

Dissertation

by Maia Renault

Submission date: 16-May-2018 05:43PM (UTC+0100)

Submission ID: 89356966

File name: 6001_Maia_Renault_Dissertation_101691_358581218.docx

Word count: 12171

Character count: 75190



Prifysgol Cymru
Y Drindod Dewi Sant
University of Wales
Trinity Saint David

University of Wales Trinity Saint David

School of Engineering

Dissertation

An analysis of the impact of port automation based on the case
study of Rotterdam port

Maïa Renault

1704254

Third year

May 2018

Dissertation (M6X01293)

Acknowledgements

In first time, I would like to express my sincere gratitude to my project supervisor, Dr Irina Neaga, for her support and guidance throughout the whole research journey.

Also, I would like to thank towards my family back in France, for all their unconditional support and patience. They have been very understanding and supportive to me.

Lastly, I would like to thank my friends and classmates, they have been supporting and helping me out with this research. They have also been giving me comfort and encouragement through this phase.

Table of content

List of Figures.....	6
List of Tables.....	7
Chapter 1: Introduction.....	8
1.1. Introduction.....	8
1.2. Aims and objectives	10
1.3. Justification of Research.....	11
1.4. Overview of Research	12
Chapter 2: Literature review	13
2.1. Introduction.....	13
2.2. The commercial ports and the automation.....	14
2.2.1. The beginning of the maritime activity and the apparition of the ports	14
2.2.2. The evolution of the commercial ports.....	16
2.3. Principle and development of the automated ports	18
2.3.1. Apparition of the automation	18
2.3.2. Operation and management of the automation.....	20
2.4. Presentation of the impacts and the case study based on the Rotterdam's port.....	22
2.4.1 The different impacts of an automated port.....	22
2.4.2. The presentation of the case study: the automation of the port of Rotterdam.....	24

2.5. Summary	26
Chapter 3: Methodology	27
3.1. Introduction	27
3.2. Research philosophy	28
3.3. Research approach	30
3.4. Research strategies	32
3.5. Methodology choice	34
3.5.1. The Triangulation	35
3.6. Time horizons	36
3.7. Techniques and procedures	37
3.8. Research ethics	38
3.9. Viability and reliability of the research	39
Chapter 4: Analysis and discussion	40
4.1. Introduction	40
4.2. Analysis	41
4.2.1. Manpower impact	41
4.2.2. Environment impact: ecological impacts, respect for biodiversity and quality of life	44
4.2.3. Cost impact: cost of the automation of a Terminal	46
4.2.4. Operational impact	47
4.3. Discussion	52

Chapter 5: Conclusion.....56

References 59

List of Figures

Figure 1: Port of Rotterdam.	24
Figure 2: The research onion.	27
Figure 3: The deductive approach.	30
Figure 4: The inductive approach.	30
Figure 5: Employees at the Port of Rotterdam during the 24 hours strike.	42
Figure 6: The development of Automatic Guided Vehicles (AGV) throughout history.	44
Figure 7: Evolution of world seaborne trade volumes.	47
Figure 8: Total TEU volume at the Port of Rotterdam.	48
Figure 9: Total TEU volume and year-over-year growth in millions of TEU.	49
Figure 10: Virtual reality prototype of fully autonomous ship developed by Rolls-Royce.	57

List of Tables

Table 1: Summary of the impact of automation.	48
---	----

Chapter 1: Introduction

1.1 Introduction

Maritime transport is a millenary activity that has seen many technological revolutions over the centuries, and especially for fifty years. In the era of efficient supply chains, of their profitability, the actors seek a match between the ships, the port terminals, the terrestrial services. The solutions brought by the professional's concern on the one hand the organization of the entrepreneurial structures, whether they are the maritime armaments, or the operators managing the port terminals, and, on the other hand, the tools vectors of the transport, with the first rank of which the ship (Marcadon, 2005).

It is the technical innovations relating to ships which have played the essential role for fifty years, innovations marked by the gigantism naval, the specialization of ships, the invention of the container and container ships. From there, ports, previously versatile, have adapted (Marcadon, 2005).

Indeed, the search for the optimal size associated with the race for naval gigantism obviously has consequences for port facilities, terminals have to adapt to accommodate ships, and also handling. Large material handling operators are putting in place technical solutions to increase the efficiency of the terminals to treat increasingly large container ships. So, the automation appeared, then the ports have become a set of specialized terminals, equipped accordingly, dealing only with particular categories of ships, in bulk or general cargo (Marcadon, 2005).

The automation is appeared in the terminal in 19th century and since then has only evolved. The main components of these terminals, such as automated stacking cranes, automated ground transportation and computer-controlled operating systems. But today, 94% of all container terminals in the world are still manual. Only 2% are fully automated, and 4% are semi-automated (Mongelluzzo, 2016).

The first port with an automated terminal in the world is the port of Rotterdam. Rotterdam has a particular soul, one of the smallest countries in Europe (41 000 km²), its landscape and its economy are still in motion. In addition to these aspects, Rotterdam is home to one of the largest ports in the world, making navigation and water

the backbone of this economic hub (Expat.com, 2014). To maintain its position as a European leader in maritime traffic and to respond to a steady increase in trade and the race for gigantism of ships, the port of Rotterdam has no choice but to expand and adopt the 'automating. An evolution that allows fast processing of large volumes but not only (Dumont, 2007).

Therefore, the purpose of this research is to analyse the different impacts, negative and positive, trained by the automation and its technology used in the most important ports across the world. It also aims to analyse how these impacts affect a port thanks a case study based on the automated terminal in the port of Rotterdam. So, see if the automation is a durable solution in the future.

1.2. Aims and objectives

The study aims to analyse the impact of port automation and how these impacts affect the port of Rotterdam, more precisely its automated terminal.

The objectives are the following:

- A. To analyse the background of the maritime world, then the application of automation for ports, and the features of Port of Rotterdam.
- B. To examine the advantages and disadvantages of port automation and which influences the activities of port of Rotterdam.
- C. To investigate the present challenges faced by the port of Rotterdam.
- D. To evaluate port automation as a solution for face to the increasing of the merchandise Mondial exchanges by the way of maritime transport.

1.3. Justification of Research

The development of modern technology has resulted in a myriad of changes in the marine industry. The introduction of complex navigation software on board ships, remote-controlled giant cranes for handling goods and automated equipment in ports has made navigation and cargo handling operations easier and more efficient in ports. This makes it possible to respond to the increase in goods carried by ship as well as the management of mega-ships. In addition, investing in port technologies is a key element of port development to meet the challenges of everyday life (World Maritime News, 2016). Today, lot of companies invest for innovate and simplify the different activities in the ports. In the future, the technology will be more present in the port. Hence, the research would have a clearer view of the advantages and disadvantages of automation affecting the daily life in the ports. In order for this is to more concrete, the study will be based on the case study of the automated terminal of Rotterdam.

1.4. Overview of Research

Chapter 2: Contains a critical review of the literature to create a better understanding of the topic. It highlights the background of the maritime transport and ports, the concept of port automation, presentation of some impacts of the automation and the introduction of the port of Rotterdam.

Chapter 3: Identifies the methods and approaches used in this research which includes the research philosophy, approach, strategy, methodology choice, time horizons, data collection and data analysis techniques, ethics, viability and reliability of the research.

Chapter 4: Presents the analysis and discussion on data collected. An analysis on the impacts of automation, then based the case study of the port of Rotterdam, this, using a thematic analysis. A discussion to summarise and address the future of automation in ports.

Chapter 5: Give a conclusion to the research question and aim, the limitations of the research and identify any possible future studies.

Chapter 2: Literature review

2.1. Introduction

The goal of the literature review is to give a synthesis and analysis of existing work. So, in this chapter, all information found and examined will permit to fulfil the project's initial objective. The review will contain three key areas that are essential for this project study.

As a first step, few words on the development, the evolution of the commercial ports and the environment which surround them. Indeed, the automation is not appeared overnight, many steps have taken place. The creation of the first port have been a consequence of the development of the boats. The latter, are always become more important and efficient centuries to centuries. All that being said accelerated by the apparition of the container ships in 1960 (Log Trans, 2015) and containers in 1956 (Barjonet, 2014).

When this new technology has been created, which is the automation, this is have permit to better welcome the different generation of boats, but its operation is complex. In this second section, the literature review shall explore how the automation is born, what is a port automated, how it works according to the various types of automation and which tool and means have been created and are used.

In lot of rich countries, which possess a big port with an important commercial activity, the automation has been a solution for to be more efficient but it's not without impacts. Indeed, over times, some sources have demonstrated that this technology has consequences, negative and positive... So, for the last section, the impacts going to be identified and the port select for the case study shall be introduced. The selected port is Rotterdam, it's an excellent case, indeed in the Western Europe it is the first fully automated terminal (Garnier, 2015).

Finally, a summary of the literature shall be made detailing reliability of sources and information, the outcomes of the review and its limitations

2.2. The commercial ports and the automation

2.2.1. The beginning of the maritime activity and the apparition of the ports

The history of the sea transport begins very early. Its birth is linked to the humans needs to move on the water and to feed. Indeed, the surface of the earth being covered with 70% water (Lenntech, 2017), the humans have to find solution in order to navigate on the oceans, seas and rivers.

The first boats were built at prehistory and since they have evolved: rafts, canoe, pirogue... But very fast, the men realize that this mode of transport can offer a lot of opportunities and possibilities. In addition to fishing, this transport can permit the exploration, the trade and the war.

From that moment on, the boats have modernized thanks to multiple inventions by famous character and their utilisation diversified depending on the era or the country. But all of this was accompanied by the creation of laws, rights and especially by the territories arrangement, in term of structure in goal to shelter and facilitate the welcome of the boats.

The name of these structures is the port: *"For the first seafarers, the ports represented shelters, places of refuge or harbors more or less well laid out on the coasts when the conditions of navigation were severe. Then, they became places of loading or unloading of goods, inserted in the cities at a time when shipping was by far the most suitable way, as well as places of parking of naval forces of maritime nations"* (Caude and Scherrer, 2017). Broadly speaking, a port or maritime port, is currently defined at the following way: *"A port is a geographical area through which goods and / or passengers transit. A maritime port is a port which welcome seagoing ships, which is a meeting place, between these seagoing vessels and all the various modes of land transport"* (Scherrer, 2011).

Then, face to the development of the boats and their utilization, 4 different main types of port appeared: commercial ports; fishing ports; marina and naval ports. All of this type of ports has been gradually implanted all across the world.

So, since very a long time, the men have understood that the seas are veritable asset that they have succeed to develop, especially with the trade.

2.2.2. The evolution of the commercial ports

Over times, one of this 4 type of ports it is imposed among the others. Indeed, the commercial ports are gradually multiplied, from century to century. This is due to a large extend of the globalization and the many advantages that represent the maritime transport, which are: competitive cost, wide choice of products to carry, long distance, large quantity transported, reliable transport (Amba France, 2017).

So, boats and ports have been improved in order to better develop the commerce activity and extract the best benefits. Indeed, with the time, the boats have been created and invented in goal to be adapted for the commerce of goods, they are called container ship. This has become a real race of gigantism and have been accompanied by the apparition of the container with different size, which have facilitated the transport of goods. Thanks to these evolution, the number of merchandises transported by container ship had increase: 1970 = 1 700 containers; 1980 = 2 305 containers; 1985 = 3 220 containers; 2000 = 4 848 containers; 2005 = 7 598 containers; 2006 = 11 000 containers; 2013 = 18 000 containers (Bellot, 2017). Currently there is an average of 6 748 containers ship in the world (Bellot, 2017), directed by international companies like: CMA CGM, Maersk, Mediterranean Shg Co, Evergreen Line... (Statista, 2017).

The maritime transport is really become the mode of transport the most use in the world for the commerce: 80% of global trade of goods are effectuate by maritime transport (Ministère de la transition écologique et solidaire, 2017). But, all of this evolution is permit thanks to the ports and their structure, which have evolved a lot and known how adapted to the different generation of boat. Notably, thanks to the creation of a terminal, which allows the handling (loading, unloading) of goods (CNRTL, 1980).

Today, there is approximately 860 ports in the world (Levoyageur), whose 100 main commercial ports (AAPA). The ports have their importance because: *"Essential vectors of the commerce, the ports are also major players economic development of a country"* (Ministère de la transition écologique et solidaire, 2017).

So, a port is a real asset, a country has a big interest to develop and invest in its maritime activity which had a real impact on their economic activity. More a port possesses, technical or administrative facilities in quantity and with quality, place and terminals for welcome lot of boats, more this port will have success. Currently,

numerous countries have understood that and continue more to develop the maritime activity.

2.3. Principle and development of the automated ports

2.3.1. Apparition of the automation

A good development and operation of a port is really essential for an important global trade of a country and for the maritime companies. This is particularly important in the intermodal transport, which means: *"in the area of the transport of goods, the intermodal transport consist to use at least two successive mode of transport for forward goods to destination"* (Glossaire international, 2017). Indeed, today lot of goods forward by containers between different continents: 9 billion tons of goods (Bellot, 2017) in 701 million containers, between 2016 and 2017 (La banque mondiale, 2016).

Therefore, a port which welcome containers have to be efficient, so that the merchandises are quickly available for leave by truck, train or plane and arrive at the customer. It's the same thing for the port which welcome the containers at the beginning, it has to be fast and load them on board to the container ship. Of course, this is complicated to manage all of this merchandises outcome of this numerous exchanges, which are transported by sea.

To handle the containers, handling equipment appeared. The first machines have been created 19th century and have been improve, they are machines of the type: mobile crane, tractor-truck, forklift truck, straddle carrier... So, for facilitate the container management in the ports and terminals, a new technology is appeared it's the automation, which concern the handling equipment. This technology is characterized by: remotely controlled installations, programmed robots, systems, software...

The history of the port automation started about twenty years ago. The first port in the world whose terminal was automated was the port of ECT Delta (Rotterdam) in the Netherlands and operational since the early 1990s. It was equipped with Automated Stacking Crane (ASC) and Automated Guided Vehicles (AGV) which allowed the port to manage the handling of storage and interchange equipment respectively without operators (Martín-Soberón et al., 2014).

Then, other ports have been automated: Hamburg in Germany, Brisbane in Australia, Shanghai in China... Thereafter, some ports have begun to automate existing terminals and companies have specialized in this area (Kalmar Global, 2017). So, thanks to this invention and concept, the management of numerous containers is easier, despite their volume which increase each year. But, even if the port automation is a big evolution, its management and operation are complex.

2.3.2. Operation and management of the automation

The installation of the automation in a port is a real upheaval whose the changes are radicals. We can define this term in the following way: *"is the use of various control systems for operating equipment such as machinery, processes in factories, boilers and heat-treating ovens, switching on telephone networks, steering and stabilization of ships, aircraft and other applications and vehicles with minimal or reduced human intervention, with some processes have been completely automated"* (Rifkin, 1995). First of all, there are different types of port automation. Since its creation, the automation is install in container terminals all across the world, but we can see that, over times it is gradually used for day to day running of operations such as bulk and general cargo. The investment for this kind of technology can be multiple because there are different levels in the automation. Indeed, automation may be deployed across a port network from the foreshore to hinterland controlled by a Terminal Operating System (TOS). Or, port managers may choose to allocate certain operations specific automated systems to aid operation efficiency.

Here some tools and means use in automated ports:

- Terminal Operating System: TOS are very important for the managing port automation systems. They are multipurpose flexible systems that can be employed in numerous types of port not only container terminals. TOS mean: "a comprehensive suite of IT software, information and communications technologies (ICT) that optimise port operations and enable the integrated management of activities at the quay, yard and gate" (Global business, 2017).
- Optical Charter Recognition portals / crane: These two had improve automation, logistics, security and safety for marine container terminals. OCR gate systems allows for the recording the containers as they enter or leave the facility. OCR crane systems provide container identification as container are loaded or unload onto ships (Mi-Jacktech, 2017).
- Radio Frequency Identification (RFID) and Position Detection System (PDS): RFID and PDS are tools which complement each other. RFID is: *"an automated*

identification and data collection (AIDC) technology" (Dempsey, 2017). In each container there is a RFID which permit to track containers remotely and contains the following information: cargo information, the cargoes destination, and buyer, seller information. When the cargo approaches the arrival port, the information on the microchip are collect thanks to the PDS. The PDS permit to track all container cargoes and use the information collected in order to know where to store the cargo within the port.

- Automated Guided Vehicles (AGV) and Automated Lifting Vehicles (AVL): They are vehicles of horizontal transportation destined used for rapid and economical container transport between the quayside and the container yard. These vehicles use high tech robotics, with high powered electric motors. They are managed by a software (Kone Cranes, 2017).

Since the apparition of the automation, the ports are begun more efficient and have facilitate lot of operation thanks to this new technology. Despite that, impacts have appeared...

2.4. Presentation of the impacts and the case study based on the Rotterdam's port

2.4.1 The different impacts of an automated port

The automation of the ports it's done gradually in the world. Following this phenomenon, different media and sites are interested in are impacts, positive and negative. So, here the presentation of some important impacts of this recent technology:

Positive impacts	Negative impacts
The setup of modern devices automated, permit to gain speed in the load, unload of the containers ship, therefore increase the operational efficiency and uptime of the port.	The establishment of a port automated it's a project and site long and tedious.
Thanks to the automation and thus a best efficiency of the port, countries have been developed economically and made certain port cities very rich.	The performance of these ports leads to increase the competition between ports in the world, until to render some obsolete.
In some cities, the factories are next to ports for various reasons stuck with the old manual-labor model, the mostly new container ports rapidly stole traffic from them.	With all the new modern technology, that handles container handling or other action automated, changes the working conditions and the numerous of jobs in the ports decrease, even became obsolete.
Like this technology is recent, it demands to hire new employees competent in this specific area.	It's a project particularly expensive, so all ports cannot benefit and create inequality between them.
Without all of this traditional handling equipment and waiting for truck drivers to pick up containers, there is a reduction in CO2 emissions.	In the ports, the terminals use systems and software, then in case of breakdown or cyber threats, the activity of the port is suspended and the load, unload take delay.

(David z., 2017), (International Finance Corporation, 2017).

2.4.2. The presentation of the case study: the automation of the port of Rotterdam

The port of Rotterdam is a port located in Netherlands, more precisely in the north of the country. The port was built in twelfth century and since have lot of evolved. Today, it figures among the biggest ports in the world, being the ninth in the ranking of the main ports in the world (L'antenne, 2015) and the most important in Europe. Lot of merchandise transit by Rotterdam, an average of 461,2 million tonnes per annum, all types of goods: dry bulk, liquid bulk, containers, breakbulk. These merchandises are transported by approximately 35 000 boats, then bring to the end customer thanks 7 500 000 trucks (25 000 per day) and manage by 93 844 employees and the CEO Allard Castelein. To be able to welcome all of these goods, the port has a big capacity. Indeed, its area is equal 12 426 hectares, over 42 kilometres, divided between different port facilities zone along the mouth of the Rhine: city center, Heijplaa, Pernis, Botlek, Europoort, Maasvlakte 1&2 (Port of Rotterdam, 2017).

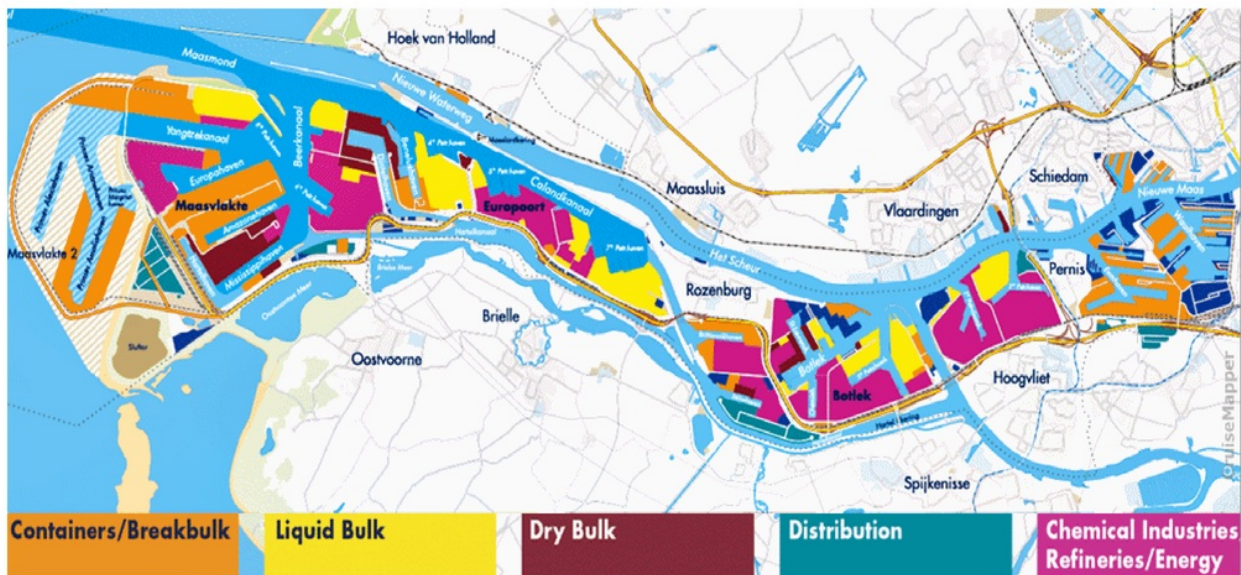


Figure 1: Port of Rotterdam
Source: (Cruise Mapper, 2017)

The port of Rotterdam is the first port automated in the world and have been operational in the 90's, since, the port has much developed and enlarged. Indeed, the port has creating two of the world's largest container terminals namely Maasvlakte 1&2, which permit providing an added output of over 120 million tons per annum. In few years, when the productivity will be maximum, 2,7 million of containers can be treated. The terminal Maasvlakte 2 is the first fully automated container terminal in the world operated by APM Terminals (Maersk group) and European Container Terminal (ECT). This important project has cost 500 million euros. Currently, the port of Rotterdam represents as one of Europe's most advanced smart port's thanks to the different engines and TOS. An evolution that responds to the race for gigantism of ships and allows the fast processing of large volumes (Garnier, 2015). But this evolution was not without impacts on the port of Rotterdam, which are more or less negative and positive.

2.5. Summary

Thanks to all data collected, many important points of this dissertation have been addressed in the literature review section. Indeed, we have discovered why and how the ports are born, more precisely the commercial ports. Then, the development of the ports and the apparition of the automation. Finally, introduced some positive, negative impacts and the case study based on the port of Rotterdam. This research had permit to better understand and encompass the subject. But during the collect, some limitations to the project are emerged, namely the availability of sensitive information over the consequences of automated systems which could impact upon the success of data collection. In that case, other sources shall be collected and analyzed to ensure the successful fulfilment of the dissertations aim and objectives.

Chapter 3: Methodology

3.1. Introduction

The following chapter is the methodology. The research methodology section is a way to find out the result of a given problem on a specific matter or problem that is also referred as research problem. In Methodology, researcher uses different criteria for solving/searching the given research problem. Different sources use different type of methods for solving the problem. If we think about the word "Methodology", it is the way of searching or solving the research problem (Williams, 2011). The chapter going to introduces the design of the research, choice of methods, strategies, approach also the methods of data analysis that were used for the project. This work will be based on the research onion as shown below (Saunders et al., 2012):

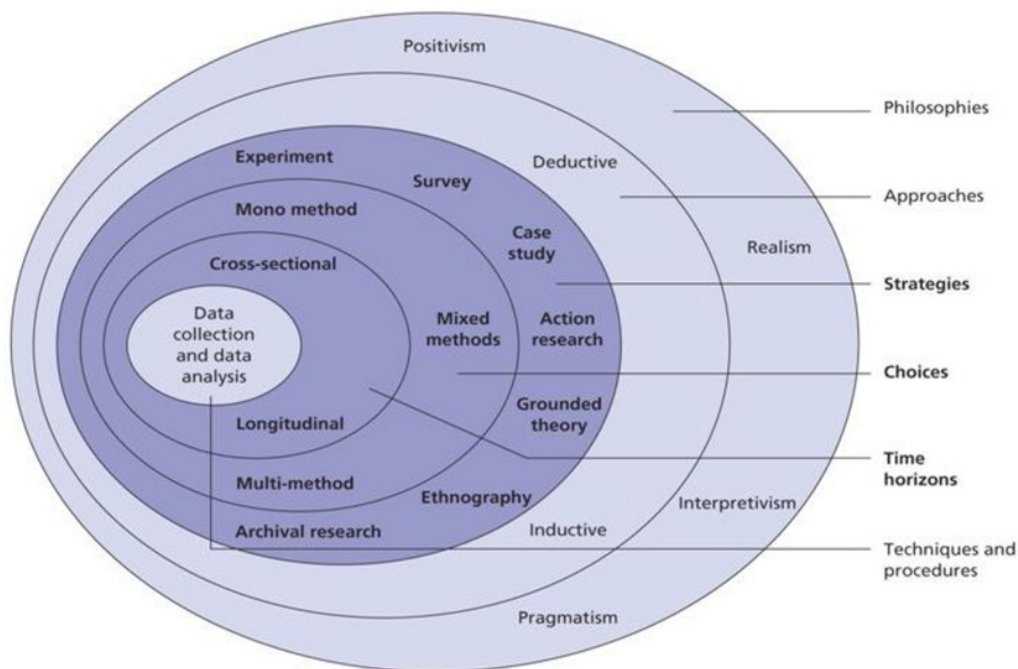


Figure 2: The research onion

Source: (Saunders et al., 2012)

3.2. Research philosophy

The research philosophy is important in order to understand the nature of the research of the subject and the way to treat the source, nature and development of knowledge. Further, a research philosophy is belief about the ways in which data about a phenomenon should be collected, analysed and used (Dudovskiy, 2017). For this part, there are four popular philosophies, often used: Positivism; Realism; Interpretivism and Pragmatism. They mean:

- Positivism: The Positivism correspond that the view that only knowledge gained through observation and the measurement, are reliable. In positivism studies, the actions of the researcher are limited to data collection and interpretation in an objective way (Dudovskiy, 2017).
- Realism: The Realism relies on the idea of independence of reality from the human mind and in the assumption of a scientific approach to the development of knowledge. There exist two groups of realism: direct and critical. The direct realism can be described as “what you see is what you get”. In other words, through personal human senses. On the other hand, critical realism argues that humans do experience the sensations and images of the real world. But this kind of realism can be deceptive and usually do not portray the real world (Dudovskiy, 2017).
- Interpretivism: The philosophy of Interpretivism involves researchers to interpret elements of the study. Accordingly, the researchers assume that access to reality is only through social constructions like the language, consciousness, shared meanings, instruments. It's also associated with the philosophy of idealism and used to group together diverse approaches like social constructivism, phenomenology and hermeneutics; approaches that reject the objectivist view. According to interpretivism, it's important for the researcher as a social actor to appreciate differences between people (Dudovskiy, 2017).

- Pragmatism: Pragmatism research philosophy accepts concepts to be relevant only if they support action. it also accepts that different ways of interpreting the world and undertaking research can exist, there is no single point of view and can ever give the entire picture because there may be multiple realities. According to this philosophy, the research question is the most important determinant of the research philosophy. Moreover, Pragmatics can combine both positions: positivist and interpretivism, within the scope of a single research according to the nature of the research question (Dudovskiy, 2017).

In the case of this project, the pragmatism research philosophy is the most appropriate. Indeed, it offers different ways of interpreting and thinking the subject in question. But, this philosophy also includes the qualitative and quantitative approach, that are useful for the research of data for the case study for example (Dudovskiy, 2017).

3.3. Research approach

In the section of research approach, two types of approach going to be introduce, deductive and inductive approach.

The deductive approach:

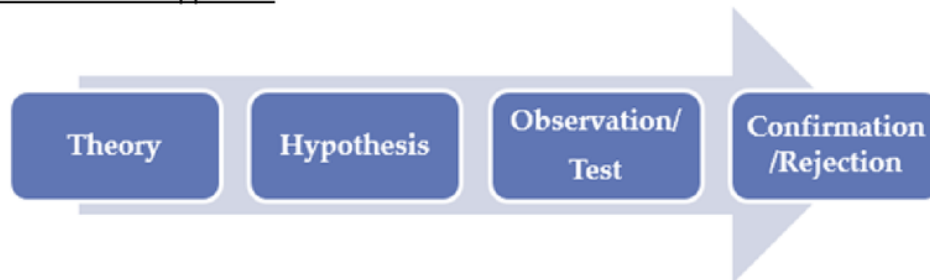


Figure 3: The deductive approach

(Source: Dudovskiy, 2017)

This approach is established the development a hypothesis / hypothesis, based on existing theory, for the next step which is to design of a research strategy to test the hypothesis in question. So, the deductive approach can be explained by the means of hypotheses, which can be derived from the propositions of the theory, and thus deducting conclusions (Dudovskiy, 2017).

The inductive approach:

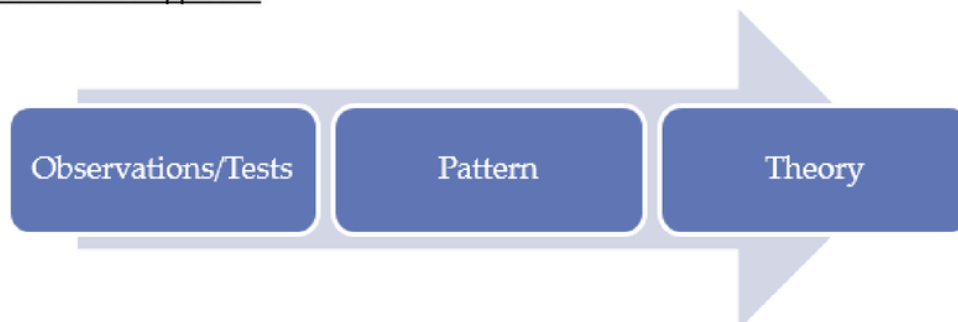


Figure 4: The inductive approach

(Source: Dudovskiy, 2017)

This approach aims to generate, to search meanings from the data collected for identify relationships and patterns in order to build a theory. But, inductive approach does also permit from using existing theory to formulate the research question to be explored.

Inductive reasoning is based on learning from experience. So, regularities, patterns and resemblances in the data collected or in experience, are observed in order to reach a theory or conclusion (Dudovskiy, 2017).

So, between these two types of approach, the inductive approach had been chosen. It going to permit to reveal lot of things on the impacts of the automation, if they are positives or negatives, the benefits, the performance of these installations in a port like Rotterdam in Netherland. But also bring to light other aspects of these technology like economic, cultural, social, characteristics... After all of this, terminate by a theory / conclusion.

3.4. Research strategies

The research strategies are multiple and are defined like the methods and the principles through which a researcher makes sense of the object of the project and inquiry. Within the part of the research methodology, research strategy is considered as the “general plan of how the researcher will go about answering the research questions” (Saunders et al, 2012). For this kind research there are seven types of strategies: experiments, surveys, case studies, action research, grounded theory, ethnography, archival research.

So, for this kind of dissertation, the strategies chosen are the case study, archival research.

Case study

The case study is a methodology that is used to study something specific in a complex phenomenon. There are many definitions of the term in the literature. According to Bichindaritz, he proposes to define the case study it as a set of empirical data. More generally, a case may be considered as an object, an event or a situation constituting a unit of analysis (Bichindaritz, 1995). During this project, the case study going to concern the port of Rotterdam, therefore the data collection going to be from port statistics, development, government publications... The case study format will allow you to start with broad questions and then focus, based on the first observations on particular points rather than predicting each outcome before the experiment is undertaken. Case studies also shed light on deep data or thick descriptions about the subject (Quentin, 2012). So, the port of Rotterdam, today it is the first port in Europe and figure among the most important in the world, represent a good case study for evaluate the impact of the automation and the challenges and consequences that this entails.

Archival research

The archival research strategy is a strategy which implies a research is conducted from already existing materials (Flick, 2011). We can also refer to historical research, where a body of source material is mined in the goal of establish results. This kind of form of research may involve a literature review, where patterns of existing research are analysed and summed up in order to establish the sum of knowledge on a particular

study, or to examine the application of existing research to specific problems. So, for the project, this kind of strategy going to permit collect data from maritime news article and companies archival for found and highlight the evolution then the impact of the automation in the ports. But also, to collect statistical quantitative data for the case study in order to show the increasing number of containers treated by the port of Rotterdam and consequently how the automation permit the good management of it activity.

3.5. Methodology choice

This section corresponds to the way in which the data analysis and data collection are done. there is three type of methodology choices: mono method, multi method and mixed methods. They mean:

Mono method	Multi method	Mixed methods
The utilisation of one of the approach proposed for the project led.	involves a research divided in different segments which furnishing specific dataset, then they are analysed thanks to techniques derived from qualitative or quantitative methodologies (Feilzer, 2010).	The utilisation of two or more method approach. Often, the researchers use of both a qualitative and a quantitative methodology.

Mixed methods research

In the case of the project, the mixed method is chosen. This methods research is the branch of multiple methods research that combines the use of quantitative and qualitative data collection techniques and analytical procedures (Saunders et al., 2012). It's a methodology research that involves collecting, analysing and the integrating qualitative and quantitative researches. Well used, this approach provides a good understanding of the research problem than either of each alone. The quantitative researches will allow to show the perpetual increasing number of containers which transit in the world and qualitative research in order to know why the automation can be a solution of this increasing and its consequences (FoodRisc Resource Centre, 2016).

Thanks to the mix between qualitative and quantitative research, a better understanding is permit but also a triangulation.

3.5.1. The Triangulation

In order to examine a phenomenon, the triangulation implies the utilisation several means: researches, data sources and methods. With different approaches of the aspects of the phenomenon, this will permit to engage a better analyse of the data provided by all methods (FoodRisc Resource Centre, 2016). The triangulation will help to finding then compare the strengths and weakness about the new technology in the ports, especially at Rotterdam.

3.6. Time horizons

The time horizons are defined by Saunders et al. like needed for the research design independent of the research methodology used (Saunders et al., 2012). It exists two types of time horizons:

- Cross-sectional: The observation of an aspect or the behaviour of a group of people or an individual at one point of time. This observation is realized by a method of research qualitative or quantitative (Smith, 2017).
- Longitudinal: The observation of an event and behaviour by means of samples, focused over a longer time. This observation can be realized in the same way that of cross-sectional method, with a research qualitative and quantitative (Smith, 2017).

For the research conducted for this project, the cross-sectional time horizon is the most appropriate due to time constraint.

3.7. Techniques and procedures

Data collection

The method of data collection is divided into two parts: Primary data and Secondary data. For the dissertation the secondary data is chosen, more precisely documentary data and multiple source. In other word the research will based on publications, news article, port authority website, academic journals from Trinity Saint David University electronic database, images, reports, organization websites... (Saunders et al. 2012). Moreover, this method had lot of advantages. It is economical, it saves efforts, expenses and time, consequently more time and effort can be used for improving the understanding of the problem and better analyse the information collected.

Data analysis

The section data analysis will permit to define how the collected data going to be analyse, thanks to two types of methods: quantitative analyse and qualitative analyse.

In quantitative data analysis, the numbers coming from graphs, charts and statistics are meaningful data through the application of critical and rational thinking. This approach can be associated with finding element, in order to reject or support the hypotheses formulated at the earlier stages in the research process. But, this analyse ask to apply careful and just judgement, because the same figure within data set can be interpreted in many different ways (Dudovskiy, 2017).

In qualitative data analysis, is an analysis of non-numeric information such as notes, interview transcripts, video, images, audio recordings and text documents. This analysis can be divided into five categories: content analysis; narrative analysis; discourse analysis; framework analysis; grounded theory (Dudovskiy, 2017).

So, these analyse from different sources and form will permit to collect data about the current situation in the port of Rotterdam. But also, to realize a comparison between the before and the after the installation of automation and see which factors have been affected, partly revealed in literature review section. Then identify the impacts on these factors, discover the reason and why they are positive or negative.

3.8. Research ethics

"Ethics" is really important all along the writing of the dissertation and can be defined in the following way: norms for conduct that distinguish between acceptable and unacceptable behaviour. The ethical norms in research are essential and have advantages like:

- Promote the aims of research (Ex: knowledge, truth...).
- Promote the values that are essential to collaborative work (Ex: trust, fairness...).
- Ensure that researchers can be held accountable to the public.
- Promote important moral and social values (Ex: social responsibility, human rights...).

The lack of ethical in research can harm human and animal subjects, students, and the public (Resnik D B et al., 2015). So, all data used for this project be properly cited to prevent plagiarism.

3.9. Viability and reliability of the research

Viability

The validity refers to how well an instrument as measures what it is intended to measure. It exists five types of validity: face validity; construct validity; criterion-related validity; formative validity and sampling validity. But also, into two groups: internal validity and external validity. The internal validity refers to how the research findings match reality, while external validity refers to the extent to which the research findings can be replicated to other environments (Research Methodology, 2017).

Reliability

The reliability correspond to the degree to which research method produces stable and consistent results. So, a specific measure is considered to be reliable if its application on the same object of measurement number of times produces the same results. It exists three categories of reliability research: test-retest reliability; Parallel forms reliability; Inter-rater reliability and Internal consistency reliability (Research Methodology, 2017).

Chapter 4: Analysis and discussion

4.1. Introduction

The chapter 4 is divide into two parts: data analysis and discussion. The data analysis is a process which the collected data are reviewed and analyzed in order to form sort of conclusion (Business Dictionary, 2017). Thanks to the data collected, different impacts created by the automation of the ports going to be operated in detail, divided into four themes: manpower, cost, environment and operational, then formatted with the case study based on the port of Rotterdam. For finish, the part of discussion, will permit to summarise the all the information deal in the analysis part and address the future of automation in ports.

4.2. Analysis

4.2.1. Manpower impact

4.2.1.1. Reduction of the workforce

According to Garnier (2015), the automation had an impact on the workforce as the replacement of the human by the engines. Depending on its importance, automation translates into a workforce reduction of 30 to 70%.

Based on analysing and interpreting these results the present research found findings that are as follows:

A few years ago, Rotterdam became the first European port to have a fully automated terminal. This is the terminal Maasvlakte 2: it runs on 3.6 km of dock and covers 265 hectares. It works thanks to 137 robotic gantries that move the containers on 265 small trolleys, also computer-guided. But all this technology has had the consequence of replacing the employees of the port... (Guillemoles, 2011).

Then in 2016, hundreds of port workers paralyzed for a 24 hours part of the container port of Rotterdam to reach an agreement with the employers on job cuts. Plans have been announced to remove up to 800 positions from a workforce of approximately 3,600 employees. This strike, which took place from January 7 to 8, was the first in 13 years. During the strike, the Dutch port workers union, FNV Havens was joined by the FET, the International Transport Workers' Federation (ITF), the Belgian trade union BTB, the German trade union Ver.di and the CGT of France. Their demand is that no one be fired until 2020 and that working conditions for older employees be improved. (La Haye AFP, 2016). In addition, the FNV, the main union in the Netherlands, deplores that "Millions of euros are invested in the automation of the port but no one thinks of the job losses" (Burns, 2016).



Figure 5: Employees at the Port of Rotterdam during the 24 hours strike.
Source: (AFP, 2016).

So, the employees are fighting to keep their work in time and this despite the agreements signed in the past. But, the construction projects for the Maasvlakte 2 terminal will end in 2030 (Burg, 2012). So, will there be other strikes by the end of the work ?

4.2.1.2. New opportunities

The ports which figures among the most important in the world had an intense activity, day and night, so they need lot of workforce in order to handle that. So, this represent a cost and the automation permits to reduce this cost thank to software and engines which replace the workforce. But for all of this technology working, qualified persons are asked, that offer new job opportunities.

In the case of Rotterdam, the dockers are organized in pool, a cooperative that manages the staff according to the demand of the companies. "We had very tough discussions with the unions, but here the dockers have accepted the principle of automated terminals," explains Frank Tazelaar, the director of the terminal Maasvlakte II. We signed an agreement with the unions that the new terminal would recruit 300 employees from the staff of our neighbouring terminal by training them, which we did" (Garnier , 2015). So, these training will permit to the employees do not need to realize routine maintenance work, but to focus on higher-level, more complex tasks. Moreover, the automation created new opportunities in other sectors, like software development, engineering, mechanical... but also new trainings and employment in the future.

With the improvement of the devices and handling machines, the employees had to adapt then allowed them to acquire new skills in port operations and new responsibilities. This is also offer better working conditions and offer an increase of wages.

In the future, established in all major ports around the world including Rotterdam, APM Terminal, which employs 20,000 people and generates \$ 4.5 billion in revenue, has already taken an option to double the size of its Maasvlakte 2 terminal. "It will be after 2020 ", says Frank Tazelaar (Garnier, 2015). A project which a project that will undoubtedly lead new employment and developments in knowledge.

So, the automation allows to the employees to improve their knowledge and skills and became a real qualified workforce, but also create or offer new job in other domain thanks to the evolution and project for the port of Rotterdam.

4.2.2. Environment impact: ecological impacts, respect for biodiversity and quality of life

Lavocat (2014) claims that the ports, many of which are industrial complexes, are environmental "black spots". Yet, by dint of regulation and labels, they try to make a green change. But the growth of international trade is making their environmental footprint ever heavier. Shoreline artificialisation, water and air pollution, ecosystem degradation... the list of grievances against the port industry is long. First, there are the impacts directly related to the activity of storing, maintaining or unloading ships.

Based on analysing and interpreting these results the present research found findings that are as follows:

The Maasvlakte 2 automated terminal in Rotterdam is a project where everything has been done to make it as eco-friendly as possible. Indeed, it is erecting in a protected area, the Voordeltan, it must therefore respect, the existing fauna and flora. So, to sustainably handle around 2.7 million TEUs (twenty-foot equivalent) of containers annually, APM Terminals Maasvlakte 2 uses a fully automated real-time operation system (Port Montréal, 2013). Indeed, the terminal is equipped with innovative engines like self-propelled elevators or again the battery electric lift AGV, that generate lower emissions of Co2 and are quieter (Port Montréal, 2013). Here the evolution of the different generation of AGV, which become more efficient and more respectful of the earth, from year to year:

1993	2006	2012	2013
VEHICLE:			
FIRST DIESEL-HYDRAULIC AGV (GOTTWALD)	FIRST DIESEL-ELECTRIC AGV (GOTTWALD)	FIRST HYBRID AGV (VDL)	FIRST BATTERY-ELECTRIC LIFT AGV (GOTTWALD)
SUITABLE FOR:			
1 x 40 foot container 1 x 20 foot container	1 x 40 foot container 2 x 20 foot container	1 x 40 foot container 2 x 20 foot container	1 x 40 foot container 2 x 20 foot container
CAPACITY:			
40 ton	40 ton for 1 container, 60 ton for 2 containers	40 ton for 1 container 70 ton for 2 containers	40 ton for 1 container 70 ton for 2 containers
SIZE:			
15,5 x 3 meter	14,8 x 3 meter	14,7 x 3,1 meter	14,8 x 3 meter
SPEED:			
3 meters per second (10,8 km/h)	6 meters per second (21,6 km/h)	6 meters per second (21,6 km/h)	6 meters per second (21,6 km/h)
DRIVE:			
Diesel-hydraulic	Diesel-electric	Hybrid	Battery-electric

Figure 6: The development of Automatic Guided Vehicles (AGV) throughout history.
Source: (Port of Rotterdam, 2012).

Then, the terminal operators are required to reuse heat and residual materials from each other. They must also focus on the new rail corridor and river barges and use trucking as a last resort. The port also engages many companies specializing in energy: fossil fuels, solar energy, wind, renewable energy for the management of the terminal. A sector that should evolve further with the European commitment to the Paris Treaty. In this sense, one of the major projects is the conversion of the port of Rotterdam to renewable sources of energy.

Another environment impact, is the improvement of the quality of life and in particular for the local and the employees. Indeed, they are less exposed to the pollutions, noise or other emissions. Moreover, concerning the employees, there is a reduction of human error in port operations and potential accidents at work.

The extension of the port, with the terminal Maasvlakte 2, generate the increase of the traffic and consequently the emission of Co2. But, thanks to their willingness, the actors of the port show their commitment aims for better respect the nature today and in the future with the investment in a terminal automated. Also, permit a better way of life for the local and working condition for the employees.

4.2.3. Cost impact: cost of the automation of a Terminal

Mongelluzzo (2016) affirm that the transition to an automated port has a cost. The infrastructure costs for automated terminals are about twice as high as for a conventional terminal. The equipment costs are three times and the information technology costs are five times higher than those of a conventional terminal. Current examples of automation cost between 300 and 1.5 billion dollars or more, depending on the degree of automation chosen by terminal operators. The repayment term for automation is about 10 years.

Based on analysing and interpreting these results the present research found findings that are as follows:

The extension in the port of Rotterdam, which is the Terminal Maasvlakte 2, had reach the cost of 2,9 billion euros. Moreover, in 2015, APM Terminals, owned by the Danish giant Maersk, opened the world's first fully automated terminal, an investment of 500 million euros. A few months later, Rotterdam World Gateway (RWG), a consortium of five companies involved in shipping, including the shipowner CMA CGM, inaugurated similar facilities for 700 million euros. One of the reasons for the investments for this project is time and cost. Indeed, shipowners have their eye on transit time, because of the cost of immobilizing their vessels: about 50 000 \$ per day for a large container ship. Shipowners who remunerate themselves by charging their customers to the transported container. To reduce the unit transport cost of each container, they order larger and larger ships and the port terminals equip themselves accordingly (Garnier, 2015).

In order to stay among the important ports in the world, the terminals need to adapt by investing in performing and efficient equipment, like those that characterize automation. Today, the time represent a cost, so you always have to deal with more goods every day. But this investment is a cost which is amortized over several years and all the commercial ports cannot. So, the cost of a terminal automatized create inequality and competitiveness.

4.2.4. Operational impact

4.2.4.1. Port productivity

According to Said Aden (2010), in general terms, productivity is defined by the relationship between the production of goods or services and the means that were necessary for its realization (humans, energy, machinery, raw materials and capital...). In the case of port productivity, different indicators help to measure, know the productivity of a port and how it is exploited. The indicators are the following: maritime port traffic; the flow of the berths; productivity per hour, by shift and by ship; the quality of the equipment. If the all of these indicators are improved, the port productivity can only increase. Moreover, the ports will have to be all the more powerful in view of actual and future forecasts, as shown in the figure below:

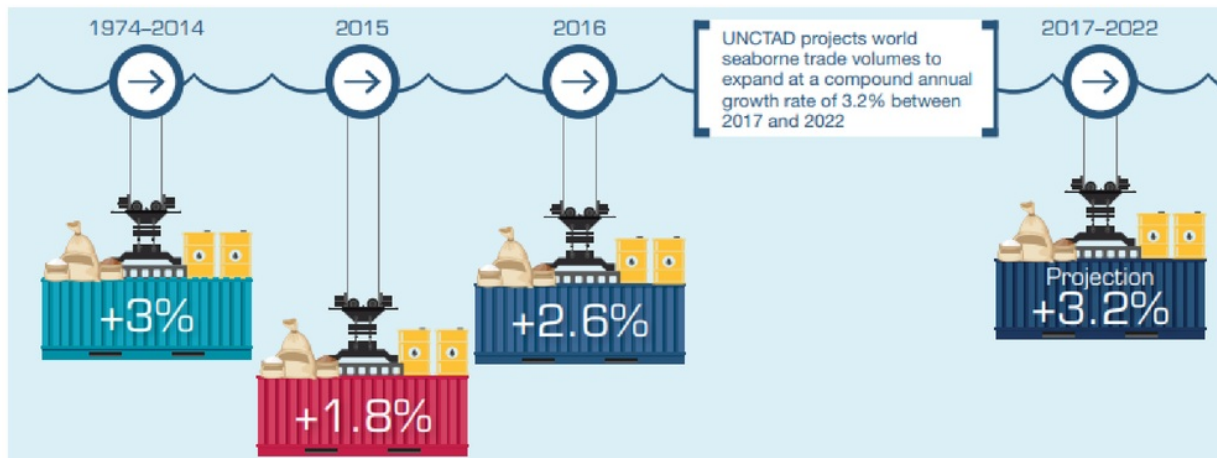


Figure 7: Evolution of world seaborne trade volumes.
Source: (United Nations Conference on Trade and Development, 2017).

Based on analysing and interpreting these results the present research found findings that are as follows:

In Rotterdam, all sorts of goods from all over the world pass through this port, open 24 hours a day, 7 days a week. But for the growth of the activity of the first European port, changes were necessary because it was risky to reach saturation around 2013

(Carronnier, 2013). Every year, the port deals with an average of 461,2 million tonnes per annum, whose 142,6 million tonnes distributed in 12,3 million of containers (Port of Rotterdam, 2017). But thanks to the automation, the productivity of the port had increase, so permit to deal with more containers. As we can see on the figure below:

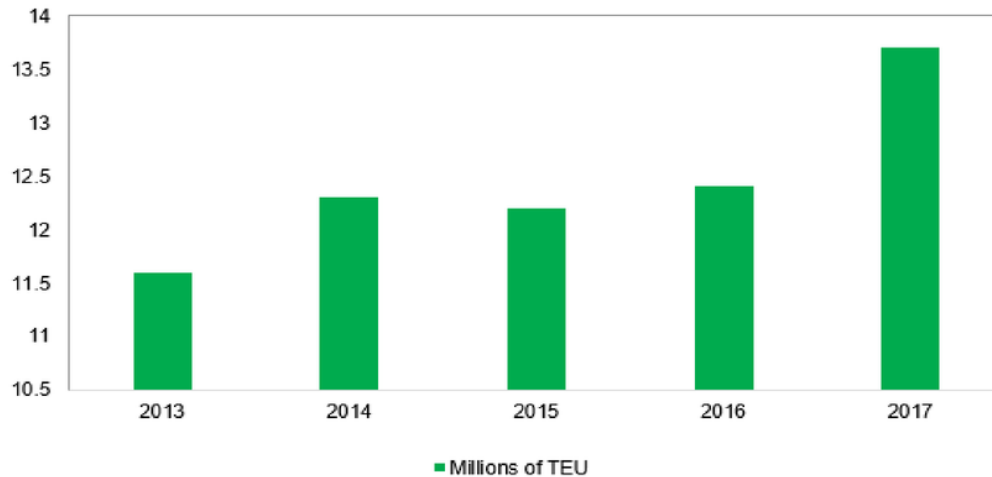


Figure 8: Total TEU volume at the Port of Rotterdam.
Source: (Knowler, 2018)

Since the end of the construction of the terminal Maasvlakte 2 in 2013, which had modernized and enlarge the port to 20%, the volume of the containers had clearly increase, which was designed to deal 2.7 million containers a year. Indeed, the extension allow to store more and handle quickly the containers. For the unloading of ships, it reaches a rate of 45 or 50 containers per hour per crane, against 35 with manually operated machines. A major challenge when the "Ultra Large Container Ships" are needed, a new generation of giant ships capable of carrying more than 18,000 containers, and which require the ability to process large volumes very quickly (Gaitzsch, 2017).

Moreover, this improvement of port productivity offers to Rotterdam to stand out from its main competitors in Northern Europe with an 11% increase in the volume of containers processed between 2016 and 2017:

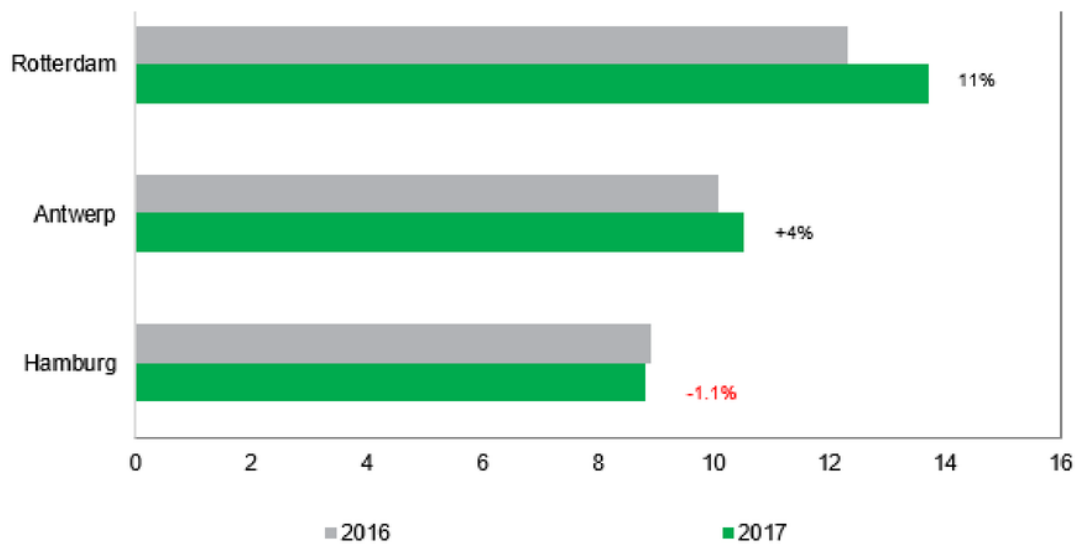


Figure 9: Total TEU volume and year-over-year growth in millions of TEU. Source: (Knowler, 2018).

So, with the automation the ports can be more efficient. The machines work 24H / 24 and 7J / 7, are most fast in their movement, less of mistakes, don't need a break against the workforce, where the performance and capacity going to depend to their physical and mental health. Today, in a world where the exchange intensifies from year to year, where the capacity and the size evolved quickly, the role of the ports is to adapt and push back their limits. The automation is a solution for this, it offers predictability, rapidity and consistency of operations, then the port productivity increases also the competitiveness between commercial ports across the world.

4.2.4.2. Risk and disadvantage

The automation has lot of advantages but not in every situation. The risks and disadvantage to an automated terminal are the following:

- Less / lack of flexibility for operational planning: During the preparation of the project, the decision about the need of the terminal are realized and think for years, so when the machines are layout it's difficult to change for example. Moreover, the activities of the terminal and the needs of its customers though may change markedly over time (Davidson, 2016).
- Cyber security risks: It's a growing threat for ports with complete or almost-complete automation. Despite having secure information sharing methods, automated systems are susceptible to malware attacks and loss of sensitive data (SHM Group, 2018).
- Difficulty to react when exceptions occur: All the processes carried out by an automated terminal are not necessarily stable and homogenous. They may be volatile and change over time (from minute to minute, day to day and year to year). Automation prefers a high degree of repetition and predictability (Davidson, 2016).
- High maintenance costs: Automated systems need to be updated at regular intervals, to keep up with advancements in the software used. Ignoring updates can result in fatal security breaches, which is why all systems need to be upgraded. This implies continuous maintenance costs for ports (SHM Group, 2018).
- Risk of the project: Automation projects carry greater risk and are harder to implement whereas manual terminals are tried and tested (Davidson, 2016).
- Reliability and performance: The automated machines have to be always operational in order to not become a technical constraint and play on the

performance on the terminal. The manual machines can work under all the conditions even with bad weather for example.

Today, the dependence face to the automation and technology increase with the years. But the problems are so unpredictable and the needs, activities change so quickly, that the reaction of the operators have to be fast, that is difficult with the automation.

4.3. Discussion

In the discussion part, the research will evaluate the different impacts of port automation, if it can be a solution for the future through meeting research's objectives. Also, the future of automation in ports and the Rotterdam's port.

The objective A (= to analyse the background of the maritime world, then the application of automation for ports and the features of Port of Rotterdam), of the research in chapter 1 is achieved through a detailed literature review in chapter 2. Since using ships for commercial purposes, for the transport of goods, man has had to look for places where ships can safely park: safe from the movement of the sea; to perform the loading and unloading of their cargoes, which translates to creating seaports. Over time, the opening up of economies around the world has led to both their internationalization and growth in international trade, particularly in the goods sector. So, the increase in trade in goods forced companies to carry more and further, which has resulted in various consequences. Indeed, the consequences have resulted in a very large increase in size and a very high specialization of equipment of the ships. As a result, seaports must constantly adapt their facilities and equipment to the characteristics of ships and traffic, which caused their evolution. An evolution that led to the automation of the ports (Planete tp, 2008).

The automated container terminal has been a reality for about ten years and the movement is intensifying. Initiated in Europe, Rotterdam (1993) and Hamburg (2002), automation is a process that has been gaining momentum for a few years now. Digitization allows greater efficiency of all activities. The software organizes ship loading plans, where the constraints accumulate. The same goes for the operation of the terminals. Gear, containers and software can exchange with each other. In these terminals, the management of the container parks (storage, provisioning) is done with fully automated equipment. The movements between the container storage and the gantry cranes are done by automated vehicles (AGV, straddle carrier) (Planete tp, 2008). Some, advantages and disadvantage have been presented I order to introduce few impacts of the automation, for better develop them in the rest of the dissertation.

So, for illustrate the dissertation, the case study of the port of Rotterdam is a good example. It is the first port with an automated terminal, named Maasvlakte 2, in

operating since 2013. With this extension and automation program, the port of Rotterdam is demonstrating its desire to grow and improve its services. But also, the need for automation aims to grow Rotterdam port and maintain its position among the most important port in the world. Indeed, until 2004, the Dutch port even occupied the first place. But the rapid growth of Asian ports, and especially Chinese, driven by the economic boom of this region, has since declined in the world hierarchy. It was therefore exceeded in 2004 by Singapore and Shanghai. Besides, today it is the eighth largest port and the largest European port (Escale de Nuit, 2015).

The objectives B, C and D are achieved through analysing the data collected and discussion based on automation's impact in general and more precisely within the Rotterdam port. Thanks to a thematic analysis, the different impacts have been identified and classified into a total of 4 themes. The researcher has summarised the impacts of the automation, in way more detail for a better understanding in the following table:

Themes	Advantages	Disadvantages
Manpower	- New job opportunities. - Up-skilling opportunities for workers. - New skills and responsibilities. - Better work conditions.	- Reduction of the workforce = 30 to 70%. - Risk of strike.
Environment	- Increased safety and reduced potential human error in port operations and accidents in port operations. - Reduction in CO2 emissions. - Improvement of the quality of life for the local and employees.	- Automation increase the traffic and consequently the emission of Co2.
Cost	- Reduction in labour costs by reducing manpower. - Increased in container throughput by reducing container handling charges.	- Requires large initial capital investment, so an amortization over several years.

	- Reduction in operating costs by increasing efficiency.	- Created inequality and competitiveness by contributing to ports that do not have access to its investments.
Operational	- 24/7 working hour thanks to the machines. - Increased speed of operation. - Increased operational productivity and berth productivity. - Better organisation due to the predictability of operations. - Shorten vessel waiting time.	- Less / lack of flexibility for operational planning. - Cyber security risks. - Difficulty to react when exceptions occur. - High maintenance costs. - Risk of the project. - Possibility of equipment breakdown.

Table 1: Summary of the impact of automation in the ports.

Source: (Author's Own, 2018)

As seen in table, it is certain that the implementation of automation has much more potential benefits than negative impacts as well as the possibility its can be a solution in the long term. For Rotterdam's port, this solution is inevitable in order to deal with its daily challenges as the welcome of the mega-ships and the growing number of containers to handle, but also stay competitive face to the other Mondial ports, which have adopted the automation too.

This digitization of the ports began some ten years ago, but its pace will accelerate to transform the entire logistics and port sector. Dematerialization and automation are the watchwords of the port of tomorrow. A smart port where the management of tools, the work of men, logistics processes and security will be carried by digitalization. A modernization necessary in view of the gigantism of ships and equipment. A major challenge for, ultimately, a fast, efficient and intelligent logistics (Les Clés de Demain, 2018).

In this area, the port of Rotterdam acts as a figurehead: by focusing on new technologies, it already foreshadows the port of the future, a smart port where

reception and ship traffic, which are automated, will be optimized (Les Clés de Demain, 2018). Indeed, by 2033, when the four basins of the extension will be fully operational, Maasvlakte 2, will almost double the port's transshipment capacity from 19 million containers per year to 36 million. The annual number of ships that can transit through the port should increase from 34,000 currently to 57,000 in 2035. It will also accommodate the world's largest container ships 24 hours a day, whose capacity has almost doubled over the last decade to reach 18,000 containers. They can also reach 400 meters long and 60 meters wide (AFP, 2013).

Chapter 5: Conclusion

Today, maritime transport is a pillar of international trade and one of the main drivers of globalization. Some 80% of global volume trade is transported by sea and handled in ports. Over the last decades, shipping and ports have been constantly changing, because beyond market issues it is due to the perpetual movement of the evolution of ships, ports and actors.

For good reason, maritime transport is one of the most competitive activities because it is at the heart of globalization. So, innovations in the field of naval technology, packaging of goods... have inevitable repercussions on port morphology, on the organization of the port sector, on the organization of the flow of exchanges in the world. Maritime and port companies in particular must adapt and innovate accordingly. Indeed, the port ecosystem must meet a multitude of challenges in a context of hyper-competition: regulatory constraints, environmental challenges, search for productivity and competitiveness, the port must understand the needs of today and tomorrow and this thanks to the maritime and port companies' innovations (Marcadon, 2005).

The use of automation in ports and container terminals is characterized by automatic devices for handling, software concerning the organization of port activities ... The automation of container handling can be done at different levels. degrees and locations: on the wharf, ship-in-shore, yard, or gate / gateway, or all three locations. This is in part an accepted method of improving operating productivity, mainly for large container terminals. One of the major benefits of technology is the ability to offset labor costs and related costs, and to move containers more efficiently to and from a ship, through operational areas of a port and through the supply chain in a more ecological way than a manual port.

The case study had permit to discover the port of Rotterdam. This port is located on the north-west side of Europe, more precisely at the mouth of the Rhine, it is the main port of the North-European range and it is also at the center of the European megalopolis. Already among the most important ports in the world, a new polder, named Maasvlakte 2, inaugurated in 2013, gives the opportunity to perform better than

it is. Indeed, this extension, of 2 000 hectares, has a new fully automated terminal. It is the first port that has it, making it a pioneer in the history of port automation. This project represents a cost but obligated for face to the new challenges of the maritime transport. The automation permits to have more space, deal quickly containers, competitive, predictability, eco-friendly, consistency of operation, new opportunities for the workforce, welcome the new generation of ship... But create also disadvantages, which have to be reduce for the automation became accepted and efficient.

Concerning the future, the digitization of port spaces will become more important. A major challenge for, ultimately, a fast, efficient and intelligent logistics. In the coming years, many technologies are still expected to develop, namely: Blockchain, augmented reality, autonomous ships and drones.



Figure 10: Virtual reality prototype of fully autonomous ship developed by Rolls-Royce. Source: (Poridis, 2014).

In addition, we should also see the emergence of deep learning, artificial intelligence, the Internet of Things (IoT), virtual reality, robotics and wearable technologies ("Cyborg Crew"). Each of these technologies will have a major impact on the marine industry, with extended ramifications for its future. Some of these technologies are already well advanced and in operational use in shipping today, while others are still in an early stage of development. Most of these technologies are already used in other industries and just need a trigger for them to be adopted in the marine sector (Richard, 2018).

For Rotterdam, the innovative tools will help to streamline its traffic, and thus to gain competitiveness. *"We are one of the most important ports in the world and we want to be at the forefront of the transformation"* says Paul Smits, chief financial officer of the port of Rotterdam responsible for innovation. With a turnover of 712 million euros in 2017 and a traffic increase of 1.3%, the Dutch port continues to charge its digital transformation. With a goal in mind: to facilitate the entry of ships and accelerate their unloading. But currently, the port deploys a large network of sensors in the mouth of the river. The challenge is to measure meteorological conditions, the depth of the water and the strength of the currents depending on the tides (Vairet, 2018).

After measuring the impacts, divided into two categories, advantages and disadvantages and realizing that the benefits were more important than the disadvantages, we can then deduce that automation is a solution to face the various challenges of the port world. There will undoubtedly be an increase in the number of ports looking to invest in automated equipment in several key regions. But progress, it seems, will still be slow. Indeed, even in 2020, the use of automation will still represent less than 5% of the total number of installations in the world (Port Strategy, 2016).

The limitations of this study include the fact that data provided by official port authorities are rather limited. In addition, because of the time constraint, the primary data could not be collected. So, the research for the dissertation focused more on collecting secondary data, particularly through archival research and analyzed using the data collected. And formatted using the case study based on the port of Rotterdam. Due to the limitations of the study, the research focused primarily on automated principles and process manipulation. As a result, the research identified some future research.

Following the study of the impact of automation on ports, further research on port technology can focus on future innovations: automated ships, IoT technology, blockchain, big data, artificial intelligence, cloud technology ... (Les Clés de Demain, 2018). Their implementation can lead to radically different needs that ports must respect. Thus, other research on future technologies could be approached, and the impacts they would generate on different types of actors or on the supply chain could be explored.

References

AAPA, (2015). *World Port Rankings 2015*. [Online] Available at: <http://www.aapa-ports.org/>

AFP (2016). *Grève de 24 heures au port de Rotterdam, la première en 13 ans*. [Online] L'express L'expansion. Available at: https://lexpansion.lexpress.fr/actualites/1/actualite-economique/greve-de-24-heures-au-port-de-rotterdam-la-premiere-en-13-ans_1751587.html

AFP (2013). *Pays-Bas: Rotterdam, plus grand port d'Europe, ouvre une immense extension*. [Online] 20 Minutes. Available at: <https://www.20minutes.fr/economie/1160131-20130522-20130522-pays-bas-rotterdam-plus-grand-port-europe-ouvre-immense-extension>

Amba France, (2017). *Les Avantages Du Transport Maritime*. [Online] Available at: <http://www.ambafrance-yu.org/avantages-transport-maritime/>

Banque Mondiale, (2017). *Trafic de conteneurs dans les ports (TEU : unités équivalents 20 pieds)*. [Online] Available at: <https://donnees.banquemondiale.org/indicateur/IS.SHP.GOOD.TU?view=chart>

Barjonet, C (2014). *Le monde mis en boîte ou l'histoire du conteneur*. [Online] Les Echos. Available at : https://www.lesechos.fr/04/09/2014/lesechos.fr/0203724934253_le-monde-mis-en-boite-ou-l-histoire-du-conteneur.htm

Bellot I, (2015). *Le commerce maritime mondial : infographies*. [Online] infos Arte. Available at : <https://info.arte.tv/fr/le-commerce-maritime-mondial-infographies>

Bichindaritz, I. (1995). Incremental concept learning and case-based reasoning: for a cooperative approach. In I.D. Watson (Ed.), *Progress in case-based reasoning* (p. 91-106), Berlin, Springer.

Blog Log Trans, (2015). *L'histoire des porte-conteneurs*. [Blog] Available at: <http://www.logtrans-services.fr/la-societe/blog-logtrans/l-histoire-des-porte-conteneurs2.html#WlerlqjblU>

Business Dictionary (2017). *Data Analysis*. [Online] Available at: <http://www.businessdictionary.com/definition/data-analysis.html>

Burg, D (2012). *Rotterdam investit toujours plus dans ses infrastructures*. [Online] Les Echos. Available at: https://www.lesechos.fr/30/05/2012/LesEchos/21194-169-ECH_rotterdam-investit-toujours-plus-dans-ses-infrastructures.htm

Burns, C (2016). *Grève des travailleurs portuaires à Rotterdam – un test pour l'Europe ?*. [Online] Equal Times. Available at: <https://www.equaltimes.org/greve-des-travailleurs-portuaires?lang=fr#.WtdnaojwbIW>

Carronnier, V (2013). *Le port de Rotterdam, toujours plus grand*. [Online] La Croix. Available at: <https://www.la-croix.com/Actualite/Economie-Entreprises/Economie/Le-port-de-Rotterdam-toujours-plus-grand-2013-05-23-963569>

Caude G and Scherrer P, (2017). *Ports maritimes*. [Online] Universalis. Available at : <https://www.universalis.fr/encyclopedie/ports-maritimes/>

Cnrtl, (1980). *Terminal*. [Online] Available at: <http://www.cnrtl.fr/definition/terminal//1>

Cruise Mapper, (2017). *Rotterdam (Holland)*. [Online] Available at: <http://www.cruisemapper.com/ports/rotterdam-port-54>

David z. Morris, (2017). *To Understand Automation's Impacts, Consider the History of Ports*. [Online] Fortune. Available at : <http://fortune.com/2017/03/12/automation-ports-shipping/>

Davidson, N (2016). *Container Terminal Automation: Pros & Cons*. . [Online] Port Technology. Available at: https://www.porttechnology.org/technical_papers/container_terminal_automation_pros_and_cons

Dempsey M, (2017). *RFID in ports and terminals: moving towards global acceptance*. [Online] Port Technology. Available at : https://www.porttechnology.org/technical_papers/rfid_in_ports_and_terminals_moving_towards_global_acceptance

Dudovskiy, J (2017). *Pragmatism Research Philosophy*. [Online] Research Methodology. Available at: <http://research-methodology.net/research-philosophy/pragmatism-research-philosophy/>

Dudovskiy, J (2017). *Positivism Research Philosophy*. [Online] Research Methodology. Available at: http://research-methodology.net/research-philosophy/positivism/#_ftn1

Dudovskiy, J (2017). *Realism Research Philosophy*. [Online] Research Methodology. Available at: <http://research-methodology.net/research-philosophy/realism/>

Dudovskiy, J (2017). *Interpretivism Research Philosophy*. [Online] Research Methodology. Available at: <http://research-methodology.net/research-philosophy/interpretivism/>

Dudovskiy, J (2017). *Research Philosophy*. [Online] Research Methodology. Available at: https://research-methodology.net/research-philosophy/#_ftnref1

Dudovskiy, J (2017). *Deductive Approach (Deductive Reasoning)*. [Online] Research Methodology. Available at: <https://research-methodology.net/research-methodology/research-approach/deductive-approach-2/>

Dudovskiy, J (2017). *Inductive Approach (Inductive Reasoning)*. [Online] Research Methodology. Available at: <https://research-methodology.net/research-methodology/research-approach/inductive-approach-2/>

Dudovskiy, J (2017). *Quantitative Data Analysis*. [Online] Research Methodology. Available at: <https://research-methodology.net/research-methods/data-analysis/quantitative-data-analysis/>

Dudovskiy, J (2017). *Qualitative Data Analysis*. [Online] Research Methodology. Available at: <https://research-methodology.net/research-methods/data-analysis/qualitative-data-analysis/>

Dudovskiy, J (2017). *Validity*. [Online] Research Methodology. Available at: <https://research-methodology.net/research-methodology/reliability-validity-and-repeatability/research-validity/>

Dudovskiy, J (2017). *Research reliability*. [Online] Research Methodology. Available at: <https://research-methodology.net/research-methodology/reliability-validity-and-repeatability/research-reliability/>

Escale de Nuit (2015). *Les 10 plus grands ports du monde*. [Online] Available at: <https://escaledenuit.com/2015/05/02/les-10-plus-grands-ports-mondiaux/>

Expat (2017). *Travailler à Rotterdam*. [Online] Available at: <http://www.expats.com/fr/guide/europe/pays-bas/11139-travailler-a-rotterdam.html>

Feilzer, M. Y (2010). Doing mixed methods research pragmatically: Implications for the rediscovery of pragmatism as a research paradigm. *Journal of Mixed Methods Research*, 4(1), pp.6-16.

Flick, U (2011). *Introducing research methodology: A beginner's guide to doing a research project*. London: Sage.

FoodRisc Resource Centre (2016). *Mixed methods research*. [Online] Available at: http://resourcecentre.foodrisc.org/mixed-methods-research_185.html

Gaitzsch, S (2017). *À Rotterdam, plongée dans le port du futur*. [Online] Swissquote. Available at: <https://fr.swissquote.com/newsroom/magazine/dossier/rotterdam-port-future>

Garnier, C (2015). *Avec les robots du port de Rotterdam*. [Online] L'usine Nouvelle. Available at: <https://www.usinenouvelle.com/article/avec-les-robots-du-port-de-rotterdam.N345781>

Global Business, (2017). *Terminal Operation System (TOS)*. [Online] Available at: https://www.globalservices.bt.com/uk/en/products/port_solutions

Glossaire International, (2017). *Transport intermodal*. [Online] Available at: <https://www.glossaire-international.com/pages/tous-les-termes/transport-intermodal.html>

Guillemoles, A (2011). *La mécanique des grands ports de l'Europe du Nord*. [Online] La Croix. Available at: https://www.la-croix.com/Actualite/Economie-Entreprises/Economie/La-mecanique-des-grands-ports-de-l-Europe-du-Nord-_NG_-2011-06-21-660952

International Finance Corporation, (2017). *Automated ports drive Iraq's economy forward*. [Online] Available at :

http://www.ifc.org/wps/wcm/connect/news_ext_content/ifc_external_corporate_site/news+and+events/news/impact-stories/iraq-automated-ports-nafith

Kalmar Global, (2017). *Industry history*. [Online] Available at: <https://www.kalmarglobal.com/industry-insights/industry-history/>

Knowler, G (2018). *Rotterdam still Europe's top port despite Antwerp record*. [Online] Joc.com. Available at: https://www.joc.com/port-news/rotterdam-extends-lead-europe-top-port-despite-antwerp-record_20180215.html

Kone Cranes, (2017). *Automated Guided Vehicles*. [Online] Available at: <http://www.konecranes.com/equipment/container-handling-equipment/automated-guided-vehicles>

La Haye AFP (2016). *Grève de 24 heures au port de Rotterdam, la première en 13 ans*. [Online] La voix du nord. Available at: <http://www.lavoixdunord.fr/archive/recup/economie/greve-de-24-heures-au-port-de-rotterdam-la-premiere-en-13-ans-ia0b0n3257821>

L'antenne, (2015). *Classements des ports mondiaux*. [Online] Available at: https://www.lantenne.com/Classements-des-ports-mondiaux_a26954.html

Lavocat, L (2014). *Les ports européens sont devenus un problème environnemental*. [Online] Reporterre. Available at: <https://reporterre.net/Les-ports-europeens-sont-devenus>

Lenntech, (2017). *FAQ sur la quantité d'eau*. [Online] Available at: <https://www.lenntech.fr/faq-eau-quantite-1.htm>

Les Clés de Demain (2018). *La digitalisation arrive à bon port*. [Online] Available at: http://lesclesdedemain.lemonde.fr/dossiers/la-digitalisation-arrive-a-bon-port_f-213.html

Levoyageur, (2017). *Ports dans le monde*. [Online] Available at: <http://www.levoyageur.net/ports.php>

Marcadon, J (2005). *L'innovation dans l'industrie du transport maritime (technologie navale, port, marché mondial, organisation des entreprises)*. [Online] Available at: <file:///C:/Users/Ma%C3%AFa/Downloads/19%20Marcadon.pdf>

Martín-Soberón, A. M., Monfort, A., Sapiña, R., Monterde, N. and Calduch, D., (2014). *Automation in port container terminals*, *Procedia - Social and Behavioral Sciences*. Volume 160, pp. 195–204.

Mi-Jacktech, (2017). *Optical Character Recognition (OCR)*. [Online] Available at: <http://mi-jacktech.com/optical-character-recognition-ocr/>

Mongelluzzo, B (2016). *Terminal automation: Expensive, unsexy but consistent*. [Online] JOC. Available at: https://www.joc.com/port-news/port-equipment/terminal-automation-expensive-unsexy-consistent_20161228.html

Planete tp (2008). *Internationalisation des échanges*. [Online] Available at: <http://www.planete-tp.com/internationalisation-des-echanges-a1166.html>

Porodis, M (2014). *Le transport maritime va connaître une véritable révolution avec l'apparition de navires autonomes sans équipage*. [Online] Daily Geek Show. Available at: <https://dailygeekshow.com/le-transport-maritime-va-connaître-une-veritable-revolution-avec-lapparition-de-navires-autonomes-sans-equipage/>

Port Montréal (2013). *Le port de Rotterdam place l'environnement en tête de liste*. [Online] Available at: <https://www.port-montreal.com/fr/au-large-mai2013.html>

Port of Rotterdam, (2017). *Facts & figures about the port*. [Online] Available at: <https://www.portofrotterdam.com/en/the-port/port-facts-and-figures/added-value-employment>

Port of Rotterdam (2012). *Celebration of 20 years AGV's*. [Online] Available at: <https://www.portofrotterdam.com/en/news-and-press-releases/celebration-of-20-years-agv%E2%80%99s>

Port of Rotterdam (2017). *Throughput*. [Online] Available at: <https://www.portofrotterdam.com/en/the-port/port-facts-and-figures/throughput>

Port Strategy (2016). *Automatic attraction*. [Online] Available at: <http://www.portstrategy.com/news101/port-operations/cargo-handling/automatic-attraction>

Quentin, I (2012). *Méthodologie et méthodes de l'étude de cas*. [Online] Word Press. Available at: <https://isabellequentin.wordpress.com/2012/04/02/methodologie-et-methodes-de-letude-de-cas/>

Resnik D Bet al. (2015). What is Ethics in Research & Why is it important ?. [Online] NIH. Available at: <https://www.niehs.nih.gov/research/resources/bioethics/whatis/index.cfm>

Richard, F (2018). *Les 10 principales technologies dans le maritime en 2018*. [Online] Shipping Lab. Available at: <http://www.shipping-lab.com/news/les-10-principales-technologies-dans-le-maritime-en-2018/>

Rifkin, J (1995). *The End of Work: The Decline of the Global Labor Force and the Dawn of the Post-Market Era*. Putnam Publishing Group. pp. 66, 75

Said Aden, S (2010). *La manutention portuaire au sein du terminal de Doraleh*. [Online] Mémoire Online. Available at: https://www.memoireonline.com/09/11/4815/m_La-manutention-portuaire-au-sein-du-terminal-de-Doraleh8.html

Saunders, M., Lewis, P. & Thornhill, A. (2012) "Research Methods for Business Students" 6th edition, Pearson Education Limited.

Scherrer P, (2011). *Principes d'implantation et d'aménagement des Ports Maritimes*. [Online] Techniques de l'ingénieur. Available at : <https://www.techniques-ingenieur.fr/base-documentaire/ingenierie-des-transports-th14/infrastructures-environnement-et-transport-par-voie-d-eau-42617210/principes-d-implantation-et-d-amenagement-des-ports-maritimes-c4630/definition-et-role-des-ports-maritimes-c4630v2niv10001.html>

SHM Group, 2018. *Everything you need to know about port automation*. [Online] Available at: <http://www.shmgroup.com/blog/everything-need-know-port-automation/>

Smith, W (2017). *Research Onion – Made easy to understand and follow*. [Online] All Assignment Help. Available at: <https://www.allassignmenthelp.co.uk/blog/research-onion-made-easy-to-understand-and-follow/>

Statista, (2017). *Principaux exploitants de porte-conteneurs selon le nombre total de navires dans le monde au 3 mai 201*. [Online] Available at: <https://fr.statista.com/statistiques/564993/exploitants-de-porte-conteneurs-dans-le-monde-nombre-de-navires/>

United Nations Conference on Trade and Development (2017). *Review of maritime Transport 2017*. [Online] Available at: <https://www.lemoci.com/wp-content/uploads/2016/11/Review-of-maritime-transport-2017-UNCTAD.pdf>

Vairet, F (2018). *Le port de Rotterdam accélère sa numérisation*. [Online] Les Echos Executives. Available at: https://business.lesechos.fr/directions-numeriques/digital/transformation-digitale/0301318694178-le-port-de-rotterdam-accelere-sa-numerisation-318980.php#formulaire_enrichi::bouton_facebook_inscription_article

Williams, J (2011). *What is Research Methodology ?*. [Online] Help With Your Dissertation. Available at: <http://www.howtodo.dissertationhelpservice.com/tag/what-is-research-methodology/>