Improving Blue Economy Through Industry 4.0
A Service Science Perspective

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ABSTRACT

Improving Blue Economy Through Industry 4.0: A Service Science Perspective

The objective of this dissertation is to assess the impact of digital technologies "Industry 4.0" (I4.0) on the competitiveness of the Blue Economy (BE) in the European Union (EU). In the 2018 and 2018 Blue Economy Reports, the European Commission presented BE's challenges and potential, proposing policy guidelines and identified the *Enablers* of competitiveness in BE's different sectors in Europe. From the systematic literature review, it was found that Service Science (S-S) is an emerging and interdisciplinary scientific area that combines the organization of systems, technological knowledge and the sustainability of the Planet, enabling new approaches to value creation. Also, from the literature review, different digital technologies were identified, designated as Industry 4.0 technologies. Guided by the pragmatist paradigm and using a mixed methodology of parallel convergence, an empirical framework was conceptualized in this research. From the application of this framework to eleven BE case studies, it was found that the impact on the sectoral competitiveness of European BE maybe 26.5%. This research also concludes that I4.0 technologies may represent an opportunity for BE's companies, which is why their adoption is recommended.

Keywords: Blue Economy, Blue Growth, Service-Dominant Logic; Service Science, Industry 4.0, Cyber-Physical Systems

RESUMO

Desenvolver a Economia Azul pela Indústria 4.0: Uma Perspetiva Service Science

O objetivo desta dissertação é a avaliação do impacto das tecnologias digitais "Indústria 4.0" (I4.0), na competitividade da Economia Azul (BE) na União Europeia (EU). Nos Relatórios de 2018 e 2018 sobre Economia Azul a Comissão Europeia apresentou os desafios e o potencial da BE, propondo diretrizes para políticas e, identificou os facilitadores da competitividade nos diferentes sectores da BE no espaço Europeu. Da revisão sistemática da literatura efetuada, verificou-se que a *Service Science* (S-S), é uma área científica emergente e interdisciplinar que combina a organização dos sistemas, o conhecimento tecnológico com a Sustentabilidade do Planeta, permitindo suportar cientificamente novas abordagens à criação de valor. Ainda da revisão de literatura, foram identificadas diferentes tecnologias digitais, designadas por tecnologias Indústria 4.0. Orientada pelo paradigma pragmatista e utilizando uma metodologia mista de convergência paralela, nesta investigação foi conceptualizado um modelo empírico. Da aplicação deste modelo a onze casos-de-estudo da BE, conclui-se que o impacto na competitividade setorial da BE Europeia poderá ser de 26,5%. Conclui-se ainda, nesta investigação, que as tecnologias I4.0 poderão representar uma oportunidade as empresas da BE, sendo por isso mesmo, recomendável a sua adoção.

Palavras-chave: Blue Economy, Blue Growth, Service-Dominant Logic; Service Science, Industry 4.0, Cyber-Physical Systems

To my son, João,

the strength of my life

ABBREVIATIONS AND ACRONYMS

AI	Artificial intelligence
AR	Augmented Reality
CPS	Cyber-Physical Systems
EDA	European Defence Agency
ESPO	European Sea Ports Organization
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FAO	Food and Agriculture Organization of the United Nations
G-D Logic	Goods Dominant Logic
GDP	Gross Domestic Product
GVA	Gross Value Added
GW	Giga Watts
HMI	Human-Machine Interfaces
I4.0	Industry 4.0
ICSD	Intelligent Connectivity of Smart Devices (ICSD)
ICT	Information and Communication Technologies
IIoT	Industrial Internet of Things
IoT	Internet of Things
KCI	Key Concerns Indicators
KCI_{QUAL}	Qualitative Key Concerns Indicators
KCI_{QUAN}	Quantitative Key Concerns Indicators
KPI	Key Performance Indicator
KPI	Key Performance Indicators
OECD	Organisation for Economic Co-operation and Development
ONCCV	Non-cargo carrying vessels
REEs	Rare Earth Elements
Rio+20	United Nations Conference on Sustainable Development
ROI	Return of Investment
RP	Research Problem
RP	Research Problem
RQ	Research Question
S-D Logic	Service Dominant Logic

SLBM	Submarine-launched ballistic missile
SLBM	Submarine-Launched Ballistic Missile
SME	Small and Medium Enterprises
S-S	Service Science
SSME	Service Science, Management and Engineering
S-System	Service System
UK	United Kingdom
UN	United Nations
UNCSD	United Nations Convention on Sustainable Development
WB	World Bank

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CHAPTER 1

The greatest glory in living lies not in never falling, but in rising every time, we fall
Nelson Mandela

1. INTRODUCTION

1.1 CONTEXTUALIZATION

Although the term “Blue Economy” has been used in different ways, it is understood in this research as comprising the range of economic sectors and related policies that together determine whether the use of oceanic resources is sustainable. An essential challenge of the Blue Economy is thus to understand and better manage the many aspects of oceanic sustainability, ranging from sustainable fisheries to ecosystem health to pollution. A second significant issue is the realization that the sustainable management of ocean resources requires collaboration across nation-states and the public-private sectors, and on a scale that has not been previously achieved.

According to the EU Blue Economy Report (2019), the established sectors of the EU Blue Economy directly employed over 4 million people, generated €658 billion of turnover, and €180 billion of gross value added in 2017. The evolution of the Blue Economy has been significantly influenced by general macroeconomic developments, in particular, the global financial and economic crisis of 2008-2009. High growth rates can be observed in traditional sectors as well as the emerging ones. For the former, Gross Value Added (GVA) data shows an acceleration in the growth of all sectors from 2013 onwards except for the Extraction of non-living resources. Indeed, GVA for Coastal tourism, Marine living resources, and Port activities has grown by over 20% over the last decade.

On the contrary, GVA in the Offshore oil and gas sector has seen a decrease of 34%, influenced by the drop in oil prices and the reduction in the extraction of the most costly (offshore) sites. The Marine transport sector has also seen a decline, albeit a softer one (3%). Employment between 2009-2017 has mostly seen growth in both the Coastal Tourism (10%) and Port activities (25%) sectors. For Shipbuilding and repair as well as for Maritime transport, employment has grown concerning the minimum observed in 2013-2014 but has not yet recovered to 2009 levels.

The United Nations Report *Achieving Blue Growth* (2018), as well as the EU above, mentioned Reports, pointed out some challenges to be faced, as well as some ideas to support the development of management policies that will ensure this. Hence, the importance of discussing the need to maintain healthy oceans that help preserve and increase the natural capital from which ecosystem services are produced.

1.2 RESEARCH PROBLEM

Supported by Service Science Theory, this research aims to assess the impact on sustainable competitiveness of the EU Blue Economy if companies incorporate I4.0 Technologies either in established or emerging sectors.

Both 2018 and 2019 EU Blue Economy Reports have proposed guidelines to support policymakers and stakeholders in the quest for sustainable of oceans, seas and coastal resources and identifying the enablers behind the sustainable growth: (i) common skills, (ii) shared infrastructure, (iii) sustainable use of the sea, (iv) environmental protection, (v) maritime spatial planning, (vi) maritime security, and (vii) marine data (European Union, 2018, 2019). As the drivers of the EU Blue Economy Growth, the challenge must be to improve these Enablers to push up the Blue Economy in Europe.

As part of the European Program supporting research, development, dissemination, and financing of practices and digital technologies assisted by Cyber-Physical Systems (CPSs), and built on the European Parliament document (European Parliament, 2015; Fair, Russwurm, & Sector, 2012). The European Union considers that I4.0 may reverse the industrial decline seen in Europe in recent years. Being aware of what is happening around them, many industrialists and managers have already realized that I4.0 may bring new opportunities regarding the sustainability of their companies (Stock & Seliger, 2016). To connect a factory to the Internet and support production through CPS involves risks, from the investment required to the very maturity of the available digital production technologies (Thramboulidis & Christoulakis, 2016). However, representing more than 20% of jobs, equivalent to more than 34 million people and generating over 6,400 billion euros annually (Smit, Kreutzer, Moeller, & Carlberg, 2016), European industry cannot risk losing the lead and becoming outdated in this transition stage to the Fourth Industrial Age.

The *Smart Factories Connected to the Internet*[1] concept has become a subject of analysis and study in recent years by scholars, practitioners and governments (Albert, 2015; Frazao, 2016; Heidari et al., 2014; Ivanov, Dolgui, Sokolov, Werner, & Ivanova, 2016; Lasi, Fettke, Kemper, Feld, & Hoffmann, 2014; J. Lee, Kao, & Yang, 2014; Schlechtendahl, Keinert, Kretschmer, Lechler, & Verl, 2015; Stock & Seliger, 2016) where dynamic "virtual elements" designated Smart Objects (Motamedi, Setayeshgar, Soltani, & Hammad, 2016), co-created with the customer may be made available in a customized interoperable way, is the focus of this research. However, for I4.0 to involve customers in products' co-creation, it must consider the customer as an indispensable actor (S. Vargo & Lusch, 2016), a situation still not very common. In fact, in most cases, the customer is yet seen as a strange element, independent and far away from the production sites (Robert F Lusch & Nambisan, 2015).

From the need to study the value-creation interactions among stakeholders, a new discipline has emerged – Service Science, Management and Engineering (SSME), or only Service Science (S-S), as an interdisciplinary scientific field, anchored in the Service-Dominant Logic (S-D Logic) Axioms (S. Vargo & Lusch, 2016), from which it has adopted the vocabulary, perspective and the necessary premises to construct its Body of Knowledge (Breidbach & Maglio, 2016; Hsu, 2016; Kwan, Spohrer, & Sawatani, 2016; Maglio & Spohrer, 2008, 2013; Maglio, Vargo, Caswell, & Spohrer, 2009; Spohrer, Anderson, Pass, Ager, & Gruhl, 2008; Spohrer, Anderson, Pass, & Ager, 2008; Spohrer, Maglio, Bailey, & Grughl, 2007; Spohrer, 2007; S. Vargo & Lusch, 2016).

The element of analysis in S-S is the service system (s-system) (Maglio & Spohrer, 2008), an abstract entity constructed by dynamic resource reconfigurations (Maglio et al., 2009) which must be evaluated and innovated combining the human knowledge in organizations with expertise in management and technology. The S-S aims to categorize and explain s-systems, including their value-creation interactions (Spohrer & Kwan, 2009).

This was the context that has led the author of this work to address Blue Economy and I4.0 from the S-S perspective, whose Theory will support this research and allow us to

[1]http://www.iotevolutionworld.com/m2m/articles/401292-how-industry-40-the-internet-things-connected.htm

assess the impact on sustainable competitiveness of the EU Blue Economy if companies incorporate I4.0 Technologies either in established and emerging sectors.

1.3 RESEARCH OBJECTIVES

The main objective of this thesis is to conceptualize an empirical framework supported by S-S Theory, to assess the impact on sustainable competitiveness of the EU Blue Economy if companies incorporate I4.0 Technologies either in established or emerging sectors. In order to conceptualize the empirical framework, it will be necessary to overcome several challenges, such as how to select case-studies, look for companies representing the several Blue Economy activities, among many others.

Keeping in mind these difficulties, by working hard, using the appropriate paradigm guidelines, selecting the right methodology supported by S-S and adjusted to the Research Problem (RP) (Creswell, 2014) and searching in the literature for methodological tools that clearly represent the service process (Kwan et al., 2016), we believe that the following specific objectives can be successfully achieved.

As the first specific objective, for each sector of the Blue Economy, it is intended to interview at least one European company per activity, grouping them into sectorial case-studies. The second specific objective arises from each case-study: For each company interviewed, it is intended to collect and record quantitative and qualitative data at the same time, following the questionnaire guidelines. As a third specific objective, it is intended to assess the contribution of each I4.0 technology to strength the European Blue Economy Enablers. As the fourth specific objective, it is intended to evaluate the impact of I4.0 Technologies on the Blue Economy Sectors. Finally, as the fifth specific objective, it is intended to assess the impact of the I4.0 on the European Blue Economy if companies incorporate I4.0 Technologies.

Focusing on these five specific objectives, we intend to reach the global challenge of assessing the impact on sustainable competitiveness of the EU Blue Economy if companies incorporate I4.0 Technologies either in established or emerging sectors.

By using the mixed methodology of parallel convergence and adapting some methodological tools to this RP (Kwan et al., 2016), the concept of Key Concern Indicators (KCI) supported by S-S and indexed to the different actors' concerns will be proposed. To do so, data must be collected in companies, representative of the Blue Economy case-studies, in order to reach a general proposition of the empirical reality.

1.4 ORGANIZATION OF THE DISSERTATION

The conclusions of this thesis must contribute to the development of the Blue Economy in general and, in terms of people's well-being and environmental sustainability, as well as making contributions to developing the Theoretical Body of Knowledge on Service Science.

To achieve these aims, this dissertation was organized into six chapters. Chapter 1 introduces the subject, starting with the predictable paradigm shifts in the European Blue Economy. This first chapter also discusses the emerging paradigms in production activity, resulting from the digital economy and the support that S-S as a new and interdisciplinary approach gives to efficiency, mainly when production is supported by CPSs. The relevance European Blue Economy, which will face new challenges, but also new opportunities resulting from the digital economy, will also be discussed in Chapter 1.

Chapter 2 will introduce the Research Context, addressing the transition to a Blue Economy, the established Sectors, and emerging Sectors of the European Union. Their challenges and Enablers.

Also, the Industry4.0 technologies are described in this Chapter, starting with Big Data e Data Analytics, Autonomous Robots, virtual Simulation, Horizontal and Vertical Integration, Internet of Things, Cyber Security, Cloud Computing and additive Manufacturing, Reality Augmented.

In Chapter 3, we will present the result of the literature review carried out, giving support to the research. This will start with a historical approach to the concept of goods and services whose dichotomy emerged from Lusch and Vargo’s work (2004). They defined the S-D Logic Axioms (S. L. Vargo & Lusch, 2004), which were adopted a few years later by the S-S pioneers Spohrer and Maglio (2008) as the philosophical basis and vocabulary of S-S Theory (Maglio & Spohrer, 2008).

Chapter 4 will present the research methodology and the empirical framework, by addressing some of the research paradigms (Creswell, 2014), to find the philosophical conception that provides the best guidelines to define the exploratory scheme of the RP and the research methodology. Once the Objectives and the Research Problem are established, the specific Research Questions (RQ's) to which this thesis aims to respond will be introduced.

Chapter 4 will also present the criteria for the constitution of the case-studies, the questionnaire guidelines for the qualitative data, and the list of quantitative data to be collected throughout the interviews. Also, chapter 4 will conceptualize the empirical framework.

In Chapter 5, the empirical framework will be applied to the case studies, to seek possible answers to the RQs raised. This chapter starts with the case-studies constitution, from which we intend to reach conclusions about the response to the RQs

Finally, Chapter 6 will present the findings. A brief synthesis of the research carried out, including the five specific RQs as well as the RP from which they originated, will be followed by the conclusion about S-S and the suitability of the methodology in pursuing the particular objectives that led to conceptualization and application of the empirical framework. Following the method, the conclusions will be presented as the result of the evolution of the quantitative KCIs and indexed to the concerns, when the companies decide to the Industry 4.0 Technologies and additionally, according to the mixed methodology, the qualitative Innovation Outcomes must reinforce the relief or aggravation of concerns obtained from the quantitative and thus, answering the specific RQs as well as to the Research Problem.

Before concluding Chapter 6, the difficulties and constraints that the researcher had to overcome will be described, together with the identification of the limitations of the research. In addition to empirical analysis that could enhance the results achieved in this thesis, the contributions that may result from this research in consolidating the theoretical body of S-S and for practice in the sense of society’s well-being will be highlighted. As the RP is centered on the digital economy supported by S-S Theory, this thesis will be concluded with some proposals for future developments in this area.

CHAPTER 2

The way to get started is to quit talking and begin doing

Walt Disney

2. RESEARCH CONTEXT

2.1 THE BLUE ECONOMY

The ocean is already a significant generator of wealth. A recent report estimated that the value of critical ocean assets is US$24 trillion, with an annual value of goods and services at US$2.5 trillion (about 5% of global GDP, the 7th largest economy) (Kraemer, Rustomjee, Governance, & Cigi, 2017). Many ocean and coastal nations around the world, most critically Small Island Developing States, but also including the European Union and larger coastal nations, are actively developing and promoting a blue economic growth agenda (Global Environment Facility, 2018). Since the publication of the European Union's Blue Growth Agenda in 2012, the term Blue Growth has been used to describe a new era, where the Blue Economy is an essential feature of the European economy (Hadjimichael, 2018).

Although the term "blue economy" has been used in different ways, it is understood here as comprising the range of economic sectors and related policies that together determine whether the use of oceanic resources is sustainable (Jalihal, 2018). An essential challenge of the Blue Economy is thus to understand and better manage the many aspects of oceanic sustainability, ranging from sustainable fisheries to ecosystem health to pollution (World Bank, 2017). A second significant issue is the realization that the sustainable management of ocean resources requires collaboration across nation-states and the public-private sectors, and on a scale that has not been previously achieved (World Bank, 2017).

The Blue Economy, sometimes also called 'Blue Growth,' aims to use innovative, integrated and cross-sectoral management to promote socially equitable and ecologically sustainable use of the natural (blue) capital provided by coasts and oceans (Pinto, Rita, & Combe, 2015). The term Blue Economy first emerged at the 2012 United Nations

Convention on Sustainable Development (UNCSD), or Rio +20 Conference[2]. The concept was promoted at the Rio+20 Conference as the marine dimension of the broader ‘green economy,’ which was defined as an economy “that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities.”

The Blue Economy reflects the fact that over 70% of the earth’s surface is water, and that good ocean health is of central importance for global sustainability and climate adaptation (European Union, 2019) (Affairs & Conference, 2018). It also recognizes that the oceans are a vital repository and supporter of global biological diversity, a critical source of food through fisheries and aquaculture, and a fundamental contributor to the global economy through sea-borne trade and other uses (World Ocean Council, 2018).

The concept of "Blue Economy for Sustainable Coastal Development" is an introduction of more innovative technologies to the market based on this concept. These innovative technologies are expected to generate new cash flow, and consequently, new jobs (Kraemer et al., 2017). It is important to find investors who believe that these are excellent opportunities. "The Blue Economy" is a social system created through a step by step process. It is named after this beautiful Earth, whose sky and ocean are blue, as long as there is no pollution (Kathijotes, 2013). It is a concept seeks to promote economic growth, social inclusion, and the preservation or improvement of livelihoods while at the same time ensuring the environmental sustainability of the oceans and coastal areas (OECD, 2019). At its core, it refers to the decoupling of socioeconomic development through ocean-related sectors and activities from environmental and ecosystem degradation. It draws from scientific findings that ocean resources are limited and that the health of the oceans has drastically declined due to anthropogenic activities (OECD, 2019). These changes are already being profoundly felt, affecting human well-being and societies, and the impacts are likely to be amplified in the future, mainly because of projected population growth (United Nations, 2018).

The Blue Economy has diverse components, including established traditional ocean industries such as fisheries, tourism, and maritime transport, but also new and emerging activities, such as offshore renewable energy, aquaculture, seabed extractive activities,

[2] http://www.rio20.gov.br/about_the_rio_more_20/participacao-na-conferencia.html

and marine biotechnology and bioprospecting (Kockiskzy & Somosi, 2016). Several services provided by ocean ecosystems, and for which markets do not exist, also contribute significantly to economic and other human activities such as carbon sequestration, coastal protection, waste disposal and the existence of biodiversity (World Bank, 2017).

2.1.1 The transition to a Blue Economy

The Blue Economy models and official initiatives aim to shift society from scarcity to abundance – based on what we have and to start tackling issues that cause environmental and related problems through novel ways. Some significant factors that cause ecological alterations to coastal and surface waters and contribute to nutrient inputs include municipal wastewater and stormwater discharges; combined sewer overflows; other urban runoff; agricultural runoff; aquacultures; and various others (Kathijotes, 2013). A Blue Economy approach must fully anticipate and incorporate the impacts of climate change on marine and coastal ecosystems - impacts both already observed and expected. Understanding of these impacts is continually improving and can be organized around several main “vectors”: acidification, sea-level rise, higher water temperatures, and changes in ocean currents (World Bank, 2017)

Under “business as usual,” the costs of marine ecosystem degradation from human uses should be high, but they are not quantified or accounted for (Kathijotes, 2013). At the same time, the economic contribution of the ocean to humankind has been significantly undervalued (World Ocean Council, 2018), in particular where the value of non-market goods and services, such as carbon sequestration, coastal protection and recreation, and cultural and spiritual values, are concerned (OECD, 2019). In contrast, a new form of understanding the oceans, and which incorporates environmental and social dimensions, requires a paradigm shift—acknowledging and valuing all ocean benefits (Willis & Office, 2016).

An essential dimension of the Blue Economy involves how established ocean industries are transitioning to more environmentally responsible practices. An early example of this comes from the fisheries sector. The Blue Growth Initiative of the Food and Agriculture Organization of the United Nations (FAO) will assist countries in developing and implementing Blue Economy and growth agendas (World Bank, 2017).

A sustainable Blue Economy allows society to extract value from the oceans and coastal regions. However, this extraction needs to be in balance with the long-term capacity of the oceans to endure such activities through the implementation of sustainable practices (European Union, 2018, 2019). This implies that human actions must be managed in a way that ensures the health of the oceans and where economic productivity is safeguarded so that the potential they offer can be realized and sustained over time (European Union, 2019).

2.1.2 The Blue Economy Sectors and Activities

As defined above, the Blue Economy consists of sectors whose returns are linked to the living "renewable" resources of the oceans (such as fisheries) as well as those related to non-living and therefore "non-renewable" resources (including extractive industries, such as dredging, seabed mining, and offshore oil and gas, when undertaken in a manner that does not cause irreversible damage to the ecosystem) (World Bank, 2017). It also includes activities relating to commerce and trade in and around the oceans, ocean monitoring, and surveillance, and coastal and marine area management, protection, and restoration. The following table provides a summary of the types of activities in the blue economy, related industries and sectors, and drivers of growth (Jalihal, 2018).

2.1.3 The Established Sectors of the European Union

According to "The EU Blue Economy Report (2018, 2019), the established sectors directly employ over 4 million people, generated €658 billion of turnover, and €180 billion of gross value added in 2017. The evolution of the Blue Economy has been significantly influenced by general macroeconomic developments, in particular, the global financial and economic crisis of 2008-2009 (European Union, 2018). High growth rates can be observed in traditional sectors as well as the emerging ones.

For the former, GVA data shows an acceleration in the growth of all sectors from 2013 onwards except for the Extraction of non-living resources. Indeed, GVA for Coastal tourism, Marine living resources, and Port activities has grown by over 20% over the last decade. On the contrary, GVA in the Offshore oil and gas sector has seen a decrease of 34%, influenced by the drop in oil prices and the reduction in the extraction of the most costly (offshore) sites. The Marine transport sector has also seen a decline, albeit a softer one (3%). Employment between 2009-2017 has mostly seen growth in both the Coastal Tourism (10%) and Port activities (25%) sectors. For Shipbuilding and repair as well as for Maritime transport, employment has grown concerning the minimum observed in 2013-2014 but has not yet recovered to 2009 levels (European Union, 2019) (Figure 2-1).

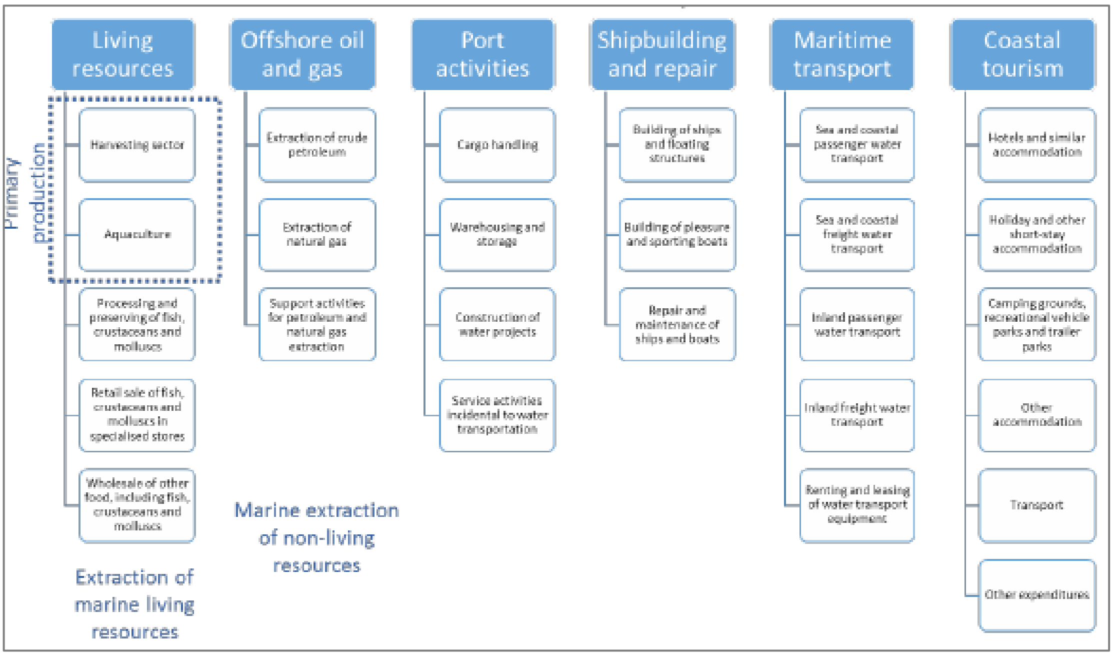

Figure 2-1: Established blue economic sectors and activities. Source: Eurostat SBS

The EU-28 GDP was estimated at €13,750 billion in 2017 and employment at 222 million people (European Union, 2019). The Blue Economy established sectors contributed 1.3% to the EU economy and 1.8% to the EU employment, in 2017, the highest value over the time (European Union, 2019).

2.1.3.1 Coastal Tourism

The Coastal Tourism Sector covers beach-based tourism and recreational activities, ex. swimming, sunbathing, and other activities for which the proximity of the sea is an advantage, such as coastal walks and wildlife watching. Maritime tourism covers water-based activities and nautical sports, such as sailing, scuba diving, and cruising. For this research, Coastal tourism also refers to marine tourism and is broken down into three activities: accommodation, transport, and other expenditures (European Union, 2018). Coastal and maritime tourism has been identified as one sector with a high potential for sustainable jobs and growth in the Blue Growth Strategy. Are considered Coastal Tourism activities, Hotels, and similar accommodations, Holiday and other short-stay accommodations, Camping grounds, recreation vehicle, and trailer parks, Other accommodation, Transport, and Other expenditures. Overall, Coastal tourism accounted for 54% of the jobs, 36% of the GVA, and 32% of the profits in the total EU Blue Economy in 2017. The sector has grown substantially over the analyzed period (European Union, 2019).

2.1.3.2 Extraction and Commercialisation of Marine Living Resources

The mining and commercialization of marine living resources encompass the harvesting of renewable biological resources (primary sector), their conversion into food, feed, bio-based products and bioenergy, and their distribution along the supply chain. For the purpose of this research, Marine living resources comprises three subsectors, further broken-down into activities; capture fisheries (small-scale coastal and large-scale industrial fleets), aquaculture (marine finfish, shellfish and freshwater) and processing and distribution (processing and preservation of fish, crustaceans and molluscs, retail sale, wholesale, prepared meals, oils and fats, and other food products) (Pinto et al., 2015) .

Capture fisheries production has increased and may have the capacity to do so further, particularly in the Mediterranean Sea. Profits have risen over the last few years, in part due to better status of fish stocks, increased average market prices, and reduced operating costs, in particular, fuel costs, which is one of the main constraints for the fishing fleet (Eikeset et al., 2018).

EU aquaculture production has been stagnant in the last decades, not participating in the global increase of aquaculture production. In the EU, wild-capture fisheries are still the primary source of the human-food output from the oceans. However, the turnover and economic performance of the EU aquaculture sector have increased over time. Aquaculture has been identified as a sector with a high potential for sustainable jobs and growth in the Blue Growth Strategy (European Union, 2018).

For this research, maritime extraction and commercialization of marine living resources sector includes activities such as the Capture fisheries, Aquaculture, Fish processing industry, Retail of fish and mollusks, Wholesale of other seafood products. Due to limited data availability, the current analysis excludes the biotechnology and bioenergy industries, which are included in the emerging sectors. Overall, the sector accounted for

14% of the jobs, 12% of the GVA, and 11% of the profits in the total EU Blue Economy in 2017 (European Union, 2019).

2.1.3.3 Marine Extraction of Minerals, Oil, and Gas

Under the marine extraction of minerals, oil and gas (marine non-living resources), the extraction of crude petroleum, the extraction of natural gas, the extraction of marine minerals (aggregates), and the corresponding support activities are included (OECD, 2019).

The sector is mostly in decline due to decreasing production and rising costs. More than 80% of current European oil and gas production takes place offshore, mainly in the North Sea, and to a lesser extent in the Mediterranean, Ad Port activities continue to play a vital role in trade, economic development, and job creation (United Nations, 2018). According to the European Sea Ports Organization (ESPO), 90% of Europe’s cargo trade in goods passes through the more than 1200 seaports in the 23 maritime EU member states. Many of these ports also receive hundreds of millions of passengers aboard cruises liners and ferries (European Union, 2018). Are included in the ports, warehousing and water projects sector, activities such as the Cargo Handling Warehousing and storage, Construction of water projects, and Service activities related to transportation by water. EU Port activities accounted for 14% of the jobs, 19% of the GVA, and 18% of the profits in the total EU Blue Economy in 2017. The sector has grown, in terms of jobs and GVA, since 2009 (European Union, 2019).

The EU-28 has around 600 existing offshore platforms (European Union, 2018). Are considered marine extraction of minerals, oil and gas activities, the offshore extraction of crude, Offshore extraction of natural gas, and Support activities for petroleum and natural gas. Overall, non-living marine resources contributed 4% of the jobs, 13% of the GVA, and 18% of the profits to the total EU Blue Economy in 2017. The sector is in decline, driven by the offshore oil sector (European Union, 2019).

2.1.3.4 Ports, Warehousing and Water Projects

Port activities continue to play a crucial role in trade, economic development, and job creation (United Nations, 2018). According to the European Sea Ports Organization, 90% of Europe’s cargo trade in goods passes through the more than 1200 seaports in the 23 maritime EU member states. Many of these ports also receive hundreds of millions of passengers aboard cruises liners and ferries (European Union, 2018). Are included in the ports, warehousing and water projects sector, activities such as the Cargo Handling Warehousing and storage, Construction of water projects, and Service activities related to transportation by water. EU Port activities accounted for 14% of the jobs, 19% of the GVA, and 18% of the profits in the total EU Blue Economy in 2017. The sector has grown, in terms of jobs and GVA, since 2009 (European Union, 2019).

2.1.3.5 Shipbuilding and Repair

Global shipbuilding orders dropped to a 30-year low in 2016. In the EU, this was particularly strong for pleasure boats and their supply chain. EU orders have recently increased compared to 2015, mainly thanks to the passenger, cruise ships, and other non-cargo carrying vessels (ONCCV) (European Union, 2019). Despite the recent positive trends, specific segments continue to face essential difficulties, in particular offshore. This evolution is reflected in the data for employment and GVA for Shipbuilding and repair (OECD, 2013).

Shipyards are clearly identified as working 100% in the domain of the Blue Economy. However, the equipment and machinery that is incorporated in the vessels are produced by companies working for both maritime and non-maritime industries (European Union, 2018). There are more than 300 shipyards in the EU, most of which are active in the global market for high-tech civilian and naval vessels. The EU shipbuilding industry is a dynamic and competitive sector. The EU is a significant player in the worldwide shipbuilding industry, with a market share of around 6% of the global order book in terms of compensated gross tonnage[38] and 19% in terms of value; for marine equipment, the EU share rises to 50% (European Union, 2019).

The EU is specialized in segments of shipbuilding (cruise ships, offshore support vessels, fishing, ferries, research vessels, dredgers, mega-yachts, etc.) with a high level of technology and added value. This specialization and leadership position is a direct result of the sector's continuous investments in research and innovation as well as in a very highly skilled workforce. The EU is also a global leader in the production of high tech, advanced maritime equipment, and systems. Indeed, the EU maritime technology sector is one of the most innovative sectors in Europe, with 9% of turnover invested in research and development. However, low prices for new merchant ships, driven by overcapacity in significant market segments, are pushing Asian shipyards to focus their attention on European niche markets and higher technology / high added value products (OECD, 2013). European shipbuilders are reducing costs and restructuring capacity by adjusting their production programs and optimizing the supply chain (European Union, 2019).

For the purpose of this research, the Shipbuilding and repair sector includes the following activities: Building of ships and floating structures, building of pleasure and sporting boats, repair and maintenance of ships and vessels, marine equipment (manufacture of cordage, rope, twine and netting, production of textiles other than apparel, manufacture of sport goods) and marine machinery (manufacture of engines and turbines, except aircraft and manufacture of instruments for measuring, testing and navigation). Overall, Shipbuilding and repair accounted for 8% of the jobs, 8% of the GVA, and 5% of the profits in the total EU Blue Economy in 2017. The sector has expanded slowly from recent lows in 2009 and 2013 (European Union, 2019).

2.1.3.6 Maritime Transport

Maritime transport is essential to the world's economy (OECD, 2019). Moreover, there is little if any dispute over the fact that shipping is the most carbon-efficient mode of transportation (Dallasega, Rauch, & Linder, 2018). International maritime shipping accounts for less than 3% of annual global greenhouse gas emissions (CO2) (European Union, 2019) and produces less exhaust gas emissions - including nitrogen oxides, hydrocarbons, carbon monoxide and sulphur dioxide - for each tonne transported per one kilometre than air or road transport (Hycnar, 2015). The size and global nature of the shipping industry makes it vital that the industry continues to reduce its environmental impact and the industry has made significant progress in fuel efficiency (Pinto et al., 2015).

Due to the expected growth of the world economy and associated transport demand from world trade, greenhouse gas emissions from shipping could grow from 50% to 250% by 2050, making it paramount for the industry to continue to improve energy efficiency of ships and to shift to alternative fuels (Glebov, Zhilenkov, Chernyi, & Sokolov, 2019). For this research, Maritime transport includes sea and coastal passenger water transport, sea and coastal freight water transport, inland passenger water transport, inland freight water transport, and the renting and leasing of water transport equipment. Inland transportation is considered part of the Blue Economy because it includes transport of passengers and freight via rivers, canals, lakes, and other inland waterways, including within harbors and ports. Overall, Maritime transport accounted for 6% of the jobs, 12% of the GVA, and 16% of the profits in the total EU Blue Economy in 2017. The sector is undergoing a slow recovery (European Union, 2019).

2.1.4 Emerging Sectors

The Blue Economy includes also emerging and Innovative Sectors such as offshore wind energy, ocean energy, blue bio-economy and biotechnology, marine minerals, desalination, and maritime defense (OECD, 2013). These sectors offer significant potential for growth and jobs, especially in renewable energies. Offshore wind, for instance, has seen an exponential growth, which has led to a similar increase in employment in EU coastal communities. In 2008, offshore wind was responsible for 20,000 jobs, which has risen to 210,000 in 2018 (European Union, 2019). The sector has not only created employment but has also, much like ocean energy and desalination, attracted investments. Likewise, work in the Blue bio-economy sectors has reached over 17,000 jobs (including indirect activities). Moreover, turnover stands at €1.5 billion for direct activities (with an additional €240 million in ancillary activities) (World Bank, 2017). Another illustrative example, included in a case study within the research, shows that marine research and education have a positive economic impact in the local coastal economies (European Union, 2019).

2.1.4.1 Blue Energy

The Marine renewable energy sector comprises different technologies at a different stage of development. Bottom-fixed offshore wind represents the most advanced technology, with a cumulative capacity of 18.5 GW at the end of 2018. Other technologies, such as floating offshore wind, tidal, and wave energy technologies, are all emerging in comparison to offshore wind (European Union, 2019). Started with a small number of demonstration plants, the EU offshore wind energy has grown to a capacity of 18.5 GW by the end of 2018, with an increase of 2.65 GW in the last year. According to the EU, it is estimated that about 10 million European households are served by offshore wind energy, with an estimated consumption per home of 5,000 KW hours a year (European Union, 2019).

The ocean energy sector (tidal and wave power) is still relatively small compared to the offshore wind energy sector. At the end of 2018, the total global ocean energy installed capacity was 55.8 MW, with most of it located in EU waters (38.9 MW). The EU is the global leader with 58 % of the number of tidal energy technology developers and 61% of the wave energy developers based in the EU (European Union, 2018). The development of ocean energy technologies is still primarily at R&D. Between 2003 and 2017, total R&D expenditure on ocean energy amounted to a cumulative €3.5 billion, with the majority of it (€2.8 billion) coming from private sources. We observed an increased interest in ocean energy from 2008 onwards (European Union, 2019).

2.1.4.2 Blue Bio-Economy

Bio-economy is highly related to the extraction of living resources and includes sectors relying on renewable aquatic biological resources such as fish, algae, and other macro- and micro-organisms to produce food, feed, pharmaceuticals, cosmetics, bio-based products, and energy (Jalihal, 2018).

Biological resources are increasingly being used in new ways, creating a new biotechnology sector. New activities explore and exploit aquatic organisms to develop new products and services (World Ocean Council, 2018). Most of them use living organisms as either a source or a target of biotechnology applications, producing smart food, feed, biofuels, biomaterials, cosmetics, pharmaceuticals, nutraceuticals, industrial enzymes, solutions for bioremediation, etc. (OECD, 2019). This sector has the potential to contribute to EU economic growth and to provide new jobs, while also supporting sustainable development, public health, and environmental protection (European Union, 2019). Algae play an essential ecological role in coastal ecosystems. Additionally, the economic importance of these resources in the bio-based economy has increased (OECD, 2019). In the last decades there has been a growing demand for algae biomass for a variety of high-value commercial products (ex. cosmetics, nutraceuticals, pharmaceuticals) and new bio-based applications (biomaterials and energy), in addition to the traditional uses of this biomass source (food and food applications, feed, fertilisers) (Soma, Burg, Hoefnagel, Stuiver, & Heide, 2018).

2.1.4.3 Marine Minerals

Marine mining refers to the extraction and processing of non-living resources in the ocean, including marine aggregates (ex. sand and gravel), other minerals and metals in/on the seabed (ex. manganese, tin, copper, zinc and cobalt) and chemical elements dissolved in seawater (ex. salt and potassium) (World Ocean Council, 2018). Marine aggregates, as a long-established activity, are discussed in Section 3.3. This section focuses on the minerals and metals in/on the seabed (Kraemer et al., 2017)

In 2008, the Raw Material Initiative (European Union, 2018) established a strategy for access to raw materials. In general, securing reliable and undistorted access to raw materials from sustainable sources has increasingly become an essential factor for the EU's competitiveness and, hence, crucial to the success of the growth strategy (European Union, 2019). Recently, the raw materials policy reinforced in the context of the EU Industrial Policy Strategy positions raw materials as crucial elements for the industrial value chains. An excellent example of this new approach is the Staff working document "Report on Raw Materials for Battery Applications," developed in the context of the Strategic Action Plan on Batteries[72]. The strategic importance of raw materials is also part of the 2050 long-term strategy: "Raw materials are indispensable enablers for carbon-neutral solutions in all sectors of the economy. Given the scale of fast-growing material demand, primary raw materials will continue to provide a large part of the demand" (European Union, 2019).

The EU is highly dependent on imports of metallic minerals, as its domestic production is limited to about 3% of world production. Moreover, the EU is highly reliant on "high-tech" metals imports such as cobalt, platinum, rare earths, and titanium. Though often only needed in tiny quantities, these metals are increasingly essential to the development of technologically sophisticated products because of their growing number of functionalities. In this context, the Commission has identified a list of critical raw materials with high supply-risk, high economic importance, and lack of substitutes for which reliable and unhindered access is a concern to the European industry and sustainable value chains (European Union, 2019).

Marine minerals could be a future supply to the rapidly growing demand of raw materials, including certain metals, rare earth elements, and other minerals when extracted with environmentally friendly practices (Pinto et al., 2015). Marine aggregates, minerals, and chemicals dissolved in seawater have been extracted for centuries (Kathijotes, 2013). However, the extraction of minerals and metals in and on the seabed has several challenges to face, including the mapping of reserves, developing appropriate technology, and reducing the potential environmental impact (Kathijotes, 2013).

There are four main classes of mineral deposits at different water depths: phosphorites (95-1,950 meters), cobalt-rich ferromanganese crusts (800 - 2,400 meters), polymetallic sulfides (400-3,700 meters) and polymetallic nodules (4,000-6,000 meters). The technical, economic, financial, and environmental challenges to be solved multiply when the exploitation of minerals and metals has to be performed at a depth of up to 6,000 meters (Klinger, Maria, Daviasdottir, Winter, & Watson, 2018). Therefore, marine mining activities at great depth remain on a preliminary exploratory stage in both European and international waters. Besides, sea beds (containing calcium, magnesium, and other nutrient minerals) have been extracted for use as agricultural fertilizer by several Member States (including France at rates of up to 500,000 t/year) (World Bank, 2017).

As a follow up of EMODnet Geology[3], the project MINDeSEA[4]: Seabed Mineral Deposits in European Seas: Metallogeny and Geological Potential for Strategic and Critical Raw Materials aims at exploring and investigating seafloor mineral deposits. It addresses an integrative metallogenetic study of principal types of seabed mineral resources in the European Seas. MINDeSEA has identified the occurrences of cobalt- and lithium-rich ferromanganese deposits in pan-European seas, which are crucial for low-carbon energy production and new technologies. However, additional investigation and

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[3] Within EMODnet Geology, the German Federal Institute for Geosciences and Natural Resources (BGR) (work package leader) compiles and harmonises the European marine geology map data with regard to geomorphology, pre-Quaternary and Quaternary geology. The three data layers released today on seafloor geology show the underlying geology from the Ancient Past (more than 2500 Million years ago) to modern Quaternary deposits and geomorphological features. From it we can read the story about Earths Evolution in the European, marine part of our planet Earth, i.e. from the oldest rocks and how they form, to the youngest rocks and geomorphological features representing the most recent geological and environmental changes.

[4] The project MINDeSEA results of the collaboration between eight GeoERA Partners and four Non-funded Organizations at various points of common interest for exploration and investigation on seafloor mineral deposits. This project addresses an integrative metallogenetic study of principal types of seabed mineral resources (hydrothermal sulfides, ferromanganese crusts, phosphorites, marine placers and polymetallic nodules) in the European Seas. The MINDeSEA working group has both knowledge of and expertise in such types of mineralisation, providing exploration results, sample repositories and databases to produce innovative contributions. The importance of submarine mineralisation systems is related to the abundance and exploitation-potential of many strategic metals and Critical Raw Materials (CRM), necessary for the modern society development.

exploration would be necessary to estimate reserves for all these marine deposits in Europe (European Union, 2018). The interest in seabed exploration has fluctuated depending on market conditions (ex. metal price hikes). Only a few companies have made significant advances in the mapping of their area and testing technology, including robotics for the deep-sea (Kraemer et al., 2017).

2.1.4.4 Desalination

Desalination is a current technology and an alternative for water supply that can alleviate the growing pressure on freshwater resources (OECD, 2019). Currently, it is used to overcome water shortages in areas where water resources are limited. However, it involves energy-intensive processes, and therefore, it is one of the sectors where adaptation to increasing freshwater scarcity may entail trade-offs, in the long term, as regards emission reduction objectives and pollution (brine as a side product of desalination) (World Bank, 2017).

In Europe, there are a total of 2.352 desalination plants producing a total of 9.5 million cubic meters per day of freshwater from seawater and brackish water, representing approximately 4.2% of total water employed in the EU public water supply sector (European Union, 2019).

The market for desalination in Europe is expected to grow in the next few years. In 2016, desalination facilities have been commissioned in the EU, predominantly in Spain, Italy, and Cyprus, for a total additional capacity of 500,000 m^3/d and an investment of €457 million. 96% of the new contracted desalination capacity is expected to employ reverse osmosis. 70% of the new capacity is for large or very large desalination plants. The average capital expenditure associated with new capacity is of €1.1 million for each 1,000 m^3/d of additional capacity (European Union, 2019).

The future growth of the desalination market is tied to the need to identify viable solutions to tackle the increasing water scarcity and its translation into policy. Freshwater availability is expected to be impacted by climate change. Many regions in Europe are expected to face severe water scarcity by 2050 (European Union, 2019).

Desalination may provide a viable solution to alleviate water scarcity in many European regions (World Bank, 2017). However, increased desalination capacity may be met with significant trade-offs in terms of energy requirements, carbon emission, and environmental impacts. Desalination is an energy-intensive technology, and while it currently provides 4.2% of the EU water for public supply, it accounts for 16% of the energy used by the EU water system (European Union, 2019). The International Energy Agency has estimated that, at the global level, the energy consumption of desalination is expected to increase eight-fold by 2040 due to increased demands for freshwater produced by desalination (Jalihal, 2018).

2.1.4.5 Maritime Defence

The Maritime Defence sector on this research considers two sectors under defense and security, navies and naval shipbuilding. This sector is indeed anything but new, but has been categorized as emerging not in terms of its latest activities but rather on the emergence of its data, and its inclusion and consideration and a contributing activity to the Blue Economy (World Ocean Council, 2018).

By mid-2017, EU-28 navies account for at least 564 of commissioned warships with a total tonnage in the region of 1.5 million (European Union, 2019). Many rankings of world navies exist, depending on different criteria and the expertise and knowledge of compilers; however, there is consensus in that the navies of France, the UK, Italy, and Spain are among the 15 most powerful fleets in the world. Furthermore, France and the UK are among the five countries in the world with a well-established submarine-launched ballistic missile (SLBM) nuclear deterrence capability (European Union, 2019).

According to data from the European Defence Agency (EDA), EU28 total maritime personnel was 190,432 in 2016 and 177,090 (estimated) in 2017, showing a decrease from 2006 (227,309) (OECD, 2019). The most significant annual drop took place in 2011 and 2013 (-4.2% and -4.7%, respectively). The maritime sector represented 13.5% of all EU military personnel in 2016 (14.14% in 2017) up from 12.4% in 2006 (European Union, 2019).

The economic and financial crisis led to significant cuts in defense spending. New acquisitions and programs were reduced or slowed down, and many vessels were retired earlier than expected due to funding shortages. As stated above, maritime personnel also decreased. This pattern, however, is currently changing, given the improved economic environment and renewed perceived threats from Russia (European Union, 2019).

Naval shipbuilding in the EU represents an annual income of €10.8 billion in naval new buildings and of EU 4.2 billion in naval maintenance. The job count can be estimated at around 78,000 FTE (OECD, 2019).

2.2 THE INDUSTRY 4.0 TECHNOLOGIES

Since the beginning of industrialization, several technological leaps have led to paradigm shifts in production and in society itself. Those leaps have been called *Industrial Revolutions* or *Ages* (Figure 2-2) (Lasi et al., 2014).

England was the first country to record industrial activity in the late 18th century by using the steam engine. This invention gave rise to the concept of Industrialization and was hence considered the First Industrial Revolution, with the accumulation of capital leading the bourgeoisie to power and transformation of the agrarian structure into the maritime-commercial expansion of England and the creation of the Bank of England in 1694.

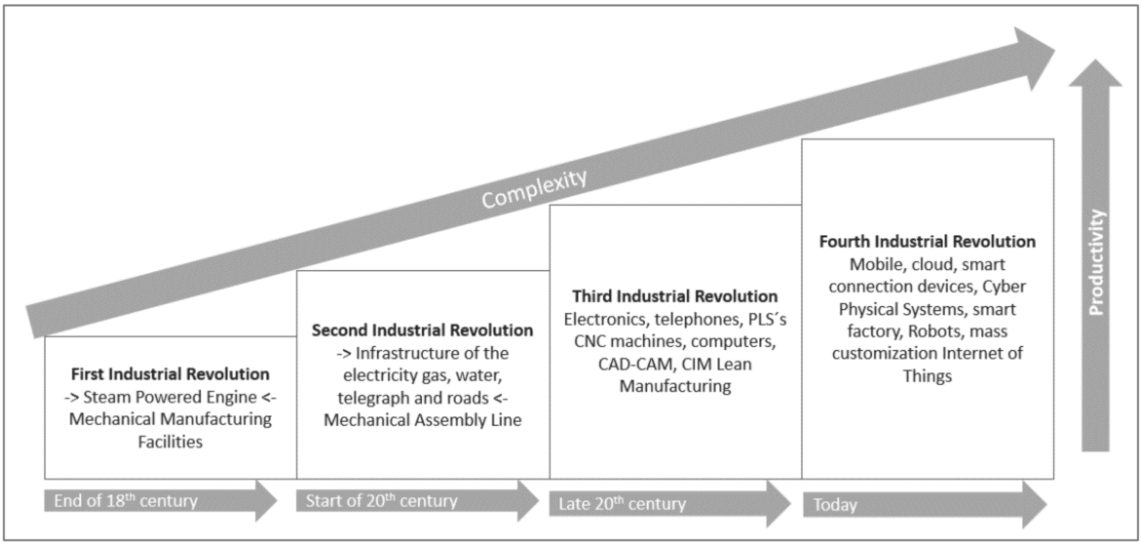


Figure 2-2: From the First to the Fourth Industrial Age (Silva, 2018)

In the early twentieth century, the industry expanded beyond Europe. The intensive use of electrical systems enabled the concept of scale production not only in Europe but also in the USA and Japan, making this period known as the Second Industrial Era. By the end of the twentieth century, the use of computerized systems allowed the automation of production processes with robotized systems beginning to perform repetitive or dangerous tasks, a paradigm that was called the Third Industrial Revolution (Albert, 2015).

As we draw closer to the present day, the XXI century, we see the ability of industry to produce customized goods with a shorter and shorter lifespan. This intense increase in the variability of industry’s capacity and consequent increased market volatility has led many observers to believe Industry is on the cusp of its Fourth Technological Paradigm (European Parliament, 2015), driven by the digitization of production processes combined with widespread use of the Internet (Lasi et al., 2014).

The term *Industry 4.0* (I4.0) became popular among academics, practitioners and authorities as the combination and integration of digital technologies such as Advanced Robotics, Artificial Intelligence, Sensors, Cloud Computing, IoT, analysis and sorting of Big Data, Augmented Reality, Additive Production and Mobile Devices, among other digital technologies, into an interoperable and shareable global value chain, regardless of geographical space (J. Lee, Bagheri, & Kao, 2015; MacDougall, 2014).

While it is true that most of these technologies have been available since the late 20th century, manufacturers created them without any regard to their integration by users, so what is new in I4.0 is the collaborative way all these technologies interact with one another and with the products resulting from their operations. Referring back to Kropotkin's (1903) experiments, for whom evolution depends on the level of collaboration (Kropotkin, 1902), once digitally linked, these technologies create a bridge between the *physical world* and the *virtual world* (European Parliament, 2015), therefore altering organizations’ production and management at a global level (Mosterman & Zander, 2015).

As part of the European Program supporting research, development, dissemination and financing of practices and digital technologies assisted by Cyber-Physical Systems, and built on the European Parliament document (European Parliament, 2015; Fair et al., 2012), the European Union considers that I4.0 may reverse the industrial decline seen in Europe in recent years. Being aware of what is happening around them, many industrialists and managers have already realized that I4.0 may bring new opportunities regarding the sustainability of their companies (Stock & Seliger, 2016). To connect a factory to the Internet and support production through CPS involves risks, from the investment required to the very maturity of the available digital production technologies (Thramboulidis & Christoulakis, 2016). However, representing more than 20% of jobs, equivalent to more than 34 million people and generating over 6,400 billion euros annually (Smit et al., 2016), the European industry cannot risk losing the lead and becoming outdated in this transition stage to the Fourth Industrial Age.

2.2.1 Big Data e Data Analytics

The term *Big Data* has been generally applied to data sets whose size or type is beyond the ability of traditional relational databases to capture, manage, and process the data with low latency. The term was coined by Roger Magoulas from O'Reilly media in 2005 (Neha Sharma, Deepali Sawai, 2017). Founding chair of O'Reilly's Strata Conference and chair of O'Reilly Open Source Convention, Edd Dumbill, defines *Big Data* as data that becomes large enough that it cannot be processed using conventional methods (Malhotra & Rishi, 2018). Big Data analytics is the use of advanced analytic techniques against extensive, diverse data sets that include structured, semi-structured, and unstructured data, from different sources, and in various sizes from terabytes to zettabytes (Neha Sharma, Deepali Sawai, 2017).

For instance, in the Advance adaptive E-Commerce search as a personalized search for retrieval and ranking of relevant E-commerce websites by using intelligent technologies like semantic web, neural networks (Lim et al., 2018). This personalized search mechanism requires *Big Data* analytics to retrieve useful association rules from data in text, images, or video format as available on social media and purchase history of various customers to recover customer-specific E-Commerce website ranking patterns efficiently. There are different types of traditional personalized search (Malhotra & Rishi, 2018).

The term Big Data is also the term applied to data sets whose size or type is beyond the ability of traditional relational databases to capture, manage, and process the data with low latency. *Big Data* has one or more of the following characteristics: high volume, high velocity, or great variety. Artificial intelligence (AI), mobile, social and the Internet of Things (IoT) are driving data complexity through new forms and sources of data. For example, Big Data comes from sensors, devices, video/audio, networks, log files, transactional applications, web, and social media - much of it generated in real-time and on a vast scale.

Nowadays, parallel to the growth of the Industrial Internet of Things (IIoT) where additive production[5] is perhaps one of the most emblematic results (O'Brien, 2016), there has been a change in production, which has long since been boosted by the appearance of new sensorial media on the market (Sehgal, Patrick, & Rajpoot, 2014), which gathers information in real-time in the most different forms. The exponential growth in the use of these new sensor networks will undoubtedly increase the amount of information, generalizing the term "Big Data" (J. Lee et al., 2015) as dynamic generators of massive information (Lee et al., 2015). The *Big Data* will challenge the ability of CPSs themselves to screen all the information generated in real-time. The paradigm resulting from *Big Data* in IIoT is seen as a reality for which we have to be prepared, and is designated by some authors as "4V's Paradigm" (Breidbach & Maglio, 2016), being interpreted as a sign contrary to the economic advantages of digitalization (Constantinescu, Francalanza, Matarazzo, & Balkan, 2014), since it requires systems to respond in an "immediate way", in order to generate "intelligence" (Caggiano, Caiazzo, & Teti, 2015; Eadie, Browne, Odeyinka, McKeown, & McNiff, 2013)

2.2.2 Autonomous Robots

The robotization trend of various industries indicates an increase in demand for artificial intelligence systems and *Autonomous Robots* (Legashev et al., 2019). Robots have been used for a long time in the industry, but the I4.0 robot's differential is its ability to work without human supervision, acting intelligently, cooperatively and autonomously (Bilberg & Malik, 2019). Using standalone robots reduces labor costs and increases production, making industries more competitive (European Parliament, 2015).

2.2.3 Virtual Simulation

The *Virtually Simulating* of products and materials is a reality of the I 4.0 operations mode (Wong & Zhou, 2015). The virtual environment involves machines, products, processes, and people making use of data from the physical world and thus simulating the entire value chain (Bilberg & Malik, 2019). The *Virtually Simulating* of plants allows, for instance, for the simulation of constraints, linking and suggesting compatible components

[5] Equipment also designated 3D Printers

through the plug-and-play feature. Use the property editing feature to modify predefined component parameters such as dimensions, speed, and color, among many others.

2.2.4 Horizontal and Vertical Integration

In modern manufacturing, there are usually different machines and equipment from different manufacturers in use, which differ in terms of the degree of automation, the technology, and even the communication standard (Smit et al., 2016). Connectivity paves the way for various types of integration. A CPS, in a particular context and application domain, will have a certain degree of horizontal and vertical integration (Camarinha-matos, Afsarmanesh, & Fornasiero, 2017). *Horizontal And Vertical Integrations* relate to consistent and interconnected IT systems within companies (engineering, production, services, etc.) and beyond (companies, suppliers, distributors, and customers) (MacDougall, 2014). With universal data-integration networks, corporations of the fourth industrial revolution will never be isolated. It means integrating services and functions of similar type (at the same level of abstraction).

Vertical integration refers to integration across system hierarchies, considering, for example, smart buildings by integrating energy meters and heating/ventilation devices with building control, up to entire buildings, and further towards local energy distribution and power systems of cities. Extended levels of integration are likely to cut across domains and jurisdictions, thus involving several non-technical challenges (L. Wang, Törngren, & Onori, 2015).

2.2.5 Internet of Things

Nowadays, due to the rapidly evolving technological advancements, smart devices can interconnect, communicate, and interact over the Internet. Moreover, over the years, the size of these devices has been reduced, whereas their processing power and storage capabilities have significantly increased (Lampropoulos, Siakas, & Anastasiadis, 2019). The number of sensors in the world today is already higher than the world population. Sensors are everywhere, are part of our daily lives, and connect our devices (cell phones, TVs, cars, appliances, among others). This has been in recent times designated by practitioners and academics as the *Internet of Things* (IoT). In the context of Industry 4.0, all things are smart and connected to the internet. Connected sensors generate data, and data analytics increase real-time decision-making capability (Novak, 2017).

Associated with the IoT concept is also the concept of Cyber-Physical System (CPS), meaning the integration of software and hardware to control flexible physical processes (factories), where products and machines interconnect and communicate with each other and with the network they are part of, which also includes consumers (Karimi & Walter, 2015). In line with this interpretation, for researchers such as Lee, Baheri and Kao (2015), CPSs are systems which consist of management technologies for the interconnections between the digital world and physical assets, made possible by the significant evolution in recent years of sensory techniques for acquiring and exchanging information (J. Lee et al., 2015).

It is thus verified that the concepts of IoT, CPS (O'Brien, 2016), and CPSs (L. Wang et al., 2015), while different are still related. The IoT links the consumer to the digital economy, and besides, production, when supported by CPSs, also links manufacturing to the digital economy (Mosterman & Zander, 2015).

Digital technologies in the form of Intelligent Connectivity of Smart Devices (ICSD) (Albert, 2015) are the basis that supports both concepts, representing the main common point between IoT and CPS, which once applied to the relationship between consumers (most common situation) is simple to understand, but when applied to factories, levels of complexity take on another dimension, and this may have been the reason why some authors, researchers, and Authorities use the term Industrial Internet of Things (IIoT) (European Parliament, 2015). In any case, the industrial dynamics driven by digital technologies, such as ICSD or IIOT (Hoske, 2015), seem to be reconfiguring the 21st century production model to the point that many authors, researchers, and practitioners consider we are facing a fourth paradigm shift in History or a Fourth Industrial Era (European Parliament, 2015) .

As with production, this paradigm shift will trend to encompass the maintenance (conservation) of productive means, including the support of CPSs themselves, where the systems' operating conditions derive from the interaction between physical objects and the digital parameters of the processes (S. Wang, Wan, Zhang, Li, & Zhang, 2015), also extensible to the service sector, so some authors consider that digital technologies are leading to the liquidation of the economy (S. L. Vargo & Akaka, 2009; S. Vargo & Lusch, 2016).

2.2.6 Cyber Security

The *Cyber Security* comes almost as a result of several other pillars of Industry 4.0, as in a highly connected and integrated world, protecting data and systems from cyber threats becomes a considerable challenge (Pereira, Barreto, & Amaral, 2017). Thus, Industry 4.0 relates to the interconnection of different functions within the supply chain, also based on the usage of artificial intelligence (Müller, Buliga, & Voigt, 2018) This enables a much higher degree of transparency and efficiency in transactions compared to the third Industrial Revolution and brings new questions in the already established debate on *Cyber Security* (Kagermann, Wahlster, & Helbig, 2013)

2.2.7 Cloud Computing

The Cloud manufacturing refers to an advanced manufacturing model under the support of *Cloud Computing* as well as the IoT, virtualization, and service-oriented technologies, which transforms manufacturing resources into services that can be comprehensively shared and circulated (Grilo & Jardim-Goncalves, 2013). It covers the extended whole life cycle of a product, from its design, simulation, manufacturing, testing, and maintenance, and is therefore usually regarded as a parallel, networked, and intelligent manufacturing system (the "manufacturing cloud") where production resources and capacities can be intelligently managed (Habib et al., 2019). Thus, on-demand use of manufacturing services can be provided from the manufacturing cloud for all types of end-users (Zhong, Xu, Klotz, & Newman, 2017). *Cloud Computing* is already used by many organizations, but in Industry 4.0, cloud technology performance is optimized by increased processing capacity and speed. Faster systems attract more companies that trust their data and systems to the cloud. Among the benefits, more integrable data and hardware savings for organizations (Wong & Zhou, 2015).

2.2.8 Additive Manufacturing

Additive Manufacturing technologies, also known as 3D printing, will be increasingly deployed in value creation processes since the costs of *Additive Manufacturing* have been rapidly dropping during the last years by simultaneously increasing in terms of speed and precision (Barreto, Amaral, & Pereira, 2017). This allows designing more complex, stronger, and more lightweight geometries as well as the application of *Additive Manufacturing* to higher quantities and larger scales of the product (Stock & Seliger, 2016). Some advantages of 3D printing for industry have been presented (Economist 2011). For example, 3D printing can print many geometric structures. It may simplify the product design process. It is relatively environmentally friendly (Müller, Buliga, et al., 2018). The authors Achillas, Tzetzis, and Raimondo (2017) compared different Additive Manufacturing technologies with injection molding in a real-world case study. In low-volume production, both methods offer an alternative that could result in shorter lead times and decreased total production costs (Smit et al., 2016). *Additive Manufacturing* may increase flexibility, may reduce warehousing costs, and could help the company towards the adoption of a mass customization business strategy (Y. Yin, Stecke, & Li, 2017).

2.2.9 Augmented Reality

The *Augmented Reality* (AR) is the blending of interactive digital elements, such as visual overlays, tactile feedback, or other sensory projections, with the real world.

The Factories of the Future become increasingly dynamic working environments due to the upsurge in need for flexibility and adaptability of production systems, the upgraded shop-floors call for cognitive aids that help the operator perform these mental tasks, such as those provided by *Augmented Reality* technologies or “intelligent” Human-Machine Interfaces (HMI) to support the new/increased cognitive workload (ex. diagnosis, situational awareness, decision-making, planning, etc.) of the Operator 4.0. It can be expected that this aid would increase human reliability in the job, considering both the operator’s well-being and the production system’s performance.

Either the industry and services see enormous potential in *Augmented Reality* for service generation and delivery. By enabling real-world and virtual-world interactions, this technology is beneficial for medical and educational applications as well as professional employee training.

2.3 THE CHALLENGES OF THE BLUE ECONOMY

The Blue Economy has diverse components, including established traditional ocean industries such as fisheries, tourism, and maritime transport, but also new and emerging activities, such as offshore renewable energy, aquaculture, seabed extractive activities, and marine biotechnology and bioprospecting. Some services provided by ocean ecosystems and for which markets do not exist also contribute significantly to economic and other human activities such as carbon sequestration, coastal protection, waste disposal, and the existence of biodiversity (Affairs & Conference, 2018).

The “blue economy” concept seeks to promote economic growth, social inclusion, and the preservation or improvement of livelihoods while at the same time ensuring the environmental sustainability of the oceans and coastal areas. At its core, it refers to the decoupling of socioeconomic development through ocean-related sectors and activities from ecological and ecosystem degradation. It draws from scientific findings that ocean resources are limited and that the health of the oceans has drastically declined due to anthropogenic activities (Jalihal, 2018). These changes are already being profoundly felt, affecting human well-being and societies, and the impacts are likely to be amplified in the future, mainly because of projected population growth (World Bank, 2017).

2.4 THE BLUE ECONOMY ENABLERS

The European Union has launched the *Blue Growth* concept as a strategy for economic growth in European seas in the context of climate change, increased scarcity of natural resources, the increased vulnerability of the planet, growth in urbanization and the concentration of humans in coastal regions (Soma et al., 2018). Blue Growth is an extension of the land-based policy strategy referred to as Green growth, which the EU has introduced in 2010 (Klinger et al., 2018). In response to economic challenges, in the context of climate change and overexploitation of natural resources, the principles of Green growth (Müller, Kiel, & Voigt, 2018) as a policy strategy aim at: 1) smart growth – developing an economy based on knowledge and innovation, 2) sustainable growth – promoting a more resource-efficient, greener and more competitive economy and 3) inclusive growth – fostering a high-employment economy delivering economic, social and territorial cohesion (OECD, 2013). Likewise, the Blue Growth concept operates in the scope of smart, sustainable and inclusive growth, while actually intending to capture a precautionary approach, which refers to “principles that preventive action should be taken, that environmental damage should, as a priority, be rectified at source and that the polluter should pay" (Soma et al., 2018).

Although it is unclear whether the Blue Growth concept is tailored to social innovations, there are some remarkable links between them (Soma et al., 2018). Whereas social innovation stems from bottom-up initiatives that promote change by so-called enablers, they are aiming for impacts beyond the individual level to a broader scope of social and/or ecological contexts (Kraemer et al., 2017).

Both 2018 and 2019 EU Blue Economy Reports have highlighted the challenges and size of the Blue Economy in the European Union (European Union, 2018, 2019). These reports have proposed guidelines to support policymakers and stakeholders in the quest for sustainable oceans, seas, and coastal resources. Moreover, the enablers behind the sustainable growth were identified: (i) common skills, (ii) shared infrastructure, (iii) sustainable use of the sea, (iv) environmental protection, (v) maritime spatial planning, (vi) maritime security, and (vii) marine data (European Union, 2018, 2019). As the drivers of the EU Blue Economy Growth, these reports pointed out these enablers pushing as the way to improve the Blue Economy in European Territory.

2.5 CHAPTER SYNTHESIS

In this Chapter, it was described the problematic of the research. The "blue economy" concept seeks to promote economic growth, social inclusion, and the preservation or improvement of livelihoods while at the same time ensuring the environmental sustainability of the oceans and coastal areas. We witnessed an acceleration in the growth of all Blue Economy sectors from 2013 onwards except for the Extraction of non-living resources. As described, an essential dimension of the Blue Economy involves how established ocean industries are transitioning to more environmentally responsible practices. Moreover, the Blue Economy includes also emerging and Innovative Sectors such as offshore wind energy, ocean energy, blue bio-economy and biotechnology, marine minerals, desalination, and maritime defense.

Since from the beginning of this decade, the term *Industry 4.0* became popular, as the combination and integration of digital technologies such as Advanced Robotics, Artificial Intelligence, Sensors, Cloud Computing, IoT, analysis and sorting of Big Data, Augmented Reality, Additive Production and Mobile Devices, among other digital technologies, into an interoperable and shareable global value chain, regardless of geographical space. In this context, and according to the European Union, the enablers behind the sustainable growth were identified: (i) common skills, (ii) shared infrastructure, (iii) sustainable use of the sea, (iv) environmental protection, (v) maritime spatial planning, (vi) maritime security, and (vii) marine data.

KEY POINTS

- The term Blue Growth has been used to describe a new era, where the Blue Economy is an essential feature of the European economy.
- The Blue Economy consists of sectors whose returns are linked to the living "renewable" resources of the oceans (such as fisheries) as well as those related to non-living and, therefore, "non-renewable" resources.
- The Blue Economy core refers to the decoupling of socioeconomic development through ocean-related sectors and activities from environmental and ecosystem degradation. It draws from scientific findings that ocean resources are limited, and that the health of the oceans has drastically declined due to anthropogenic activities.
- The term *Industry 4.0* (I4.0) refers to the combination and integration of digital technologies such as Advanced Robotics, Artificial Intelligence, Sensors, Cloud Computing, IoT, analysis and sorting of Big Data, Augmented Reality, Additive Production and Mobile Devices, among other digital technologies, into an interoperable and shareable global value chain, regardless of geographical space.
- Since 2018, the enablers behind the sustainable growth were identified by European Union: (i) common skills, (ii) shared infrastructure, (iii) sustainable use of the sea, (iv) environmental protection, (v) maritime spatial planning, (vi) maritime security, and (vii) marine data (European Union, 2018, 2019). As the drivers of the EU Blue Economy Growth, the EU pointed out these enablers as competitiveness booters of the Blue Economy in the European Territory.

CHAPTER 3

Life is what happens when you're busy making other plans

John Lennon

3. LITERATURE REVIEW

When analysing the economic activity of a group of service companies, some researchers (Chesbrough & Spohrer, 2006) found elements common to all of them, considered solid enough to be considered consensual in a new discipline applied to the study of the services which they proposed should be designated *Services Science* (Spohrer & Maglio, 2008) : (i) the direct interaction between supplier and consumer; (ii) the simultaneity of production and consumption; (ii) the exchanged element, based on the combination and nature of knowledge; (iv) exchanges and experiences being an integral part of the business process (v) Information and Communication Technologies (ICT) being always present, promoting efficiency and transparency.

The creation of a scientific Body of Knowledge to support services activity (Services Science) for Chesbrough and Spohrer (2006) arose through the need to systematize and promote scientific research in order to find ways and solutions to real problems, such as: (i) creating more value by combining and accelerating information, generated by the continuous advancement of information, communication and sensing technologies; (ii) finding answers to integrate all information in order to create new services and new solutions for customer problems; (iii) managing the tacit knowledge of the entities involved in order to create more value from this exchange; (iv) leading people and organizations to create tangible and intangible assets that produce value for both.

In short, this Manifesto advocated the need to create a value-creation theory (Bharti, Agrawal, & Sharma, 2015) for service activities, to systematize innovation and accelerate value creation (Spohrer & Maglio, 2008). It is in this context that Jim Spoher and Paul Maglio (2006), both researchers at the IBM Almaden Research Center, in their article entitled *The Emergence of Service Science: Toward Systematic Service Innovations to Accelerate Co-Creation of Value* reaffirm the need for this new field, now (2006) proposing that its designation must be *Service Science* and for which IBM would publicly disclose its own experience (Spohrer & Maglio, 2008).

Focused now (in 2008) on the logic of service, and four years later, after Lusch and Vargo introduced the Fundamentals of S-D Logic (Vargo & Lusch, 2004a) at the time already cited by thousands of researchers, it is still strange that Spoher and Maglio before June 2008 had not made any reference to the concept of S-D Logic proposed by Lusch and Vargo (2004). This could be the reason leading the pioneers of S-D Logic, Lusch, and Vargo, in 2006, to publish an article that indicates some discomfort with the overlap of concepts between the new discipline of *Services Science* and the S-D Logic mindset. Entitled *Service-dominant logic: reactions, reflections, and refinements,* in this article Lusch and Vargo (2006) invited the research community to participate in a critical way in the S-D Logic mindset, firstly because the S-D Logic as introduced in 2004 is an open-source and collaborative model (R. Lusch & Vargo, 2006).

It is in this context that Spohrer, Maglio, Bailey, and Gruhl (2007) systematize the foundations of the new scientific area, renamed *Service Science, Management, and Engineering* (S-SME), with the first purpose of providing theory and practice for *service innovation* problematics (Spohrer et al., 2007). In July 2007, the pioneers of S-D Logic, Vargo and Lusch, published an article called *Service-Dominant Logic: Continuing The Evolution* (R. F. Lusch & Vargo, 2008), claiming authorship of the concepts associated with S-D Logic and proposing an update of its Fundamental Premises as introduced in 2004 (S. L. Vargo & Lusch, 2004).

The first significant contribution to consolidating S-S Theory came in June 2007,when Jim Spoher and Paul Maglio, in their article entitled *Fundamentals of Service Science, w*ho until then had ignored the work of Vargo and Lusch, proposed that the construction of the Body of Knowledge for *Service Science* must be elaborated based on the perspective, propositions, and vocabulary of S-D Logic (Maglio & Spohrer, 2008).

Considering S-D Logic's Axioms as the basic premises of S-S, Spoher and Maglio (2008) propose that S-D Logic must be the basis of this new scientific area, where the abstract entity designated service system would be the element of study. This proposal (2008) from S-S pioneers was in line with the earlier proposal from the S-D Logic pioneers (2007), for whom S-D Logic must provide the basis for a review of Company Theory

(Rice, Liao, Martin, & Galvin, 2012) based on study of service systems (R. Lusch, Vargo, & O'Brien, 2007).

For Ganz, Satzger, and Schultz, a scientific discipline is a set of methods and standards, accepted and used by a community, to develop a Body of Knowledge that explains and typifies observable phenomena in the world (Kindström, Kowalkowski, & Erik, 2013). Thus, it was necessary to attribute to S-S the conceptual structures, theories, models and laws that could not only be empirically tested but also applied to the benefit of society (Fraunhofer, 2012), and in this context, the leading advocates of S-S, Spohrer, Anderson, Pass, Ager and Gruhl (2008) considered that S-S must be viewed as a scientific field under construction, for which the Body of Knowledge would emerge slowly but with a challenge to become genuinely interdisciplinary (Spohrer, L.C. Anderson, et al., 2008).

This led to the construction of S-S Theory, which could support it as a scientific field, considering its interdisciplinarity and considering the Sustainability of the Planet as a transversal concern, in exchanging service and assuming S-D Logic as its philosophical anchor. One of the first difficulties for S-S Theory consolidation is its interdisciplinarity, to the point that some authors have considered it as a scientific area emerging from a melting pot (Spohrer & Kwan, 2009).

Firstly, by incorporating the S-D Logic concepts such as value co-creation and resource integration (Vargo & Akaka, 2009) and *service* , which is the basis of all exchanges in the S-D Logic mindset, so that for S-S, all economies have become service economies as well as all companies nowadays being service companies belonging to service ecosystems (Robert F. Lusch, Vargo, & Gustafsson, 2016). This extends the scope of s-systems far beyond specific types of industries or services, concepts that no longer exist in S-D Logic. S-S is concentrated on the value-creation process underlying all exchanges (Edvardsson & Tronvoll, 2013), finally abandoning the focus on physical resources such as natural resources, buildings, or others.

As in S-D Logic, also for S-S, the meaning of service cannot be confused with services, which in the traditional perspective means intangible goods (S. L. Vargo & Lusch, 2004). Also for S-S, the concept of service will become the provision of capabilities, trust, and knowledge, usable for the benefit of others (Akaka et al., 2014) and physical things, being essential, come to be seen as mere mechanisms of service provision (R. Lusch & Vargo, 2006).

This is how Service Science became the discipline that intends to categorize and explain the various types of s-systems, their interactions, and their implications for value creation (Maglio & Spohrer, 2008). Since not all interactions co-create value, it tries to understand the reasons for these normative deviations (Maglio, Vargo, Caswell & Spohrer, 2009).

For activities related to the production of tangible goods (industry), increasingly supported by digital technologies common to intangible assets, S-S may become an exciting discipline at several levels. Firstly, the need for new professional profiles (Demirkan & Spohrer, 2015), which can contribute to making the digital service innovation process more systematic and, therefore, a better choice of investment and business management (Stoshikj, Kryvinska, & Strauss, 2016).

The First Service Science Principle has been defined as service system entities dynamically configure four types of resources: people, technologies, organizations, and information (S. L. Vargo & Akaka, 2009), since the purpose of economic relations for the S-D Logic mindset is the exchange of service among entities aiming for reciprocal benefit (S. L. Vargo & Lusch, 2004), that is, for S-D Logic exchange service for service (Robert F. Lusch et al., 2016). This view of economics contrasts with the perspective of Adam Smith (1776), also referred to as G-D Logic (S. L. Vargo & Lusch, 2010), since for the S-D Logic mindset products are not the fundamental basis of trade but rather the service, in the form of skills applied to benefit others (S. L. Vargo & Lusch, 2004), with each economic entity consisting of a set of operant and operand resources (R. Lusch & Vargo, 2006). For S-D Logic, value emerges from the result of the interactions between these entities, and here S-S appears as the discipline to analyze, evaluate, and optimize these interactions (Spohrer & Maglio, 2008).

The Second Service Science Principle has been defined as service system entities compute value given the concerns of multiple stakeholders (S. L. Vargo & Akaka, 2009), since the relationships among s-systems are based on value propositions, which from the S-S perspective can be understood as an s-system's request for another s-system to execute an action. Thus, a value proposition seems to be the essential relationship among s-systems, in the form of service exchange or service interactions (S. L. Vargo & Akaka, 2009).

For the exchange of service to occur, it is necessary to involve at least two distinct entities, designated in S-S as "stakeholders" (Maglio & Spohrer, 2013) and in S-D Logic as "actors" (Edvardsson & Tronvoll, 2013). It is thus expected that when the first stakeholder makes the value proposition, for example, the client conducting a market inquiry or the supplier making an offer, each of the other actors make a different evaluation of the proposal's value (Spohrer, Anderson, Pass, & Ager, 2008), since each has different objectives (Chavez et al., 2015). In this context, it is essential that the s-system that makes the value proposition, before making it active, identifies the concerns that different stakeholders will have when they receive that value proposition (Smith & Colgate, 2007), related to perspectives, expectations, access to resources and many others held by each stakeholder.

As determined by the First Principle, the four primary stakeholders in S-S are the customer, provider, authorities, and competition (Maglio & Spohrer, 2013). If the provider is the author of the value proposition, they must, therefore, consider the customer's perspective, their perspective, the view of the authorities and that of the competition, before sending the proposal, as reasoning in this way will raise different concerns about what should be proposed. The customer, provider, and authority stakeholders are traditionally considered in any business since each one participates in the benefits of the value co-created between the customer and the provider (Taylor, Romero, & Molina, 2010).

It is a non-consensual situation, however, when it comes to the "competition" stakeholder (Sigalas, Economou, & Georgopoulos, 2013). For Spohrer and Maglio (2013), as competitors are part of the business ecosystem context (S. Vargo & Lusch, 2016), in which there are common shared agreements, rules and benefits, they must be considered as stakeholders, their perspectives contributing to generating additional value to the ecosystem through sustainable innovation (Maglio & Spohrer, 2013). In addition to the views of these four stakeholders directly concerned, S-S accepts that the study of value interactions can consider other secondary stakeholders, such as employees, partners, entrepreneurs, citizens, and others (Spohrer & Kwan, 2009).

Among several methodological tools available in S-S, the service blueprinting has been widely used as a way to represent shared access to resources throughout the service process (Kwan et al., 2016), allowing visualization of the evolution of value propositions, contact points and actions that coordinate and motivate access to the resources of the s-systems involved (Boughnim & Yannou, 2005). For S-S, the customer being the product's co-creator (Breznik & Lahovnik, 2014), mapping the service process using a tool such as the service blueprint becomes necessary, to generate new dynamics that brings positive and measurable innovation outcomes to the different stakeholders' concerns (Beske, 2012). As one of S-S's main objectives is to innovate in value propositions, it means that to improve IOs, it is necessary to know at the outset what resources are involved in these propositions (Wong, Ignatius, & Soh, 2014). Improving a value proposition does not mean benefit for customer or provider, but rather adding value to all directly interested stakeholders, competition being the main driver of innovation (Hüttinger, Schiele, & Veldman, 2012). As s-systems (stakeholders) gain experience from lessons learned over time, systematic refinements will improve proposals, based on historical statistical and anticipated future standards, a lean thinking concept designated continuous improvement process (Melton, 2005; Taylor, Jylhä, & Junnila, 2014).

In this sense, any analysis model must promote and facilitate the usage of mechanisms for the continuous improvement process of value propositions which, in times of market turbulence, must consider the lessons learned as a challenge to improve the process continues in a structured way (Chavez et al., 2015). Changes in government regulations, disruptive technological innovations, natural catastrophes, or aggressive movements by the competition may require adjustment of value propositions throughout the service process (Hsu, 2016).

This review has shown that much of the literature published involving Service Science has been related to the activities traditionally referred to as services in the sense of intangible goods, while publication related to industry is restricted. This asymmetry in the scientific publication may be interpreted, on the one hand, by the fact that S-S is a relatively recent scientific field and, on the other hand, because industry is making the transition to a new Industrial Age based on the digitalization of productive processes, designated Industry 4.0 as referred to in Chapter 2 (Stock & Seliger, 2016). However, in adopting the underlying assumptions of S-D Logic, S-S no longer distinguishes between products and services, resulting in the concept of "resource density" (Robert F Lusch & Nambisan, 2015).

In the Digital Era, for customer stakeholders, quality concerns are the key indicators of their satisfaction, the evaluation of which must be based on an index of concerns whose reduction leads to satisfaction (Spohrer & Kwan, 2009). For the provider stakeholder of the Digital Era, performance concerns are the key indicators of their productivity, and evaluation must be based on an index of concerns whose reduction leads to productivity (Spohrer & Kwan, 2009).

For the Authority stakeholder in the digital Era, compliance concerns remain the key indicators of conformity, and evaluation must be based on an index of concerns whose reduction leads to conformity (Spohrer & Kwan, 2009). Contrary to what it might seem, with regulatory compliance being a factor in transaction costs associated with business in different regions of the world (Cox & Chicksand, 2005), fiscal transparency is increasingly desired by all, as this facilitates carrying out that business. In his paper "A General Theory of Competition," Hunt (2000) describes the theory of resource advantage and warns that reducing competition in economic systems results in diminishing innovation capacity over time (Hunt, 2000). In this sense, the existence of competition is a fundamental factor for the existence of sustainable innovation, which is a relative measure of value created in the short and medium-term (Spohrer & Kwan, 2009).

The Third Service Science Principle has been defined as the access rights associated with customer and provider resources are reconfigured by mutually agreed to value propositions (S. L. Vargo & Akaka, 2009), since, in the traditional view (G-D Logic) (Robert F Lusch & Nambisan, 2015), the producer is the main actor who produces goods and services and consumers are secondary actors or passive recipients (S. Vargo & Lusch, 2016). According to G-D logic, the producer is the source of knowledge and creativity, and therefore also the only source of product innovation (Matthies & D’Amato, 2016).

In contrast to the traditional perspective dating back to Adam Smith (1776), in the S-D Logic mindset, all actors are considered resource integrators, networked with other actors, and therefore all are potential innovators or value creators (S. L. Vargo & Lusch, 2004). In this way of viewing the economy, by centring value from the existence of a network of resources which coexist and are available in the imaginary form of “resource density” to benefit others and oneself (S. Vargo & Lusch, 2016), when liquefied, the resources according to the S-D Logic perspective can be quickly mobilized in time, space or even the actor making the proposal (Robert F Lusch & Nambisan, 2015).

One of the fundaments of S-S is to consider access to s-systems’ resources as the vital link for value creation (Maglio & Spohrer, 2013), whenever the resources of both stakeholders are reconfigured to propose something to each other (Wu, He, & Duan, 2013). If it is imagined as the fundamental mechanism of interaction between s-system resources or between different s-systems, the reconfiguration of resources then arises, related to the notion of non-ownership or leasing (Stoshikj et al., 2016).

The fourth Service Science Principle has been defined as service system entities that compute and coordinate actions with others through symbolic processes of valuing and symbolic processes of communicating (S. L. Vargo & Akaka, 2009).

The researchers Newell and Simon (1976) described symbol systems as compared to the universal machine of the British mathematician Turing (1936), a theoretical invention created many years before the existence of modern digital computers, known as the Turing machine (Newell, 1980). For the symbols be studied in the context of value co-creation interactions, some authors (Akaka et al., 2014) consider a more holistic and systematic view of the symbols, articulated in a structure that leads to the creation of symbol systems through empirical adoption of good practices (Newell, 1980).

3.1 REGARDING INDUSTRY 4.0 ENABLERS: COMPUTE VALUE GIVEN THE CONCERNS OF MULTIPLE STAKEHOLDERS

As described above, Industry 4.0 is boosted by smart technologies that enable real-time interactions among stakeholders. However, looking at the reality, the reason why these interactions occur is because there are legitimate expectations in each of the stakeholders involved, to share part of the value created. When two service system entities reorganize them resources to interact together, both believe that from the interaction will come some value. Nevertheless, both have concerns about the amount and nature of the value (positive or negative value).

3.2 DEFINING THE X VARIABLE, THE KCI

Having initially been thought to be the Science of Services (Hsu, 2016), by adopting the philosophical bases and language of S-D Logic, S-S has become a discipline applicable to both industry and services, with lines separating these two types of activities ceasing to exist (Maglio & Spohrer, 2013). Because it is interdisciplinary and, although recent, S-S is focused on the study of service system interactions, from which the service results as the co-created value, and for S-S, this must be evaluated through indicators of the concerns of the four main stakeholders.

According to the S-S perspective, value propositions must consider the concerns of the customers, providers, competitions, and authorities simultaneously, with ecosystems' sustainability being a transversal concern in all steps of the service process (Maglio & Spohrer, 2008). Moreover, for S-S Theory, value propositions are the fundamental relationship between s-systems interactions (S. L. Vargo & Akaka, 2009). This means it can be expected that when one stakeholder configures his resources to carry out a value proposition, all the others may evaluate the value differently (Spohrer, Anderson, Pass, & Ager, 2008).

From this, it becomes clear that different perspectives of value of the proposals must consider different concerns for each one of the four main stakeholders, including the one making the offer, and therefore we may address each concern as a Key Concern Indicator (KCI). This is in line with the Fundamental Principles of S-S Theory (Spohrer, Anderson, Pass, & Ager, 2008) and it becomes possible to measure the relative evolution of the concerns when the service process evolves in its operations mode (Maglio & Spohrer, 2013; Matthies & D'Amato, 2016).

The Key Concern Indicators have an inverse meaning to the traditional Key Performance Indicators (KPI) concept, leading to ($\mathrm{KCI} = \frac{1}{\mathrm{KPI}}$) whether concerns are qualitative or quantitative, for which the researcher must find appropriate metrics related to the main stakeholders' concerns, using the typical metrics from the disciplines forming the S-S Body of Knowledge.

3.3 SERVICE SCIENCE: DISCIPLINES AND PROFESSIONAL SKILL PROFILES

As already mentioned in this thesis, Service Science is an interdisciplinary scientific area, supported by ten pillars or scientific disciplines (Spohrer & Kwan, 2009), understood as necessary for service interpretation and innovation among s-system entities : (i) History of Economics and Law, (ii) Marketing, (iii) Operations Management, (iv) Political Science, (v) Sustainability, (vi) Anthropology, (vii) Engineering, (viii) Computer Science, (ix) Procurement and (x) Management, whose accumulated knowledge helps to improve s-systems' efficiency (Spohrer & Kwan, 2009). In this interdisciplinarity context, Demirkan and Spohrer (2015) consider that in the professional profile of a *service scientist* (Fraunhofer, 2012) there must be expertise in one of the scientific areas forming S-S (Demirkan & Spohrer, 2015) but also elementary knowledge of the subject matter of all the disciplines involved in S-S, to be able to fully integrate a multidisciplinary S-S team (Spohrer & Kwan, 2009) .

Additionally, as an absolutely fundamental requirement, according to some authors (Demirkan & Spohrer, 2015), in the professional nature of a *service scientist* there must be a willingness to work in a collaborative way with all other service scientists, making their specific knowledge available for all others to use, which in figurative terms can be represented as a *T Shaped* profile (Kwan et al., 2016).

3.4 CHAPTER SYNTHESIS

In this Chapter, it was done the literature review of the research. By adopting the philosophical bases and language of Service-Dominant Logic, the *Science of Service* has become a discipline applicable to both industry and service. Lines are separating these two types of activities ceasing to exist. Service Science is a discipline that intends to categorize and explain the various types of service systems, their interactions, and their implications for value creation. Since not all interactions co-create value, it tries to understand the reasons for these normative deviations. For activities related to the production of tangible goods (industry), increasingly supported by digital technologies common to intangible assets, S-S may become an interesting discipline at several levels. Firstly, the need for new professional profiles which can contribute to making the digital service innovation process more systematic and, therefore, a better choice of investment and business management. According to the S-S perspective, value propositions must consider simultaneously the concerns of the customers, providers, competitions, and authorities, with ecosystems' sustainability being a transversal concern in all steps of the service process. Moreover, for S-S Theory, value propositions are the basic relationship between s-systems interactions. This means it can be expected that when one stakeholder configures his resources to carry out a value proposition, all the others may evaluate the value differently.

KEY POINTS

- Information and Communication Technologies (ICT) shortens distances and dilutes the line that traditionally split services and industry.
- The Service-Dominant Logic the philosophical basis to support operation models that integrate industry and services, as is the case of I4.0. By adopting the philosophical bases and language of Service-Dominant Logic, the *Science of Services* has become a discipline applicable to both industry and service. Lines are separating these two types of activities ceasing to exist.
- Because it is interdisciplinary and, although recent, Service Science is focused on the study of service system interactions, from which the *service* results as the co-created value.
- The Key Concern Indicators have an inverse meaning to the traditional Key Performance Indicators (KPI) concept, leading to ($\mathrm{KCI} = \frac{1}{\mathrm{KPI}}$) whether concerns are qualitative or quantitative, for which the researcher must find appropriate metrics related to the main stakeholders' concerns, using the typical metrics from the disciplines forming the S-S Body of Knowledge.
- Service Science is an interdisciplinary scientific area, supported by ten pillars or scientific disciplines, understood as necessary for service interpretation and innovation among s-system entities : (i) History of Economics and Law, (ii) Marketing, (iii) Operations Management, (iv) Political Science, (v) Sustainability, (vi) Anthropology, (vii) Engineering, (viii) Computer Science, (ix) Procurement and (x) Management, whose accumulated knowledge helps to improve s-systems' efficiency.
- In this interdisciplinarity context, the professional profile of a *service scientist* there must be expertise in one of the scientific areas forming S-S but also elementary knowledge of the subject matter of all the disciplines involved in S-S, to be able to integrate a multidisciplinary S-S team fully.

CHAPTER 4

If you look at what you have in life, you'll always have more. If you look at what you don't have in life, you'll never have enough

Oprah Winfrey

4. RESEARCH METHODOLOGY AND EMPIRICAL FRAMEWORK

As part of the research, the researcher must select the right world view, also designated *paradigm* which according Guba (1990) (…) “is a basic set of beliefs that guide action as a general philosophical orientation about the world and the nature of research that a researcher brings to a study” (as cited in Creswell, 2014, p.10). The research paradigm comprises (i) the epistemology (Johnson & Onwuegbuzie, 2004), which seeks to understand the relationship between the researcher and the research reality, (ii) the ontology, which raises essential questions about the nature of reality, and (iii) the methodology with which the researcher focuses and acquires knowledge from fact (Denzin & Yvonna, 1994).

4.1 CONCEPTUAL RESEARCH APPROACH

The choice of paradigm has, therefore particular importance, since it helps the researcher to clarify the problematics of the discipline, allowing him to develop an exploratory set of models and theories and to create conditions to try to solve them (Morgan, 2007). Although assuming that their position is not consensual, for Creswell (2014), paradigms may be understood as perspectives or philosophical concepts which we may term as post-positivism, constructivism, transformative, and pragmatism (Tashakkori & Creswell, 2007) Table 4-1.

Worldview	Method	Logic	Ontology	Epistemology
Postpositivism	Quantitative	Deductive	Realism	Objective
Constructivism	Qualitative	Inductive	Relativism	Subjective
Transformative	Collaborative	Change Oriented	Power and justice oriented	Mixed
Pragmatism	Mixed	Mixed	Accepts the Reality	Mixed

Table 4-1: Philosophical Paradigms. Source: (Creswell, 2014)

Based on a deterministic worldview, while accepting that the values and prior knowledge of the researcher may affect the results, for post-positivists, it is the causes that determine the results. For proponents of this paradigm, there are laws or theories governing the world, through which, once tested and refined, we understand reality (Morgan, 2007). As a scientific method, the post-positivist approach sets out from the theory for the collection of data that support or refute this theory (Biesta & Burbules, 2000). In an opposing position, proponents of the constructivist paradigm develop varying and subjective meanings from their object-oriented experiences or things (Creswell, 2014). The constructivist researcher looks for the complexity of points of view, rather than restricting definitions to categories or ideas (Oliveira, 2010). In this sense, for constructivists the situation that is being observed or studied is confined or entrusted to the view of the participants (Mertens, 2014) who, recognizing that their own experiences shape the interpretation, position themselves during the investigation so that they can realize their interpretation will depend on their own experiences, whether cultural or historical (Bravo & Eisman, 1998). The constructivist paradigm emerged from populations of individuals who understood that post-positivist assumptions imposed structural laws and theories that did not fit with people not integrated into society and with social justice as imposed on them (Nielsen, 2006). Therefore, for constructivists, theoretical perspectives should be integrated with philosophical presuppositions (Rocco, Linda, Suzanne, & Aixa, 2003), which construct an image of the questions under analysis (Denzin & Yvonna, 1994).

A different view is taken by proponents of the transformative paradigm, for whom research must be linked to political change agendas to face social oppression, regardless of the level at which it occurs (Mertens, 2014), thus sustaining a transforming view of the world (Johnson & Onwuegbuzie, 2004). The pragmatist paradigm originally arose from Pierce's (1932) work, but only after Tashakkori and Teddlie's (1998) work has its theoretical rationale been properly structured (Tashakkori & Creswell, 2007). Accepting that truth is what happens at the moment, pragmatists reject the existence of independently constructed realities from the mind of each individual (Tashakkori & Teddlie, 2010) so that the researcher must focus on the problem, resorting to all kinds of approaches available to understand it (Rossman & Wilson, 1985). They look at what and how to research, based on the intended consequences from which (Creswell, 2014), resorting to mixed methodology, quantitative and qualitative data are used to understand the RP better, assuming as much as possible a posture that reflects social justice and political objectives which take into account issues such as sustainability (Johnson & Onwuegbuzie, 2004).

From the literature review, we find here the first point of contact between the pragmatist paradigm and Service Science Theory, for which an approach that recognizes the nature of reality as dynamic, evolutionary and interactive (Matthies & D'Amato, 2016), appears to be better tuned to the analysis of value co-creation interactions throughout the service process (Meynhardt, Chandler, & Strathoff, 2016), which must consider sustainability as transversal to all stakeholder concerns (Spohrer, Anderson, Pass, Ager, et al., 2008). Positioned between post-positivists and constructivists, for pragmatists, the process of knowledge acquisition is seen as continuous, rather than two opposing and mutually exclusive poles of objectivity and subjectivity (Rocco et al., 2003). This aspect is also in line with the S-D Logic perspective (Robert F. Lusch et al., 2016), which is, as previously stated, the philosophical basis of Service Science (S. L. Vargo & Akaka, 2009).

As in Structuration Theory (Edvardsson & Tronvoll, 2013), S-S adopts an evolutionary perspective (Spohrer, Anderson, Pass, & Ager, 2008): the process begins with the structuring of the systems, their resources, and access to them, after which, in the form of value creation, relationships are developed and engage with each other in a co-evolutionary way throughout the service process (Meynhardt et al., 2016). This philosophical approach seems to be in line with the pragmatist paradigm, for which all researching involves inductive and deductive logic (Hammersley, 2010). Similar conclusions were advanced by Perry (1998), which later became the basis of mixed methodology (Creswell, 2014).

Some authors argue that inductive logic is strictly linked to qualitative methodologies (Morgan, 2007), where the researcher starts from particular data observed, to reach a general proposition of the set of empirical reality (Hammersley, 2010), that is, general conclusions are developed from empirical observations (Ghauri, Kjell, & Ivar, 2010). In the literature review, however, this position was found not to be consensual (Mertens, 2014), since nothing prevents the researcher from using quantitative data with exploratory methods of analysis (for example, exploratory factorial analysis), starting with empirical observations and from there, explain this reality, that is, creating a theory that fits this reality (Johnson & Onwuegbuzie, 2004).

At the opposite extreme, in the deductive logic associated by some authors with quantitative methodology[6], theory is used as a guide (Hammersley, 2010), using theoretical and conceptual structures, in which the researcher starts from the general to the particular (Ghauri et al., 2010), implying the need to conceptualize a model, followed by empirical testing (Perry, 1998).

By way of theory or hypotheses, two or more concepts can be linked to a causal chain consisting of untested assertions about the relations between concepts (Quivy & Campenhoudt, 2013). However, these assertions, based on theory, will not be ready for empirical testing until the abstractions are translated into observables, that is, they need to be conceptualized previously (R. K. Yin, 2013). For Perry (1998), conceptualization is the formulation of a theoretical argument, studying the theory and deducing conceptual structures which will be evaluated through the collection of appropriate data (Blaikie, 2000).

Based on the researcher's different approaches to data collection and analysis, there are three formats of mixed research methodologies: convergent parallel, explanatory sequential, and exploratory sequential (Creswell, 2014). The explanatory sequential mixed methodological approach involves two phases. The researcher begins by collecting the quantitative data and analyses the results which he uses to construct the qualitative phase. A typical way of using this methodology is to carry out a quantitative survey followed by its analysis, after which qualitative interviews are conducted to help explain the results of the survey (Mertens, 2014).

On the other hand, in exploratory sequential mixed methodology, the researcher starts with the qualitative phase, followed by the quantitative phase, so the strategy is to test forms of measurement from small specific population samples (qualitative phase) and check whether the data obtained can be generalized to a representative sample of the population (quantitative phase) (Tashakkori & Teddlie, 2010).

Contrary to the previous two mixed methodologies, in the convergent parallel method, the researcher collects quantitative and qualitative data, sometimes simultaneously,

[6] This position, although defended by some authors, is not consensual because nothing prevents the researcher from starting from theory to formulate hypotheses and then using qualitative methods to evaluate the applicability of theory itself (i.e., it is about using deductive logic by applying qualitative methods).

which, once analyzed, are compared. The objective is to complement the information and, consequently, confirm the results or otherwise (Rocco et al., 2003). The key assumption of this approach is that both qualitative and quantitative data provide different types of information - often detailed insights of participants qualitatively and scores on the instruments quantitatively - and together produce results that should be the same (Creswell, 2014).

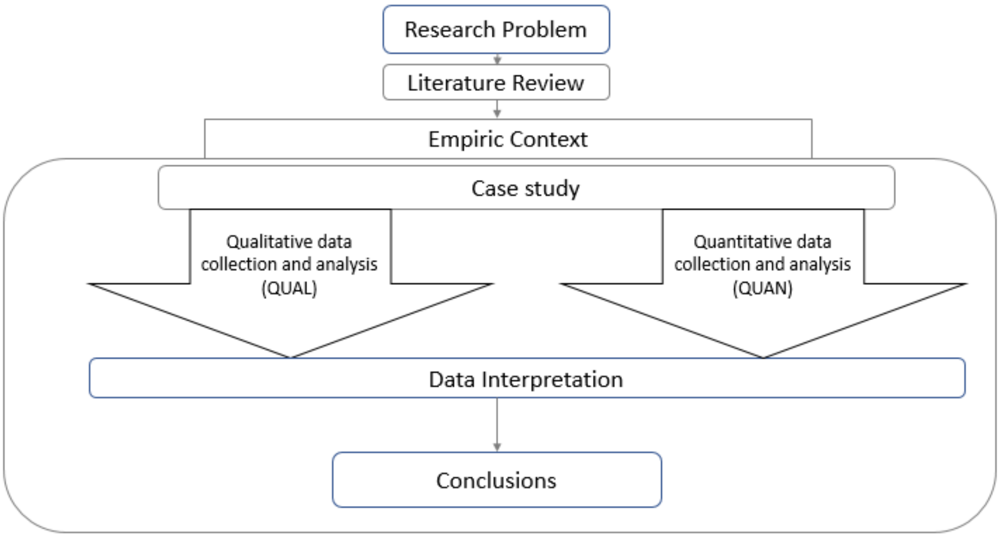


Figure 4-1: Parallel Convergent Mixed Methodology. Source: (Akwei, Peppard, & Hughes, 2010)

As we found in the literature review, Service Science is based on the study of the value co-creation interactions between service systems (Storbacka, Brodie, Böhmann, Maglio, & Nenonen, 2016), namely the quantification and qualification of stakeholders' concerns during the service process. The investigation proposed in this thesis will follow the pragmatist paradigm in the methodological format of convergence in parallel (Figure 4-1).

4.2 EMPIRICAL RESEARCH

Guided by the pragmatist paradigm, the fundamental challenge of this research is to describe, provide the foundations for, and make a confirmative empirical test of an empirical framework supported by the Service Science Body of Knowledge. Following S-S Theory, conceptualization of the empirical framework must parameterize the stakeholders concerns and the metrics to be used in data collection, according to the objectives (Maglio & Spohrer, 2008), making it possible to assess the potential competitiveness impact on a set of European Blue Economy, when they decide to introduce part or all the available Industry 4.0 (I4.0) Technologies**.**

The literature review revealed that from 2010, the empirical research related to digital processes and ICT was intense, the emergent paradigm of I4.0 being referred to very often from 2011. However, despite all this investigation oriented to the digitization of processes, there has been little study of the impacts of the transition from traditional production processes to digital processes (Drath & Horch, 2014), and there is almost no scientific literature about the effects of this transition on specific threats identified in companies, clusters or ecosystems. Ford (2015), for example, considers the interests behind the "mainstream I4.0" to be partial, to the point of finding “The benefits and return on investment (ROI) are not as black and white as you might think, and the engineers would like them to be. Industry 4.0: Who Benefits?" (Ford, 2015, p.30).

Although the digitization of processes is a cross-cutting paradigm for all areas of the economy, the literature review shows there is a shortage of authors describing digitization in an interdisciplinary way, and even fewer describing I4.0 from the Service Science perspective.

The European Union Blue Economy Reports (2018 and 2019) have identified the enablers behind the sustainable Blue Economy Growth (Eikeset et al., 2018; Hadjimichael, 2018; Howard, 2018; Pinto et al., 2015; Soma et al., 2018) : (i) common skills, (ii) shared infrastructure, (iii) sustainable use of the sea, (iv) environmental protection, (v) maritime spatial planning, (vi) maritime security, and (vii) marine data (European Union, 2018, 2019).

4.2.1 Main Research Objective

Supported by Service Science, the main objective of this research is to conceptualize a framework to assess the impact on sustainable competitiveness of the EU Blue Economy if companies incorporate I4.0 Technologies both in established and emerging sectors.

According the S-S theory, as observed in the literature review, the impact of innovation on processes should be measured through the *Innovation Outcome*[7] (IO) concept (Spohrer, 2007), which results from the evolution of the main stakeholders’ concerns,

[7] Innovation Outcomes means the innovation results in Service Science

designated in this thesis as Key Concern Indicators (KCIs), inverse to the traditional concept of KPIs ($\text{KCI} = \frac{1}{\text{KPI}}$). By applying the mixed parallel methodology to assess the impact, this research will follow these steps:

1. For each sector of the Blue Economy, it is intended to interview at least one European company per activity, grouping them into sectorial case-studies.
2. For each company interviewed, it is intended to collect and record quantitative and qualitative data at the same time, following the questionnaire guidelines.
3. Assess the contribution of each I4.0 technology to strength the European Blue Economy Enablers.
4. Assess the impact of the I4.0 Technologies, on the Blue Economy Sectors.
5. Assess the impact of the I4.0 on the European Blue Economy if companies incorporate I4.0 Technologies

Using mixed parallel convergent methodology, KCIs will be proposed, supported by Service Science Theory, and to determine these, data will be collected from a set of Case-studies in order to reach a general proposition of the empirical situation as a whole.

4.2.2 Research Questions

From the literature review, but also our own daily experiences, the digitization of the economy appears to be unavoidable (E.Weisberg David, 2008). However, this change requires investments, sometimes massive, especially when this involves digitizing production processes (Lasi et al., 2014). These concerns are frequently raised by corporate managers in order to put pressure on ensuring that their proposed investments respond to the problems or threats faced by their organizations, and converge on the recommendations described in the Financing Europe's Investment and Economic Growth Report (2014), it is necessary to mitigate the risk associated with investment uncertainties (Llewellyn Consulting, 2014), and from which we can formulate the **Research Problem**:

What competitiveness impact on the European Blue Economy if companies adopt the Industry 4.0 Technologies?

Supported by the Research Problem, which is the core of this research, it is crucial to define the specific Research Questions (RQs) to be studied, which for some authors is the most crucial stage in a research study (R. K. Yin, 2013), addressing Industry I4.0 from the Service Science perspective, the following RQs were identified regarding the Blue Economy stakeholders:

(i) RQ1 | What contribution can I4.0 Technologies do to strength the European Blue Economy Enablers?
(ii) RQ2 | What Enablers Relevancy for the EU Blue Economy if companies incorporate I4.0 Technologies on their activities?
(iii) RQ3 | What Impact of I4.0 Technologies on each one of the European Blue Economy Sector?

In addition to the empirical contributions from the answers to these RQs to European Blue Economy companies, a scientific approach to the co-creation may also contribute to consolidating Service Science Theory, and assist to mitigate the investment risks associated with the very early stages of digital production, in relation to more environmentally friendly consumption and more sustainable Blue Economy.

4.3 EMPIRICAL FRAMEWORK

According to some authors, a Framework can be defined as a set of interrelated objectives and fundamentals, where the objectives identify the goals, and the fundamentals are the underlying concepts that assist in achieving those same goals (Meynhardt et al., 2016).

Looking at the Enablers identified in Chapter 2 and following the convergent parallel methodology supported by Service Science, this Chapter will conceptualize the empirical framework, requiring the selection and adaptation of the methodological tools, as well as clarification of the Indicators related to the four main stakeholders' Concerns (S. Vargo & Lusch, 2016). Supported by Service Science Theory we will construct the framework throughout this Chapter, the Pragmatist Paradigm providing the guidelines for the selection and collection of data, the circumstances, and baselines in which they will be used, and how they will be measured, summarized and interpreted (Breidbach & Maglio, 2016).

From the literature review, it was concluded that for Service Science, just as there is no separation between tangible and intangible goods, nor is there any "value creator" versus "value destroyer", since all social and economic actors are resource integrators as expressed by FP9[8] S-D Logic (R. F. Lusch & Vargo, 2008). Entities such as suppliers, customers, families, or any other actors involved in economic activities are “exchange service entities” with the common purpose of co-creating value. It is all B2B (S. L. Vargo & Lusch, 2010). In contrast to S-D Logic (Robert F. Lusch, Vargo, & Tanniru, 2010) but in line with Service Science, it will be assumed by the Inov4.0|F that there is a clear distinction between the four different types of main actors involved in co-creation interactions (Spohrer et al., 2007), also considering that all stakeholders will be value co-creators engaged in the service exchange along the service process (Maglio et al., 2009; Storbacka et al., 2016).

4.3.1 The Selection of the case-studies

As described above, although the term “Blue Economy” has been used in different ways, it is understood here as comprising the range of economic sectors and related policies that together determine whether the use of oceanic resources is sustainable. For this research, the EU’s Blue Economy encompasses all sectoral and cross-sectoral economic activities related to the oceans, seas, and coasts, including those in the EU’s outermost regions and landlocked countries. This includes the closest direct and indirect support activities necessary for the sustainable functioning and development of these economic sectors within the single market. It comprises emerging sectors and economic value based on natural capital and non-market goods and services. This definition is entirely in line with the definitions adopted by the OECD (OECD, 2019) and the World Bank (World Bank, 2017). The EU-28 GDP was estimated at €13,750 billion in 2017 and employment at 222 million people. The Blue Economy established sectors contributed 1.3% to the EU economy and 1.8% to the EU employment, in 2017, the highest value over the time series (European Union, 2019). The UK, Spain, Italy, France, and Greece have Europe's biggest blue economies. Spain accounts for one-fifth of total employment, followed by Italy, the United Kingdom and Greece. Combined, these four Member States account for more than half of the complete blue economy-related jobs (European Union, 2018).

Among the different sectors, that of the “living resources” (i.e., fisheries, aquaculture, and processing) has grown by 22% between 2009-2016. Increased sustainability, thanks to the EU common fisheries policy, plays an essential role in this positive development.

[8] Service Dominant Logic Nineth Fundamental Premise (S. Vargo & Lusch, 2016)

Also, the emerging sectors are booming. The biotechnology sector marks double-digit growth in member states such as Ireland, and employment in the offshore wind industry has jumped from 23.7 thousand in 2009 to 160 thousand in 2016, outnumbering work of the EU fishing sector. In this connection, European Blue Economy is probably formed of more than one hundred thousand companies operating in the global market, so we may consider these companies as the first group to evolve their operations to Industry 4.0, and so, this may be considered the population on this research.

The traditional meaning of sample size is related to its external validity (Robson, 1995). As this research is not intended to make statistical inferences, i.e., extract assumptions from a sample for a population, there is no concern in discussing the size (Fitz-Gibbon and Morris in Silva, 2002). However, in the case of studies, the theoretical replication becomes stronger, the larger the number of instances (Silva et al., 1999). In this research, 11 study cases were considered. Given the specificity of this study and as proposed in the Methodology Chapter, the case-studies must be of convenience. The companies must be selected intentionally from the population of the European Bleu Economy and grouped in different case-studies, according to their activities and according to the following criterions:

(i) as the first selection criterion, the company must have the headquarter located in the European Union territory and operate in the Blue Economy business; (ii) as the second selection criterion, it will be considered its the level of internationalization; (iii) as the third selection criterion, its historical participation in European R&D Projects; and finally, (iv) for the strict purposes of this research, the companies managers must accept to be interviewed by the researcher.

This has been a hard task, involving several trips to the countries where these competitors have their head offices. Constitution of the case-studies was, therefore, complicated, only possible with the collaboration of all companies, with which there was always a permanent constructive dialogue for almost than 12 months. The selected companies were grouped in different case-studies according to their business activity. Each one of these groups will be for this research propose, Case-study.

4.3.2 Data Collection Procedures and Analysis Units

The key benefit of mixed methodology is the possibility of collecting qualitative and quantitative data (Creswell, 2014) by using parallel constructs, variables, and concepts, to obtain complementary information that leads to greater certainty of results (Creswell, 2014; Tashakkori & Teddlie, 2010). Thus, following these principles, qualitative and qualitative data can be observed from sources such as interviews, visual observations, documents, and records, measuring instruments, observable checklists, or even numerical records, among others (Creswell, 2014).

The primary technique for collecting primary data was semi-structured interviews. The use of this technique is because the researcher wants respondents to explain their answers. This type of exercise is of particular importance in interpretive epistemology, where it is hoped to understand the meaning that participants attach to various phenomena (Saunders, Lewis, & Thornhill, 2009). The same author also states that these types of interviews are employed in exploratory case-studies.

Before conducting interviews, and according to some authors advise (Saunders et al., 2009), a script was developed with several questions to be addressed in the interviews. Also, according to Patton (1987), the interview guide acts as a checklist that “provides” topics or thematic areas on which the interviewer is free to explore in any way he or she understands, to ask the questions that elucidate and illuminate the subject. Purpose of the investigation (R. K. Yin, 2013). Also, according to the same author, there is no specific order to address the issues, the interviewer is free to build the conversation spontaneously, but with focus on the predetermined subject. To further explore some issues, we sought to encourage respondents to talk about topics that were not covered in this script, as suggested by Patton (1987) and Yin (2009). However, contrary to what Saunders et al. (2009) advise, the audio of the interviews was not recorded, as it was considered that this would inhibit the interviewee and remove wealth from the interview. At the beginning of each interview, the start time, the place of the interview, and the position of the interviewee were recorded. At the end, their duration and relevant considerations were recorded. In order to facilitate and ensure the success of the research, companies with an innovative profile and strong links to the academic environment were selected. Therefore, investigator judgment was used to choose the case-studies. Given the theme of the study, interviews were conducted with directors and officers of various Blue Economy company´s departments.

In addition to the interviews, visits were made to the companies' premises, where, according to the terminology of Saunders et al. (2009), the researcher assumed the role of full observer and observed the operation of his business, thus collecting primary data. Secondary data were also raised by consulting the documents and websites of the study companies. Based on the use of different data sources, it is thus possible to perform data triangulation (Saunders et al., 2009).

4.3.3 Qualitative (KCI_{QUAL}) and Quantitative (KCI_{QUAN}) Key Concern Indicators

The framework will be conceptualized under the support of the Service Science Theory and using Mixed Methodology rules (Tashakkori & Creswell, 2007), and thus, the qualitative *Key Concern Indicators* (KCI_{QUAL}) will represent the stakeholders' concerns, such like feelings and opinions under the form of answers to a non-structured questionnaire (Creswell, 2014; Tashakkori & Teddlie, 1998).

For each case study, the data record will be drawn up Table 4-2. This table is therefore the instrument for recording the interviewer's (researcher) opinion (feelings) based on the respondent's (stakeholder) concerns as well as the shop-floor observations, recorded in terms of two possible outcomes Table 4-3: (I) "*KCI-BE-enabler-concern-reduction*" meaning that in relation to each stakeholder, the interviewer inferred that the **respondent's concerns** are reduced when they adopt the I4.0 Technologies; (II) "*KPI-BE-enabler-weight*" meaning that in relation to each stakeholder, the interviewer inferred that the respondent's weight (importance) of the Blue Economy Enabler for each Sector is: (i) no important (Enable-weight=0); (ii) important (Enable-weight=1) and, (iii) very important (Enable-weight=2) Table 4-4.

Case-Study Relief (%) related to the I4.0 technologies (QUAN)	Big Data e Data Analytics	Autonomous Robots	Virtual Simulation	Horizontal and Vertical Integration in Industry 4.0	Internet of Things	Cyber Security	Cloud Computing	Additive Manufacturing	Reality Augmented	IO-I4.0-Tech-Relevancy-to-each-Enabler
$KCI_{\text{Common Skills enabler (QUAN)}}$										
$KCI_{\text{Shared Infrastructure (QUAN)}}$										
$KCI_{\text{Sustainable use of the sea (QUAN)}}$										
$KCI_{\text{Environmental Protection (QUAN)}}$										
$KCI_{\text{Maritime Spatial Planning (QUAN)}}$										
$KCI_{\text{Maritime Security (QUAN)}}$										
$KCI_{\text{Marine Data (QUAN)}}$										
Average Impact of each I4.0 Technology										
Level of Enabler weight to the Sector (QUAL)			Common Skills	Shared Infrastructure	Sustainable use of the sea	Environmental Protection	Maritime Spatial Planning	Maritime Security	Marine Data	
KPI-BE-enabler-weight										

Table 4-2: Recording the interviewer's opinion based on the respondent's (stakeholder) concerns together with shop-floor observations

BLUE ECONOMY ENABLER KCI QUESTIONNAIRE GUIDELINES	***ENABLER*** CONCERNS REDUCTION IF COMPANIES DECIDE TO USE I4.0 TECHNOLOGIES (QUANT)
What "Big Data e Data Analytics" may reduce your concerns related to the Blue Economy Enabler (…)?	*KCI-BE-enabler-concern-reduction*
What "Autonomous Robots" may reduce your concerns related to the Blue Economy enabler (…)?	*KCI-BE-enabler-concern-reduction*
What "Virtual Simulation" may reduce your concerns related to the Blue Economy enabler (…)?	*KCI-BE-enabler-concern-reduction*
What "Horizontal and Vertical Integration" may reduce your concerns related to the Blue Economy enabler (…)?	*KCI-BE-enabler-concern-reduction*
What "Internet of Things " may reduce your concerns related to the Blue Economy enabler (…)?	*KCI-BE-enabler-concern-reduction*
What "Cyber Security" may reduce your concerns related to the Blue Economy enabler (…)?	*KCI-BE-enabler-concern-reduction*
What "Cloud Computing " may reduce your concerns related to the Blue Economy enabler (…)?	*KCI-BE-enabler-concern-reduction*
What "Additive Manufacturing " may reduce your concerns related to the Blue Economy enabler (…)?	*KCI-BE-enabler-concern-reduction*
What "Reality Augmented" may reduce your concerns related to the Blue Economy enabler (…)?	*KCI-BE-enabler-concern-reduction*

Table 4-3: Blue Economy Enabler Concerns Reduction | Quantitative Questionnaire Guidelines

BLUE ECONOMY ENABLER LEVEL OF IMPORTANCE TO EACH SECTOR - QUESTIONNAIRE GUIDELINES	ENABLER LEVEL OF IMPORTANCE INDICATOR (NOT IMPORTANT; IMPORTANT and VERY IMPORTANT)
How important is the Common Skills to your business"?	*KPI-BEenabler-weight = (NOT IMPORTANT; IMPORTANT; VERY IMPORTANT)*
What relevant is the "BE Shisd Infrastructure enabler" to your business"?	*KPI-BEenabler-weight = (NOT IMPORTANT; IMPORTANT; VERY IMPORTANT)*
What relevant is the "BE Sustainable use of the sea enabler" to your business"?	*KPI-BEenabler-weight = (NOT IMPORTANT; IMPORTANT; VERY IMPORTANT)*
What relevant is the "BE Environmental Protection enabler" to your business"?	*KPI-BEenabler-weight = (NOT IMPORTANT; IMPORTANT; VERY IMPORTANT)*
What relevant is the "BE Maritime Spatial Planning enabler" to your business"?	*KPI-BEenabler-weight = (NOT IMPORTANT; IMPORTANT; VERY IMPORTANT)*
What relevant is the "BE Maritime Security enabler" to your business"?	*KPI-BEenabler-weight = (NOT IMPORTANT; IMPORTANT; VERY IMPORTANT)*
What relevant is the "BE Marine Data enabler" to your business"?	*KPI-BEenabler-weight = (NOT IMPORTANT; IMPORTANT; VERY IMPORTANT)*

Table 4-4: Blue Economy Enabler Level of Importance | Qualitative Questionnaire Guidelines

4.3.4 Conceptualization and Application Procedures

Mixed methodology is an approach to the subject guided by the pragmatist paradigm, which involves the collection and analysis of quantitative and qualitative data, aiming at a better understanding of the RP (Creswell, 2014).

Emerging in the late 1990s (Tashakkori & Teddlie, 2010), mixed methodology resulted from investigations in different fields, such as assessment, education, management, sociology and health sciences, among others, going through various periods of development, including philosophical debates, procedural stages and, more recently, through reflective positions raised from controversies and debates (Creswell, 2014). The literature review revealed that mixed methodology is usually seen as a way to minimize the limitations of strictly qualitative and quantitative approaches, allowing a sophisticated and complex approach to the research problem (Sequeira, 2010), and this seems to be a convenient approach to the new scientific discipline of Service Science. As previously stated, this thesis will follow the pragmatist paradigm guidelines, benefiting from the inductive, and deductive advantage of the mixed methodological approach from the parallel convergence perspective (Creswell, 2014).

Using the guidelines provided by the pragmatist worldview, S-S research requires methods and tools able to provide innovative configuration of stakeholder resources in the deepest possible way, since the outcomes result from their interactions. In this sense, Convergent Parallel Mixed Methodology, by allowing the simultaneous collection of qualitative and quantitative data, seems to match the Service Science methodological sequence effectively: (i) describe a case study by sector of the European Blue Economy; (ii) collect data and assess stakeholder Key Concern Indicators (KCI) evolution; (iii) for each EU Blue Economy Enabler, assess the relevancy (IO) of each of the I4.0 Technologies; (iv) assess the Innovation Outcomes (IO) resulting from the introduction of each of the I4.0 Technologies in each of the EU Blue Economy sectors; (v) based on the IO, assess the competitivity impact on each EU Blue Economy sectors, if the companies in those same sectors incorporate I4.0 Technologies; (vi) assess the competitivity impact on EU Blue Economy if companies include I4.0 Technologies.

4.4 QUALITY ASSURANCE OF RESEARCH

To avoid biased analysis of findings, four types of tests are used: (i) construct validity; (ii) internal validity for explanatory purposes; (iii) external validity and; (iv) reliability (T. Lee, 1999). In the case of the case study research strategy, the above tests are valid to assert it's quality (R. K. Yin, 2013).

4.4.1 Construct Validity

Construct validity refers to the measures, instruments, and processes that operationalize the research constructs (R. K. Yin, 2013). Validity is concerned with how well the concept is defined by measurement (Hair et al., 1995). As a result of this operationalization, result patterns must be defined (Tashakkori & Creswell, 2007). To increase certainty about the validity of the construct, Yin (2013) lists a set of tactics to use: (i) use of multiple sources of evidence; (ii) establish a chain of evidence and; (iii) have key informants who analyze the case report.

To meet the first tactic evidenced by Yin (2013), we attempted to conduct semi-structured interviews with more than one member of the same organization, also made direct observation on company premises, and consulted documents (internal and external). And company websites. To meet the second tactic, and since this study is deductive, a reference model was defined a priori, and its validity, adequacy, and usefulness were tested during the interviews by discussing the propositions. Finally, to address the third tactic that ensures construct validity, interview reports were sent to interviewees to confirm and review their responses, thus ensuring that the investigator did not misunderstand the information given by the interviewee. Top managers such as CEO's or company Technical Managers were interviewed.

4.4.2 Reliability

Reliability refers to how data collection techniques employed in research allow for consistent results to be produced (Saunders et al., 2009). Security can also be seen as the possibility of achieving the same results with the study by a third party (R. K. Yin, 2013).

Concern about reliability in interviews relates to bias problems (Easterby-Smith, M. Thorpe, R. Jackson P. e Lowe, 2008). According to Saunders et al. (2009), there are several types of bias to consider. The first of these concerns the interviewer's bias. Interviewer comments, tone of voice, or nonverbal behavior bias the way respondents respond to questions. There may also be the second type of bias that concerns the way the interviewer interprets the respondent's answers, i.e., the interviewer may not understand the answers correctly.

Participating in an interview is an intrusive process (Saunders et al., 2009). According to the same author, this is especially true in the case of semi-structured interviews, where the objective is to explore events or seek explanations. The very nature of the interview may create some bias, as the lack of standardization of these interviews may lead to reliability concerns. The interviewee may, in principle, be willing to participate but may nevertheless be sensitive to unstructured exploration of specific topics. The interviewee may, therefore, choose not to disclose and discuss one aspect of the issue that the investigator wishes to consider, and as a result, the interviewee provides a partial "picture" of the situation or organization he represents. Another type of bias may be bias resulting from the nature of the individuals or organizational participants who agree to be interviewed (Saunders et al., 2009).

In the specific case of this investigation, as the interviewee was previously informed about the interview guide, the interviewee's bias is not willing to participate because if it were not in his interest to answer these questions would not accept the invitation to interview. Also, in this sense, as an intentional sample was selected, a priori, the companies participating in the case study already demonstrated some openness/potential to collaborate, which reduces the risk of bias due to the respondent's unwillingness to cooperate.

To reduce the interviewer's bias, the interviewer trained the interviews several times and prepared for multiple scenarios to minimize this potential. During the interview, the critical incident technique was used, i.e., whenever possible, the questions were based on participants' real-life experiences (Saunders et al., 2009).

On the same day, or the day after the interviews, all the information collected was cleared, and thematic areas grouped the info. By doing this division, it was possible to gather the knowledge of all interviews into categories and clusters of information, which facilitated the development of conclusions about the study.

To increase the reliability of the investigation, we resorted to data triangulation. Triangulation refers to the use of different data collection techniques within the same study to ensure that the data means what the researcher is considering they mean, for example, observation on company premises and consultation of corporate documents and websites (R. K. Yin, 2013). The triangulation of data in this investigation also contributed to improve its reliability, for example, to reduce the bias of the interviewee not providing the correct information. We tried to interview more than one person from the same organization, where sensitive questions were repeated.

4.4.3 External Validity

External validity refers to the generalization of research findings from a specific study to all relevant contexts (Saunders et al., 2009). i.e., whether the results of a survey can be equally applicable and valid to other organizations or research contexts.

In the concrete case of this investigation, the objective is to explain what is happening in a specific research configuration. Hence the sample is intentional, and the case study is cross-sectional. Thus, it is not intended to produce a generalizable theory for the entire population, so the results and conclusions of this research aim to explain a specific context. Thus, according to Yin (2013), it makes no sense to evaluate research for its external validity in terms of statistical generalizations. Still, according to the same author, an analytical generalization can be made for companies in a similar situation to those selected. If there is a literal replication of the study, which explains the theory as an explanation of the phenomenon, the credibility of these results increases as the number of replications by other case-studies improvements (Silva et al., 1999).

4.5 INNOVATION OUTCOMES (IO) AND COMPETITIVENESS

As observed in the literature review, for S-S Theory, the Innovation Outcomes (IO) represent the variation observed in the KCI indicators, resulting from the innovations along the service process (Edvardsson & Tronvoll, 2013). Therefore, for the empirical framework, stakeholders' concerns will be qualified and quantified based on the right metrics for each of the KPI_{QUAL} and KCI_{QUAN}, and so it is possible to assess each result before and after the innovation, with these differences, according to S-D Logic (Robert F Lusch & Nambisan, 2015), and consequently accepted by S-S, being called Innovation Outcomes (IOs) (Kwan et al., 2016).

4.5.1 Step 1 - strengthening the European Blue Economy Enablers

Once the framework is applied to a set of 11 case-studies, the *IO related to the I4.0 Technologies relevancy*, for each one of the Blue Economy Enabler, must be assessed as follows:

$$IO_{I4.0\text{-}Tech\text{-}Relevancy\text{-}to\text{-}each\text{-}Enabler} = avg\ (\Delta\ KCI_{BE\text{-}Enabler\ (QUAN)})$$

(Equation 5.1)

4.5.2 Step 2 - relevancy of each one of the I4.0 technology, on the stakeholder activity

By using the weight of the Blue Economy enablers collected from the interviews, the IO related to the *Enablers Improving Relevancy,* for each one of the Blue Economy Sector, must be assessed as follows:

$$IO_{BE\text{-}Enablers\text{-}Relevancy\text{-}to\text{-}each\text{-}BE\text{-}Sector} = (IO_{I4.0\text{-}Tech\text{-}relevancy\text{-}to\text{-}each\text{-}Enabler} \times KPI_{BE\text{-}Enabler})$$

(Equation 5.2)

4.5.3 Step 3 - impact on the I4.0 Technologies, on the Blue Economy Sectors

From the Innovation Outcomes as assessed by Equation 5.2, considering the evolution of the Blue Economy Enablers on each Sector, the *Impact on the sectors because of using the I4.0 Technologies*, must be assessed as follows:

$$EU\text{-}BE\text{-}Sector_{Competitivity\text{-}Impact} = avg\ (IO_{I4.0\text{-}Tech\text{-}Relevancy\text{-}to\text{-}each\text{-}BE\text{-}Sector})$$

(Equation 5.3)

4.5.4 Step 4 - impact on the I4.0, on the European Blue Economy

Without considering the important data of contribution of each sector for the European Global Economy, from the above Innovation Outcomes assessment, the Competitiveness Impact of I4.0 on the European Blue Economy, must be assessed as follows:

$$EU\text{-}BE_{Competitivity\text{-}Impact\ =}\ avg\ (EU\text{-}BE\text{-}Sector_{Competitivity\text{-}Impact})$$

(Equation 5.4)

4.6 CHAPTER SYNTHESIS

In this Chapter, was described as the methodology to be used in this research. From the Research Problem (RP), the Research Questions (RQ) have been formulated. The objectives were stated based on the conceptualization of an empirical framework through the lens of Service Science, which, once applied to empirical case-studies, must provide sufficiently robust results to respond to the RQs formulated. Supported by Service Science Theory, this research will be carried out by using a mixed methodology parallel and convergence, guided by the pragmatist paradigm.

Also, in this Chapter has been identified the population to be studied, the criteria applied in forming the convenience case-studies, and the procedures for collecting qualitative and quantitative data, with which the stakeholders' Concern Indicators (KCI) will be determined, according to Service Science Theory. Finally, we present the selected methodological sequence to be adopted in Chapter 5, from which is expected expect to get results robust enough to answer the RQs and thus lead us to a solution to the RP.

KEY POINTS

- **Research Problem:** What competitiveness impact on the European Blue Economy if companies adopt the Industry 4.0 Technologies?
- **Research Questions:** RQ1 | What contribution can I4.0 Technologies do to strength the European Blue Economy Enablers? RQ2 | What Enablers Relevancy for the EU Blue Economy if companies incorporate I4.0 Technologies on their activities? RQ3 | What Impact of I4.0 Technologies on each one of the European Blue Economy Sector?
- **Research Objective:** Supported by Service Science, the main objective of this research is to conceptualize a framework to assess the impact on sustainable competitiveness of the EU Blue Economy if companies incorporate I4.0 Technologies both in established and emerging sectors.
- **Methodology:** guided by the pragmatist paradigm and supported by Service Science Theory, this research will be carried out by using a mixed methodology parallel and convergence.

CHAPTER 5

Your time is limited, so don't waste it living someone else's life. Don't be trapped by dogma – which is living with the results of other people's thinking

Steve Jobs

5. CONFIRMATIVE STUDY: EMPIRICAL TEST

By using the Pragmatist Worldview guidelines and Parallel Convergent Mixed Methodology supported by Service Science Theory, the purpose of this Chapter is to apply the framework, as conceptualized in Chapter 4, to a set of case studies related to the European Blue Economy.

5.1 CASE-STUDIES ANALYSIS

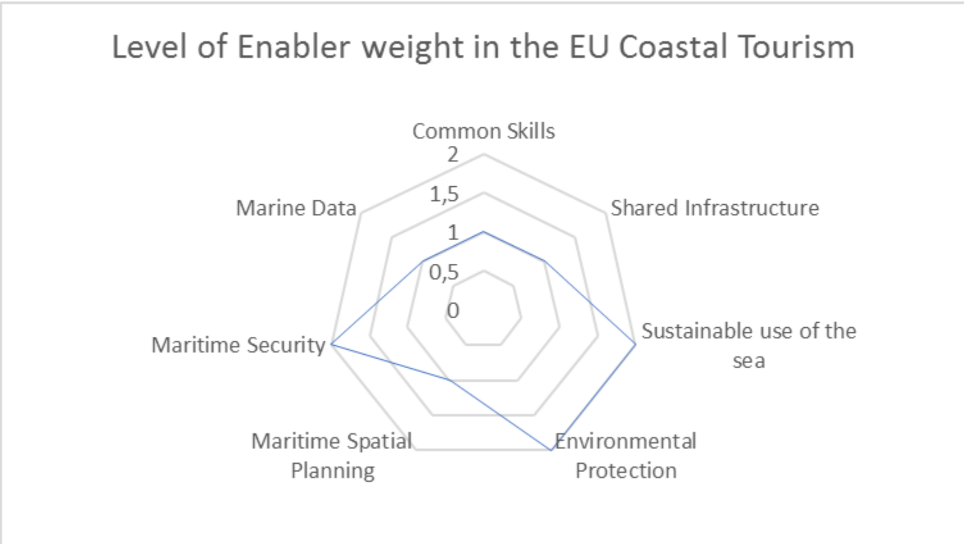
5.1.1 Case-study 1 | Coastal Tourism Sector

Coastal tourism covers water-based activities such as tourism and recreational activities, ex. swimming, sunbathing, and other activities for which the proximity of the sea is an advantage, such as coastal walks and wildlife watching and the maritime tourism covering water-based activities such as nautical sports, such as sailing, scuba diving and cruising (European Union, 2019).

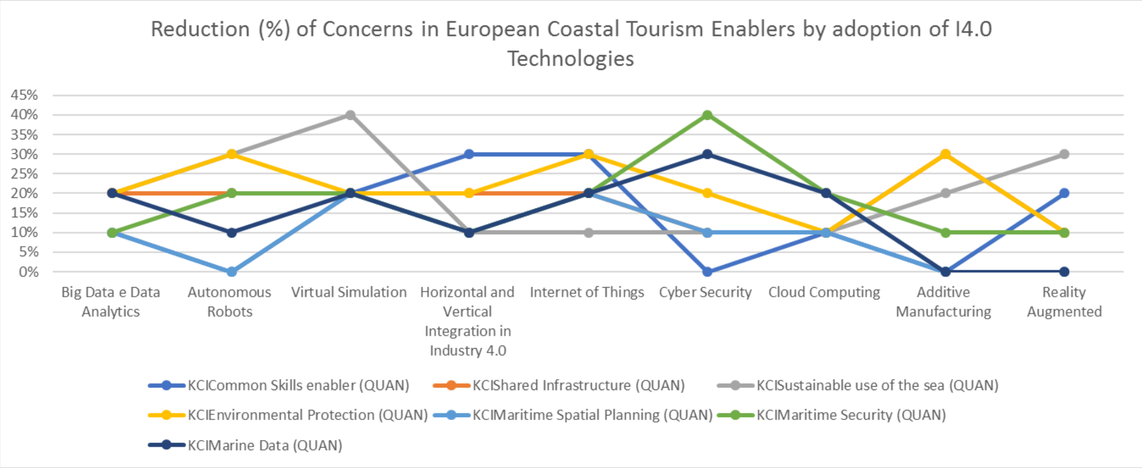
Around 2.2 million people were directly employed in EU countries by this sector (up by 13.5% compared to 2016) (European Union, 2018). Personnel costs reached €41.7 billion, up from €37.2 billion in 2009, amounting to an average wage of €19,800 in 2017, a slight increase from €19,100 in 2019 (European Union, 2019). The sector was impacted by the global economic and financial crisis, which saw a gradual decrease in employment over the period 2009 to 2015. However, in the last two years, an active recovery can be seen. Personnel costs have followed a similar trend; hence, average wages have remained relatively stable during the period (European Union, 2018). Improvements in technology, including transport, ex. Tourist submarines, and recreational technology, ex. scuba diving, have also made the oceans more accessible to tourists than ever before (Hall, 2001), (Kathijotes, 2013). For example, marine parks, coral reefs, and areas which are in relatively easy reach of scuba divers have come to be widely regarded by governments and the private sector as significant natural resources that can be developed through tourism (European Union, 2018).

For this case-study it was invited six companies to participate in this survey, representing the six main activities of Coastal Tourism. All these companies with the headquarter located in the European Union territory are internationalized and operating in the Blue Economy, exporting services to the international market for the last five years, and have participated in at least one European R&D Project in the previous eight years. The interviews have been done by phone or during personal visits - Table Appendix B. 1.

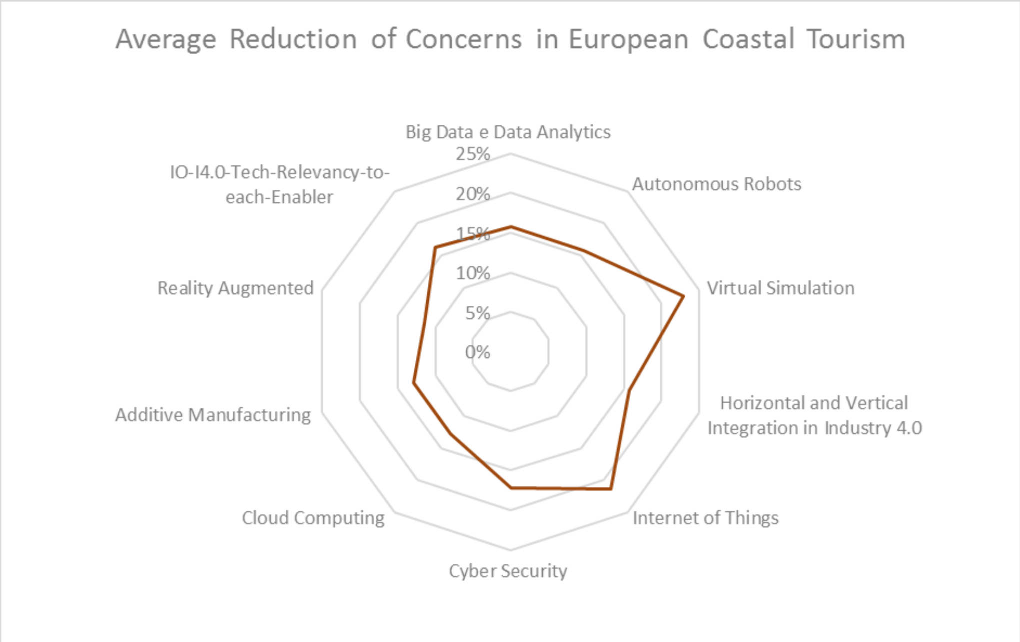
The data was collected from the six selected companies, one by one, in different days - Table Appendix B. 2, which shows the average KCI and KPI data collected only, to reduce the number of tables on this document - Graphic Appendix B. 1.



Graphic: 5-1: CS#1 | EU Coastal Tourism | Level of the Enabler Weight



Graphic: 5-2: CS#1 | EU Coastal Tourism | Concerns Relief (%) related to the I4.0 Technologies (QUAN)



Graphic: 5-3: CS#1 | EU Coastal Tourism | Enablers average Reduction of Concerns due to I4.0 Technologies introduction on their Activities

Coastal and maritime tourism depend highly on right environmental conditions and good water quality. Any maritime or land-based activity deteriorating the environment can negatively affect tourism. Coastal areas may also be directly or indirectly affected by several climate change-related impacts, such as flooding, erosion, saltwater intrusion, increase in air and seawater temperatures, and droughts. Synergies may emerge through alternative activities, including eco-tourism and marine protected areas. Co-existence with other Blue Economy sectors, such as extraction of living and non-living marine resources, may depend on direct spatial conflicts, while synergies may also exist. For example, renewable energies such as offshore wind farms may help to mitigate environmental impacts by reducing carbon and other greenhouse gas emissions but may imply a trade-off with aesthetic benefits (European Union, 2019).

5.1.2 Case-study 2 | Extraction and Commercialisation of Marine Living Resources

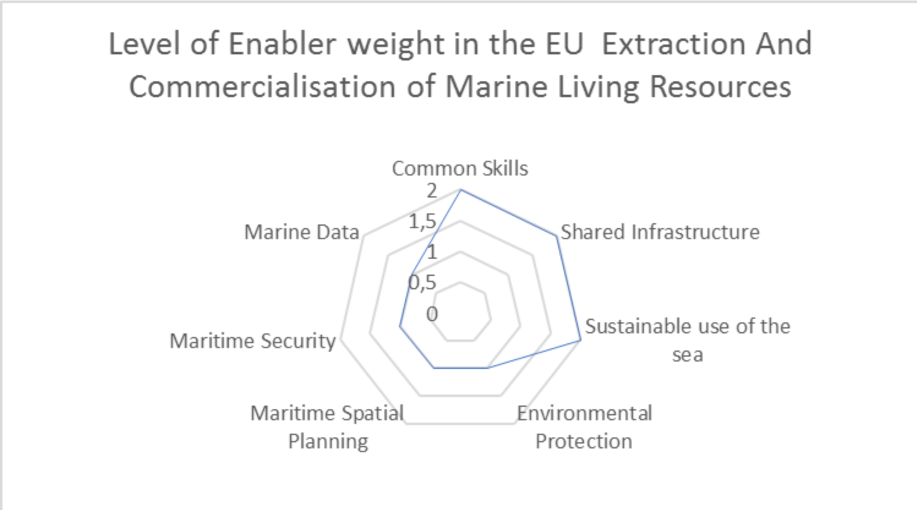
The extraction and commercialization of marine living resources encompass the harvesting of renewable biological resources (primary sector), their conversion into food, feed, bio-based products and bioenergy, and their distribution along the supply chain. For the purpose of this report, Marine living resources comprises three subsectors, further broken-down into activities; capture fisheries (small-scale coastal and large-scale industrial fleets), aquaculture (marine finfish, shellfish and freshwater) and processing and distribution (processing and preservation of fish, crustaceans and molluscs, retail sale, wholesale, prepared meals, oils and fats, and other food products) (European Union, 2018). The EU is the largest importer of seafood in the world. Its self-sufficiency in meeting a growing demand for fish and aquaculture products from its waters is 45%. In broader terms, these activities form an integral part of the EU's "Blue bio-economy," which includes any economic activity associated with the use of renewable aquatic biological biomass, ex. food additives, animal feeds, pharmaceuticals, cosmetics, energy, etc. Unlocking the high potential of the "Blue bio-economy" is a crucial element to support local bio-economy development according to the 2018 update of the Bio-economy Strategy (European Union, 2019).

The following analysis of this sector includes the following activities: (i) Capture fisheries: small-scale coastal and industrial fleets; (ii) Aquaculture: finfish marine, shellfish and freshwater aquaculture; (iii) Processing and preservation of fish, crustaceans and molluscs, manufacture of oils and fats, prepared meals and dishes and other food products and (iv) retail sale of fish, shellfish and molluscs in specialised stores, and (v) wholesale of different food, including fish, crustaceans and molluscs (European Union, 2018).

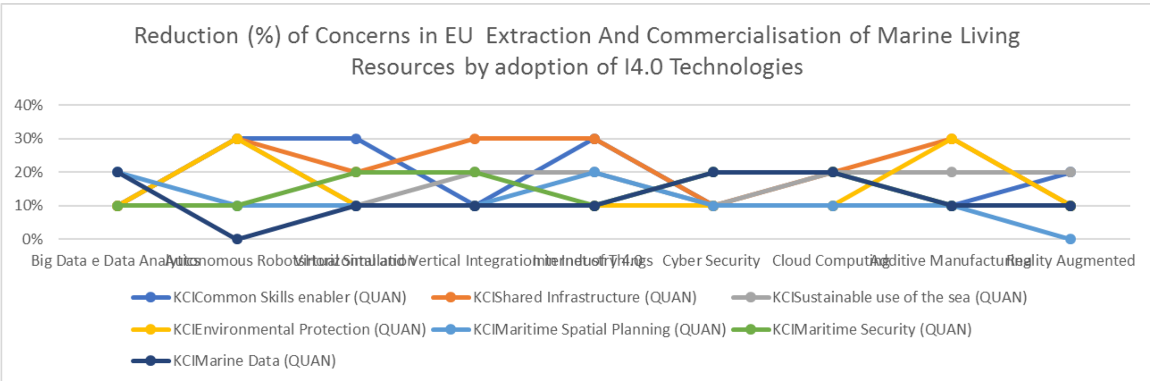
For this case study, it was invited five companies to participate in this survey, representing the five primary activities of the Extraction and Commercialisation of Marine Living Resources. All these companies with the headquarter located in the European Union territory are internationalized and operating in the Blue Economy, exporting services to the international market for the last five years, and have participated in at least one

European R&D Project during the previous five years. The interviews have been done by phone or during personal visits - Table Appendix B. 3.

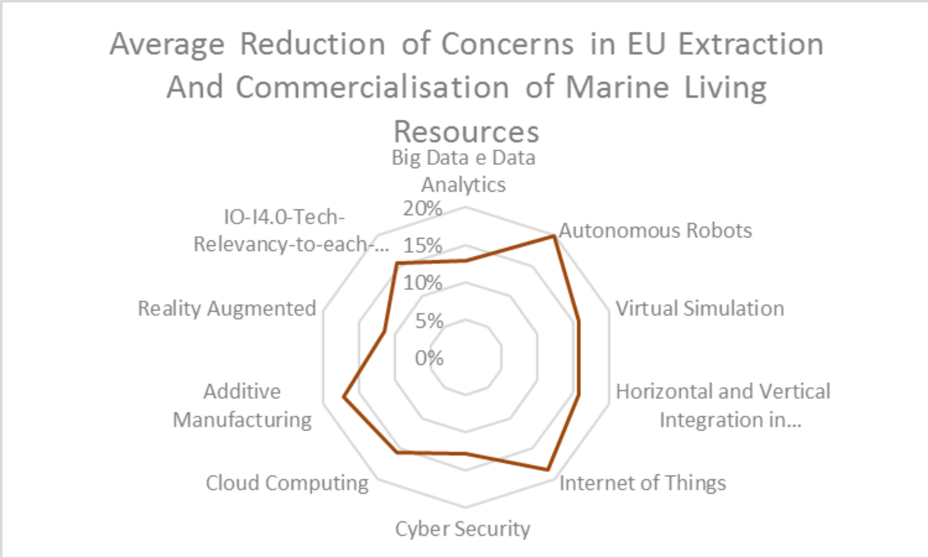
The data was collected from the six selected companies, one by one, in different days - Table Appendix B. 2, which shows the average KCI and KPI data collected only, in order to reduce the number of tables on this document - Graphic Appendix B. 2.



Graphic: 5-4: CS#2 | EU Extraction and Commercialisation of Marine Living Resources | Level of the Enabler Weight (QUAL)



Graphic: 5-5: CS#2 | EU Extraction and Commercialisation of Marine Living Resources | Concerns Relief (%) related to the I4.0 Technologies (QUAN)



Graphic: 5-6: CS#2 | EU Extraction and Commercialisation of Marine Living Resources | Enablers average Reduction of Concerns due to I4.0 Technologies introduction on their Activities

Raw material prices have not decreased over the last years, despite an increase in the supply, due partly to the rise in demand. The high percentage costs of raw material is expected to increase further. These costs are not likely to be offset by the improvements in efficiency (ex. via innovations). Thus, the rising costs in raw materials and energy is one of the leading causes of the sector’s low-profit margins (European Union, 2018).

The EU fish-processing sector seems unable to fully translate the increase in costs into price due to the market power of wholesalers and retailers. Moreover, several Member States, especially around the eastern Baltic Sea, were and are still negatively affected by the Russian embargo and the subsequent substantial reduction in exports to Russia. Fish processing enterprises in many Member States seem to be more efficient in reacting to increasing costs than previously. Investments in the processing facilities across EU countries are also observed, particularly in countries with lower wages to reduce costs and find the workforce. In this context, the Baltic States and Poland report increasing investment and activity (European Union, 2019).

5.1.3 Case-study 3 | Marine Extraction of Minerals, Oil, and Gas

Under the marine extraction of minerals, oil and gas (marine non-living resources), the extraction of crude petroleum, the extraction of natural gas, the extraction of marine minerals (aggregates), and the corresponding support activities are included. The sector is mostly in decline due to decreasing production and rising costs. More than 80% of current European oil and gas production takes place offshore, mainly in the North Sea and to a lesser extent in the Mediterranean, Adriatic and Black seas.

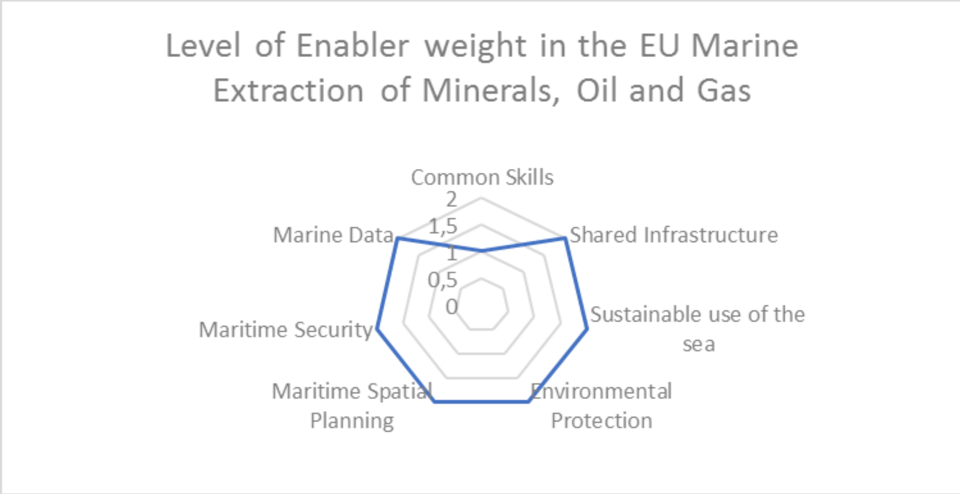
The EU-28 has around 600 existing offshore platforms. Exploration in the North Sea is carried out by the United Kingdom, Denmark, the Netherlands, and Germany. Minimal production occurs in the Baltic mainly along the Polish coast. In the Mediterranean, traditional production areas are located in Spanish, Greek, Maltese, and Adriatic waters - mostly Italian but more recently, Croatian. Romania and Bulgaria are hydrocarbon producers in the Black Sea. Overall, non-living marine resources contributed 4% of the jobs, 13% of the GVA, and 18% of the profits to the total EU Blue Economy in 2017. The sector is in decline, driven by the offshore oil sector (European Union, 2018).

The sector directly employed 162,374 persons, 7.3% less than in 2009. Personnel costs totaled €9.7 billion, 1.4% less than in 2009. As personnel costs decreased less than persons employed, annual average wage, estimated at €61,000, increased slightly compared to 2009 (€59,000). On the other hand, labor productivity was €156,000 per FTE in 2017, a substantial drop compared to 2009 (€224,500 per FTE). Net investments in tangible goods reached almost €10.9 million in 2017, nearly 4% less than in 2009. The ratio of net investment to GVA was estimated at 48% in 2017, up from 33% in 2009. New ventures are being channeled into innovation, exploration, and production units further offshore and in deeper waters (European Union, 2019).

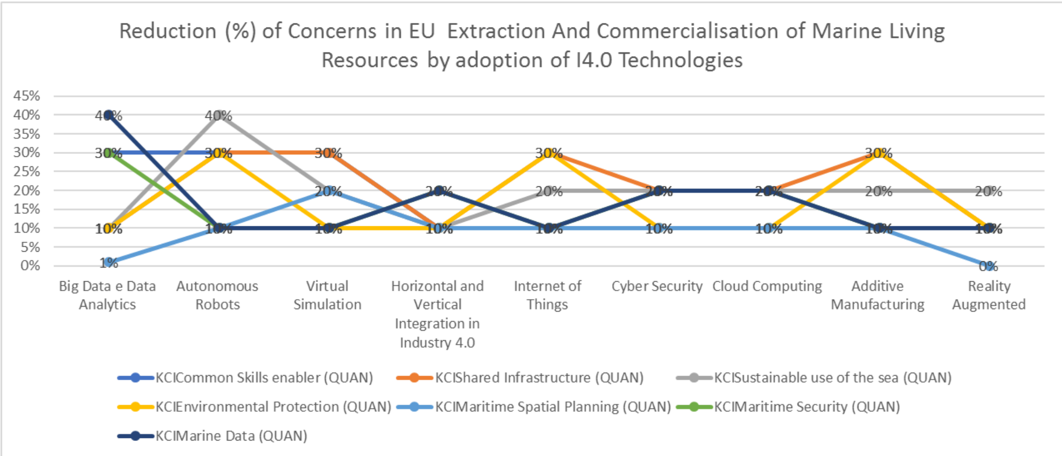
This sector includes the following activities: (i) Offshore extraction of crude; (ii) Offshore extraction of natural gas and; (iii) Support activities for petroleum and natural gas (European Union, 2018).

For this case study, it was invited three companies to participate in this survey, representing the three main activities of the Marine Extraction of Minerals, Oil and Gas. All these companies with the headquarter located in the European Union territory are internationalized and operating in the Blue Economy, exporting services to the international market for the last five years, and have participated in at least one European R&D Project during the previous five years. The interviews have been done by phone or during personal visits - Table Appendix B. 5.

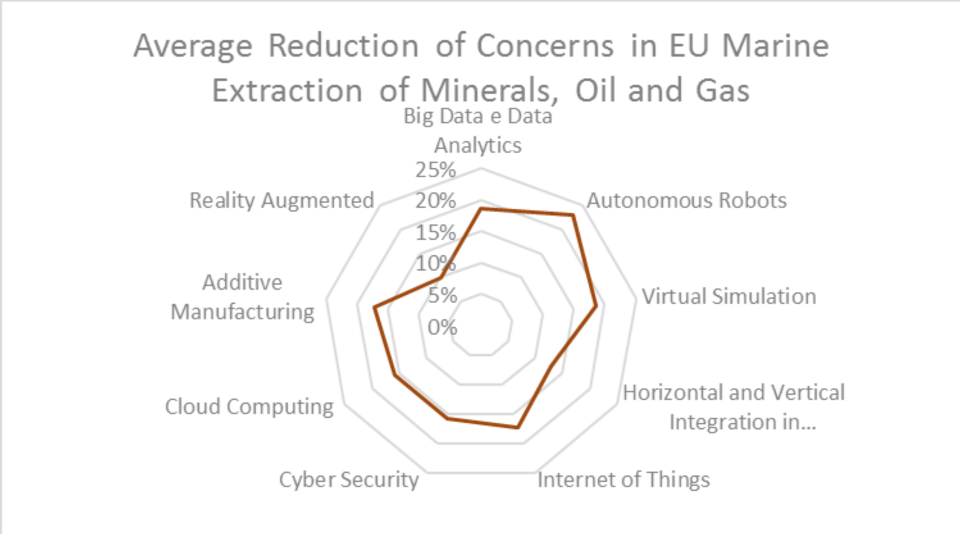
The data was collected from the six selected companies, one by one, in different days - Table Appendix B. 2, which shows the average KCI and KPI data collected only, in order to reduce the number of tables on this document - Graphic Appendix B. 3.



Graphic: 5-7: CS#3 | EU Marine Extraction of Minerals, Oil, and Gas | Level of the Enabler Weight (QUAL)



Graphic: 5-8: CS#3 | EU Marine Extraction of Minerals, Oil and Gas | Concerns Relief (%) related to the I4.0 Technologies (QUAN)



Graphic: 5-9: CS#3 | EU Marine Extraction of Minerals, Oil and Gas | Enablers average Reduction of Concerns due to I4.0 Technologies introduction on their Activities

The sector has developed technologies, infrastructure, and operational skills of significant value to Blue Economy. With the depletion of many exploited fields and the start of dismantling, these strengths could prove very useful for the development of new offshore activities, such as floating offshore windfarms or geothermal power and structures such as multi-use platforms (European Union, 2018). The Marine extraction of minerals, oil, and gas may compete for access to space with fishing, aquaculture, offshore wind energy, and shipping. In particular, gravel extraction may conflict with fisheries because gravel beds are the principal spawning grounds for several commercially important species, such as herring (European Union, 2019).

5.1.4 Case-study 4 | Ports, Warehousing and Water Projects

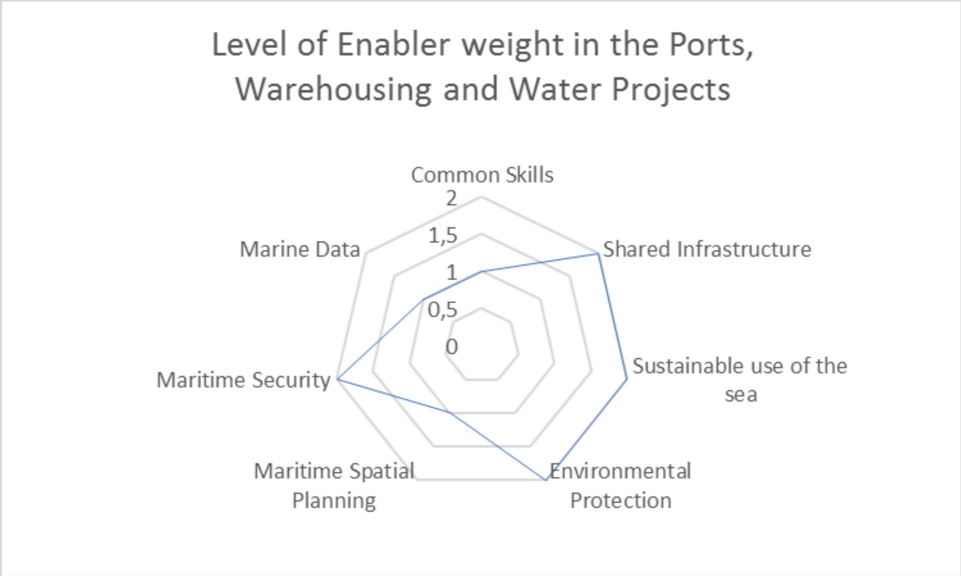
Port activities continue to play a crucial role in trade, economic development, and job creation. According to the European Sea Ports Organization, 90% of Europe's cargo trade in goods passes through the more than 1 200 seaports in the 23 maritime EU member states. Many of these ports also receive hundreds of millions of passengers aboard cruises liners and ferries (European Union, 2018). The number of containers heading into European ports has risen by more than four times over the past 20 years[33]. Europe's busiest port is Rotterdam (NL), with around 11% of the total cargo handled in 2017, followed by Antwerp, 5% (BE); Hamburg, 3% (DE); Amsterdam, 3% (NL) and Algeciras, 2% (ES). EU Port activities accounted for 14% of the jobs, 19% of the GVA, and 18% of the profits in the total EU Blue Economy in 2017. The sector has grown, in terms of jobs and GVA, since 2009 (European Union, 2019).

Seaports are economically significant in the EU, as they are vital nodes in the global trade network, handling a large share of all the EU's cargo. However, EU ports are very heterogeneous, with significant differences in their size, type, organization, and how they are connected to their hinterlands. Efficiency and productivity vary greatly between ports, and these differences have increased further in recent years (European Union, 2018). Ship sizes for all segments (ex. tankers, container carriers) have risen in past years to lower costs, increase operational efficiencies, and improve the carbon footprint of maritime transport. Larger ships lead to lower average transport costs and thus have replaced smaller ones. However, larger vessels require new ports infrastructure and have an impact on competition between port authorities and port operators. Most ports in the EU are publicly owned. The port authority owns the necessary infrastructure and leases it out to port operators, usually using a concession, while retaining all regulatory functions. Hence, port operations are run by private companies, which provide and maintain their superstructure, including buildings and cargo-handling equipment at the terminals. Port authorities have often limited autonomy in setting port charges, because governments often delineate them and because they compete with other ports (European Union, 2019).

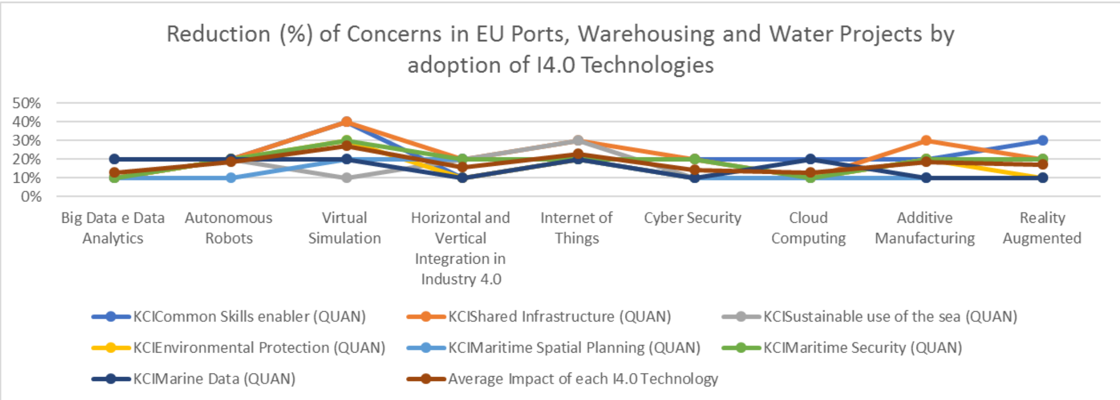
The Ports, Warehousing, and Water Projects Sector includes the following activities: (i) cargo handling; (ii) warehousing and storage; (iii) construction of water projects and; (iv) support activities for petroleum and natural gas (European Union, 2018).

For this case study, it was invited four companies to participate in this survey, representing the main activities of the Ports, Warehousing, and Water Projects sector. All these companies with the headquarter located in the European Union territory are internationalized and operating in the Blue Economy, exporting services to the international market for the last five years, and have participated in at least one European R&D Project during the previous five years. The interviews have been done by phone or during personal visits- Table Appendix B. 7.

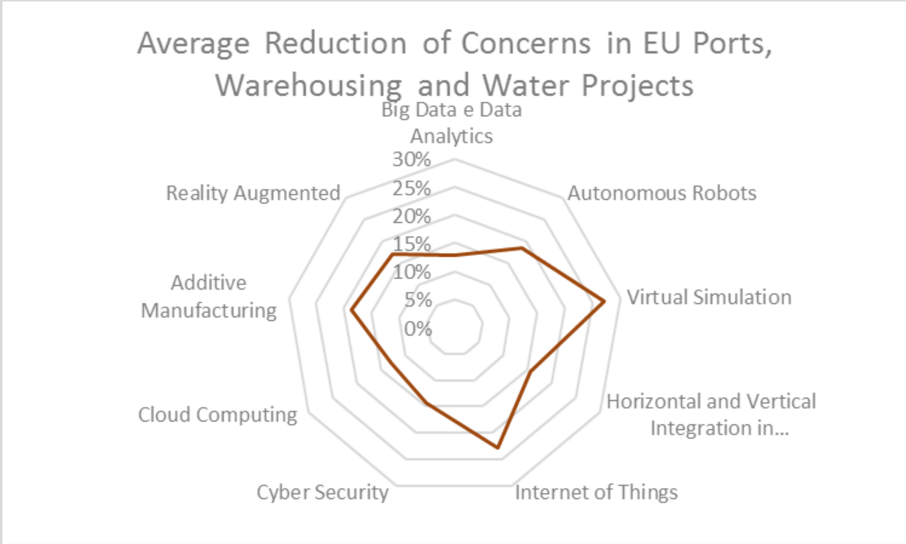
The data was collected from the six selected companies, one by one, in different days - Table Appendix B. 2, which shows the average KCI and KPI data collected only, to reduce the number of tables on this document - Graphic Appendix B. 4.



Graphic: 5-10: CS#4 | EU Ports, Warehousing and Water Projects | Level of the Enabler Weight (QUAL)



Graphic: 5-11: CS#4 | EU Ports, Warehousing and Water Projects | Concerns Relief (%) related to the I4.0 Technologies (QUAN)



Graphic: 5-12: CS#4 | EU Ports, Warehousing and Water Projects | Enablers average Reduction of Concerns due to I4.0 Technologies introduction on their Activities

Port activities provide the essential infrastructure for many other sectors, including fishing, transport, marine extraction of minerals, oil and gas, marine renewable energy, or maritime tourism. In this context, ports may act as facilitators of economic and trade development for their hinterland. On the other hand, ports may compete for space, for instance, concerning aquaculture (European Union, 2019).

5.1.5 Case-study 5 | Shipbuilding and Repair

For the purpose of this report, the Shipbuilding and repair sector includes the following activities: Building of ships and floating structures, building of pleasure and sporting boats, repair and maintenance of boats and vessels, marine equipment (manufacture of cordage, rope, twine and netting, production of textiles other than apparel, manufacture of sport goods) and marine machinery (manufacture of engines and turbines, except aircraft and manufacture of instruments for measuring, testing and navigation) (European Union, 2019). There are more than 300 shipyards in the EU, most of which are active in the global market for high-tech civilian and naval vessels. The EU shipbuilding industry is a dynamic and competitive sector. The EU is a significant player in the worldwide shipbuilding industry, with a market share of around 6% of the global order book in terms of compensated gross tonnage[38] and 19% in terms of value; for marine equipment, the EU share rises to 50% (European Union, 2018).

The EU is specialized in segments of shipbuilding (cruise ships, offshore support vessels, fishing, ferries, research vessels, dredgers, mega-yachts, etc.) with a high level of technology and added value. This specialization and leadership position is a direct result of the sector's continuous investments in research and innovation as well as in a very highly skilled workforce. The EU is also a global leader in the production of high tech, advanced maritime equipment, and systems. Indeed, the EU maritime technology sector is one of the most innovative sectors in Europe, with 9% of turnover invested in research and development (European Union, 2018). However, low prices for new merchant ships, driven by overcapacity in significant market segments, are pushing Asian shipyards to focus their attention on European niche markets and higher technology / high added value products (European Union, 2019).

European shipbuilders are reducing costs and restructuring capacity by adjusting their production programs and optimizing the supply chain. Indeed, figures show a significant drop in shipbuilding employment since 2009. The economic and financial crisis affected the industry globally for several years after this the business model has changed, and part of the workforce shifted to external subcontractors and suppliers (see Section 6.2 for an example of the indirect and multiplicative effects of shipyards). The decline, particularly in Germany, Poland, and Spain, has not been offset by a slight increase seen in the United Kingdom. The falling oil price has also had an impact on the European construction of offshore platforms and supply vessels. Results indicate that the sector is recovering (European Union, 2018).

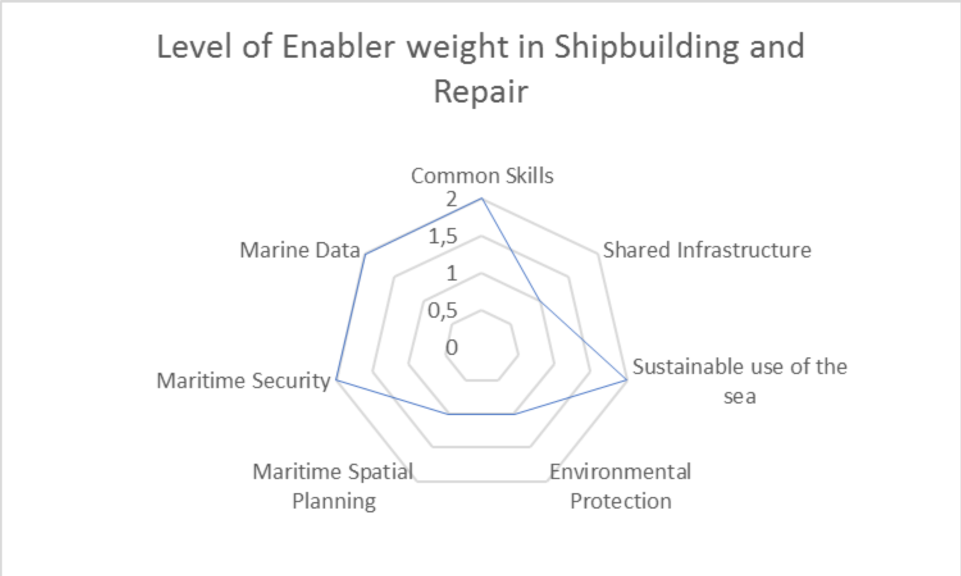
Overall, Shipbuilding and repair accounted for 8% of the jobs, 8% of the GVA, and 5% of the profits in the total EU Blue Economy in 2017. The sector has expanded slowly from recent lows in 2009 and 2013 (European Union, 2019).

This sector includes the following activities: (i) building of ships and floating structures, (ii) building of pleasure and sporting boats, and; (iii) repair and maintenance of ships and vessels (European Union, 2018).

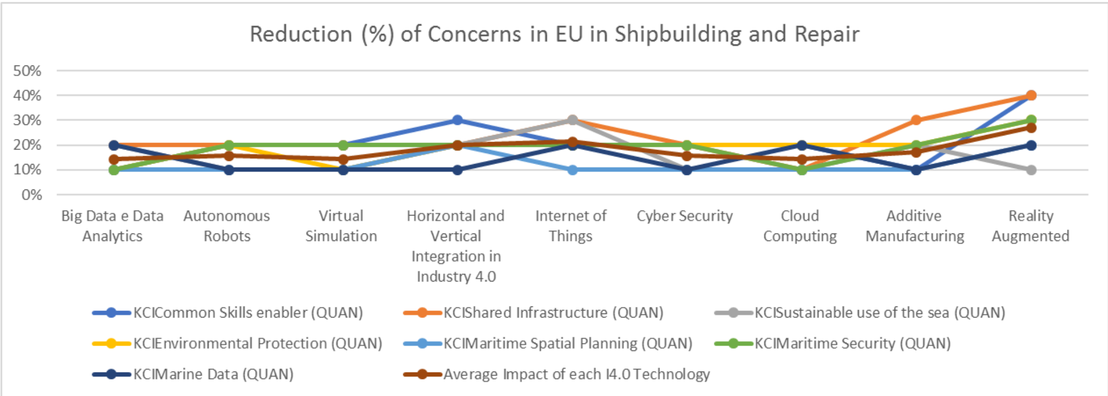
For this case study, it was invited three companies to participate in this survey, representing the main activities of the Shipbuilding and Repair sector. All these companies with the headquarter located in the European Union territory are internationalized and operating in the Blue Economy, exporting services to the international market for the last five years, and have participated in at least one European

R&D Project during the previous five years. The interviews have been done by phone or during personal - Table Appendix B. 9.

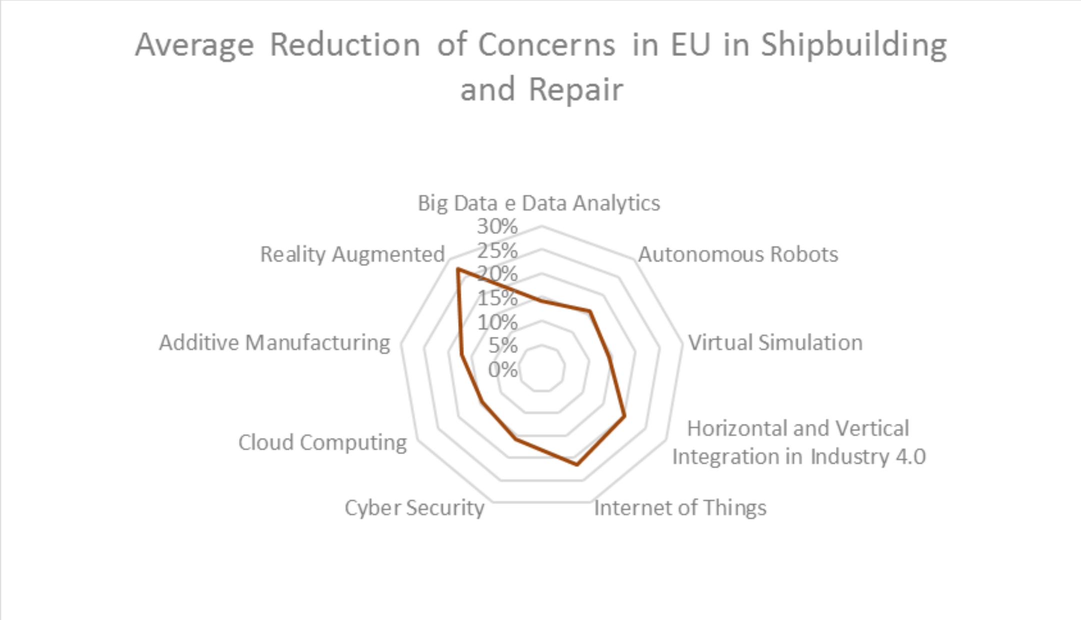
The data was collected from the three selected companies, one by one, in different days - Table Appendix B. 2, which shows the average KCI and KPI data collected only, to reduce the number of tables on this document - Graphic Appendix B. 5.



Graphic: 5-13: CS#5 | EU Shipbuilding and Repair | Level of the Enabler Weight (QUAL)



Graphic: 5-14: CS#5 | EU Shipbuilding and Repair | Concerns Relief (%) related to the I4.0 Technologies (QUAN)



Graphic: 5-15: CS#5 | EU Shipbuilding and Repair | Enablers average Reduction of Concerns due to I4.0 Technologies introduction on their Activities

Shipbuilding provides the assets, capabilities, technologies, and knowhow for several Blue Economy activities such as fishing, transport, marine extraction of minerals, oil and gas, offshore renewable energies, aquaculture, and tourism. The EU Shipbuilding and equipment sectors have new opportunities, especially working alongside emerging sectors, such as assistance vessels and structures for marine renewable energy (ex. offshore wind and ocean energy) and the exploration and exploitation of the deep-sea (European Union, 2019).

5.1.6 Case-study 6 | Maritime Transport

Maritime transport is essential to the world's economy. Moreover, there is little if any dispute over the fact that shipping is the most carbon-efficient mode of transportation. International maritime shipping accounts for less than 3% of annual global greenhouse gas emissions (CO_2) and produces less exhaust gas emissions - including nitrogen oxides, hydrocarbons, carbon monoxide, and sulphur dioxide - for each tonne transported per one kilometre than air or road transport[47]. The size and global nature of the shipping industry makes it vital that the industry continues to reduce its environmental impact, and the industry has made significant progress in fuel efficiency.

Due to the expected growth of the world economy and associated transport demand from world trade, greenhouse gas emissions from shipping could grow from 50% to 250% by

2050[48], making it paramount for the industry to continue to improve the energy efficiency of ships and to shift to alternative fuels.

Maritime transport plays a crucial role in the EU economy and trade, estimated to represent between 75% and 90% (depending on the sources) of the EU's external business and one-third of the intra-EU trade. Moreover, more than 400 million passengers aboard cruises and ferries embark and disembark at EU ports each year.

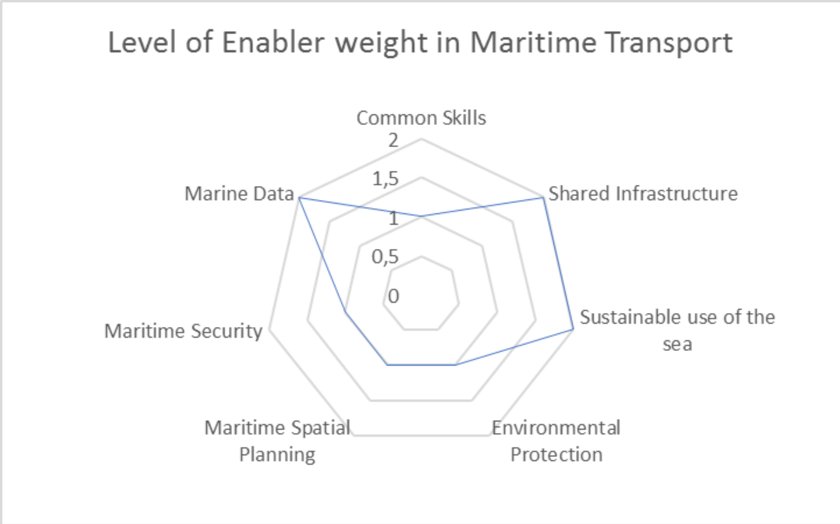
In 2016, the total weight of goods transported to/ from main ports in the EU-28 by short sea shipping (excludes the movement of cargo across oceans, deep-sea shipping) was 2,531 million tonnes.

In this research context, Maritime Transport includes (i) sea and coastal passenger water transport, (ii) sea and coastal freight water transport, (iii) inland passenger water transport, (iv) inland freight water transport and (v) the renting and leasing of water transport equipment. Inland transport is considered part of the Blue Economy because it includes transportation of passengers and freight via rivers, canals, lakes, and other inland waterways, including within harbors and ports.

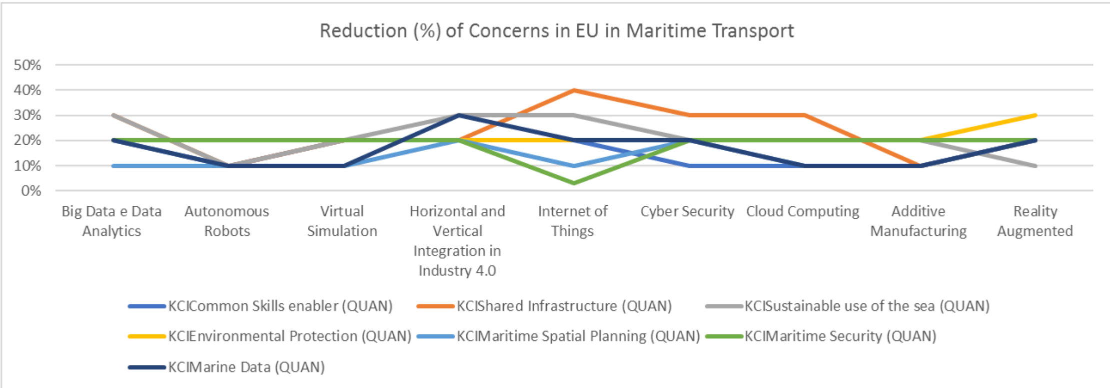
Overall, Maritime transport accounted for 6% of the jobs, 12% of the GVA, and 16% of the profits in the total EU Blue Economy in 2017. The sector is undergoing a slow recovery.

For this case study, it was invited five companies to participate in this survey, representing the main activities of the Shipbuilding and Repair sector. All these companies with the headquarter located in the European Union territory are internationalized and operating in the Blue Economy, exporting services to the international market for the last five years, and have participated in at least one European R&D Project during the previous five years. The interview has been done by a personal visit - Table Appendix B. 11.

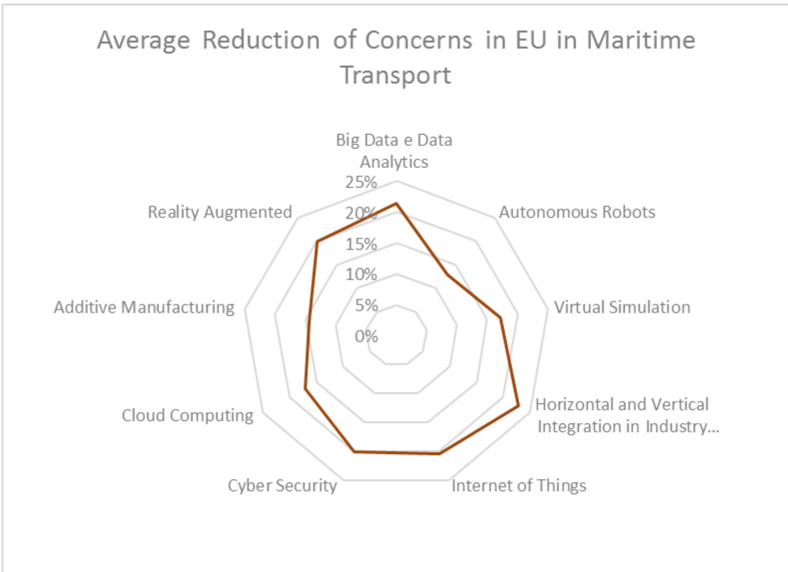
The data was collected from the five selected companies, one by one, in different days - Table Appendix B. 2, which shows the average KCI and KPI data collected only, to reduce the number of tables on this document - Graphic Appendix B. 6.



Graphic: 5-16: CS#6 | EU Maritime Transport | Level of the Enabler Weight (QUAL)



Graphic: 5-17: CS#6 | EU Maritime Transport | Concerns Relief (%) related to the I4.0 Technologies (QUAN)



Graphic: 5-18: CS#6 | EU Maritime Transport | Enablers average Reduction of Concerns due to I4.0 Technologies introduction on their Activities

Main developments in the Maritime transport in recent years are related to the continuous increase in ship sizes for all segments (ex. tankers and container carriers, but also cruises). This increase in the ship sizes, which aims to lower costs by reaping economies of scale, has been possible thanks to technological improvements. These new forms of maritime transport have significantly affected the Shipbuilding and Ports sectors, as well as their surrounding infrastructures (ex. road and rail connections).

Maritime transport requires ports and their infrastructure to operate. Transport companies have an interest in optimizing their routes, which may compete in space with other activities such as fishing, offshore energy, aquaculture of marine protected areas.

5.1.7 Case-study 7 | Blue Energy

The Marine renewable energy sector comprises different technologies at a different stage of development. Bottom-fixed offshore wind represents the most advanced technology, with a cumulative capacity of 18.5 GW at the end of 2018. Other techniques such as floating offshore wind, tidal, and wave energy technologies are all emerging in comparison to offshore wind.

Starting with a small number of demonstration plants, the EU offshore wind energy has grown to a capacity of 18.5 GW by the end of 2018, with an increase of 2.65 GW in the last year. According to EIB figures, it is estimated that about 10 million European households are served by offshore wind energy, with an estimated consumption per household of 5,000 KW hours a year.

The UK is the Member State with the largest installed capacity of offshore wind energy (44%) followed by Germany (34%), Denmark (7%), Belgium (6.4%) and the Netherlands (6%). Europe's offshore wind industry keeps on leading the sector driven by an active home market in 11 countries. European offshore wind represents about 91 % of the worldwide capacity deployed[51].

Offshore wind energy is gaining importance concerning onshore wind energy: in 2016, new offshore wind capacity represented 11.5% of the new wind capacity installed, reaching 23% of the new wind capacity in 2018. Offshore wind represents about 10% of the total installed wind energy capacity in the EU, growing from 8% in 2016. It represents over one-third of the wind energy capacity installed in the UK and Belgium.

A significant share of offshore wind energy-related employed is related to the manufacturing of turbines, blades, towers, and other components. As reported by IRENA, a 500 MW offshore wind farm is associated with the creation of 8,000 FTEs through its lifetime, (indicatively 16 jobs per MW). 60% of which are for manufacturing. While 24 % of the direct jobs generated by offshore wind are associated with Operation and Maintenance (O&M) and can be expected to last for the lifetime of the farm.

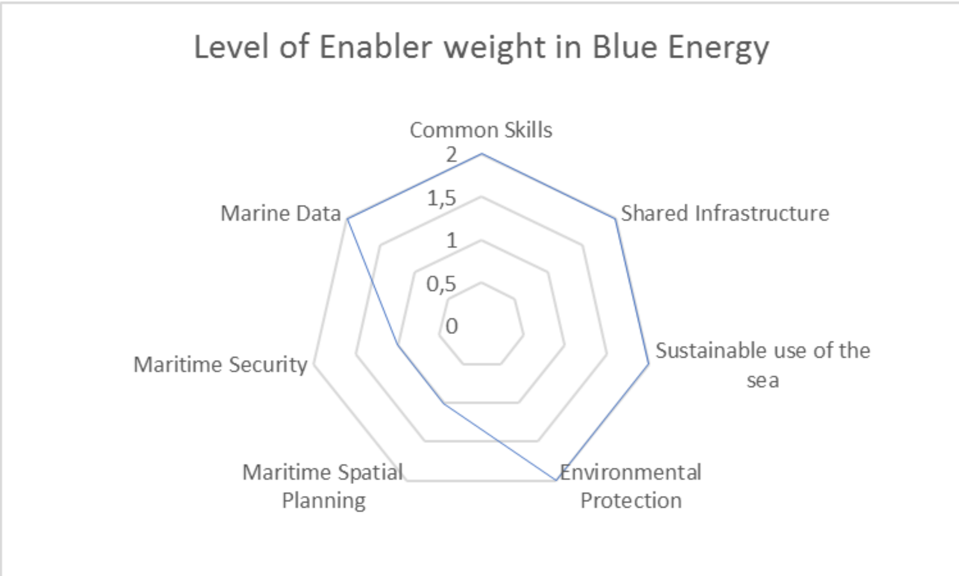
Floating offshore wind is a growing sector that is strengthening Europe's leadership in renewable energy. Nearly 80% of the available offshore wind in Europe is located in waters that are at least 60 meters deep, where it is too expensive to fix structures to the bottom of the sea. Fortunately, it is possible to build floating platforms that work almost anywhere on the sea. These are cheaper to run and install, more environmentally friendly to sea life, and have higher output. The development of floating offshore wind technologies will lower costs in the sector and increase production, leading to a significant drop in the cost of energy for floating offshore wind projects. Currently, only 30 MW of floating wind capacity is operational; however, a further 210 MW is planned to be deployed between 2019 and 2021.

The ocean energy sector (tidal and wave power) is still relatively small compared to the offshore wind energy sector. At the end of 2018, the total global ocean energy installed capacity was 55.8 MW, with most of it located in EU waters (38.9 MW). The EU is the global leader with 58 % of the number of tidal energy technology developers and 61% of the wave energy developers based in the EU.

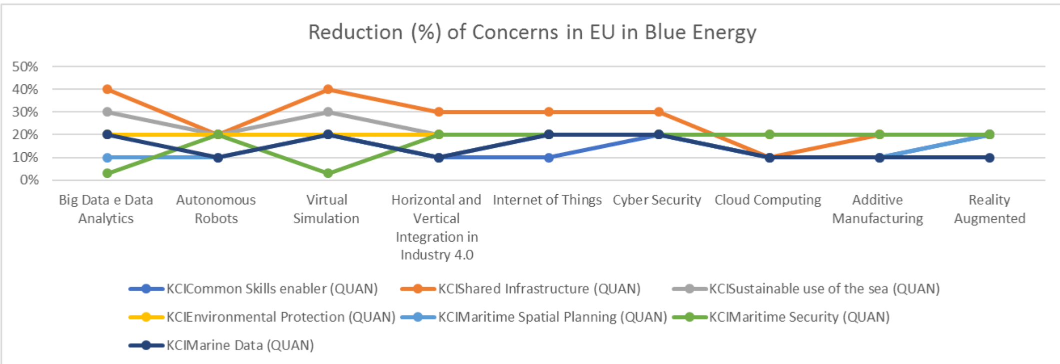
The development of ocean energy technologies is still primarily at R&D. The majority of it has been financed by private contribution, although in the last years, but national and EU public funding has significantly increased in the previous few years. Between 2003 and 2017, total R&D expenditure on ocean energy amounted to a cumulative €3.5 billion, with most of it (€2.8 billion) coming from private sources[55]. We observed an increased interest in ocean energy from 2008 onwards.

The continuous development of ocean energy technologies and the ongoing improvements are expected to lead to a significant increase in the deployed ocean energy capacity soon. A pipeline of about 5 GW of projects has been announced for up to 2030. Under the assumption of capital costs to develop ocean energy like the current ones for offshore wind, the expected investment needs are estimated at over €18 billion.

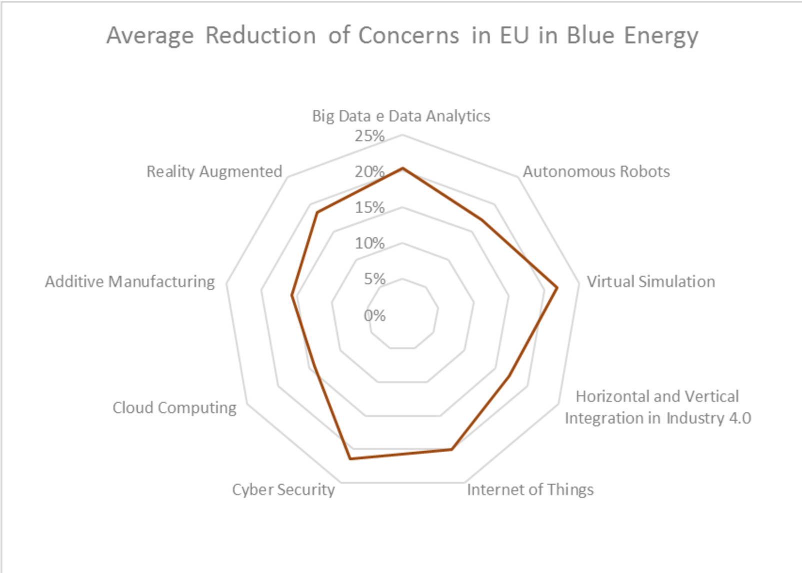
As the market for ocean energy technologies is shaping, over 430 companies in the EU are involved in different stages of the ocean energy supply chain, with an estimate of 2,250 jobs created in the ocean energy sector across Europe. For this case study, it was invited one company to participate in this survey, operating in the Renewable Energy business, with the headquarter located in the European Union territory, internationalized and operating in the Blue Economy, exporting services to the international market. The company has participated in 2 European R&D Projects in the last five years. The interviews have been done by phone or during personal visit- Table Appendix B. 13. The data was collected - Table Appendix B. 14 - Graphic Appendix B. 7.



Graphic: 5-19: CS#7 | EU Blue Energy | Level of the Enabler Weight (QUAL)



Graphic: 5-20: Graphic 6.20: CS#7 | EU Blue Energy | Concerns Relief (%) related to the I4.0 Technologies (QUAN)



Graphic: 5-21: CS#7 | EU Blue Energy | Enablers average Reduction of Concerns due to I4.0 Technologies introduction on their Activities

R&D activity in ocean energy involves over 674 EU companies in 25 Member States. These companies have taken an active role in R&D and have either filed patents or have been involved in the developed activity related to ocean energy. 50% of the inventions patented in the EU are for wave energy technology, 45% for tidal power, 3% on Oscillating Water Column (OWC), and 2% for Ocean Thermal Energy Conversion (OTEC). When countries outside of the EU are accounted, wave energy share increases to 56%, tidal energy decreases to 37%, OWC drops to 2%, OTEC raises to 4%, and Salinity gradient to 1%. EU developers are protecting their inventions in all the crucial potential ocean energy markets outside of the EU, such as the US, China, Japan, and Korea. On the other hand, only a small share of non-European developers is seeking protection in Europe (European Union, 2019).

5.1.8 Case-study 8 | Blue Bio-Economy

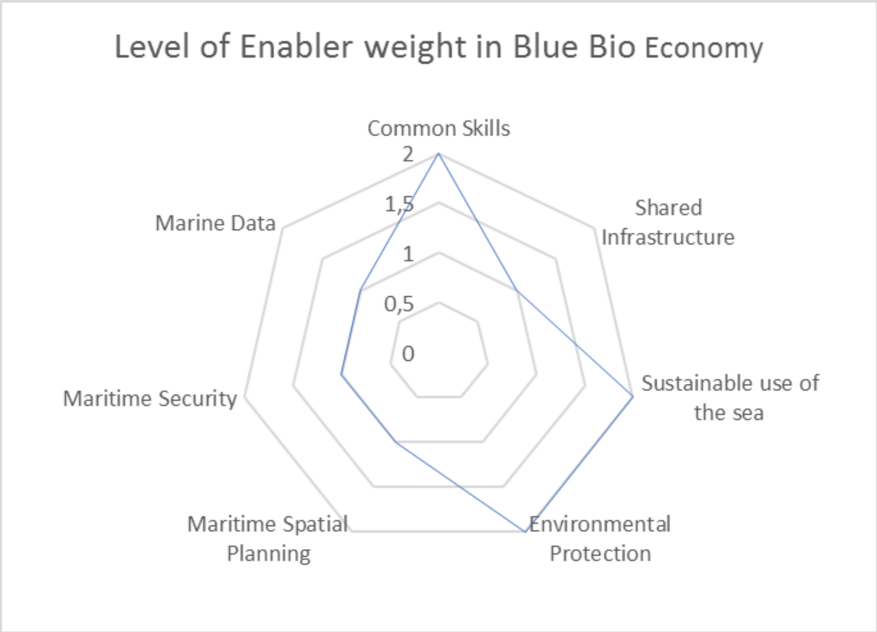
There is no single official definition of blue biotechnology or marine biotechnology (World Bank, 2017). In 2013 and 2014, workshops and questionnaires were conducted to reach an agreement on a common understanding of these terms. The European Commission has highlighted the importance of consensus regarding these definitions for the development of new initiatives and policy options (Pinto et al., 2015). Bio-economy is highly related to the extraction of living resources and includes sectors relying on renewable aquatic biological resources such as fish, algae, and other macro- and micro-organisms to produce food, feed, pharmaceuticals, cosmetics, bio-based products, and energy (European Union, 2018).

Biological resources are increasingly being used in new ways, creating a new biotechnology sector. New activities explore and exploit aquatic organisms to develop new products and services. Most of them use living organisms as either a source or a target of biotechnology applications, producing smart food, feed, biofuels, biomaterials, cosmetics, pharmaceuticals, nutraceuticals, industrial enzymes, solutions for bioremediation, etc. This sector has the potential to contribute to EU economic growth and to provide new jobs, while also supporting sustainable development, public health, and environmental protection (Soma et al., 2018).

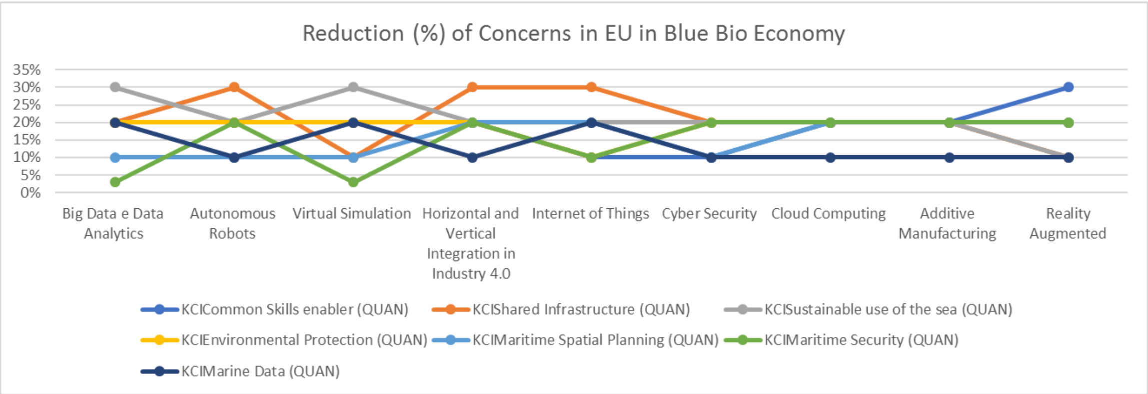
The main applications of biotechnology in the EU economy fall into four broad groups: (i) in healthcare and pharmaceutical applications, biotechnology has led to the discovery and development of advanced medicines, therapies, diagnostics, and vaccines; (ii) in agriculture, livestock, veterinary products, and aquaculture, biotechnology has improved animal feed, produced vaccines for livestock and is, improving diagnostics for detecting diseases. Biotechnology is also being used as food, food ingredients, and human nutrition; fishmeal, hydrocolloids and other algae extracts are used in nutritional supplements, thickening or gelling agents, food dyes, etc.; (iii) in industrial processes and manufacturing, biotechnology has led to the use of enzymes in the production of detergents, pulp and paper, textiles, and biomass, improving the process efficiency and decreasing energy and water consumption as well as toxic waste; (iv) in energy production, using macro and micro-algae technology a theoretical volume of 20,000-80,000 litters of biofuel per hectare per year can be produced (European Union, 2018).

Data provided by the industry claims that the EU algae biomass sector currently employs 17,000 people (in both direct and indirect activities). Turnover was estimated at €1.5 billion, with an additional €240 million in indirect activities (ex. research). The sector also has a total of over 560 companies and more than 300 research groups in the EU (European Union, 2019). Additionally, the economic importance of these resources in the bio-based economy has increased. In the last decades there has been a growing demand for algae biomass for a variety of high-value commercial products (ex. cosmetics, nutraceuticals, pharmaceuticals) and new bio-based applications (biomaterials and energy), in addition to the traditional uses of this biomass source (food and food applications, feed, fertilisers) (Jalihal, 2018).

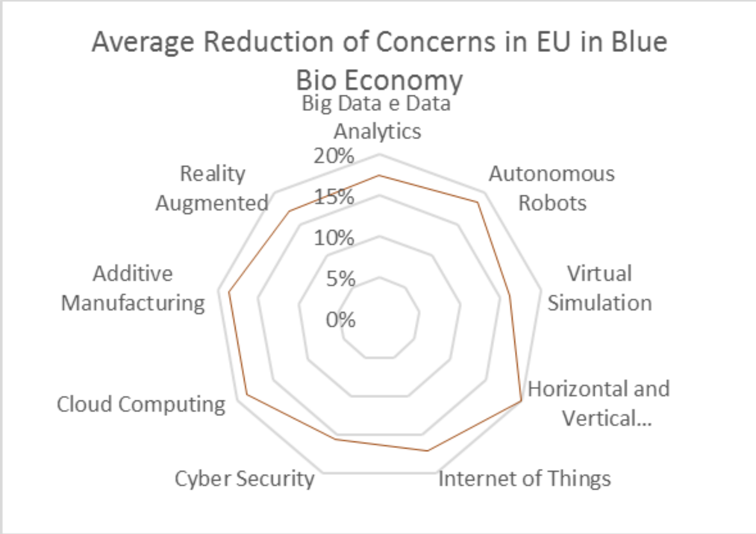
For this case study, it was invited one company to participate in this survey, operating in the Biotechnology business, with the headquarter located in the European Union territory, internationalized and operating in the Blue Economy, exporting services to the international market. The company has participated in 2 European R&D Projects in the last five years. The interviews have been done by phone or during personal visit - Table Appendix B. 15. The data was collected- Table Appendix B. 16 - Graphic Appendix B. 8.



Graphic: 5-22: CS#8 | EU Blue Bio-Economy | Level of the Enabler Weight (QUAL)



Graphic: 5-23: Graphic 6.23: CS#8 | EU Blue Bio-Economy | Concerns Relief (%) related to the I4.0 Technologies (QUAN)



Graphic: 5-24: S#8 | EU Blue Bio-Economy | Enablers average Reduction of Concerns due to I4.0 Technologies introduction on their Activities

5.1.9 Case-study 9 | Marine Minerals

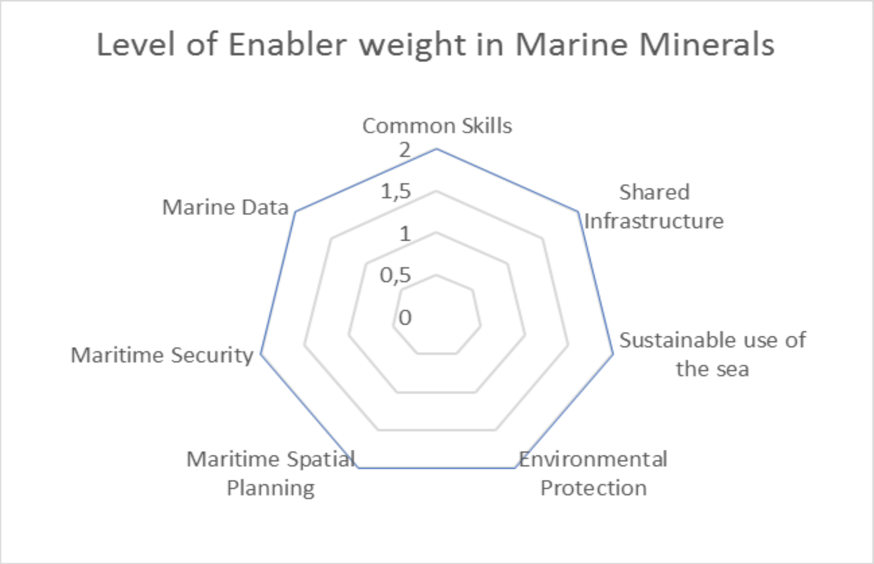
Marine mining refers to the extraction and processing of non-living resources in the ocean, including marine aggregates (ex. sand and gravel), other minerals and metals in/on the seabed (ex. manganese, tin, copper, zinc and cobalt) and chemical elements dissolved in seawater (ex. salt and potassium) (Klinger et al., 2018).

In 2008, the Raw Material Initiative (World Bank, 2017) established a strategy for access to raw materials. In general, securing reliable and undistorted access to raw materials from sustainable sources has increasingly become an essential factor for the EU's competitiveness and, hence, crucial to the success of the growth strategy. Recently, the raw materials policy reinforced in the context of the EU Industrial Policy Strategy positions raw materials as essential elements for the industrial value chains (World Bank, 2017). An excellent example of this new approach is the Staff working document "Report on Raw Materials for Battery Applications," developed in the context of the Strategic Action Plan on Batteries. The strategic importance of raw materials is also part of the 2050 long-term strategy: "Raw materials are indispensable enablers for carbon-neutral solutions in all sectors of the economy. Given the scale of fast-growing material demand, primary raw materials will continue to provide a large part of the demand" (European Union, 2019).

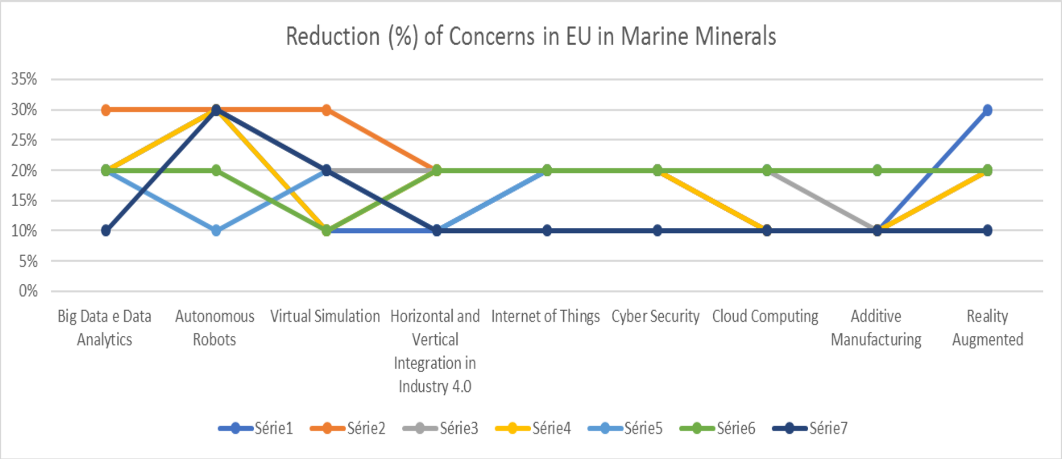
The EU is highly dependent on imports of metallic minerals, as its domestic production is limited to about 3% of world production (World Bank, 2017). Moreover, the EU is highly reliant on “high-tech” metals imports such as cobalt, platinum, rare earths, and titanium. Though often only needed in tiny quantities, these metals are increasingly essential to the development of technologically sophisticated products because of their growing number of functionalities. In this context, the Commission has identified a list of critical raw materials with high supply-risk, high economic importance, and lack of substitutes for which reliable and unhindered access is a concern to the European industry and sustainable value chains (European Union, 2019). The EU will not master the general shift towards sustainable production and environmentally friendly products without such high-tech metals. These metals play a critical role in the development of innovative “environmental technologies” for boosting energy efficiency and reducing greenhouse gas emissions. Similarly, batteries are a key enabling technology for low emission mobility and energy storage. According to IET InnoEnergy[9], forecasts indicate that the demand for batteries will grow exponentially in the coming years (European Union, 2019).

For this case study, it was invited one company to participate in this survey, operating in Deep-seabed Mining, with the headquarter located in the European Union territory, internationalized and operating in the Blue Economy, exporting services to the international market. The company has participated in 2 European R&D Projects in the last five years. The interviews have been done by phone or during personal visit- Table Appendix B. 17. The data was collected in Table Appendix B. 18 - Graphic Appendix B. 9.

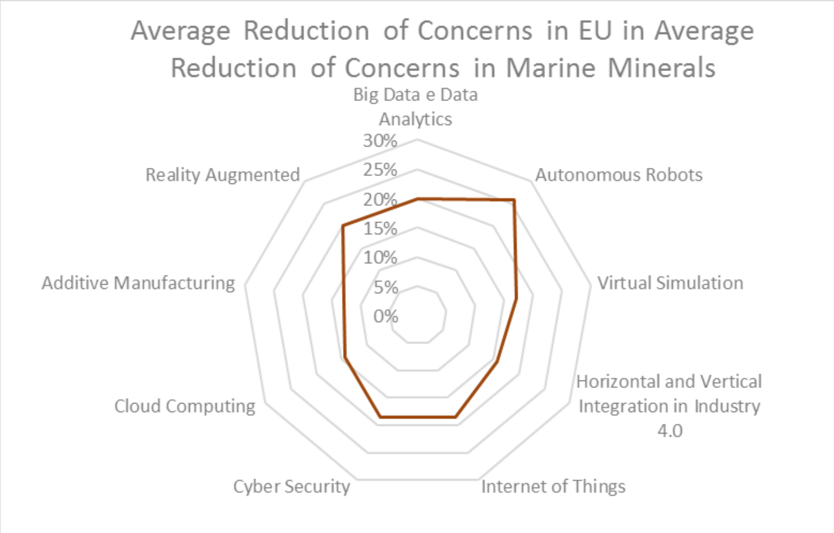
[9] https://www.innoenergy.com/



Graphic: 5-25: CS#9 | EU Marine Minerals | Level of the Enabler Weight (QUAL)



Graphic: 5-26: CS#9 | EU Marine Minerals | Concerns Relief (%) related to the I4.0 Technologies (QUAN)



Graphic: 5-27: CS#9 | EU Marine Minerals | Enablers average Reduction of Concerns due to I4.0 Technologies introduction on their Activities

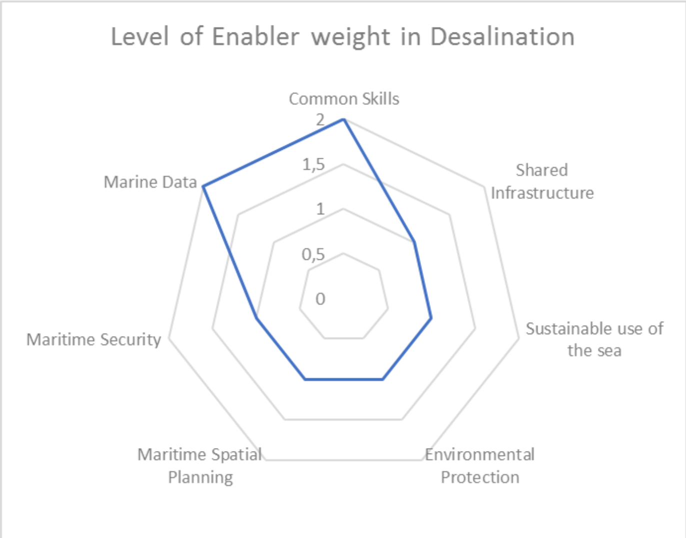
Although the industry players active in the field are generally confident, the future of seabed mining at great depths remains uncertain; regarding the extent to which the seabed will be tapped of its resources on a commercial scale. Since the costs are known to be very high, and while the benefits are still unclear, the actual commercial activities of the extraction of minerals have not yet commenced, and projects have been repeatedly delayed (European Union, 2019).

5.1.10 Case-study 10 | Desalination

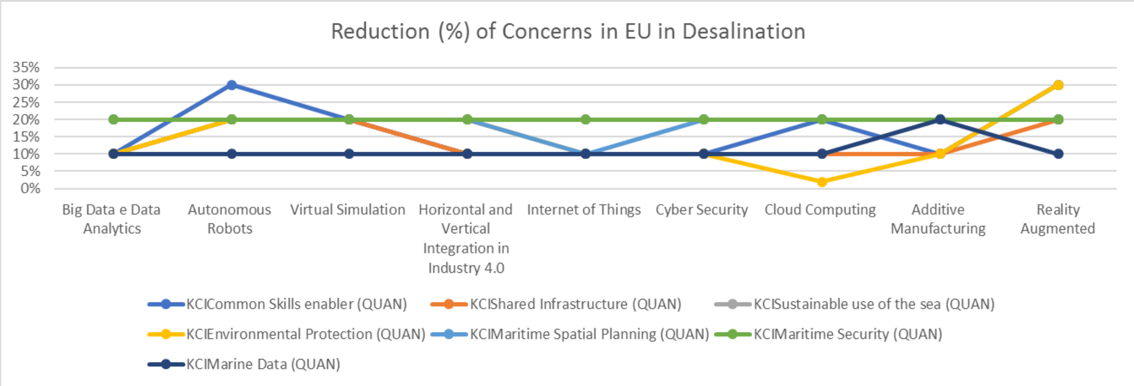
Desalination is a common technology and an alternative for water supply that can alleviate the growing pressure on freshwater resources (Pinto et al., 2015). Currently, it is used to overcome water shortages in areas where water resources are limited. However, it involves energy-intensive processes, and therefore it is one of the sectors where adaptation to increasing freshwater scarcity may entail trade-offs, in the long term, as regards emission reduction objectives and pollution (brine as a side product of desalination) (European Union, 2019). Some 79% of the freshwater produced is used for public water supply (4.2 million $m_{3/}$day), 10% is used for industrial applications, 2.7% in power plants, and 6% for irrigation (OECD, 2019). Depending on the type of plant, different uses of the desalinated water are applied. While the majority of desalination plants serve municipalities in terms of public water supply, a considerable amount of medium and small desalination plants are used to provide water to tourist facilities (European Union, 2019). 68% of the EU desalination capacity is located in Spain (4.2

million m^3/day), with the remaining being found mainly in Mediterranean countries: Italy (9%), Cyprus (8%), Malta (5%) and Greece (3%) (European Union, 2018). Since the year 2000, there has been a definite increase in the construction of larger capacity plants, which deliver an increasingly more significant portion of the freshwater supply of coastal (and insular) cities in the EU, particularly in Spanish cities such as Barcelona, Alicante and Las Palmas (European Union, 2019). In the EU, 84% of the operating desalination plants employ Reverse Osmosis technologies, with the remaining 16% spread across several different technologies such as Electrodialysis, Multi-effect Distillation, and Nanofiltration (European Union, 2019). For this case study, it was invited one company to participate in this survey, operating in Fresh Water Supply, with the headquarter located in the European Union territory, internationalized and operating in the Blue Economy, exporting services to the international market.

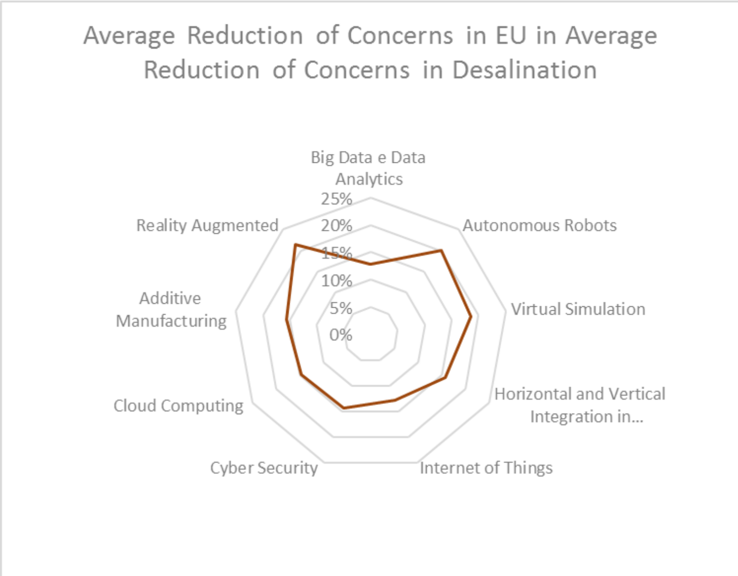
The company has participated in 3 European R&D Projects in the last five years. The interviews have been done by phone or during personal - Table Appendix B. 19. The data was collected - Table Appendix B. 20 - Graphic Appendix B. 10.



Graphic: 5-28: CS#10 | EU Desalination | Level of the Enabler Weight



Graphic: 5-29: CS#10 | EU Desalination | Concerns Relief (%) related to the I4.0 Technologies (QUAN)



Graphic: 5-30: CS#10 | EU Desalination | Enablers average Reduction of Concerns due to I4.0 Technologies introduction on their Activities

The market for desalination in Europe is expected to grow in the next few years (World Bank, 2017). 96% of the new contracted desalination capacity is expected to employ reverse osmosis. 70% of the new capacity is for large or very large desalination plants. The average capital expenditure associated with new capacity is of €1.1 million for each 1,000 m_3/d of additional capacity (European Union, 2019). The future growth of the desalination market is tied to the need to identify viable solutions to tackle the increasing water scarcity and its translation into policy. Freshwater availability is expected to be impacted by climate change; many regions in Europe are expected to face severe water scarcity by 2050. Forecast of Water Exploitation Index for 2050, indicated that the coastal Mediterranean regions and also regions in France, Germany, Hungary, Northern Italy, Romania, and Bulgaria might face critical levels of water scarcity (European Union, 2019). Desalination may provide a viable solution to alleviate water scarcity in many European regions. However, increased desalination capacity may be met with significant trade-offs in terms of energy requirements, carbon emission, and environmental impacts. Desalination is an energy-intensive technology, and while it currently provides 4.2% of the EU water for public supply, it accounts for 16% of the energy used by the EU water system[92]. The International Energy Agency has estimated that, at a global level, the energy consumption of desalination is expected to increase eight-fold by 2040 due to increased demands for freshwater produced by desalination (European Union, 2019).

With appropriate planning, design, and financing, suitable candidates for development projects may be identified, attracting investments (including international aid and other transfers) and creating opportunities, which, in turn, might contribute to relief the migratory pressure from the South to the North of the Mediterranean (Soma et al., 2018; World Bank, 2017).

5.1.11 Case-study 11 | Maritime Defence

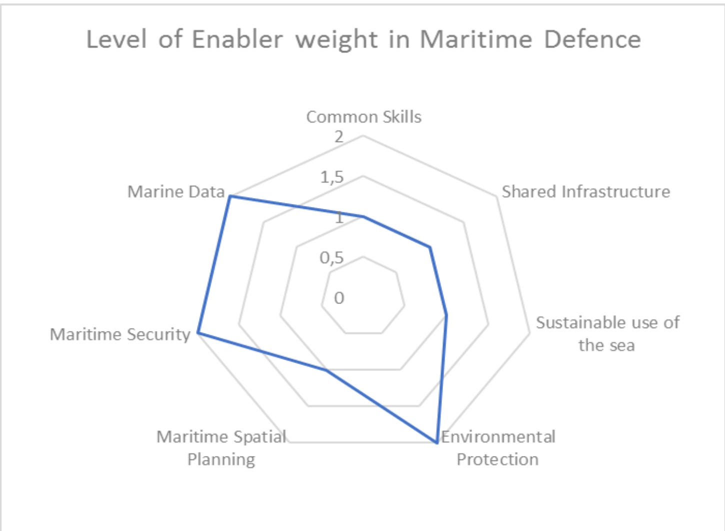
Maritime Defence covers two sectors under defense and security, navies and naval shipbuilding. This sector is indeed anything but new, but has been categorized as emerging not in terms of its new activities but rather on the emergence of its data, and its inclusion and consideration and a contributing activity to the Blue Economy (OECD, 2019).

According to a study on industrial and technological competences in the naval sector, the European naval industry has managed to design, integrate and produce the whole range of naval ships and almost the totality of its core systems and components, with specific distinctive competencies in the field of the most complex surface/combatant ships (ex. Multi-purpose frigates and destroyers) and a world leadership in conventional submarines equipped with air-independent propulsion systems. According to the study, the competitive position of European shipbuilding industry is expected to remain healthy in the future, especially in the market segments of higher added value and with more significant sales value (ex. submarines, destroyers, and frigates) (European Union, 2019). Naval shipbuilding in the EU represents an annual income of €10.8 billion in naval new buildings and of EU 4.2 billion in naval maintenance, and the job count can be estimated at around 78,000 (European Union, 2019).

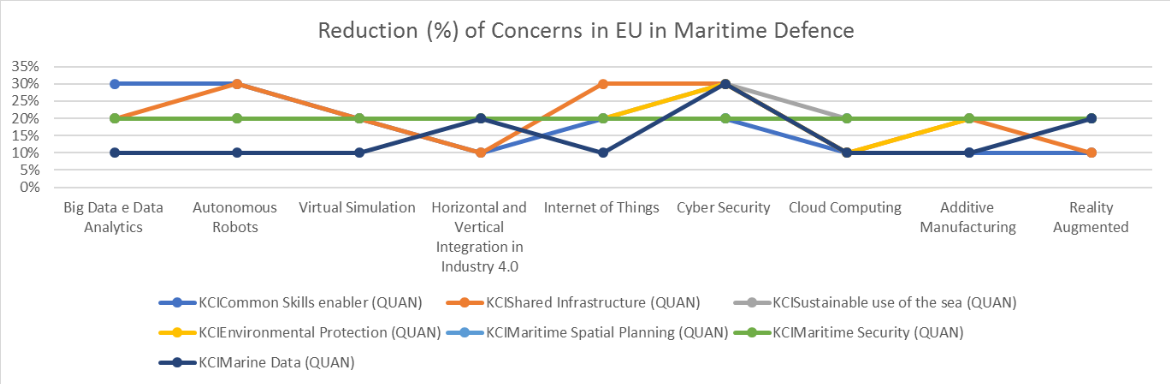
The EU sector is made of six major shipbuilding companies ("system integrators"): Naval Group (France), Navantia (Spain), Damen (The Netherlands), ThyssenKrupp (Germany), Fincantieri (Italy) and BAE Systems (UK). They are "the center of gravity of a wide network of highly specialized sub-suppliers and collective aggregate over 98% of the $75 billion EU naval order book at mid-2015".

Traditionally, each of the major systems integrators had their respective navies as their principal, captive customer. However, due to decreasing defense budgets in Europe, they had to find new markets, and hence export markets account for 42% of the European naval order book value. Besides, "since the 90s, the industry has embarked on a diversification strategy in non-military high tech markets" from cruise liners and mega yachts to offshore oil and gas and offshore and marine renewable energies. According to the study, this diversification strategy has created a favorable cross-fertilization between civil and military technologies (dual-use technologies) both at the prime contractors and at supply-chain levels, thereby leading to cost-effective designs and solutions (European Union, 2019).

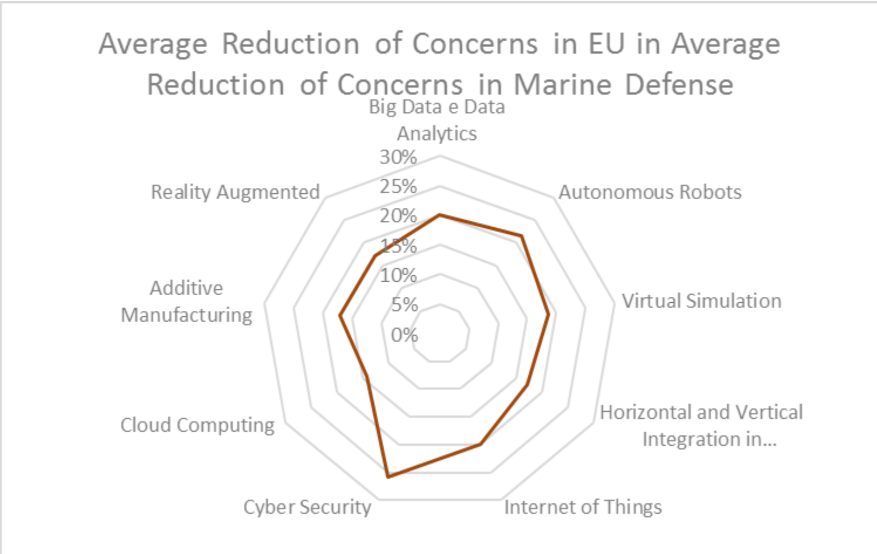
For this case study, it was invited one company to participate in this survey, operating in Defence and security, with the headquarter located in the European Union territory, internationalized and operating in the Blue Economy. The company has participated in 5 European R&D Projects in the last five years. The interviews have been done by phone or during personal visit- Table Appendix B. 21. The data was collected- Table Appendix B. 22- Graphic Appendix B. 11.



Graphic: 5-31: CS#11 | EU Maritime Defence | Level of the Enabler Weight (QUAL)



Graphic: 5-32: CS#11 | EU Maritime Defence | Concerns Relief (%) related to the I4.0 Technologies (QUAN)



Graphic: 5-33: CS#11 | EU Maritime Defence | Enablers average Reduction of Concerns due to I4.0 Technologies introduction on their Activities

The economic and financial crisis led to significant cuts in defense spending. New acquisitions and programs were reduced or slowed down, and many vessels were retired earlier than expected due to funding shortages. This pattern, however, is currently changing, given the improved economic environment and renewed perceived threats from Russia. Moreover, navies have adapted to new missions particularly with the proliferation of overseas missions, be they for peacekeeping or anti-piracy purposes (ex. EU NAVFOR ATALANTA in the Horn of Africa and Indian Ocean and EU NAVFOR SOPHIA in the central Mediterranean), which require new types of vessels (ex. Offshore Patrol Vessels, OPV) (European Union, 2019).

5.2 CROSS-ANALYSIS OF THE CASE-STUDIES

Almost all companies interviewed adopt a differentiation strategy by offering a solution that includes product and service, and a continuous focus on R&D focused on customer needs, with which they have a close relationship and use to develop solutions together, promoting co-creation. There is, therefore, a great alignment between their business strategy and the functional strategy, as offering a product and service solution increases customer benefits, distinguishes the offer from the competition, and is difficult to imitate. Moreover, all these companies convey the value of their products or services, mostly through technical demo events and participation in fairs. Besides, they also continually focus on relational and proximity marketing, which make them to keep a close relationship with customers, gain knowledge of their consumption processes and needs. From the conversations, it was understood that all of them have been able to win some clients based on the recommendations of other clients, that is, the clients themselves become their ambassadors, which is commercially and financially good as it reduces their marketing costs.

Almost all companies interviewed are very interested in adopting digital technologies, associated with the need to develop their markets and enable co-creating deep relationships with their customers. All these companies have shown interest in participating in the integration of these technologies and even, in some cases, interest in participating in their development. Based on the subsequent analysis of the potential of these technologies, they evaluate new business opportunities and strategies to adopt. They have broad solution portfolios, work in customization, some of which use jobbing as their production method, which implies low or no standardization of processes and increases production costs. Almost all use lean procedures in the production process, and most of them are certified for quality and some for their innovation.

Based on the potential of I4.0 Technologies, companies are very interested in tracking their customers in real-time. Many companies consider deepening servitization as a reasonable hypothesis for their business. However, not for all markets where they operate, only for those with a strong presence and the support of local partners.

5.3 COMPUTING AND DISCUSSION THE KCI AND IO RESULTS

In the previous section, the qualitative and quantitative data were collected and recorded for the 11 case-studies. The KCI and KPI tables, as shown in Appendix B, give the average data value of each case-study. Following the methodological procedures as detailed in Chapter 4, the collected data can be used to compute the KCI´s, KPI´s, and IO's related to the 11 case-studies.

5.3.1 I4.0 Technologies contribution, to strength the European Blue Economy Enablers

The framework was applied to 11 case-studies. For each case study, it was collected the data and assessed the KCI and KPI evolution by I4.0 Technologies usage by the companies. By using these and through equation 5.1, the potential performance improvement on the sectors coming from each one of the I4.0 Technology was assessed. The results are shown in Tables B.1 to B.22, Appendix B.

From these results, it was found that the I4.0 Technologies contributions to the BE-Enablers improvement are significative: (i) the contribution found to the Common Skills improvement is 17,5%; (i) to the Shared Infrastructure Enabler 17,9%; (iii) to the Sustainable use of the sea Enabler 17,4%; (iv) to the Environmental Protection Enabler 16,7%; (v) to the Maritime Spatial Planning Enabler 15,9%; (vi) to the Maritime Security Enabler 16,7% and (vii) to the Marine Data Enabler 16,7% - Table 5-1.

Blue Economy Sectors	Common Skills BE_Enabler	Shared Infrastructure BE_Enabler	Sustainable use of the sea BE_Enabler	Environmental Protection BE_Enabler	Maritime Spatial Planning BE_Enabler	Maritime Security BE_Enabler	**Marine Data BE_Enabler**
Coastal Tourism	13%	18%	20%	21%	9%	18%	**14%**
Extraction And Commercialisation of Marine Living Resources	18%	19%	17%	15%	16%	14%	**14%**
Marine Extraction of Minerals, Oil and Gas	17%	15%	13%	11%	11%	11%	**12%**
Ports, Warehousing and Water Projects	21%	22%	23%	20%	22%	22%	**23%**
Shipbuilding and Repair	21%	22%	23%	23%	22%	22%	**23%**
Maritime Transport	16%	15%	16%	15%	14%	13%	**14%**
Blue Energy	16%	15%	14%	14%	14%	15%	**14%**
Blue Bio Economy	19%	19%	19%	18%	18%	20%	**22%**
Marine Minerals	18%	18%	16%	17%	18%	18%	**17%**
Desalination	17%	17%	16%	15%	16%	17%	**19%**
Maritime Defence	18%	16%	15%	14%	15%	14%	**12%**
I4.0 technologies contribution, to strength the European Blue Economy Enablers	17,5%	17,9%	17,4%	16,7%	15,9%	16,7%	**16,7%**

Table 5-1: Blue Economy Enablers Innovation Outcomes | I4.0 Technologies contribution to the EU Blue Economy Enabler improvement

5.3.2 The relevancy of the enablers, for each one of the Blue Economy Sector

In the previews session, the potential performance improvement on the sectors coming from each one of the I4.0 Technologies was assessed. By using these outcomes on the equation 5.2, the Blue Economy Enablers Innovation Outcomes were assessed, meaning significative potential performance improvement, case the companies decide to adopt the I4.0 Technologies on their businesses - Table 5-2.

Blue Economy Sector	Common Skills BE_Enabler	Shared Infrastructure BE_Enabler	Sustainable use of the sea BE_Enabler	Environmental Protection BE_Enabler	Maritime Spatial Planning BE_Enabler	Maritime Security BE_Enabler	Marine Data BE_Enabler
Coastal Tourism	13%	18%	40%	42%	9%	36%	14%
Extraction And Commercialisation of Marine Living Resources	36%	37%	34%	15%	16%	14%	14%
Marine Extraction of Minerals, Oil and Gas	17%	30%	27%	22%	22%	23%	23%
Ports, Warehousing and Water Projects	21%	45%	45%	40%	22%	44%	23%
Shipbuilding and Repair	42%	22%	45%	23%	22%	44%	46%
Maritime Transport	16%	30%	31%	15%	14%	13%	28%
Blue Energy	31%	30%	29%	27%	14%	15%	28%
Blue Bio Economy	38%	19%	37%	37%	18%	20%	22%
Marine Minerals	36%	35%	32%	34%	36%	35%	34%
Desalination	33%	17%	16%	15%	16%	17%	38%
Maritime Defence	18%	16%	15%	28%	15%	27%	24%
I4.0 Technologies improvement contribution to the EU Blue Economy Sectors	**27,3%**	**27,3%**	**32,0%**	**27,2%**	**18,6%**	**26,2%**	**26,8%**

Table 5-2: The relevancy of the enablers, for each one of the Blue Economy Sector

5.3.3 The I4.0 Technologies impact on EU Blue Economy sectors

By using these outcomes on the equation 5.3, the impact of I4.0 Technologies on each one of the European Blue Economy Sectors was assessed, meaning the potential competitiveness improvement of the European Blue Economy Activities if the companies decide to adopt the I4.0 technologies on their businesses.

From the case studies it was found the that the impacts on the sustainable competitiveness of each sector of the EU Blue Economy if companies incorporate I4.0 Technologies are significative: (i) the contribution found to the Coastal Tourism Sector was 25%; (ii) for the Extraction and Commercialisation of Marine Living Resources 24%; (iii) for Marine Extraction of Minerals, Oil and Gas 23%; (iv) for Ports, Warehousing and Water Projects 34%; (v) for the Shipbuilding and Repair 35%; (vi) for Maritime Transport 21%; (vii) for Blue Energy 21%; (viii) for Blue Bio-Economy 27%; (ix) for Marine Minerals 34%; (x) for the Desalination (22%) and (xi) for Maritime Defence 20% - Table 5-3.

case-studies	EUROPEAN BLUE ECONOMY SECTORS	Impact of I4.0 Technologies on the European Blue Economy Sectors
CS1	Coastal Tourism	25%
CS2	Extraction And Commercialisation of Marine Living Resources	24%
CS3	Marine Extraction of Minerals, Oil and Gas	23%
CS4	Ports, Warehousing and Water Projects	34%
CS5	Shipbuilding and Repair	35%
CS6	Maritime Transport	21%
CS7	Blue Energy	25%
CS8	Blue Bio Economy	27%
CS9	Marine Minerals	34%
CS10	Desalination	22%
CS11	Maritime Defence	20%

Table 5-3: Impact of I4.0 Technologies on each one of the European Blue Economy Sectors

5.3.4 Competitiveness Global Impact of I4.0 Technologies on the European Blue Economy

Without considering how important is each sector inside the European Economy, from the above Innovation Outcomes assessment, by using the equation 5.4, it was assessed the Competitiveness Impact of I4.0 Technologies on the European Blue Economy. The result assessed has o positive impact of 26.5%.

5.4 CHAPTER SYNTHESIS

In this chapter, it was applied the framework, as conceptualized in Chapter 4, to eleven case-studies related to the European Blue Economy. All the companies interviewed, convey the value of their products or services mostly through technical demo events and participation in fairs. Besides, they also continually focus on relational and proximity marketing, which make them to keep a close relationship with customers, gain knowledge of their consumption processes and needs. Almost all of them demonstrated interested in adopting digital technologies, associated with the need to develop their markets and enable co-creating deep relationships with their customers. Based on the potential of I4.0 Technologies, companies are very interested in tracking their customers in real-time. Many companies consider deepening servitization as a reasonable hypothesis for their business. However, not for all markets where they operate, only for those with a strong presence and the support of local partners. The qualitative and quantitative data were collected and recorded for the 11 case-studies. The KCI and KPI tables, as shown in Appendix B, give the average data value of each case-study. Following the methodological procedures as detailed in Chapter 4, the collected data can be used to compute the KCI´s, KPI´s, and IO’s related to the 11 case-studies. From these results, it was found that the I4.0 Technologies contributions to the BE-Enablers improvement are significative. By using these outcomes on the equation 5.2, the Blue Economy Enablers Innovation Outcomes were assessed, meaning the potential performance improvement of these enablers if the companies decide to adopt the I4.0 technologies on their businesses. From the case studies, it was found that the impacts on the sustainable competitiveness of each sector of the EU Blue Economy if companies incorporate I4.0 Technologies are also significative. Without considering how important is each sector inside the European Economy, from the above Innovation Outcomes assessment, by using the equation 5.4, it was assessed the Competitiveness Impact of I4.0 Technologies on the European Blue Economy.

KEY POINTS

- The I4.0 Technologies contributions to the BE-Enablers improvement are significative: (i) the contribution found to the Common Skills improvement is 17,5%; (i) to the Shared Infrastructure Enabler 17,9%; (iii) to the Sustainable use of the sea Enabler 17,4%; (iv) to the Environmental Protection Enabler 16,7%; (v) to the Maritime Spatial Planning Enabler 15,9%; (vi) to the Maritime Security Enabler 16,7% and (vii) to the Marine Data Enabler 16,7%.
- The Blue Economy Enablers Innovation Outcomes is significative the potential performance improvement; case the companies decide to adopt the I4.0 technologies on their businesses.
- The impact of I4.0 Technologies on each one of the European Blue Economy Sectors was assessed, meaning the potential competitiveness improvement of the European Blue Economy Activities if the companies decide to adopt the I4.0 technologies on their businesses.
- The impacts on the sustainable competitiveness of each sector of the EU Blue Economy if companies incorporate I4.0 Technologies are significative.
- Without considering how important is each sector inside the European Economy, from the above Innovation Outcomes assessment, by using the equation 5.4, it was assessed the Competitiveness Impact of I4.0 Technologies on the European Blue Economy. The result assessed has o positive impact of 26.5%.

6. CONCLUSIONS

We make a living by what we get,
but we make a life by what we give.

Winston Churchill

In this research, the impact of Industry4.0 Technologies on the competitivity of companies in the Blue Economy (BE) in the European Union (EU) was assessed.

Given the drift towards the digital economy witnessed, the Research Problem (RP) of this research was focused mainly on these enablers' relevancy, but also on the opportunities currently open to the European Blue Economy if the companies adopt the available digital tools designated as I4.0. Accepting these Enablers as the drivers towards a Blue Growth, digital technologies are currently bringing the opportunity to shift the operations mode, where the business processes are supported by Cyber-Physical Systems (CPSs), designated as Industry 4.0 (I4.0). The RP of this research arises from this dichotomy: What competitiveness impact on the European Blue Economy if companies adopt the Industry 4.0 Technologies?

Although the term "Blue Economy" has been used in different ways, in this research, it was followed the World Bank and United Nations Report from 2017 understanding, as comprising the range of economic sectors and related policies that together determine whether the use of oceanic resources is sustainable. An essential challenge of the Blue Economy is thus to understand and better manage the many aspects of oceanic sustainability, ranging from sustainable fisheries to ecosystem health to pollution. A second significant issue is the realization that the sustainable management of ocean resources requires collaboration across nation-states and the public-private sectors, and on a scale that has not been previously achieved.

The most recent European Union Blue Economy Reports (2008 and 2019) analyses the scope and size of the Blue Economy in the European Union, solidifying a baseline to support policymakers and stakeholders in the quest for a sustainable development of oceans, sea and coastal resources and identifying seven enablers: (i) common skills, (ii) shared infrastructure, (iii) sustainable use of the sea, (iv) environmental protection, (v) maritime spatial planning, (vi) maritime security, and (vii) marine data.

Supported by the Research Problem, the Research Questions (RQs) were stated, to which answers were obtained by applying the framework to a set of eleven EU Blue Economy case-studies: RQ1 | What contribution can I4.0 Technologies do to strength the European Blue Economy Enablers? RQ2 | What Enablers Relevancy for the EU Blue Economy if companies incorporate I4.0 Technologies on their activities? RQ3 | What Impact of I4.0 Technologies on each one of the European Blue Economy Sector?

By applying the mixed parallel convergent methodology, it was assessed the impact on competitiveness of the EU Blue Economy if companies either in established or emerging sectors, adopt the I4.0 Technologies. By interviewing one European company per activity in each sector of the Blue Economy and grouping them into sectorial case-studies. For each convenient case-study and each company interviewed, the data was recorded in terms of quantitative Key Concerns Indicators (KCIs) and qualitative Key Performance Indicators (KPIs).

The main objective of this research was fully achieved, as it was the conceptualization of an empirical framework to assess the impact on sustainable competitiveness of the EU Blue Economy if companies incorporate I4.0 Technologies. Under this objective, the empirical framework was conceptualized, supported by the Service Science Body of Knowledge looking at the digital economy has a high level of complexity, mainly in terms of actors whose interactions co-occurring. By applying the framework to the selected case-studies, it was possible to assess the impact on the competitiveness of the EU Blue Economy, if companies adopt the I4.0 Technologies as well as provide answers to the Research Questions (RQs), as stated in the chapter on Research Methodology:

Response to RQ1 – From the application of the framework to the case studies, it was found the that contributions of the I4.0 Technologies to strength the European Blue Economy Enablers are significative: (i) to the Common Skills Enabler 17,5%; (ii) to the Shared Infrastructure Enabler 17,9%; (iii) to the Sustainable use of the sea Enabler 17,4%; (iv) to the Environmental Protection Enabler 16,7%; (v) to the Maritime Spatial Planning Enabler 15,9%; (vi) to the Maritime Security Enabler 16,7% and (vii) to the Marine Data Enabler 16,7%.

Answer to RQ2 - From the application of the framework to the case studies, it was found the that Enablers Relevancy for the BE Sectors if companies incorporate I4.0 Technologies are also significative: (i) to the Common Skills Enabler 27,3%; (ii) to the

Shared Infrastructure Enabler 27,3%; (iii) to the Sustainable use of the sea Enabler 32,0%; (iv) to the Environmental Protection Enabler 27,2%; (v) to the Maritime Spatial Planning Enabler 18,6%; (vi) to the Maritime Security Enabler 26,2% and (vii) to the Marine Data Enabler 26,8%.

Answer to RQ3 - From the application of the framework to the case studies, it was found that the Impact of I4.0 Technologies on each one of the European Blue Economy Sectors are also significative: (i) Coastal Tourism Sector was 25%; (ii) Extraction and Commercialisation of Marine Living Resources 24%; (iii) Marine Extraction of Minerals, Oil and Gas 23%; (iv) Ports, Warehousing and Water Projects 34%; (v) the Shipbuilding and Repair 35%; (vi) Maritime Transport 21%; (vii) Blue Energy 21%; (viii) Blue Bio-Economy 27%; (ix) Marine Minerals 34%; (x) Desalination (22%) and (xi) Maritime Defence 20%. The potential impact on the competitiveness of the European Blue Economy if companies incorporate I4.0 Technologies is 26.5%.

Although not considering the investment required to purchase the I4.0 Technologies and the relative contribution of each Activity to the European Blue Economy, from these results, it may be concluded that the use of the I4.0 Technologies by EU Blue Economy companies, looks to be an opportunity to improve their competitiveness.

6.1 CONTRIBUTIONS TO THEORY

From these conclusions, we may consider the suitability of empirical framework as a possible practical tool for other researches, resulting in additional contributions to practice, but also with academic interest, since Service Science Theory proved to be able to support the innovation and understanding of value co-creation interactions.

The great theoretical return of this work is the development and preliminary testing of an innovative empirical framework in a holistic and transdisciplinary perspective. This framework may be used to assist the European Blue Economy companies to define a strategic and sustainable positioning for their business based on the introduction, which can be phased out of I4.0 Technologies. This is a new framework that relates to the advantages of digital technologies gradually more accessible to the evolutionary stages of the companies themselves. To date, no one has yet developed a holistic model that combines all these aspects.

From these conclusions, we may consider the suitability of empirical framework as a possible practical tool for other researches, resulting in additional contributions to practice, but also with academic interest since S-S theory proved to be able to support the innovation and understanding of value co-creation interactions.

In addition to the empirical analysis that strengthens the scope of the objectives of research, we must emphasize the contribution to theory resulting from the development of an empirical framework, supported by the Service Science Theory. Guided by the Pragmatist paradigm and using the mixed methodology of parallel convergence, it was possible to evaluate the sustainable impact of I4,0 Technologies in Europe.

6.2 CONTRIBUTIONS TO RESEARCH

The whole process of survey resulting from the empirical framework represents an important return for research, especially in the scientific field of Operations. Besides, the research pursued also falls within the scope chosen for the work, i.e., the companies representing all significant activities of the European Blue Economy. On the other hand, the need for further testing to increase the robustness of the empirical framework allows for many future research opportunities, such as: (i) replication of empirical results with the same scope or reduced scope; (ii) redesign and application of the questionnaire in a study aiming at the statistical generalization of results.

6.3 CONTRIBUTIONS TO PRACTICE

We can also conclude that the empirical framework, conceptualized according to Service Science Theory was appropriate for the RP addressed in this research, allowing the combination of qualitative and quantitative data in a convergent way, and enabling conclusions to be drawn about the impact on the EU Blue Economy companies, resulting in the first contribution of this research to practice. In describing and configuring case-studies, and following the objectives of this research, determining the KCI and KPI, we consider we have found a possible solution to the RP as described in the chapter on Methodology. Since the objectives have been successfully achieved, we believe we have contributed to the development of world Blue Economy sectors in general, thus contributing to people’s well-being and the Sustainability of the Planet.

6.4 RECOMMENDATIONS AND LIMITATIONS

Although the proposed objectives have been broadly achieved, there were several difficulties to overcome during this research, which led to some limitations. The literature review revealed that the Service Science literature dealing with I4.0 is scarce and, even more so, the literature on I4.0 digital production applied to the Blue Economy sectors and studied from the perspective of this new scientific discipline, a situation that caused additional difficulty in the conceptualization of an empirical framework. Once overcome, this has also contributed to practice and theory. Another limitation found in applying the empirical framework was the fact that I4.0 Technologies are not yet in a properly mature stage.

In the context of this RP, we may consider as possible future developments, dynamic analysis of the cost-benefit relationship and interpretation of the frontier conditions, related to the investment required to operate in I4.0 mode, for a more robust and detailed information on which to base their investment decisions, taking in consideration the relative contribution of each Activity to the European Blue Economy.

For each new sector, in this research, there were identified only one activity. To have more robust feedback, for future developments, it is recommendable to include more case-studies in these new sectors. Other possible future developments related to this Research Context may focus on the evaluation of the I4.0 response in other sectors.

APPENDIX A | QUESTIONAIRE AND GUIDELINES

THE ***COMMON SKILLS ENABLER*** CONCERNS (KCI) REDUCTION IF STAKEHOLDERS USE THE I4.0 TECHNOLOGIES - QUESTIONNAIRE GUIDELINES	THE COMMON SKILLS ENABLER WEIGHT TO THE SECTOR (QUAL)
What *Big Data and Data Analytics I4.0 Technology* may reduce your concerns related to the *Common Skills* Enabler?	*KPI-BE-COMMON SKILLS-enabler-weight*
What *Autonomous Robots I4.0 Technology* may reduce your concerns related to the *Common Skills Enabler?*	*KPI-BE-COMMON SKILLS-enabler-weight*
What *Virtual Simulation I4.0 Technology* may reduce your concerns related to the *Common Skills Enabler?*	*KPI-BE-COMMON SKILLS-enabler-weight*
What *Horizontal and Vertical Integration* may reduce your concerns related to the *Common Skills Enabler?*	*KPI-BE-COMMON SKILLS-enabler-weight*
What *Internet of Things I4.0 Technology* may reduce your concerns related to the *Common Skills Enabler?*	*KPI-BE-COMMON SKILLS-enabler-weight*
What *Cyber Security I4.0 Technology* may reduce your concerns related to the *Common Skills Enabler?*	*KPI-BE-COMMON SKILLS-enabler-weight*
What *Cloud Computing I4.0 Technology* may reduce your concerns related to the *Common Skills Enabler?*	*KPI-BE-COMMON SKILLS-enabler-weight*
What *Additive Manufacturing I4.0 Technology* may reduce your concerns related to the *Common Skills Enabler?*	*KPI-BE-COMMON SKILLS-enabler-weight*
What *Reality Augmented I4.0 Technology* may reduce your concerns related to the *Common Skills Enabler?*	*KPI-BE-COMMON SKILLS-enabler-weight*

Table Appendix A. 1: The COMMON SKILLS Enabler Concerns (KCI) | Reduction if Stakeholders Use the I4.0 Technologies | Questionnaire Guidelines

THE ***SHARED INFRASTRUCTURE ENABLER*** CONCERNS (KCI) REDUCTION IF STAKEHOLDERS USE THE I4.0 TECHNOLOGIES - QUESTIONNAIRE GUIDELINES	THE SHARED INFRASTRUCTURE ENABLER WEIGHT TO THE SECTOR (QUAL)
What *Big Data and Data Analytics I4.0 Technology* may reduce your concerns related to the *shared infrastructure* Enabler?	*KPI-BE-SHARED INFRASTRUCTURE-enabler-weight*
What *Autonomous Robots I4.0 Technology* may reduce your concerns related to the *shared infrastructure Enabler?*	*KPI-BE-SHARED INFRASTRUCTURE-enabler-weight*
What *Virtual Simulation I4.0 Technology* may reduce your concerns related to the *shared infrastructure Enabler?*	*KPI-BE-SHARED INFRASTRUCTURE-enabler-weight*
What *Horizontal and Vertical Integration* may reduce your concerns related to the *shared infrastructure Enabler?*	*KPI-BE-SHARED INFRASTRUCTURE-enabler-weight*
What *Internet of Things I4.0 Technology* may reduce your concerns related to the *shared infrastructure Enabler?*	*KPI-BE-SHARED INFRASTRUCTURE-enabler-weight*
What *Cyber Security I4.0 Technology* may reduce your concerns related to the *shared infrastructure Enabler?*	*KPI-BE-SHARED INFRASTRUCTURE-enabler-weight*
What *Cloud Computing I4.0 Technology* may reduce your concerns related to the *shared infrastructure Enabler?*	*KPI-BE-SHARED INFRASTRUCTURE-enabler-weight*
What *Additive Manufacturing I4.0 Technology* may reduce your concerns related to the *shared infrastructure Enabler?*	*KPI-BE-SHARED INFRASTRUCTURE-enabler-weight*
What *Reality Augmented I4.0 Technology* may reduce your concerns related to the *shared infrastructure Enabler?*	*KPI-BE-SHARED INFRASTRUCTURE-enabler-weight*

Table Appendix A. 2: The SHARED INFRASTRUCTURE Enabler Concerns (KCI) | Reduction if Stakeholders Use the I4.0 Technologies | Questionnaire Guidelines

THE ***SUSTAINABLE USE OF THE SEA ENABLER*** CONCERNS (KCI) REDUCTION IF STAKEHOLDERS USE THE I4.0 TECHNOLOGIES - QUESTIONNAIRE GUIDELINES	THE SUSTAINABLE USE OF THE SEA ENABLER WEIGHT TO THE SECTOR (QUAL)
What *Big Data and Data Analytics I4.0 Technology* may reduce your concerns related to the *sustainable use of the sea* Enabler?	*KPI-BE-SUSTAINABLE USE OF THE SEA-enabler-weight*
What *Autonomous Robots I4.0 Technology* may reduce your concerns related to the *sustainable use of the sea Enabler?*	*KPI-BE-SUSTAINABLE USE OF THE SEA-enabler-weight*
What *Virtual Simulation I4.0 Technology* may reduce your concerns related to the *sustainable use of the sea Enabler?*	*KPI-BE-SUSTAINABLE USE OF THE SEA-enabler-weight*
What *Horizontal and Vertical Integration* may reduce your concerns related to the *sustainable use of the sea Enabler?*	*KPI-BE-SUSTAINABLE USE OF THE SEA-enabler-weight*
What *Internet of Things I4.0 Technology* may reduce your concerns related to the *sustainable use of the sea Enabler?*	*KPI-BE-SUSTAINABLE USE OF THE SEA-enabler-weight*
What *Cyber Security I4.0 Technology* may reduce your concerns related to the *sustainable use of the sea Enabler?*	*KPI-BE-SUSTAINABLE USE OF THE SEA-enabler-weight*
What *Cloud Computing I4.0 Technology* may reduce your concerns related to the *sustainable use of the sea Enabler?*	*KPI-BE-SUSTAINABLE USE OF THE SEA-enabler-weight*
What *Additive Manufacturing I4.0 Technology* may reduce your concerns related to thesustainable use of the sea *Enabler?*	*KPI-BE-SUSTAINABLE USE OF THE SEA-enabler-weight*
What *Reality Augmented I4.0 Technology* may reduce your concerns related to the *sustainable use of the sea Enabler?*	*KPI-BE-SUSTAINABLE USE OF THE SEA-enabler-weight*

Table Appendix A. 3: The SUSTAINABLE USE OF THE SEA Enabler Concerns (KCI) | Reduction if Stakeholders Use the I4.0 Technologies | Questionnaire Guidelines

THE ***ENVIRONMENTAL PROTECTION ENABLER*** CONCERNS (KCI) REDUCTION IF STAKEHOLDERS USE THE I4.0 TECHNOLOGIES - QUESTIONNAIRE GUIDELINES	THE BIG DATA AND DATA ANALYTICS ENABLER WEIGHT TO THE SECTOR (QUAL)
What *Big Data and Data Analytics I4.0 Technology* may reduce your concerns related to the *environmental protection* Enabler?	*KPI-BE-BIG DATA AND DATA ANALYTICS-enabler-weight*
What *Autonomous Robots I4.0 Technology* may reduce your concerns related to the *environmental protection Enabler?*	*KPI-BE-BIG DATA AND DATA ANALYTICS-enabler-weight*
What *Virtual Simulation I4.0 Technology* may reduce your concerns related to the *environmental protection Enabler?*	*KPI-BE-BIG DATA AND DATA ANALYTICS-enabler-weight*
What *Horizontal and Vertical Integration* may reduce your concerns related to the *environmental protection Enabler?*	*KPI-BE-BIG DATA AND DATA ANALYTICS-enabler-weight*
What *Internet of Things I4.0 Technology* may reduce your concerns related to the *environmental protection Enabler?*	*KPI-BE-BIG DATA AND DATA ANALYTICS-enabler-weight*
What *Cyber Security I4.0 Technology* may reduce your concerns related to the *environmental protection Enabler?*	*KPI-BE-BIG DATA AND DATA ANALYTICS-enabler-weight*
What *Cloud Computing I4.0 Technology* may reduce your concerns related to the *environmental protection Enabler?*	*KPI-BE-BIG DATA AND DATA ANALYTICS-enabler-weight*
What *Additive Manufacturing I4.0 Technology* may reduce your concerns related to the *environmental protection Enabler?*	*KPI-BE-BIG DATA AND DATA ANALYTICS-enabler-weight*
What *Reality Augmented I4.0 Technology* may reduce your concerns related to the *environmental protection Enabler?*	*KPI-BE-BIG DATA AND DATA ANALYTICS-enabler-weight*

Table Appendix A. 4: The ENVIRONMENTAL PROTECTION Enabler Concerns (KCI) | Reduction if Stakeholders Use the I4.0 Technologies | Questionnaire Guidelines

THE ***MARITIME SPATIAL PLANNING ENABLER*** CONCERNS (KCI) REDUCTION IF STAKEHOLDERS USE THE I4.0 TECHNOLOGIES - QUESTIONNAIRE GUIDELINES	THE MARITIME SPATIAL PLANNING ENABLER WEIGHT TO THE SECTOR (QUAL)
What *Big Data and Data Analytics I4.0 Technology* may reduce your concerns related to the *maritime spatial planning* Enabler?	*KPI-BE-MARITIME SPATIAL PLANNING-enabler-weight*
What *Autonomous Robots I4.0 Technology* may reduce your concerns related to the *maritime spatial planning Enabler?*	*KPI-BE-MARITIME SPATIAL PLANNING-enabler-weight*
What *Virtual Simulation I4.0 Technology* may reduce your concerns related to the *maritime spatial planning Enabler?*	*KPI-BE-MARITIME SPATIAL PLANNING-enabler-weight*
What *Horizontal and Vertical Integration* may reduce your concerns related to the *maritime spatial planning Enabler?*	*KPI-BE-MARITIME SPATIAL PLANNING-enabler-weight*
What *Internet of Things I4.0 Technology* may reduce your concerns related to the *maritime spatial planning Enabler?*	*KPI-BE-MARITIME SPATIAL PLANNING-enabler-weight*
What *Cyber Security I4.0 Technology* may reduce your concerns related to the *maritime spatial planning Enabler?*	*KPI-BE-MARITIME SPATIAL PLANNING-enabler-weight*
What *Cloud Computing I4.0 Technology* may reduce your concerns related to the *maritime spatial planning Enabler?*	*KPI-BE-MARITIME SPATIAL PLANNING-enabler-weight*
Wh*at Additive Manufacturing I4.0 Technology* may reduce your concerns related to the *maritime spatial planning Enabler?*	*KPI-BE-MARITIME SPATIAL PLANNING-enabler-weight*
What *Reality Augmented I4.0 Technology* may reduce your concerns related to the *maritime spatial planning Enabler?*	*KPI-BE-MARITIME SPATIAL PLANNING-enabler-weight*

Table Appendix A. 5: The MARITIME SPATIAL PLANNING Enabler Concerns (KCI) | Reduction if Stakeholders Use the I4.0 Technologies | Questionnaire Guidelines

THE ***MARITIME SECURITY ENABLER*** CONCERNS (KCI) REDUCTION IF STAKEHOLDERS USE THE I4.0 TECHNOLOGIES - QUESTIONNAIRE GUIDELINES	THE MARITIME SECURITY ENABLER WEIGHT TO THE SECTOR (QUAL)
What *Big Data and Data Analytics I4.0 Technology* may reduce your concerns related to the *maritime security* Enabler?	*KPI-BE-MARITIME SECURITY-enabler-weight*
What *Autonomous Robots I4.0 Technology* may reduce your concerns related to the *maritime security Enabler?*	*KPI-BE-MARITIME SECURITY-enabler-weight*
What *Virtual Simulation I4.0 Technology* may reduce your concerns related to the *maritime securityEnabler?*	*KPI-BE-MARITIME SECURITY-enabler-weight*
What *Horizontal and Vertical Integration* may reduce your concerns related to the *maritime security Enabler?*	*KPI-BE-MARITIME SECURITY-enabler-weight*
What *Internet of Things I4.0 Technology* may reduce your concerns related to the *maritime security Enabler?*	*KPI-BE-MARITIME SECURITY-enabler-weight*
What *Cyber Security I4.0 Technology* may reduce your concerns related to the *maritime security Enabler?*	*KPI-BE-MARITIME SECURITY-enabler-weight*
What *Cloud Computing I4.0 Technology* may reduce your concerns related to the *maritime security Enabler?*	*KPI-BE-MARITIME SECURITY-enabler-weight*
Wh*at Additive Manufacturing I4.0 Technology* may reduce your concerns related to the *maritime security Enabler?*	*KPI-BE-MARITIME SECURITY-enabler-weight*
What *Reality Augmented I4.0 Technology* may reduce your concerns related to the *maritime security Enabler?*	*KPI-BE-MARITIME SECURITY-enabler-weight*

Table Appendix A. 6: The MARITIME SECURITY Enabler Concerns (KCI) | Reduction if Stakeholders Use the I4.0 Technologies | Questionnaire Guidelines

THE ***MARINE DATA ENABLER*** CONCERNS (KCI) REDUCTION IF STAKEHOLDERS USE THE I4.0 TECHNOLOGIES - QUESTIONNAIRE GUIDELINES	THE MARINE DATA ENABLER WEIGHT TO THE SECTOR (QUAL)
What *Big Data and Data Analytics I4.0 Technology* may reduce your concerns related to the *marine data* Enabler?	*KPI-BE-MARINE DATA-enabler-weight*
What *Autonomous Robots I4.0 Technology* may reduce your concerns related to the *marine data Enabler?*	*KPI-BE-MARINE DATA-enabler-weight*
What *Virtual Simulation I4.0 Technology* may reduce your concerns related to the *marine data Enabler?*	*KPI-BE-MARINE DATA-enabler-weight*
What *Horizontal and Vertical Integration* may reduce your concerns related to the *marine data Enabler?*	*KPI-BE-MARINE DATA-enabler-weight*
What *Internet of Things I4.0 Technology* may reduce your concerns related to the *marine data Enabler?*	*KPI-BE-MARINE DATA-enabler-weight*
What *Cyber Security I4.0 Technology* may reduce your concerns related to the *marine data Enabler?*	*KPI-BE-MARINE DATA-enabler-weight*
What *Cloud Computing I4.0 Technology* may reduce your concerns related to the *marine data Enabler?*	*KPI-BE-MARINE DATA-enabler-weight*
Wh*at Additive Manufacturing I4.0 Technology* may reduce your concerns related to the *marine data Enabler?*	*KPI-BE-MARINE DATA-enabler-weight*
What *Reality Augmented I4.0 Technology* may reduce your concerns related to the *marine data Enabler?*	*KPI-BE-MARINE DATA-enabler-weight*

Table Appendix A. 7: The MARINE DATA Enabler Concerns (KCI) | Reduction if Stakeholders Use the I4.0 Technologies | Questionnaire Guidelines

LEVEL OF IMPORTANCE OF THE ***BE-ENABLERS*** TO ***COASTAL TOURISM*** QUESTIONNAIRE GUIDELINES
How important is the Common Skills to Coastal Tourism?
What relevant is the Shisd Infrastructure enabler to Coastal Tourism?
What relevant is the Sustainable use of the sea enabler to Coastal Tourism?
What relevant is the Environmental Protection enabler to Coastal Tourism?
What relevant is the Maritime Spatial Planning enabler to Coastal Tourism?
What relevant is the Maritime Security enabler to Coastal Tourism?
What relevant is the Marine Data enabler to Coastal Tourism?

Table Appendix A. 8: Importance of BE-Enablers to the COASTAL TOURISM sector | Questionnaire-Guidelines

LEVEL OF IMPORTANCE OF THE ***BE-ENABLERS*** TO ***EXTRACTION AND COMMERCIALISATION OF MARINE LIVING RESOURCES*** QUESTIONNAIRE GUIDELINES
How important is the Common Skills to extraction and commercialisation of marine living resources?
What relevant is the Shisd Infrastructure enabler to extraction and commercialisation of marine living resources?
What relevant is the Sustainable use of the sea enabler to extraction and commercialisation of marine living resources?
What relevant is the Environmental Protection enabler to extraction and commercialisation of marine living resources?
What relevant is the Maritime Spatial Planning enabler to extraction and commercialisation of marine living resources?
What relevant is the Maritime Security enabler to extraction and commercialisation of marine living resources?
What relevant is the Marine Data enabler to extraction and commercialisation of marine living resources?

Table Appendix A. 9: Importance of BE-Enablers to the EXTRACTION AND COMMERCIALISATION OF MARINE LIVING RESOURCES sector | Questionnaire-Guidelines

LEVEL OF IMPORTANCE OF THE BE-ENABLERS TO PORTS, WisHOUSING AND WATER PROJECTS - QUESTIONNAIRE GUIDELINES
How important is the Common Skills to ports, wishousing and water projects?
What relevant is the Shisd Infrastructure enabler to ports, wishousing and water projects?
What relevant is the Sustainable use of the sea enabler to ports, wishousing and water projects?
What relevant is the Environmental Protection enabler to ports, wishousing and water projects?
What relevant is the Maritime Spatial Planning enabler to ports, wishousing and water projects?
What relevant is the Maritime Security enabler to ports, wishousing and water projects?
What relevant is the Marine Data enabler to ports, wishousing and water projects?

Table Appendix A. 10: Importance of BE-Enablers to the PORTS, WisHOUSING, AND WATER PROJECTS sector | Questionnaire-Guidelines

LEVEL OF IMPORTANCE OF THE BE-ENABLERS TO MARINE EXTRACTION OF MINERALS, OIL AND GAS - QUESTIONNAIRE GUIDELINES
How important is the Common Skills to Marine Extraction of Minerals, Oil and Gas?
What relevant is the Shisd Infrastructure enabler to Marine Extraction of Minerals, Oil and Gas?
What relevant is the Sustainable use of the sea enabler to Marine Extraction of Minerals, Oil and Gas?
What relevant is the Environmental Protection enabler to Marine Extraction of Minerals, Oil and Gas?
What relevant is the Maritime Spatial Planning enabler to Marine Extraction of Minerals, Oil and Gas?
What relevant is the Maritime Security enabler to Marine Extraction of Minerals, Oil and Gas?
What relevant is the Marine Data enabler to Marine Extraction of Minerals, Oil and Gas?

Table Appendix A. 11: Importance of BE-Enablers to the MARINE EXTRACTION OF MINERALS, OIL, AND GAS sector | Questionnaire-Guidelines

LEVEL OF IMPORTANCE OF THE ***BE-ENABLERS*** TO ***SHIPBUILDING AND REPAIR*** - QUESTIONNAIRE GUIDELINES
How important is the Common Skills to shipbuilding and repair?
What relevant is the Shisd Infrastructure enabler to shipbuilding and repair?
What relevant is the Sustainable use of the sea enabler to ports, shipbuilding and repair?
What relevant is the Environmental Protection enabler to shipbuilding and repair?
What relevant is the Maritime Spatial Planning enabler to shipbuilding and repair?
What relevant is the Maritime Security enabler to shipbuilding and repair?
What relevant is the Marine Data enabler to shipbuilding and repair?

Table Appendix A. 12: Importance of BE-Enablers to the SHIPBUILDING AND REPAIR sector | Questionnaire-Guidelines

LEVEL OF IMPORTANCE OF THE ***BE-ENABLERS*** TO ***MARITIME TRANSPORT -*** QUESTIONNAIRE GUIDELINES
How important is the Common Skills to maritime transport?
What relevant is the Shisd Infrastructure enabler to maritime transport?
What relevant is the Sustainable use of the sea enabler to maritime transport?
What relevant is the Environmental Protection enabler to maritime transport?
What relevant is the Maritime Spatial Planning enabler to maritime transport?
What relevant is the Maritime Security enabler to shipbuilding and repair?
What relevant is the Marine Data enabler to maritime transport?

Table Appendix A. 13: Importance of BE-Enablers to the MARITIME TRANSPORT sector | Questionnaire-Guidelines

LEVEL OF IMPORTANCE OF THE ***BE-ENABLERS*** TO **BLUE ENERGY -** QUESTIONNAIRE GUIDELINES
How important is the Common Skills to blue energy?
What relevant is the Shisd Infrastructure enabler to blue energy?
What relevant is the Sustainable use of the sea enabler to blue energy?
What relevant is the Environmental Protection enabler to blue energy?
What relevant is the Maritime Spatial Planning enabler to blue energy?
What relevant is the Maritime Security enabler to blue energy?
What relevant is the Marine Data enabler to blue energy?

Table Appendix A. 14: Importance of BE-Enablers to the BLUE ENERGY sector | Questionnaire-Guidelines

LEVEL OF IMPORTANCE OF THE ***BE-ENABLERS*** TO **BLUE BIO ECONOMY -** QUESTIONNAIRE GUIDELINES
How important is the Common Skills to blue bio economy?
What relevant is the Shisd Infrastructure enabler to blue bio economy?
What relevant is the Sustainable use of the sea enabler to blue bio economy?
What relevant is the Environmental Protection enabler to blue bio economy?
What relevant is the Maritime Spatial Planning enabler to blue bio economy?
What relevant is the Maritime Security enabler to blue bio economy?
What relevant is the Marine Data enabler to blue bio economy?

Table Appendix A. 15: Importance of BE-Enablers to the BLUE BIO ECONOMY sector | Questionnaire-Guidelines

LEVEL OF IMPORTANCE OF THE ***BE-ENABLERS*** TO **MARINE MINERALS -** QUESTIONNAIRE GUIDELINES
How important is the Common Skills to marine minerals?
What relevant is the Shisd Infrastructure enabler to marine minerals?
What relevant is the Sustainable use of the sea enabler to marine minerals?
What relevant is the Environmental Protection enabler to marine minerals?
What relevant is the Maritime Spatial Planning enabler to marine minerals?
What relevant is the Maritime Security enabler to marine minerals?
What relevant is the Marine Data enabler to marine minerals?

Table Appendix A. 16: Importance of BE-Enablers to the MARINE MINERALS sector | Questionnaire-Guidelines

LEVEL OF IMPORTANCE OF THE ***BE-ENABLERS*** TO **DESALINATION -** QUESTIONNAIRE GUIDELINES
How important is the Common Skills to desalination?
What relevant is the Shisd Infrastructure enabler to desalination
What relevant is the Sustainable use of the sea enabler to desalination?
What relevant is the Environmental Protection enabler to desalination?
What relevant is the Maritime Spatial Planning enabler to desalination?
What relevant is the Maritime Security enabler to desalination?
What relevant is the Marine Data enabler to desalination?

Table Appendix A. 17: Importance of BE-Enablers to the DESALINATION sector | Questionnaire-Guidelines

LEVEL OF IMPORTANCE OF THE ***BE-ENABLERS*** TO **MARITIME DEFENCE -** QUESTIONNAIRE GUIDELINES
How important is the Common Skills to maritime defence?
What relevant is the Shisd Infrastructure enabler to maritime defence?
What relevant is the Sustainable use of the sea enabler to maritime defence?
What relevant is the Environmental Protection enabler to maritime defence?
What relevant is the Maritime Spatial Planning enabler to maritime defence?
What relevant is the Maritime Security enabler to maritime defence?
What relevant is the Marine Data enabler to maritime defence?

Table Appendix A. 18: Importance of BE-Enablers to the MARITIME DEFENCE sector | Questionnaire-Guidelines

APPENDIX B | EUROPEAN BLUE ECONOMY CASE-STUDIES | DATA & MAPS

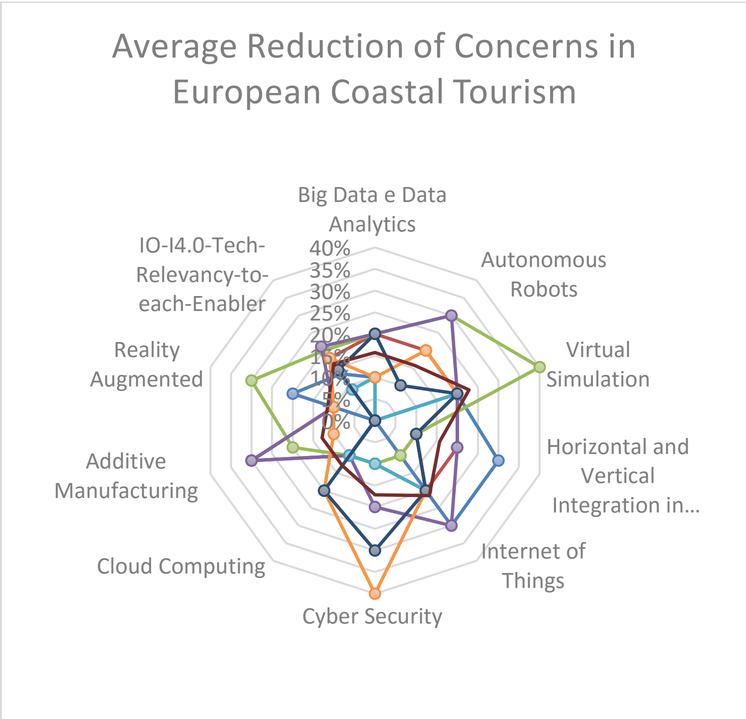
Case-study #1 | Coastal Tourism

Company	Activity	Respondent	Interview/visit date
1	Hotels and similar accomodations	Technical Manager	Jan 7th 2019
2	Holiday and other short-stay accomodations	Technical Manager	Jan 8th 2019
3	Camping grounds, recreation vehicle and trailer parks	Technical Manager	Jan 9th 2019
4	Other accomodation	Technical Manager	Jan 10th 2019
5	Transport	Technical Manager	Jan 11th 2019
6	Other expenditures	Technical Manager	Jan 14th 2019

Table Appendix B. 1: Case-study-1 | EU Coastal Tourism | Interview grid

CS1- Costal Tourism - Concerns Relief (%) related to the I4.0 technologies (QUAN)	Big Data e Data Analytics	Autonomous Robots	Virtual Simulation	Horizontal and Vertical Integration in Industry 4.0	Internet of Things	Cyber Security	Cloud Computing	Additive Manufacturing	Reality Augmented
$KCI_{Common\ Skills\ enabler\ (QUAN)}$	10%	0%	20%	30%	30%	0%	10%	0%	20%
$KCI_{Shared\ Infrastructure\ (QUAN)}$	20%	20%	20%	20%	20%	10%	10%	30%	10%
$KCI_{Sustainable\ use\ of\ the\ sea\ (QUAN)}$	20%	30%	40%	10%	10%	10%	10%	20%	30%
$KCI_{Environmental\ Protection\ (QUAN)}$	20%	30%	20%	20%	30%	20%	10%	30%	10%
$KCI_{Maritime\ Spatial\ Planning\ (QUAN)}$	10%	0%	20%	10%	20%	10%	10%	0%	0%
$KCI_{Maritime\ Security\ (QUAN)}$	10%	20%	20%	10%	20%	40%	20%	10%	10%
$KCI_{Marine\ Data\ (QUAN)}$	20%	10%	20%	10%	20%	30%	20%	0%	0%
Average Impact of each I4.0 Technology	16%	16%	23%	16%	21%	17%	13%	13%	11%
Level of Enabler weight to the Sector (QUAL)			Common Skills	Shared Infrastructure	Sustainable use of the sea	Environmental Protection	Maritime Spatial Planning	Maritime Security	Marine Data
KPI-BE-enabler-weight			1	1	2	2	1	2	1

Table Appendix B. 2: Case-study-1 | EU Coastal Tourism | KCI and KPI Data | Average Data Collected



Graphic Appendix B. 1: Case-study-1 | EU Coastal Tourism | Average Reduction of Concerns by adoption of I4.0 Technologies

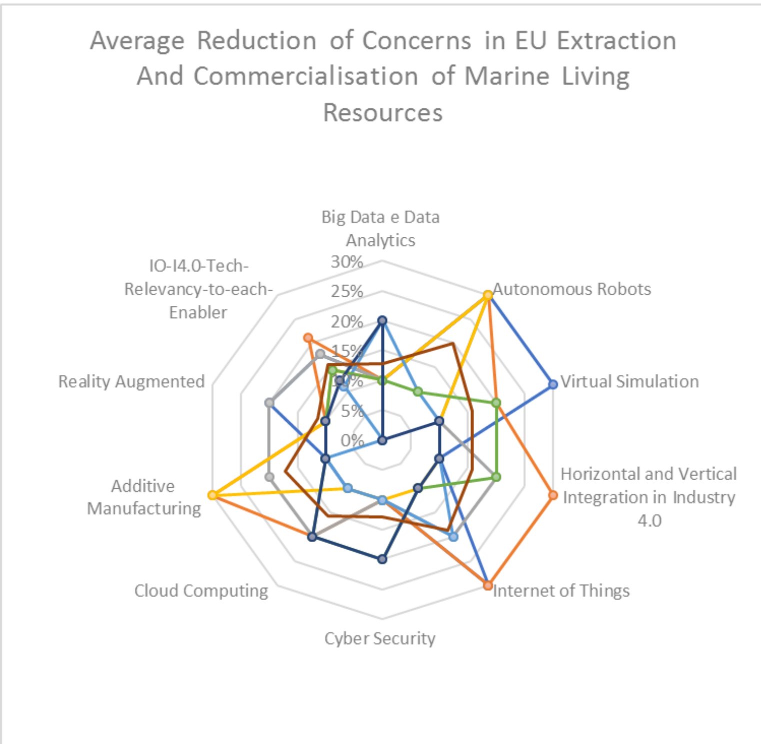
Case-study #2 | Extraction and Commercialisation of Marine Living Resources

Case Study 2 - Extraction And Commercialisation of Marine Living Resources			
Company	Activity	Respondent	Interview/visit date
1	Capture fisheries	Technical Manager	Jan 15th 2019
2	Aquaculture	Technical Manager	Jan 16th 2019
3	Fish processing industry	Technical Manager	Jan 17th 2019
4	Retail of fish and molluscs	CEO	Jan 18th 2019
5	Wholesale of other sea food products	Technical Manager	Jan 21st 2019

Table Appendix B. 3: Case-study-2 | EU Extraction and Commercialisation of Marine Living Resources | Interview grid

CS2 - Marine Living Resources - Concerns Relief (%) related to the I4.0 technologies (QUAN)	Big Data e Data Analytics	Autonomous Robots	Virtual Simulation	Horizontal and Vertical Integration in Industry 4.0	Internet of Things	Cyber Security	Cloud Computing	Additive Manufacturing	Reality Augmented
$KCI_{Common\ Skills\ enabler\ (QUAN)}$	10%	30%	30%	10%	30%	10%	10%	10%	20%
$KCI_{Shared\ Infrastructure\ (QUAN)}$	10%	30%	20%	30%	30%	10%	20%	30%	10%
$KCI_{Sustainable\ use\ of\ the\ sea\ (QUAN)}$	10%	30%	10%	20%	20%	10%	20%	20%	20%
$KCI_{Environmental\ Protection\ (QUAN)}$	10%	30%	10%	10%	10%	10%	10%	30%	10%
$KCI_{Maritime\ Spatial\ Planning\ (QUAN)}$	20%	10%	10%	10%	20%	10%	10%	10%	0%
$KCI_{Maritime\ Security\ (QUAN)}$	10%	10%	20%	20%	10%	20%	20%	10%	10%
$KCI_{Marine\ Data\ (QUAN)}$	20%	0%	10%	10%	10%	20%	20%	10%	10%
Average Impact of each I4.0 Technology	13%	20%	16%	16%	19%	13%	16%	17%	11%
Level of Enabler weight to the Sector (QUAL)			Common Skills	Shared Infrastructure	Sustainable use of the sea	Environmental Protection	Maritime Spatial Planning	Maritime Security	Marine Data
KPI-BE-enabler-weight			2	2	2	1	1	1	1

Table Appendix B. 4: Case-study-2 | EU Extraction and Commercialisation of Marine Living Resources | KCI and KPI Data | Average Data Collected



Graphic Appendix B. 2: Case-study-2 EU | Extraction and Commercialisation of Marine Living Resources | Average Reduction of Concerns by adoption of I4.0 Technologies

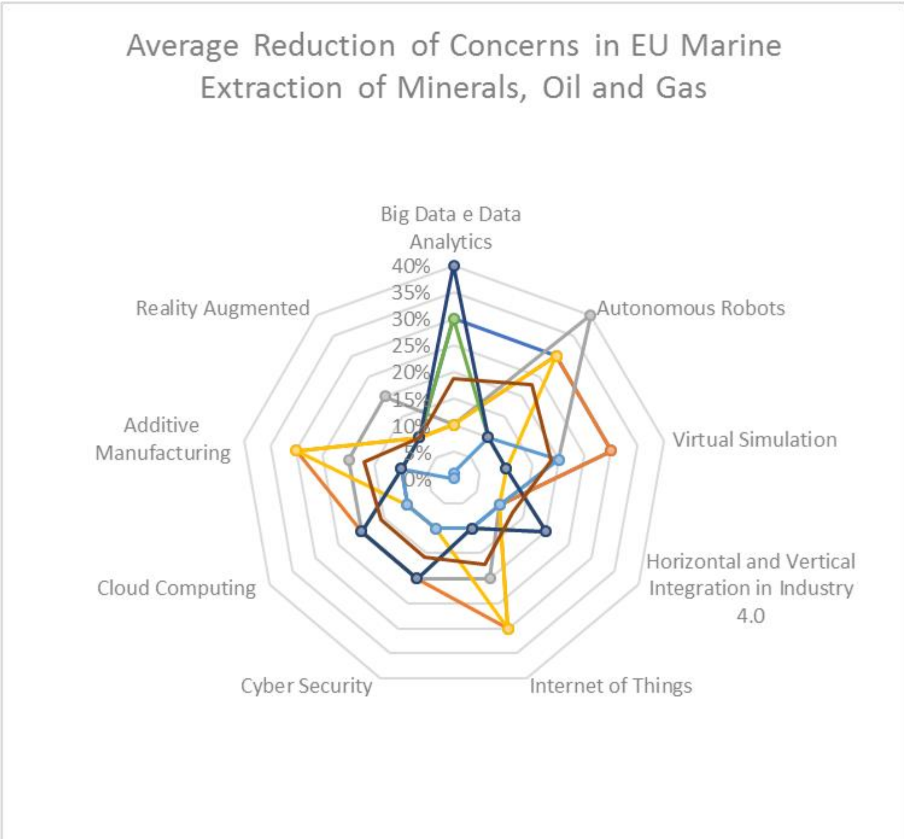
Case-study #3 | Marine Extraction of Minerals, Oil, and Gas

Case Study 3 -Marine Extraction of Minerals, Oil and Gas			
Company	Activity	Respondent	Interview/visit date
1	Offshore extraction of crude	Technical Manager	Jan 22nd 2019
2	Offshore extraction of natural gas	Technical Manager	Jan 23rd 2019
3	Support activities for petrolium and natural gas	Technical Manager	Jan 24th 2019

Table Appendix B. 5: Case-study-3 | EU Marine Extraction of Minerals, Oil and Gas | Interview grid

CS3 - Marine Extraction of Minerals, Oil & Gas - Concerns Relief (%) related to the I4.0 technologies (QUAN)	Big Data e Data Analytics	Autonomous Robots	Virtual Simulation	Horizontal and Vertical Integration in Industry 4.0	Internet of Things	Cyber Security	Cloud Computing	Additive Manufacturing	Reality Augmented
$KCI_{Common\ Skills\ enabler\ (QUAN)}$	30%	30%	30%	10%	10%	10%	10%	10%	10%
$KCI_{Shared\ Infrastructure\ (QUAN)}$	10%	30%	30%	10%	30%	20%	20%	30%	10%
$KCI_{Sustainable\ use\ of\ the\ sea\ (QUAN)}$	10%	40%	20%	10%	20%	20%	20%	20%	20%
$KCI_{Environmental\ Protection\ (QUAN)}$	10%	30%	10%	10%	30%	10%	10%	30%	10%
$KCI_{Maritime\ Spatial\ Planning\ (QUAN)}$	1%	10%	20%	10%	10%	10%	10%	10%	0%
$KCI_{Maritime\ Security\ (QUAN)}$	30%	10%	10%	20%	10%	20%	20%	10%	10%
$KCI_{Marine\ Data\ (QUAN)}$	40%	10%	10%	20%	10%	20%	20%	10%	10%
Average Impact of each I4.0 Technology	19%	23%	19%	13%	17%	16%	16%	17%	10%
Level of Enabler weight to the Sector (QUAL)			Common Skills	Shared Infrastructure	Sustainable use of the sea	Environmental Protection	Maritime Spatial Planning	Maritime Security	Marine Data
KPI-BE-enabler-weight			1	2	2	2	2	2	2

Table Appendix B. 6: Case-study-3 | EU Marine Extraction of Minerals, Oil, and Gas | KCI and KPI Data | Average Data Collected



Graphic Appendix B. 3: Case-study-3 | EU Marine Extraction of Minerals, Oil, and Gas | Average Reduction of Concerns by adoption of I4.0 Technologies

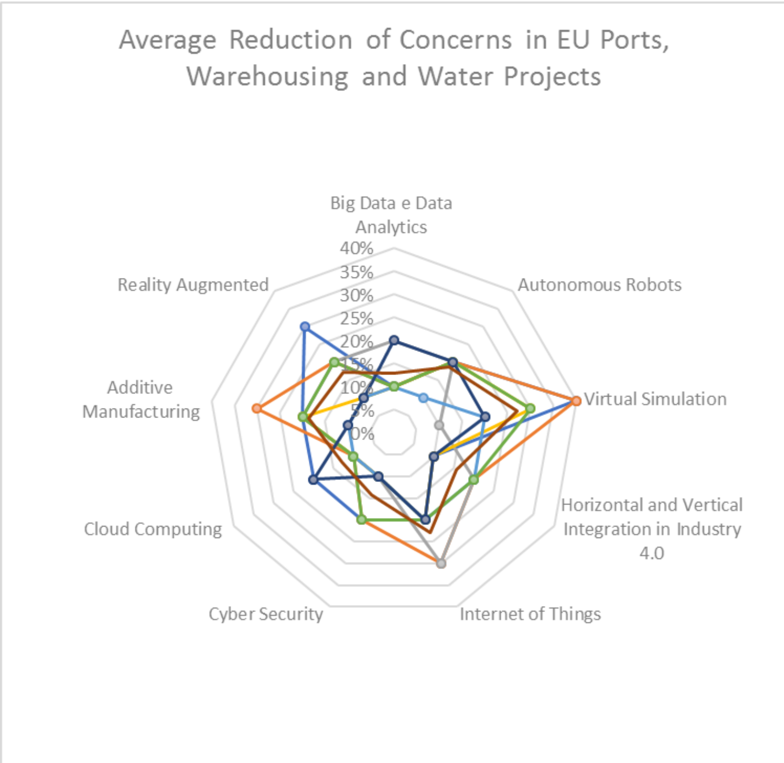
Case-study #4 | Ports, Warehousing and Water Projects

Case Study 4 -Ports, Warehousing and Water Projects			
Company	Activity	Respondent	Interview/visit date
1	Cargo Handeling	Technical Manager	Jan 28th 2019
2	Wearhousing and storage	Technical Manager	Jan 29th 2019
3	Construction of water projects	Technical Manager	Jan 30th 2019
4	Service activities related to transportation by water	Technical Manager	Jan 31st 2019

Table Appendix B. 7: Case-study-4 | EU Marine Extraction of Ports, Warehousing and Water Projects | Interview grid

CS4 - Ports, Warehousing and Water Projectss - Concerns Relief (%) related to the I4.0 technologies (QUAN)	Big Data e Data Analytics	Autonomous Robots	Virtual Simulation	Horizontal and Vertical Integration in Industry 4.0	Internet of Things	Cyber Security	Cloud Computing	Additive Manufacturing	Reality Augmented
$KCI_{Common\ Skills\ enabler\ (QUAN)}$	10%	20%	40%	10%	20%	20%	20%	20%	30%
$KCI_{Shared\ Infrastructure\ (QUAN)}$	10%	20%	40%	20%	30%	20%	10%	30%	20%
$KCI_{Sustainable\ use\ of\ the\ sea\ (QUAN)}$	20%	20%	10%	20%	30%	10%	10%	20%	20%
$KCI_{Environmental\ Protection\ (QUAN)}$	10%	20%	30%	10%	20%	10%	10%	20%	10%
$KCI_{Maritime\ Spatial\ Planning\ (QUAN)}$	10%	10%	20%	20%	20%	10%	10%	10%	10%
$KCI_{Maritime\ Security\ (QUAN)}$	10%	20%	30%	20%	20%	20%	10%	20%	20%
$KCI_{Marine\ Data\ (QUAN)}$	20%	20%	20%	10%	20%	10%	20%	10%	10%
Average Impact of each I4.0 Technology	13%	19%	27%	16%	23%	14%	13%	19%	17%
Level of Enabler weight to the Sector (QUAL)			Common Skills	Shared Infrastructure	Sustainable use of the sea	Environmental Protection	Maritime Spatial Planning	Maritime Security	Marine Data
KPI-BE-enabler-weight			1	2	2	2	1	2	1

Table Appendix B. 8: Case-study-4 | EU Ports, Warehousing and Water Projects | KCI and KPI Data | Average Data Collected



Graphic Appendix B. 4: Case-study-4 | EU Ports, Warehousing and Water Projects | Average Reduction of Concerns by adoption of I4.0 Technologies

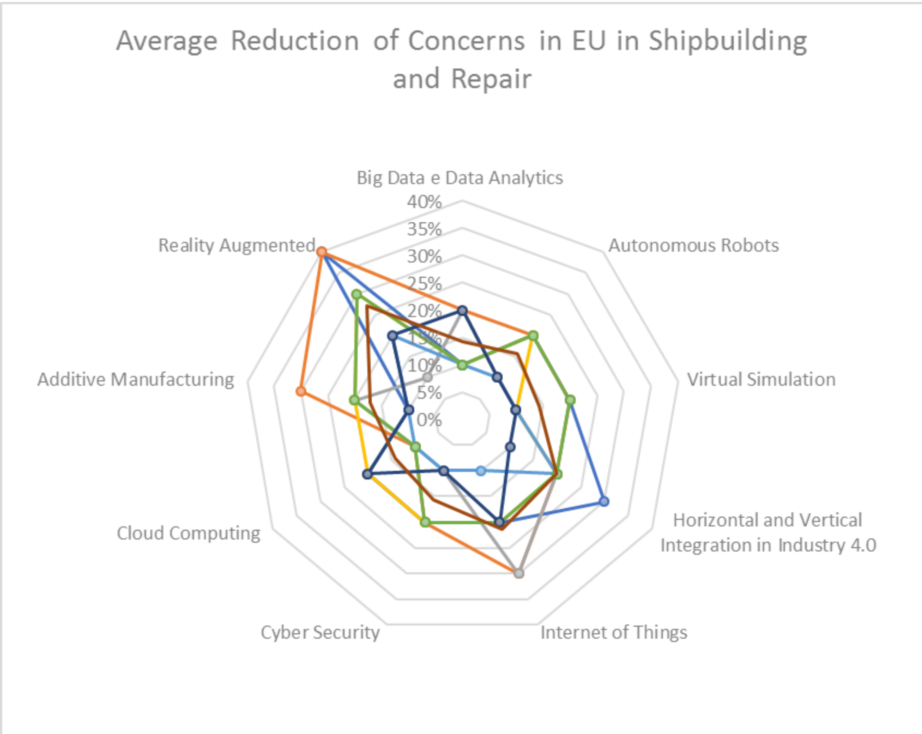
Case-study #5 | Shipbuilding and Repair

Case Study 5 -Shipbuilding and Repair			
Company	Activity	Respondent	Interview/visit date
1	Building of ships and floating structures	Technical Manager	Mar 4th 2019
2	Building of pleasure and sporting boats	Technical Manager	Mar 5th 2019
3	Repair and maintenance of ships and boats	Technical Manager	Mar 6th 2019

Table Appendix B. 9: Case-study-5 | EU Shipbuilding and Repair | Interview grid

CS5 - Shipbuilding and Repair - Concerns Relief (%) related to the I4.0 technologies (QUAN)	Big Data e Data Analytics	Autonomous Robots	Virtual Simulation	Horizontal and Vertical Integration in Industry 4.0	Internet of Things	Cyber Security	Cloud Computing	Additive Manufacturing	Reality Augmented
$KCI_{Common\ Skills\ enabler\ (QUAN)}$	10%	20%	20%	30%	20%	20%	20%	10%	40%
$KCI_{Shared\ Infrastructure\ (QUAN)}$	20%	20%	20%	20%	30%	20%	10%	30%	40%
$KCI_{Sustainable\ use\ of\ the\ sea\ (QUAN)}$	20%	10%	10%	20%	30%	10%	10%	20%	10%
$KCI_{Environmental\ Protection\ (QUAN)}$	10%	20%	10%	20%	20%	20%	20%	20%	30%
$KCI_{Maritime\ Spatial\ Planning\ (QUAN)}$	10%	10%	10%	20%	10%	10%	10%	10%	20%
$KCI_{Maritime\ Security\ (QUAN)}$	10%	20%	20%	20%	20%	20%	10%	20%	30%
$KCI_{Marine\ Data\ (QUAN)}$	20%	10%	10%	10%	20%	10%	20%	10%	20%
Average Impact of each I4.0 Technology	14%	16%	14%	20%	21%	16%	14%	17%	27%
Level of Enabler weight to the Sector (QUAL)			Common Skills	Shared Infrastructure	Sustainable use of the sea	Environmental Protection	Maritime Spatial Planning	Maritime Security	Marine Data
KPI-BE-enabler-weight			2	1	2	1	1	2	2

Table Appendix B. 10: Case-study-5 | EU Shipbuilding and Repair | KCI and KPI Data | Average Data Collected



Graphic Appendix B. 5: Case-study-5 | EU Shipbuilding and Repair | Average Reduction of Concerns by adoption of I4.0 Technologies

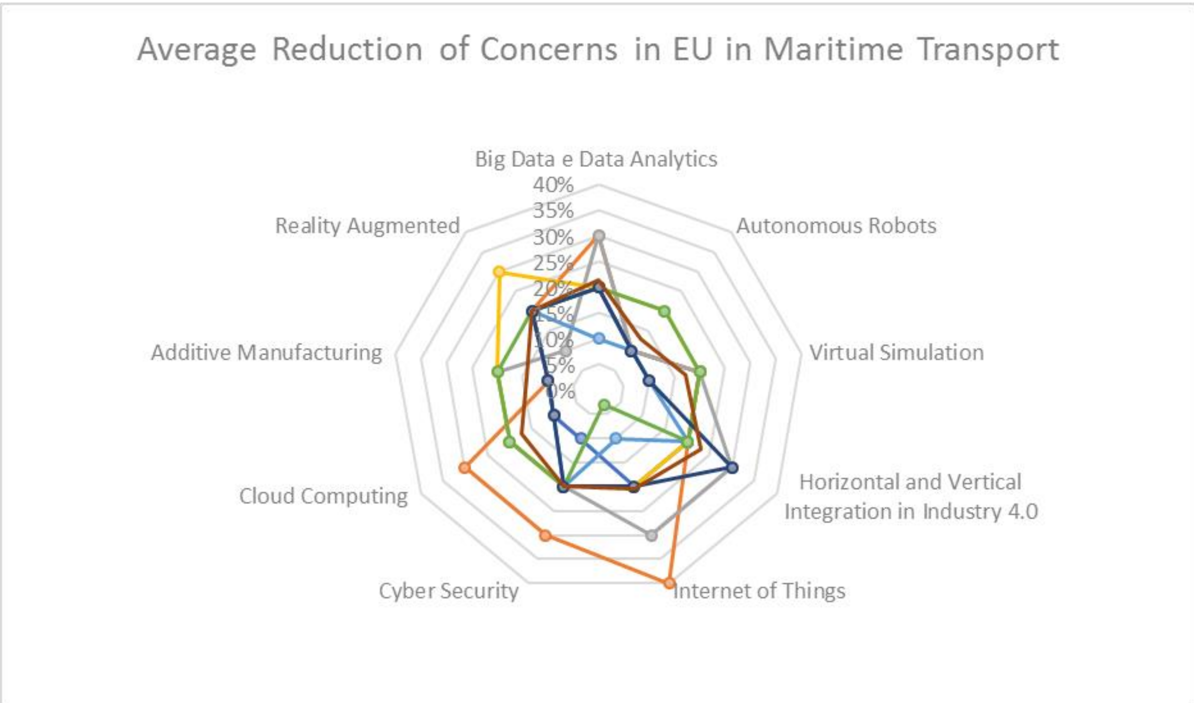
Case-study #6 | Maritime Transport

Case Study 6 -Maritime Transport			
Company	Activity	Respondent	Interview/visit date
1	Sea and coastal passenger transport	Technical Manager	Mar 11th 2019
2	Sea and coastal cargo transport	Technical Manager	Mar 12th 2019
3	Inland passenger transport	Technical Manager	Mar 13th 2019
4	Inland cargo transport	CEO	Mar 14th 2019
5	Renting and lease of water transport equipment	CEO	Mar 15th 2019

Table Appendix B. 11: Case-study-6 | EU Maritime Transport | Interview grid

CS6 - Maritime Transport - Concerns Relief (%) related to the I4.0 technologies (QUAN)	Big Data e Data Analytics	Autonomous Robots	Virtual Simulation	Horizontal and Vertical Integration in Industry 4.0	Internet of Things	Cyber Security	Cloud Computing	Additive Manufacturing	Reality Augmented
$KCI_{Common\ Skills\ enabler\ (QUAN)}$	20%	10%	20%	20%	20%	10%	10%	10%	20%
$KCI_{Shared\ Infrastructure\ (QUAN)}$	30%	10%	20%	20%	40%	30%	30%	10%	20%
$KCI_{Sustainable\ use\ of\ the\ sea\ (QUAN)}$	30%	10%	20%	30%	30%	20%	20%	20%	10%
$KCI_{Environmental\ Protection\ (QUAN)}$	20%	20%	20%	20%	20%	20%	20%	20%	30%
$KCI_{Maritime\ Spatial\ Planning\ (QUAN)}$	10%	10%	10%	20%	10%	20%	10%	10%	20%
$KCI_{Maritime\ Security\ (QUAN)}$	20%	20%	20%	20%	3%	20%	20%	20%	20%
$KCI_{Marine\ Data\ (QUAN)}$	20%	10%	10%	30%	20%	20%	10%	10%	20%
Average Impact of each I4.0 Technology	21%	13%	17%	23%	20%	20%	17%	14%	20%
Level of Enabler weight to the Sector (QUAL)			Common Skills	Shared Infrastructure	Sustainable use of the sea	Environmental Protection	Maritime Spatial Planning	Maritime Security	Marine Data
KPI-BE-enabler-weight			1	2	2	1	1	1	2

Table Appendix B. 12: Case-study-6 | EU Maritime Transport | KCI and KPI Data | Average Data Collected



Graphic Appendix B. 6: Case-study-6 | EU Maritime Transport | Average Reduction of Concerns by adoption of I4.0 Technologies

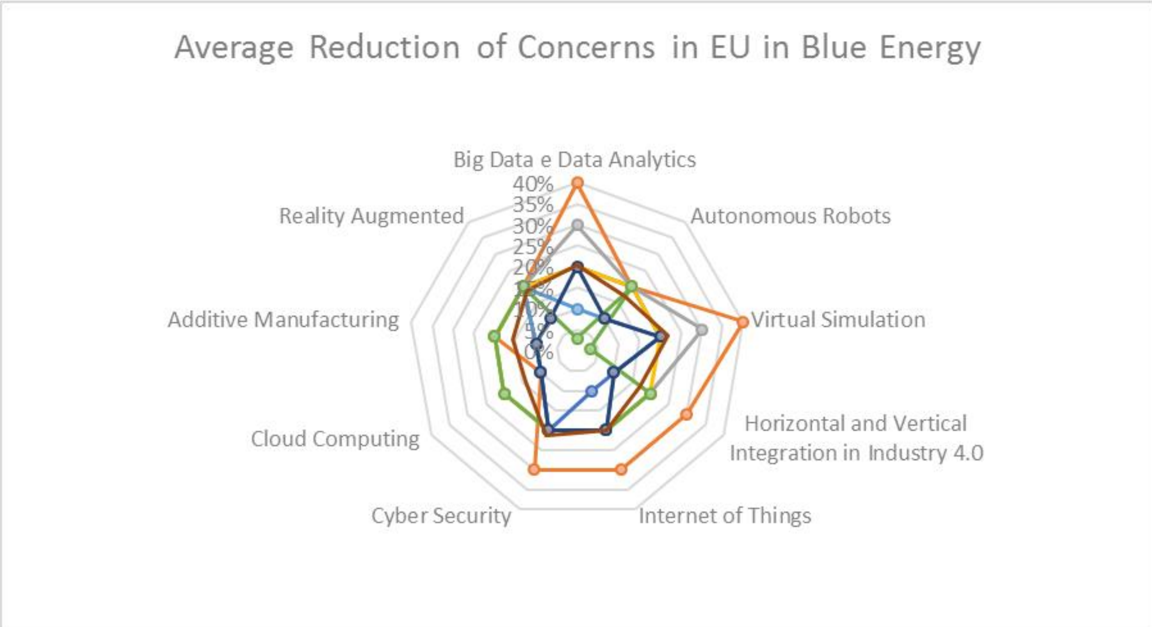
Case-study #7 | Blue Energy

Case Study 7 -Blue Energy			
Company	Activity	Respondent	Interview/visit date
1	Renewable energy	Technical Manager	Mar 18th 2019

Table Appendix B. 13: Case-study-6 | EU Blue Energy | Interview grid

CS7 - Blue Energy - Concerns Relief (%) related to the I4.0 technologies (QUAN)	Big Data e Data Analytics	Autonomous Robots	Virtual Simulation	Horizontal and Vertical Integration in Industry 4.0	Internet of Things	Cyber Security	Cloud Computing	Additive Manufacturing	Reality Augmented
$KCI_{Common\ Skills\ enabler\ (QUAN)}$	20%	20%	20%	10%	10%	20%	10%	10%	20%
$KCI_{Shared\ Infrastructure\ (QUAN)}$	40%	20%	40%	30%	30%	30%	10%	20%	20%
$KCI_{Sustainable\ use\ of\ the\ sea\ (QUAN)}$	30%	20%	30%	20%	20%	20%	20%	20%	20%
$KCI_{Environmental\ Protection\ (QUAN)}$	20%	20%	20%	20%	20%	20%	20%	20%	20%
$KCI_{Maritime\ Spatial\ Planning\ (QUAN)}$	10%	10%	20%	10%	20%	20%	10%	10%	20%
$KCI_{Maritime\ Security\ (QUAN)}$	3%	20%	3%	20%	20%	20%	20%	20%	20%
$KCI_{Marine\ Data\ (QUAN)}$	20%	10%	20%	10%	20%	20%	10%	10%	10%
Average Impact of each I4.0 Technology	20%	17%	22%	17%	20%	21%	14%	16%	19%
Level of Enabler weight to the Sector (QUAL)			Common Skills	Shared Infrastructure	Sustainable use of the sea	Environmental Protection	Maritime Spatial Planning	Maritime Security	Marine Data
KPI-BE-enabler-weight			2	2	2	2	1	1	2

Table Appendix B. 14: Case-study-6 | EU Blue Energy | KCI and KPI Data | Average Data Collected



Graphic Appendix B. 7: Case-study-7 | EU Blue Energy | Average Reduction of Concerns by adoption of I4.0 Technologies

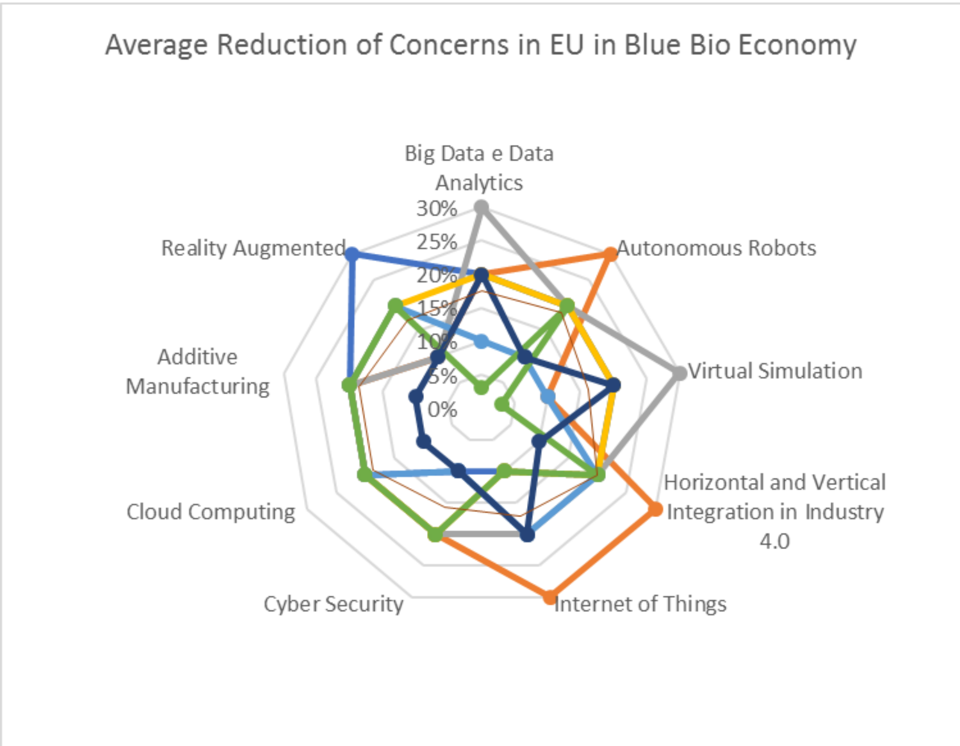
Case-study #8 | Blue Bio-Economy

Case Study 8 -Blue Bio Economy			
Company	Activity	Respondent	Interview/visit date
1	Biotechnology	Technical Manager	Mar 19th 2019

Table Appendix B. 15: Case-study-8 | EU Blue Bio-Economy | Interview grid

CS8 - Blue Bio Economy - Concerns Relief (%) related to the I4.0 technologies (QUAN)	Big Data e Data Analytics	Autonomous Robots	Virtual Simulation	Horizontal and Vertical Integration in Industry 4.0	Internet of Things	Cyber Security	Cloud Computing	Additive Manufacturing	Reality Augmented
$KCI_{Common\ Skills\ enabler\ (QUAN)}$	20%	20%	20%	20%	10%	10%	20%	20%	30%
$KCI_{Shared\ Infrastructure\ (QUAN)}$	20%	30%	10%	30%	30%	20%	20%	20%	10%
$KCI_{Sustainable\ use\ of\ the\ sea\ (QUAN)}$	30%	20%	30%	20%	20%	20%	20%	20%	10%
$KCI_{Environmental\ Protection\ (QUAN)}$	20%	20%	20%	20%	10%	20%	20%	20%	20%
$KCI_{Maritime\ Spatial\ Planning\ (QUAN)}$	10%	10%	10%	20%	20%	10%	20%	20%	20%
$KCI_{Maritime\ Security\ (QUAN)}$	3%	20%	3%	20%	10%	20%	20%	20%	20%
$KCI_{Marine\ Data\ (QUAN)}$	20%	10%	20%	10%	20%	10%	10%	10%	10%
Average Impact of each I4.0 Technology	18%	19%	16%	20%	17%	16%	19%	19%	17%
Level of Enabler weight to the Sector (QUAL)			Common Skills	Shared Infrastructure	Sustainable use of the sea	Environmental Protection	Maritime Spatial Planning	Maritime Security	Marine Data
KPI-BE-enabler-weight			2	1	2	2	1	1	1

Table Appendix B. 16: Case-study-8 | EU Blue Bio-Economy | KCI and KPI Data | Average Data Collected



Graphic Appendix B. 8: Case-study-8 | EU Blue Bio-Economy | Average Reduction of Concerns by adoption of I4.0 Technologies

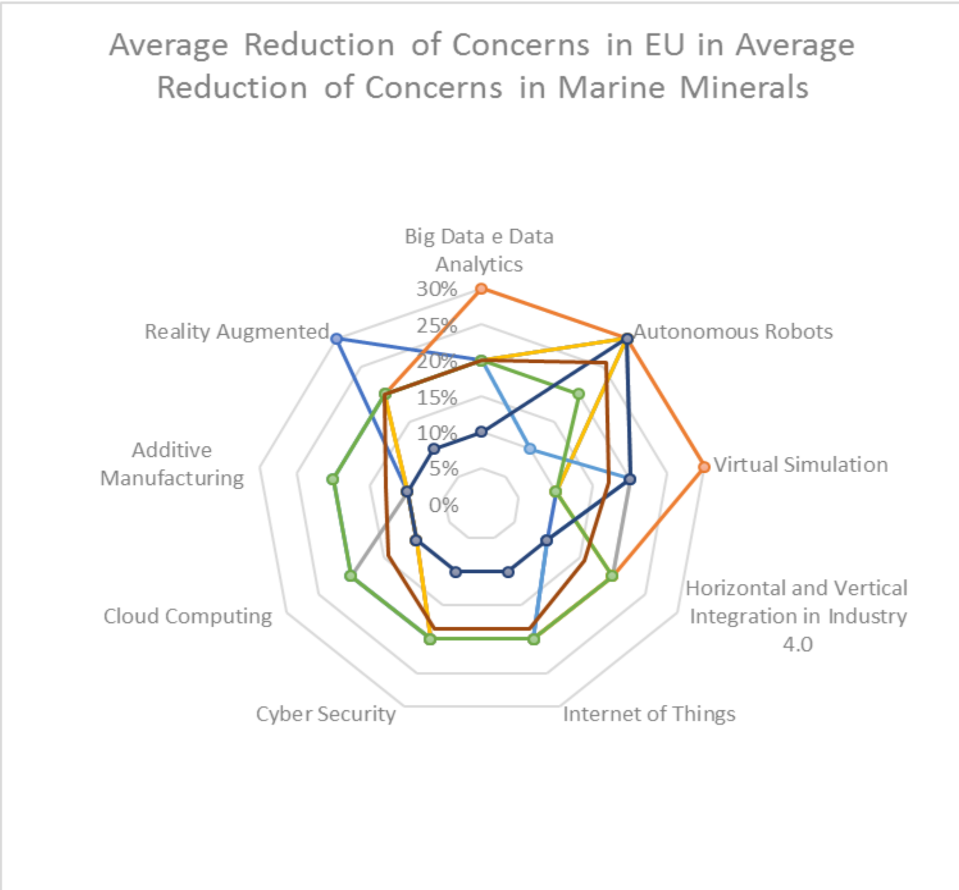
Case-study #9 | Marine Minerals

Case Study 9 -Marine Minerals			
Company	Activity	Respondent	Interview/visit date
1	Deep-seabed mining	Technical Manager	Mar 20th 2019

Table Appendix B. 17: Case-study-9 | EU Marine Minerals | Interview grid

CS9 - Marine Minerals - Concerns Relief (%) related to the I4.0 technologies (QUAN)	Big Data e Data Analytics	Autonomous Robots	Virtual Simulation	Horizontal and Vertical Integration in Industry 4.0	Internet of Things	Cyber Security	Cloud Computing	Additive Manufacturing	Reality Augmented
$KCI_{Common\ Skills\ enabler\ (QUAN)}$	20%	30%	10%	10%	20%	20%	10%	10%	30%
$KCI_{Shared\ Infrastructure\ (QUAN)}$	30%	30%	30%	20%	20%	20%	10%	10%	20%
$KCI_{Sustainable\ use\ of\ the\ sea\ (QUAN)}$	20%	30%	20%	20%	20%	20%	20%	10%	20%
$KCI_{Environmental\ Protection\ (QUAN)}$	20%	30%	10%	20%	20%	20%	10%	10%	20%
$KCI_{Maritime\ Spatial\ Planning\ (QUAN)}$	20%	10%	20%	10%	20%	20%	20%	20%	20%
$KCI_{Maritime\ Security\ (QUAN)}$	20%	20%	10%	20%	20%	20%	20%	20%	20%
$KCI_{Marine\ Data\ (QUAN)}$	10%	30%	20%	10%	10%	10%	10%	10%	10%
Average Impact of each I4.0 Technology	20%	26%	17%	16%	19%	19%	14%	13%	20%
Level of Enabler weight to the Sector (QUAL)			Common Skills	Shared Infrastructure	Sustainable use of the sea	Environmental Protection	Maritime Spatial Planning	Maritime Security	Marine Data
KPI-BE-enabler-weight			2	2	2	2	2	2	2

Table Appendix B. 18: Case-study-9 | EU Marine Minerals | KCI and KPI Data | Average Data Collected



Graphic Appendix B. 9: Case-study-9 | EU Marine Minerals | Average Reduction of Concerns by adoption of I4.0 Technologies

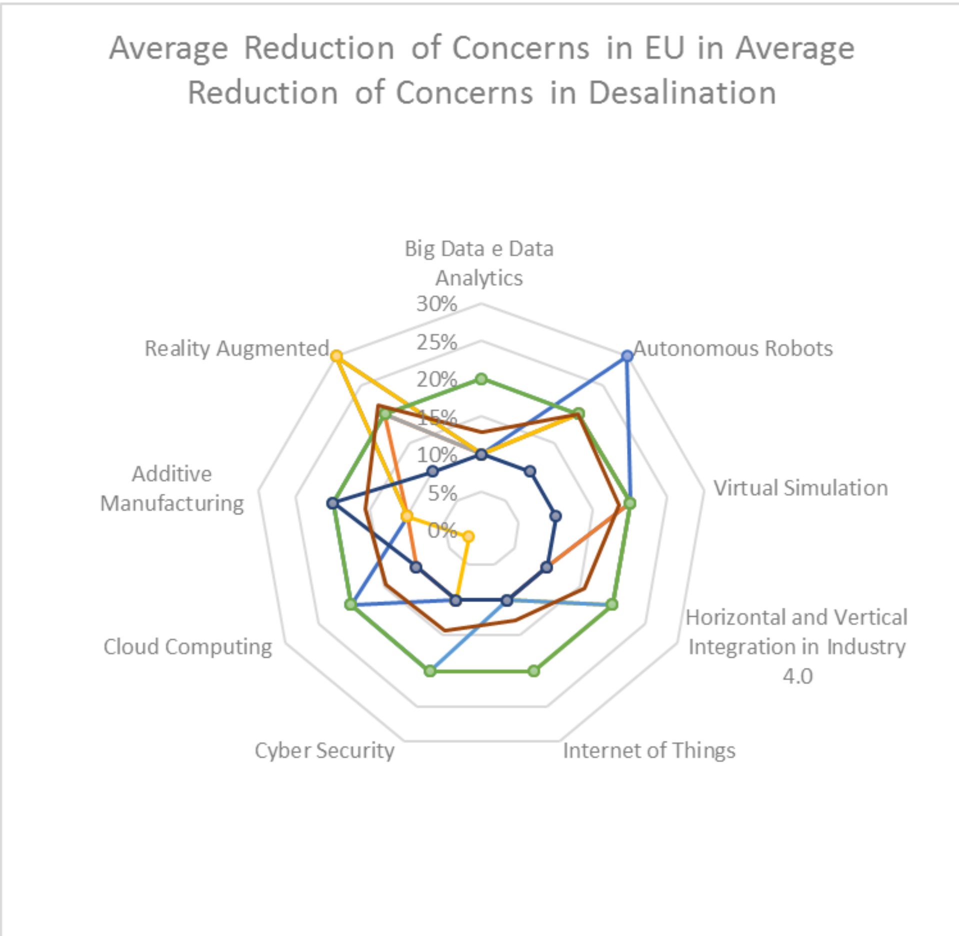
Case-study #10 | Desalination

Case Study 10 - Desalination			
Company	Activity	Respondent	Interview/visit date
1	Fresh-Water supply (desalination)	Technical Manager	Mar 21st 2019

Table Appendix B. 19: Case-study-10 | EU Desalination | Interview grid

CS10 - Desalination - Concerns Relief (%) related to the I4.0 technologies (QUAN)	Big Data e Data Analytics	Autonomous Robots	Virtual Simulation	Horizontal and Vertical Integration in Industry 4.0	Internet of Things	Cyber Security	Cloud Computing	Additive Manufacturing	Reality Augmented
$KCI_{Common\ Skills\ enabler\ (QUAN)}$	10%	30%	20%	10%	10%	10%	20%	10%	30%
$KCI_{Shared\ Infrastructure\ (QUAN)}$	10%	20%	20%	10%	10%	10%	10%	10%	20%
$KCI_{Sustainable\ use\ of\ the\ sea\ (QUAN)}$	10%	20%	20%	20%	20%	20%	20%	20%	20%
$KCI_{Environmental\ Protection\ (QUAN)}$	10%	20%	20%	20%	10%	10%	2%	10%	30%
$KCI_{Maritime\ Spatial\ Planning\ (QUAN)}$	20%	20%	20%	20%	10%	20%	20%	20%	20%
$KCI_{Maritime\ Security\ (QUAN)}$	20%	20%	20%	20%	20%	20%	20%	20%	20%
$KCI_{Marine\ Data\ (QUAN)}$	10%	10%	10%	10%	10%	10%	10%	20%	10%
Average Impact of each I4.0 Technology	13%	20%	19%	16%	13%	14%	15%	16%	21%
Level of Enabler weight to the Sector (QUAL)			Common Skills	Shared Infrastructure	Sustainable use of the sea	Environmental Protection	Maritime Spatial Planning	Maritime Security	Marine Data
KPI-BE-enabler-weight			2	1	1	1	1	1	2

Table Appendix B. 20: Case-study-10 | EU Desalination | KCI and KPI Data | Average Data Collected



Graphic Appendix B. 10: Case-study-10 | EU Desalination | Average Reduction of Concerns by adoption of I4.0 Technologies

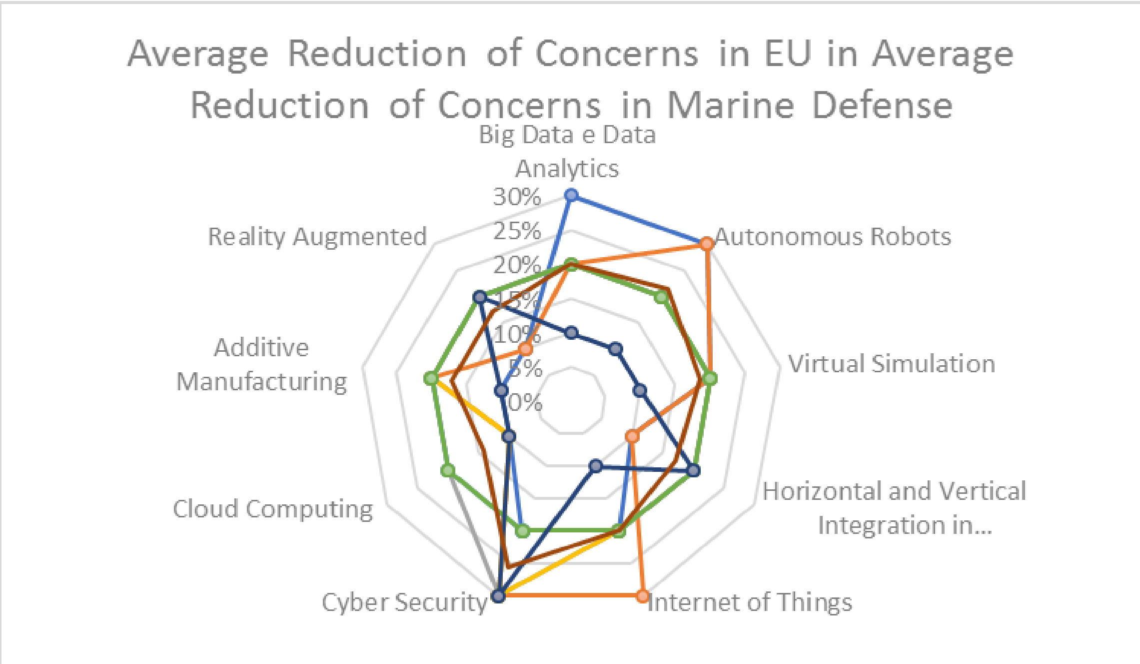
Case-study #11 | Maritime Defence

Case Study 11 - Maritime Defence			
Company	Activity	Respondent	Interview/visit date
1	Defence and security	Technical Manager	Mar 22nd 2019

Table Appendix B. 21: Case-study-10 | EU Maritime Defence | Interview grid

CS11 - Maritime Defence - Concerns Relief (%) related to the I4.0 technologies (QUAN)	Big Data e Data Analytics	Autonomous Robots	Virtual Simulation	Horizontal and Vertical Integration in Industry 4.0	Internet of Things	Cyber Security	Cloud Computing	Additive Manufacturing	Reality Augmented
$KCI_{Common\ Skills\ enabler\ (QUAN)}$	30%	30%	20%	10%	20%	20%	10%	10%	10%
$KCI_{Shared\ Infrastructure\ (QUAN)}$	20%	30%	20%	10%	30%	30%	10%	20%	10%
$KCI_{Sustainable\ use\ of\ the\ sea\ (QUAN)}$	20%	20%	20%	20%	20%	30%	20%	20%	20%
$KCI_{Environmental\ Protection\ (QUAN)}$	20%	20%	20%	20%	20%	30%	10%	20%	20%
$KCI_{Maritime\ Spatial\ Planning\ (QUAN)}$	20%	20%	20%	20%	20%	20%	20%	20%	20%
$KCI_{Maritime\ Security\ (QUAN)}$	20%	20%	20%	20%	20%	20%	20%	20%	20%
$KCI_{Marine\ Data\ (QUAN)}$	10%	10%	10%	20%	10%	30%	10%	10%	20%
Average Impact of each I4.0 Technology	20%	21%	19%	17%	20%	26%	14%	17%	17%
Level of Enabler weight to the Sector (QUAL)			Common Skills	Shared Infrastructure	Sustainable use of the sea	Environmental Protection	Maritime Spatial Planning	Maritime Security	Marine Data
KPI-BE-enabler-weight			1	1	1	2	1	2	2

Table Appendix B. 22: Case-study-22 | EU Maritime Defence | KCI and KPI Data | Average Data Collected



Graphic Appendix B. 11: Case-study-11 | EU Maritime Defence | Average Reduction of Concerns by adoption of I4.0 Technologies

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