to motivate other members of the supply chain to innovate at the same pace as them. APB has been the most important institution in charge of implementing new ideas and investing on improvements such as Portic, the port community system, digitalization of entry gates, CarEsmatic program that tries to adapt the port to the flow of electric vehicles, etc. These changes and implementations towards digitization, are meant to improve efficiency in both internal (employees at APB and within businesses at the port) and external actors (clients, suppliers and others). These changes are carried out progressively as the market evolves and are supported by many training programs. This slow implementation of changes achieves a level of low impact on the workplace but continuous improvement in the workplace. The APB has a proactive attitude when looking for improvements, but also as small problems appear on daily basis work, and they need to be answer in a reactive way (Managers at the APB, 2018).

### 4.2.1 Internet of Things

The Port of Barcelona has implemented technological solutions to improve its monitoring systems. For example, there is a monitoring program for waves. The aim is to know their

tendency through a net of buoys, there are multiple sensors for environmental purposes, and also cameras that apart from recording for security purposes they can also work as license plate readers (LPR) and track containers or trucks within the property of the port. All these sensors and cameras can be controlled through an app allowing the personnel to follow the evolution of the desired vehicle or container. Another characteristic of IoT that has been working for several years is the digital access of the gates of the port. This change was implemented over a decade ago in order to eliminate paper, to achieve more control on the apparition of queues and improve security. This digitalization has made the flow of transportation become faster and more efficient (Managers at the BEST, 2018). This implementation on the gates of a port is still uncommon in Spain and has put the Port of Barcelona in one of the most innovative ones in the country and also a European reference (Managers at the APB, 2018). Employees at the main gates of entry of the port were eliminated together with the use of paper. Nowadays trucks enter the logistic terrain by using digital codes that a machine reads at the entrance and automatically identifies the truck its driver and its cargo. This operation that has an efficient rate of almost 99% also avoids human mistakes and long waiting queues. Moreover, security from national police is reduced to only one employee (instead of having one in each door) that controls the 1% of errors that the system may have (Managers at the BEST, 2018).

Apart from these digital system characteristics that IoT managers at the APB (2018) commented, there are many other areas in which technological improvements fit in and need to be developed. In addition to that, managers at the BEST (2018), also commented that the use of sensors will continue to expand along the terminal since their manufacturing costs are constantly lowering. On the other hand, they are also aware that the installation of more sensors does not translate to more efficiency if they are not relevant to the overall performance of the operation.

An example provided from the development of IoT in the industry consists on the implementation of digital systems which allow containers to travel on their own, knowing where their destination is and what is the optimal route to reach it. Moreover, these containers will be supported by strong data processing software that will allow them to change modes of transport along their journey in order to avoid delays for example if the ship that is needed to be taken is stuck in a port.

### 4.2.2 Big Data

As some Managers at the APB (2018) mentioned in the interviews, data is the most valuable asset in the port. There is no exact idea of how much data is generated at the Port of Barcelona every single day, but considering the enormous amount of activities, operations, services that are carried out it is reasonable to think about Big Data in all its parts. There are thousands of trucks that pass through the gates of the port every day, thousands of cruise passengers, and thousand of operations with containers, machinery or ships that are monitored with multiple sensors. With all this information, the biggest challenge is to find the right way to manage all this data and the value derived from it.

As mentioned in the previous subsection of Internet of Things, the gates of the port are currently managed digitally and work in a fast and efficient way. Only in these gates there are multiple sensors that read the license plates of the trucks (LPR cameras), Optical Character Recognition systems (OCR) that identify the container they are carrying, card readers for the drivers, pressure plates on the ground to count their trucks, etcetera. Despite all of that, the port could improve the use of the Big Data generated because it suffers from the variability of the flow of transportation, with peaks on Mondays and Fridays. This causes an uneven load of trucks that go through the gates along the week. The new objective from the Operation and Planning department is to work on the Big Data being collected from the trucks in the gates and implement a new system based on previous appointments in which drivers ask for these appointments, which are being spread along the week and queues are avoided at the entrances of the port. The use of Big Data in this case helps the port plan the future, achieve knowledge of the behaviour of the transport sector and add value to the optimized supply chain. Furthermore, this example suits perfectly in how Big Data needs to be treated in the port, achieve knowledge from it, get the value from it and optimise the whole supply chain (Managers at the APB, 2018).
Although each operator of the port gets its own data and uses for its own purpose, the sharing of this data can be also useful for other agents working at the port. For that reason APB needs to work as a central data administrator and process all data generated within the port in order to make it valuable for others. From the amount of data gathered at the port from the flow of goods, containers and passengers, the port needs to supply the data after filtering it. After this, customers will appreciate the valuable data offered by the port and will rely on the performance of the port, starting a loyalty process achieved not only by the quality of the contracted logistic services of the port but also from its reward on valuable data that is returned to them.

Another crucial point on the management of Big Data at the port is Portic, the Port Community System at the Port of Barcelona. It works as an electronic platform in where all participants are connected for the functioning of the port (consignees, private operators, terminals, custom agents, port police, public administration, etc.). In this platform they can exchange all needed documentation as well as access to published information in an easy way. This facilitates logistic operations to be carried out effectively, safely, offering transparency and being beneficial for everyone. At the beginning there appeared to be reluctance from some operators of the port, due to the transparency that the platform offers. The transparency was understood as showing who is working well and who is not, which made some businesses feel under pressure. At the end, Portic was broadly accepted after all participants saw the potential in it, creating synergies and improving the communication among them (Managers at the APB, 2018). Therefore, it can be said that the current use and acceptance of Portic entirely matches with its initial mission, described as “to improve the competitiveness of business in the port community of Barcelona through a technological platform that facilitates the interaction between all of them” (Port de Barcelona, n.d.).

### 4.2.3 Cloud technology

Cloud technology is something that has been considered at the APB and in other businesses of the port. It is used in some measure in specific departments or cases but there is not a general utilization of this technology due to some concerns. The Cloud has an image of insecurity on informatics. Managers at the BEST (2018) feel like this technology offers less control and security on their management and storage of data than having their own servers.

The Information Systems department at the APB has owned for several years a great amount of servers that remain competitive nowadays. Since they already have the infrastructure with all implemented system, it would make it very expensive and nonsense for APB to start using the Cloud. Moreover, Managers at the APB (2018) commented that Cloud technology need to evolve a bit more to become more attractive. Nowadays Cloud vendors do not offer a level of competence high enough to compete with business-owned severs because they do not offer programs and systems to be updated automatically, which is what the department of Information Systems value the most. On the other hand they agree that Cloud technology will continue to improve and become more competitive as time goes by. They also think that it is very appropriate for small or starting businesses, since contracting Cloud service would mean not to invest on expensive servers of their own. Additionally, the APB has hired Cloud technology on specific projects or cases for its convenience. For instance, they are currently working on the implementation of a new email program which will be using Cloud technology.

### 4.2.4 Cybersecurity

The huge cyber attack that the giant shipping company Maersk suffered last summer affected the terminal APM at the Port of Barcelona. Maersk bought the operations services of this terminal about a year before the attack and decided to implement its cybersecurity systems. When Maersk was globally attacked this caused all its businesses, including the APM terminal of Barcelona, to be exposed to the attack. This caused the whole port to become more aware of the risks that digitalization entails. Maerks was known to be a giant in the shipping sector with great cybersecurity systems, and the successful attack showed that the size and investments on digital security of a company does not mean that it is fully secured from these attacks. As traditional security, cybersecurity needs to be a balance between covering risks and costs. The more a company invests the more secure it will be, but companies need to assume some risks in order to avoid large costs (Managers at the APB, 2018).

The researcher found a great level of awareness in every interview in both organizations, BEST and APB. The two companies have been constantly training their employees on cybersecurity and these trainings increased in number and diversifications in the past year since the cyber attack on Maersk. The Port Authority has recently offered different training programs on cybersecurity. For instance, the last one was meant to make its employees aware of cybersecurity on their smart phones since it is known that they use it for both private and work life (Managers at the APB, 2018).

The APB has also trained its employees to identify fake emails and to follow a security guideline if something wrong is identified in their computers or programs. There was recently a case of a fake email that offered travels for the employees at the APB, as if the organization was offering them. This email asked the receiver to provide the user name and password to confirm that they were workers at the APB, but it was quickly eliminated. On the other hand,

the Information Systems department is constantly checking the reliability of their programs and testing the cybersecurity systems to make sure they remain efficient. They are also in charge to eliminate viruses from computers or programs. In addition, the APB is constantly running drills on fake emails or viruses to test the awareness of its employees. These tests have proven that the workforce is improving it awareness on security but there is still areas of improvement (Managers at the APB, 2018).
The BEST has also implemented innovative solutions to improve the level of its cybersecurity. For instance, they have a double station of servers that mirrors the obtained data. This creates a safe storage of crucial information that would sustain the operations and full functioning of the terminal if the main computing systems were attacked. In addition, they also have training and specific protocols for the employees at the terminal (Managers at the BEST, 2018).

### 4.2.5 Automation

In this subsection the interviews carried out to managers working at BEST take more relevance since it is harder to wholly understand automation from the administration offices of the port. That is the reason why the interviewees from BEST were chosen to have an engineering or technological focus on their jobs. As mentioned above, Barcelona European South Terminal is a semiautomatic terminal located in the southern part of the port. The terminal is a clear example of automation, where technologic advances took over the execution and planning of the disposal of containers. As mentioned in the previous subsection of Hutchinson Port Holdings, the automation process takes place when large cranes position containers autonomously in order of relevance (type of goods, day and time of departure, location of the ship, etc.). This process used to be manually controlled and thought but now it is being run by a TOS computer program specialised in managing the terminal.
Another automated process that can be found in the terminal BEST is the cranes used to load or unload the containers from the trucks. These cranes are still being driven by humans but in a very different context than it used to be; there are no longer drivers on the crane but an office with computers where trained personnel run the cranes in the distance. This would be a case of semi-automation again. Technology has improved the workplace and the working conditions since workers are inside a building sitting steadily on a table. In addition, they are being helped through computer programs that make the operations more precise and efficient. Once one operation is done, the program automatically displays on the computer screen the next operation that the worker should carry out. These operations are displayed in the order of relevance that the operation system calculates (Managers at the BEST, 2018).

Other automation processes appear on the general illumination of the port. Most lights use LED technology to become less energy consuming and are automatically managed using sensors that observe the daylight in order to turn on the lamps. Moreover, the lighthouses and additional illumination installations are also managed automatically, using digital programs that manage their performance. As managers at the APB (2018) suggested, the future of the industry will be based on using machines for all types of work and processes that do not need thinking and communication. These two actions should be the ones being carried out by humans (Managers at the APB, 2018).

### 4.3 Workplace changes

As it has been shown in the previous sections of this chapter, many technological changes have been made at the port. These changes have altered the workplace in many occasions and have also transformed the workforce to become more digital-orientated. The installations of new automated gates eliminated all manual jobs that were done there. There used to be a person in each door responsible to read the documentation of the driver and his truck. Moreover, the personnel at the gates were responsible for giving instructions to drivers regarding their operations at the port. Human errors were common at that time, the gate employee could understand the documentation in a wrong way or commit mistakes when addressing to the driver regarding his operations. In addition, when transcribing the paper documentation to their computers, mistakes could also be done, and it represented a waste of time and efficiency on the process.

A similar situation was found on the security and customs employees. There used to be an agent on each gate responsible of checking the licence plate and the carried container of the truck. With the implementation of OCR and LPR, the human operations became obsolete. Nowadays there is no workforce at the gates of the port. The port police has lowered its presence to only one member being in charge of the gates, controlling only when an error occurs (Managers at the BEST, 2018). On the other hand, there needs to be a constant maintenance of the technology installed at the gates, which requires human interaction of trained employees when needed.

The introduction of Portic entirely changed the way the port works and communicates. When most data exchange was traditionally made on paper, Portic offered a digital platform in which data could be directly generated and transferred there for the use of the actors that need it. This had some reticence in the beginning since people were not used to this system, and there were employees at the APB in charge of transferring the documentation to computers. This platform, together with the improvements of technology that allowed systems to directly generate and upload data to Portic without human interaction, made the whole operation systems of the port more efficient. On the other hand, some employees found themselves obsolete, but the public characteristic of the APB made them transform their performance in the workplace. They were trained to carry out new tasks, and they were given digital skills in order to evolve together with the systems. Other private organizations may have fired these workers and hired new ones based on their digital competences, but as a public administration, APB had to train and relocate its employees, achieving experienced and motivated personnel (Managers at the APB, 2018). On the contrary, new organizations are constructed under hiring highly skilled employees on the digital field, making a long term investment on them (Managers at the BEST, 2018).

Similar situations are constantly taking place at the Port of Barcelona. The introduction of apps, programs or new informatics systems make the workforce evolve at the same speed as the market to remain competitive. Furthermore, this evolution makes jobs and the whole port more productive (Managers at the APB, 2018).

In relation to Portic and the new communication systems, exchange of data has become faster, efficient and secure. Nowadays, there is a constant improvement in communication all along the supply chain and the tendency is this to make it better. There will be a point in a near

future where the customers of the port will be able to know at any time and at any step of the supply chain the current situation and status of their supplies (Managers at the APB, 2018). On the other hand, this tendency has been analysed by managers at the APB (2018) to make communication between different parties to become less personal. The communication between the APB and other organizations is found to become less and less verbal. Since the exchange of data is automatic and errors are rare, there are fewer discussions, which can be considered good but also a loss in businesses synergies. Digitalization is perceived to bring closer companies but to move people away from each other (Managers at the APB, 2018).

Another important aspect in the work environment at the APB is the use of personal smart phones. Managers at the APB (2018) have found themselves to be constantly using their phone for work purposes; "if I forget my keys I don't go back to pick them up, but I forget my smart phone I drive all the way back to get it, it is and indispensable tool for my job". The port has several apps that offer interesting tools for the employees to use. For instance, the truck monitoring of the gates can be done on the phone with the specific app. This app is also useful for truck drivers because it shows the queue lines in each terminal and the estimated time of being served for their operations. That way they can choose the time they decide to go to the port depending on the observed data on the app.

Another clear example of change at work is the current situation of stevedores at the terminal BEST. They have been reduced in number, in comparison with traditional terminals, and their jobs have become more technology-orientated (Managers at the BEST, 2018). Their traditional work consisted on loading and unloading ships, using cranes and other machines to carry out the process. Nowadays, at BEST, the stevedores work with computers. They operate the cranes with computer programs and are being guided by a TOS instead of their own criteria. Moreover, they have been trained to understand the programs they use on their computers and to identify useful data from them (Managers at the BEST, 2018).
The workplace landscape of the stevedores has changed completely. They used to work up in the driving cabin of the cranes, exposed to climate conditions and the shaking of machines. This special workforce works now inside an office, sitting in a comfortable chair while operating with computers. They are no longer exposed to the variation of temperatures or the shaking of the cranes and can work from a steady position, controlling their operations from different perspectives with the use of multiple cameras. They are also guided and helped by the operation system of the terminal, which indicates the stevedores on their screens the right parameters to follow to complete a successful operations (Managers at the BEST, 2018).

Another program that the APB is planning for the port is CarEsmatic. This is an innovative project that consists on the improvement of the supply chain of electric cars. This type of car has several needs that make them different from the gas or diesel powered ones. They require electric batteries and problems on the transportation of these cars have to be solved in relation to their electrical needs. For instance, if a train has to unload electric cars and the first one in line does not work, this will stop the rest of the cars for being unloaded. To repair the problematic car, a supply of electricity with its special charger may be needed. This example can be applied to all points of its supply chain, making the port aware of the needs of these cars and studying to implement infrastructures to support the transportation of this type of

vehicles. Moreover, personnel in charge of the car loading and unloading in the port will have to be trained in order to identify and solve problems that electric cars may cause (Managers at the APB, 2018).

It can be said that, in general, the Port of Barcelona has been reacting properly when changes in processes and workplaces have occurred. In addition, despite the old characterization of the workforce of the APB, there is a high degree of technology acceptance due to the efforts of training programs that the organization offers. On the contrary, the mentality of these employees is less orientated on the implementation of changes and the traditional system that runs on the organization can be noticed.

# 5. ANALYSIS

In this chapter, an analysis of the research will be carried out. This analysis will consist on comparing the presented theory in the Literature Review and the Empirical Data obtained through interviews and official documentation of the Port of Barcelona. In addition, this chapter will also identify patterns that were found in the data collection process, indicating new theory and problems presented by the interviewees.

The mentioned "codes" in the Methodology chapter structure the analysis regarding the five highlighted technologies of Industry 4.0 and the workplace changes. After that, research gaps that were found along the analysis process of the interviews will also be presented.

## 5.1 Analysis of Industry 4.0

The port was found to be very proactive in most of departments in terms of innovation. Industry 4.0 was a widespread concept and there was a strong use of its technologies and the implication of them in current and future projects. The implications of Industry 4.0 at the Port of Barcelona have already been presented in the previous chapter, Empirical Data, an analysis of them will be conducted.

Table 2: Analysis of the presence of the five chosen technologies of Industry 4.0 at the Port of Barcelona.

| Technology | Presence | Analysis |
|---|---|---|
| Internet of Things | High | Characteristic technology of IoT was found to be largely spread along most processes and operations of the port. From sensors on environmental data collectors, sea monitoring and gate functioning, to OCR, LPR, phone apps, distance driven cranes, illumination system, etc. These technologies, which are now becoming cheaper, will continue to spread and increase levels of control and automation on all operational levels at the port.<br>On the other hand, managers at the APB and at the BEST need to remain aware that the installation of more and more sensors does not directly translate to more efficiency. Sensors are required to be chosen depending on the relevance of their performance because of the big amount of data they generate. Sensors need to be chosen for their value adding, getting information for every single small operation process does not guarantee efficiency. |
| Big Data | Very high | The use of IoT and the introduction of new digital systems of communication and data collection generate a huge amount of data. Therefore, it can be said that Big Data is the most important characteristic of Industry 4.0 at the Port of Barcelona. Without it, the port would find it impossible to exist.<br>The APB should continue to provide added value to their services to create customer loyalty. This would mean for the Port Authority to work as a data gatherer and processor, handling easy and useful data to its customers. Moreover, the use of Portic creates a great platform for Big Data to continue to develop at the port. |

| | | |
|---|---|---|
| Cloud technology | Low | The presence of Cloud computing at the Port of Barcelona is currently low. The fact that the APB has been functioning for many years with its own infrastructure of powerful servers makes it complicated to shift to Cloud technology. Moreover, the huge amount of information and programs that are being managed locally would make the change too expensive. In addition, Cloud technology is found to need advances to become more competitive for big corporations.<br>On the other hand, small or starting business in the port could benefit from the advantages of the Cloud by having little initial investment (servers infrastructure is not needed). |
| Cybersecurity | High | Since the cyber attack of the mentioned shipping company during the last summer, which also affected a terminal of the Port of Barcelona, cybersecurity was found to be a known topic among interviewees.<br>The APB and the BEST currently own strong cybersecurity measures and systems. Moreover, both of them offer periodic training to their employees regarding this topic. There is nothing else for them to keep testing the security of their programs and systems. They also, improve their cybersecurity as new solutions are offered in the market. On the other hand, these organizations have to find the proper balance between assuming some risks and investing a large amount of money. |
| Automation | Intermediate | Despite the Port of Barcelona works as service provider more than a manufacturing company, automations can be found in many of its operation processes. Some examples, mentioned in the previous chapter, are the automation of terminals, gates systems, and others.<br>The level of automation on processes at the port is indicated as intermediate due to the pressure labour unions make. The mentioned case of stevedores caused the BEST to adapt the automation levels to satisfy this workforce. On the contrary, this is being perceived as a positive social decision, since it creates equilibrium between employees and machines. Not all processes have to be automated at a 100% to become efficient. Many errors, maintenance and supervision still require the presence of digital-skilled humans in the workplace.<br>Therefore, the Port of Barcelona needs to keep growing in this direction, improving the efficiency of its performance with technology but maintaining the human asset at some extent. Additionally, employees should be trained to become more collaborative with the automation devices. |

As it can be seen on the previous table, there are general implications of Industry 4.0 at the Port of Barcelona and in its workplaces. Despite the fourth industrial revolution is being classified in a beginning stage, the role APB and other organizations at this port play a very

advanced role within the supply chain. The APB is found to push the sector towards innovation by training its employees and offering improvements and solutions among the participants in the port. On the other hand, the Port Authority needs to improve the education of its customers to follow their lead. Furthermore, the international market is also evolving, bringing new suppliers and businesses with innovations and new needs. The APB is responsible to manage and adapt the operations of the port to meet the evolution of the market.

From the obtained data, it can be said that the implications of these 5 technologies in the Port of Barcelona are addressed to the IT departments of all business working with the port. They need updated system to use and treat Big Data that can be obtained through the portal Portic. In addition, they have to be aware of the cybersecurity levels that are expected to maintain the information flow safe. Moreover, they are responsible for the correct development of digital ideas that improve processes and the overall management of the operations (for example new computer programs or apps). These operations are continuously under improvements caused by the evolution of automated machinery. Consequently, all personnel in charge of carrying out the operations that uses this type of machines are also responsible for learning how to operate them and also to provide feedback to managers (for instance, employees at BEST who run remotely controlled cranes). Furthermore, managers are the ultimate group affected by the impact of Industry 4.0 in a port. They coordinate, plan and supervise the function of the logistical hub, in which they are responsible for continuous improvement. Thus, they must stay updated with innovations they may appear in the market, bring up new ideas in order to improve efficiency, improve IoT with its digital systems and devices from which data is gathered, and to properly train employees on the right direction of the fourth industrial revolution. Additionally, other groups may also experience influences coming from Industry 4.0. One of these groups could be the one in charge of transportation; boat, train and truck drivers. They will have to adapt to the changes imposed by the port, as they did for instance with automated gates systems, and cooperate with the digitalization and improvement of information flows.

### 5.2 Workplace changes at the Port of Barcelona

Through the answers from the interviews, it was confirmed what it was mentioned in the Literature Review; the logistics sector in Spain is very traditional and not facilitating the introduction of solutions. The interviewees confirmed the heterogeneous speed of improvement implementations on the sector. On the other hand, it was verified that the Port of Barcelona plays an important role on being an example to follow when talking about adopting Industry 4.0.

The changes at work caused by the implementation of new technologies and processes, was found to be managed in an efficient way. Through training, employees at the APB where to stay up to date with new computer programs or new systems implemented to improve their job performance. Moreover, despite the average age of the workforce being high, training and motivation made workers less reluctant to changes.

As mentioned in the Literature Review, companies have a tendency on shifting their offer from plain products to service-products and the Port of Barcelona is also focused in adding value to its offered services. This tendency also involves more connection with the customers and this port is oriented towards this way. APB seeks for improvement in the communication of the

supply chain, implementing changes, sensors and data management to make them become loyal to the Port of Barcelona.

Changes at work are influenced by this value adding to the service of customers. Employees are required to be able to work with computer programs that process and analyse data, and this data is the most valuable asset the port owns. In relation to that, the competences of employees, both at APB and in operations of the port, shift to a more digital-skilled profile. On the other hand, this digitalization of the workplace was found to bring businesses closer but to put distance between people. As it has been explained in the Empirical Data, there is less verbal communication and fewer debates. Most of communication is carried out via email or the use of the platform Portic. This topic, as well as the other ones, has already been presented in the previous chapter.

Another change at work noted at the Port of Barcelona is the use of smart phones for work purposes. The creation of simple apps that allow employees to monitor processes, as well as the direct connection to email, messages and other programs, has made smart phones another tool for the employees. This has changed their perception of workplace, admitting that they also work with their phone even if they are not in working hours.

To conclude, it can be said that the Port of Barcelona is currently in good shape in terms of change implications at workplaces. The APB is a clear example of that because it provides education and training for employees and for customers. This allows them to achieve new levels of openness and flexibility to be able to evolve as changes appear, as mentioned in the literature review. The literature review also indicated that, on managerial levels, the evolution of companies towards the usage of technologies characteristic of Industry 4.0 needs strong leadership on digital levels. However, managers and high ranks at the APB are found to be people with a high average age which could cause a bad leadership in that matter. On the one hand, the majority of the interviewed managers in this research showed awareness on the upcoming opportunities and challenges of automation and data processing. On the other hand, they showed a certain concern about directive team members and other administrations having poor attitude towards the knowledge and implementation of these technologies. This negative attitude can work as a bad example when dealing with changes at workplace, creating traditional systems that do not encourage adopting new digital ideas of Industry 4.0.

### 5.3 Identified problems

In this subsection of the Analysis chapter, the problems that the Port of Barcelona is facing regarding the proper implementation Industry 4.0 will be developed. As mentioned above, the APB was found to be very competitive and aware of new technologies and market tendencies. This explains why most problems presented below are general for the industry and the public administrations and are not specifically the responsibilities of for the Port of Barcelona. The implications on operation and administration levels of these problems will be presented together with derived ideas for improvement. In some occasions, these ideas were mentioned by the interviewees and later elaborated by the author of the thesis, in other occasions these solutions where directly constructed from the critical thinking of the researcher.

### 5.3.1 Age of the workforce

It has been pointed out that the average age of the employees working at the Port Authority is very high; above 50 years old. This has been caused by the public nature of the organization, where firing people is an uncommon practice and the hiring of new members is delimitated by the central administration of the country. Moreover, when hiring is open for new candidates, the procedure and guidelines are found to be stuck in the past, becoming complex and unattractive for younger generations.

Despite the fact that the workforce at the APB is generally old, the attitude and competences from them generally meet the competitive levels desired for the innovation of the sector. This is being caused for the mentioned non-firing preference of a public administration system, which makes people to stay longer in an organization by shifting departments and responsibilities. This makes the employees fully understand the industry they are in and to continuously be more open minded towards changes. Furthermore, the large amount of training courses that the Port authority provides to its employees makes them to have a growing diverse set of skills.

On the other hand, despite this positive point on relocating and constantly training its employees, the APB is found to have old organization systems, with an archaic directive functioning. Moreover, this gets worse as the ranks are higher, making top managers or board of directors the oldest and less innovative group. Despite innovation and digitalisation is a key factor of many departments and managers, the fact that the system and higher ranks are not evolving slows down the whole digitalization process of the organization, and consequently of the port. In addition many systems that leads the way in how things are still unchanged and add time consumption and burdens to innovation.

The problem of old employees and outdated systems does not have a direct or easy solution. The constant training that the workforce is provided with is a positive aspect to consider, but high ranked managers are also found to be the less participative on them. As most of these job positions will get retired in 5 to 10 years, it is a matter of time that systems and the organization will slowly evolve to become more dynamic and smooth. The responsibility lies on the Human Resources department in this case; it is the one to keep up with the training of employees, and to make sure new incorporations bring fresh mentality to the administration. For this reason they are also responsible to makeing the hiring process more attractive and digital for the new candidates.

### 5.3.2 Public administration

The fact that the APB is a public administration characterises the Port of Barcelona in the way it is managed. As all ports have to be administrated as a public institution by law, there is little to do with it. The only task left for the APB is to empower the positive implications and try to diminish the negative ones. While being a public administration means having a great financial, infrastructure and network support, it also means to have to deal with lots of bureaucracy, controls and delimitations.

A clear example of the public administration pressure of the APB is that every single project that is wanted to be implemented in the port needs to go through extensive budgeting justification. This is required to be carried out through filling up paperwork and communicating it to the Ministry of Development of Spain. This process is very time consuming, both for the

preparation of this paperwork and for the wait for approval or corrections. In addition, innovative proposals may be questioned by the ministry and postponed or cancelled at will.
Projects and innovations are not the only ones to suffer from the public administration restrains. How the APB is being managed is also controlled and leaded by public system rules. Therefore, any change on core functioning of the Port Authority also needs approval from the authorities. This is linked to the previous problem in this section of the chapter. Human Resources find it hard to implement changes on the hiring process since they have to fulfil with public rules that have been established by the Ministry of Development. It also forces the structure of the APB to remain the same. To flatten the hierarchical design of the organization is very hard despite the advances from departments to improve communication and transversal flow of information between them.
The Port Authority is responsible for pushing the central administration to become more flexible as time passes. It has been mentioned by interviewees that the tendency seems to go on the other way, with more controls and slow processes. Therefore, it could be good for the APB to unite with all organizations that administrate ports in Spain and come together with improvements on the imposed systems and bureaucracy.

### 5.3.3 Sector reluctant to changes

The logistic sector in Spain is known to be very traditional, with strong labour unions despite a majority of small businesses running it. This makes the whole industry dependant on their reluctance to changes, creating strong pressures to keep operations and systems the same way. Moreover, the segmentation of the sector and its traditional attitude creates many obstacles on the flow of information and its improvements.
The performance of stevedores used to be a key factor for the proper functioning of a port. The labour union of this group of workers has consolidated along the years to become a strong organization that puts pressure against innovations on their workplace. For instance, when Hutchinson Port Holding started the semiautomatic terminal in the port, it received pressures from this union in order to make sure stevedores could participate on the operations of this new terminal. Despite innovating and introducing autonomy in many processes, Hutchinson reorganized the plan of the terminal to include this group in their operations. Despite their work could have been automated, an agreement was established and stevedores are currently working at BEST. They are fewer in number than in a traditional terminal but they have also become more skilled and digital-orientated.

Transport agents are also an essential group for the functioning of a port. Trucks represent a big part of transportation for inbound and outbound logistics; there can be over 8.000 truck operations a day in the Port of Barcelona. These operations also need improvement in order for the port to gain competitiveness and the traditional and fragmented characteristics of the truck agencies make this process complicated. When the port introduced automated gates, eliminating human interaction at the doors and the use of paper, truck drivers had to adapt and learn about the new system. Now that the APB wants to improve the arrival procedure for trucks, applying previous arrangements in specific time slots, truck agents are complaining again and are reluctant to the change.

The solution for these types of logistic groups is for the Port of Barcelona to teach the sector. The Port Authority should implement strategies to make reluctant agents be aware of the positive implications of these innovations and make sure they evolve in the same way. Globalisation spreads technologies and know-how around the world, and market changes. Ports should implement agreements with these groups because, while remaining essential for port operations, the tendency is to automate processes and transport. Therefore, they should collaborate with the former to gain competitiveness and with the latter to keep jobs and become more efficient.

Another aspect of the logistics sector being too traditional is that, as interviewees suggested, there are many intermediaries. For instance, there are some figures at a port that could be adopted by others, making the functioning of the port better communicated and simplified. Improving communication is something that has been seen in the chapter of Empirical Data. The more intermediaries there are in a chain, the more it will take for information to flow from one actor to the client. The same happens in a port, if the way information flows is not smooth; intermediaries just represent another obstacle for this information to circulate efficiently. For example, if a ship is late, there are many occasions where it is not communicated on time and trucks are stuck waiting in the port for hours. Furthermore, communication is also needed to improve in order to add value to the services of the port for customers, that way they will be able to locate and control their goods. With less intermediaries and better communication among operation and supply chains, the impact of these communication problems would be minimised.

A way of improving communication, as well as eliminating intermediaries, is by using the concept blockchain. This theory was introduced in the Literature Review and commented by interviewees. These comments agreed that it was something the Port Authority was studying and will be part of a not so far future. Inside the port, some agencies are adopting some characteristics of blockchain. For example, some logistic operators work as custom agents, as transportation representatives and as freight forwarders. These figures were traditionally separated and now can become part of a single operator through technologic integration typical of blockchain. Employees at the APB and at BEST indicated that this is the tendency; more communication and transparency will lead to more vertical and horizontal in the sector. This tendency will also lead to the sector to have fewer small actors and big general operators. Therefore, the Port of Barcelona should accommodate this technology. APB should also encourage blockchain to become more common in the sector, integrating most members from supplier to customer to create a more communicative, collaborative and transparent supply chain.

### 5.3.4 Standardization and synergies

Another problem that the industry presents is the lack of standardisation of physical and operational elements. The lack of standardisation is caused by the mentioned segmentation of the industry and its traditional attitude. A clear example of that is the use of different and old containers. The design of these containers, while making them resistant and stackable, has been unchanged for many decades. Globalization has led to the circulation of a large amount

of containers that have differences among them. For instance, reference numbers of containers, written on the exterior of them, have been and painted in different locations of the container. The paint used is often in different colours and the numbers in different sizes. Moreover, when a container deteriorates the lack of paint or dents causes reference numbers to be mixed up. OCR readers are the new technology that identify these numbers and recognises the container and its cargo, destination and origin. Despite that this technology has eliminated human errors, problems on finding the reference number on the container or the deterioration of it, causes the identification process to have errors and delays. This problem could be solved by introducing an international standard on size, location and type of reference to be used. Bar or QR codes could also be used.

Another element of containers to be standardised is the seal used to close the containers and make sure it is not opened until it reaches its destination. The seals are found to be different in many occasions and hard to identify. Therefore, the same solution presented above could be implemented; creating an international standard in using bar or QR codes. Finally, refrigerated containers are also complicated to manage since different providers use diverse models. By standardising them, the connecting process to the installations of the port could be more efficient. Moreover, adding sensors too would allow customers to track their temperature and status at all time.

These standardization processes would only be possible with the collaboration of all port and shipping companies to make the Port Equipment Manufacturer Association (PEMA) put pressure on manufacturers, and maintenance companies, from all over the world to adopt the agreed specifications. This will make port operations become faster and more efficient.

# 6. CONCLUSIONS

This final chapter provides the answers to the Research Questions presented in the Introduction chapter. In addition, this chapter also presents an explanation of the accomplished purpose together with a description of the completed research.

## 6.1 Answering the Research Questions

At this point, it is important to remember that the process of finishing the research was carried out by following the Research Questions. Therefore, all interviews, data collection, writings and analysis where accomplished through the guidance of the formulated questions. As the investigation is now concluded, it is time to go back to the Research Questions and answer them.

> **Research Question 1:** What are the workplace implications of implementing characteristics of Industry 4.0 in the Port of Barcelona?

As it has been studied through interviews, there are implications on the workplaces of the Port of Barcelona when implementing technologies of Industry 4.0. These repercussions are often related to the digitalization of the profile of the employees. In addition, employees are found to have more technological elements in their work environment, with more computer programs, smart phone application, and several ways of sharing information like the Portic platform.

The implications of these characteristics also involve training programs that are created in Human Resources for the employees at APB. This training strategy offers support for employees when needed and also creates new educational programs when new systems or technologies are installed at their workplace. This creates a dynamic workforce, constantly learning, and getting better with their digital skills and data analysis. On the other hand, employees are required to keep up with the evolution of the sector, having to participate on these trainings or to find their own motivation to be constantly updated.

> **Research Question 2:** How is the application of Industry 4.0 perceived by managers at the Port of Barcelona?

Managers working at the Port of Barcelona are also employees, and the mentioned implications of Industry 4.0 in their workplace are also affecting them. A part from dealing with these changes while providing example to their subordinates, managers are responsible for the correct development of the Port of Barcelona. Managers at the APB perceive the application of Industry 4.0 as something that goes beyond their organization and even the port. Managers found themselves pushing the logistic sector to adapt the innovations and technologies characteristic of the fourth industrial revolution. Additionally, they are found to be limited by the public nature of the organization they represent, in terms of bureaucracy and old systems. This slows down the process of applying changes for the proper application and development of Industry 4.0 in their work environment.

However, managers consider the Port of Barcelona to be in an advanced position in comparison with other ports in Spain, Europe and the world. This is caused by the correct strategy that the port is following, which involves implementing innovative solutions to the operations and administration of the port. In addition, they found themselves pushing the businesses and customers to follow their steps in the same direction, enriching the organization, the port and its hinterland.

Managers at the BEST are in a similar situation than the ones at the APB. They are ahead with technology applications in the sector and have to deal with other businesses of the port to make them improve and perform at the same level. For example, the presented issues with the labour unions of stevedores and truck agencies made them aware of the reluctance of the market to change towards technology. Managers adapt their strategies to meet their requirements while gaining competitiveness and efficiency.

### 6.2 Discussion and findings at the Port of Barcelona

Despite a port runs as service provider for customers needing logistical services, the improvements in processes and operational levels at the port work similarly as it was a manufacturing environment (which is the origin of the theory of Industry 4.0). The whole port can be seen as a production plant in where no actual goods are produce but moved around the facilities as if they were so. Products arrive at the port by boat, train or truck; they are later stored and classified in order to be shipped in another mode of transport in order for the product to reach its next destination. Therefore, all processes at the port are carried out as warehousing, with charging and unloading operations together with transportation within the port, often operating with cranes. On the other hand, the strong asset of the Port of Barcelona is the information flow that goes through the organization. It is a point in the supply chain where many actors are put together and information is the key to offer a good service and add value to the customer. Therefore, despite the essential and transitional warehousing function of the port, what really differentiates it from other ports and warehousing is the level of added value in its services. For instance, the port is responsible to use the flow of information that receives from products, gather data when they are in the facilities of the port, and lately share it with all affected business within the port and to the final customer as well as to the provider. With all that, Industry 4.0 is crucial for the healthy evolution of the Port of Barcelona in order to remain competitive and offer efficiency in their operations and great levels of data gathering and processing. With IoT, data is gathered in the port, Big Data takes this data and analyses it, Cloud technology (yet to be competitive in the logistics sector) could improve data sharing and storage. Additionally all these three characteristics require a good level of cybersecurity to not compromise confidential data. Finally, automation is responsible for increasing levels of productivity and efficiency in the operations of the port.

In a practical level, this thesis has achieved deep understanding of the introduced concepts as well as the current situation of Industry 4.0 in the Port of Barcelona. This has been completed through semi-structured interviews in managerial positions at the Port Authority and at the terminal BEST. These interviews have created a picture of the ongoing impact of the five chosen technologies from the fourth industrial revolution (IoT, Big Data, Cloud, cybersecurity and automation).

It can be said that the interviewees were aware of the appearing new technologies which are modifying the work environment in many levels. These technologies have been introduced in the organization by many of the same managers that were interviewed. The introduction process of innovations usually originated from inside projects, market analysis and collaboration with other businesses and organizations within the economical boundaries of the port. In addition, the innovative technologies involving Big Data processing, were found to be obtained by the application of sensors or devices characteristic of IoT and were supported by

strong cybersecurity. Furthermore, these changes involved improvement of processes that enhanced productivity and efficiency, symbolising a step towards automation in operations and in the orientation of management.

The changes in the port, Industry 4.0 related, also required training in order to make employees and customers aware of the new technology being implemented. The training courses were found to be a good functioning element of the APB, where constant training programs were offered for both groups of people, workers and clients. Moreover, the department in charge of these courses was also found to be responsive and offer training under the request of the mentioned groups.

In general, the port was found to be updated with the new technologies characteristic of Industry 4.0. Moreover, they represent an example for the rest of the ports in Spain in terms of innovation and compete in Europe and in a global scale offering great levels of efficiency. Internet of Things, despite being in an introductory phase in all markets, is found applied in the port in a great extent. The use of Big Data was found to be well spread in all businesses and departments of the port. The huge amount of information shared via Portic or other programs was under strong cybersecurity systems, and the level of automation of the operations at the port were found to be improving despite internal pressures of labour unions such as the one from stevedores. O the other hand, the use of Cloud technology was found to be minimal, and that the technology needs to gain competitiveness in order to become applicable for the Port of Barcelona.

Despite the old average of age of the personnel at the APB, the application of these technologies was not compromised by that fact as it would appear. Employees at the APB were found to have a proactive and adaptive attitude towards new technologies enhanced by the public nature of the organization, where renovation of the workforce is hardly possible. The only problem occurred in highly ranked positions of the organization, where the average of age of the workforce was found to be higher, and the power of decision stronger. This group represents an obstacle in the proper evolution and development of the organization towards new technologies. In addition, is the group that is more reluctant to changes and support the antiquate systems that run the whole administration.

### 6.3 Further research

In order to obtain a more detailed set of results further research on all levels of the operation businesses of the port should be carried out. In this future research, all type of operators, such as stevedores, different logistics operators, ship representatives, truck agencies and others actors should be included in the study. Furthermore, a comparison study considering other ports will allow researchers to achieve a global perspective of the sector and a better understanding of the level of innovation that the Port of Barcelona has. Additionally, all nine components of Industry 4.0 may also be included in further research as markets and technologies continue to evolve. In that matter new technologies and new applications of the existing ones may appear. Therefore, future researchers should also be updated with contemporary innovations.

The subjective and qualitative character of the study offers limitation on the appliance of this research in other logistic businesses or ports. In addition, the results presented in this thesis should not be considered as definite; they should be seen as indicators of what further researchers may want to study in order to complete them. This thesis has focused the research

in managerial levels of the administration of the Port of Barcelona, a public organization. This means that future researchers that base their study on other international ports have to consider the public or private nature of the organization, its mission and objectives. In Spain all ports are administrated by public entities which they focus on enriching the region and hinterland they work with. In other countries ports may be administrated privately and therefore the mission may change.

Future researchers could also use different approaches to achieve new levels of knowledge. For instance, a quantitative approach utilizing observations and surveys could help define a more subjective situation of the workplaces at the Port of Barcelona. On the other hand, mixing both approaches, qualitative and quantitative, could result appropriate in order to reaffirm results obtained in both cases.

# 7. REFERENCES

## 7.1 Verbal References

The verbal references used in this thesis came from semi-structured interviews. These interviews focused on the answers of managers from both the Port Authority (APB) and the terminal BEST (from the international company of Hutchinson Port Holdings). After some managers requested to keep their identity anonymous, the researcher decided to keep all managers anonymous. That is the reason why references written in the thesis do not specify name or department. To avoid a possible identification of the interviewees, references are only divided between managers at the APB and managers at the BEST. A table indicating the time spent per organization and the number of interviews is listed below. Additionally, in the Methodology chapter, another table includes the time spent for each interview and the involved departments.

| Interviewed organization | Total time | Total interviews |
|---|---|---|
| APB | 11h 29’ | 11 |
| Hutchinson Port Holdings - BEST | 2h 24’ | 2 |

## 7.2 Written references

All written references are listed below. It is important to know that the chosen articles were cautiously analyzed in order to stay away from untrustworthy theories. Furthermore, some of these references were compared to delete misunderstandings and generalizations in order to build reliability on this thesis.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# 8. APPENDIX

**Appendix 1**

Interview guideline:

With the expansion of the automation of processes, data collection and the Internet of Things, industries are facing a new revolution that is changing the interactions and systems in all participants of the supply chains. The application of innovative tools and technologies in production processes and services must be carried out by professionals to avoid errors, unnecessary waste of time and resources and to adjust to the modus operandi of the company.
It has been shown that the main characteristics of Industry 4.0 (Internet of Things, Big Data and automation) improve the efficiency of product and information flows in companies and in their supply chains, but what are the implications in the work force? What is the impact of the application of new technologies, data processing and innovative production systems to managers and workers? Thus, this interview will focus on answering these questions and those that are generated from them.

**General information of the interviewee:**

- When did you start working in the Port of Barcelona?
- What position do you occupy? And with what responsibilities?
- What is your professional and student background?
- Have you required training in any technological aspect inside the Port of Barcelona?
    - Have you been trained in some of the offered courses?
    - Do you know of someone who has taken one or should?
    - Do you think that these courses will become more useful in the future?

**Information of the department and work position:**

- What competencies does your department cover?
- How is the communication with other employees and departments?
- How is the information being shared, in what frequency, confidentiality and by what means?
- Have you heard about cyber security and the risks of sending information online? Have you been instructed on the subject at your workplace?
- How does your department work in relation to future plans and predictions?
- What is the purpose of gathering information in your department? And in the Port in general?
- How is data collected? And how is it analyzed?
- Do you think that this system could be improved?
- Have you experienced any change in data collection during your working life? How did it affect you, your position and your colleagues?

**Industry 4.0 and its effects:**

- Do you know the concept Industry 4.0? IoT? The Cloud?
- How would you define it?
- And now applying it in the Port of Barcelona or in your workplace?
- What information do you think should be collected for the implementation (or an improvement) of Industry 4.0?
- Do you think this could affect your job? And other employees?
- Do you feel any kind of pressure to be up to date on new concepts and systems that improve the sector in which you work?

- Who do you think is the main promoter of the application of characteristics of Industry 4.0 in the Port of Barcelona?

**Appendix 2**

Hinterland of the Port of Barcelona: